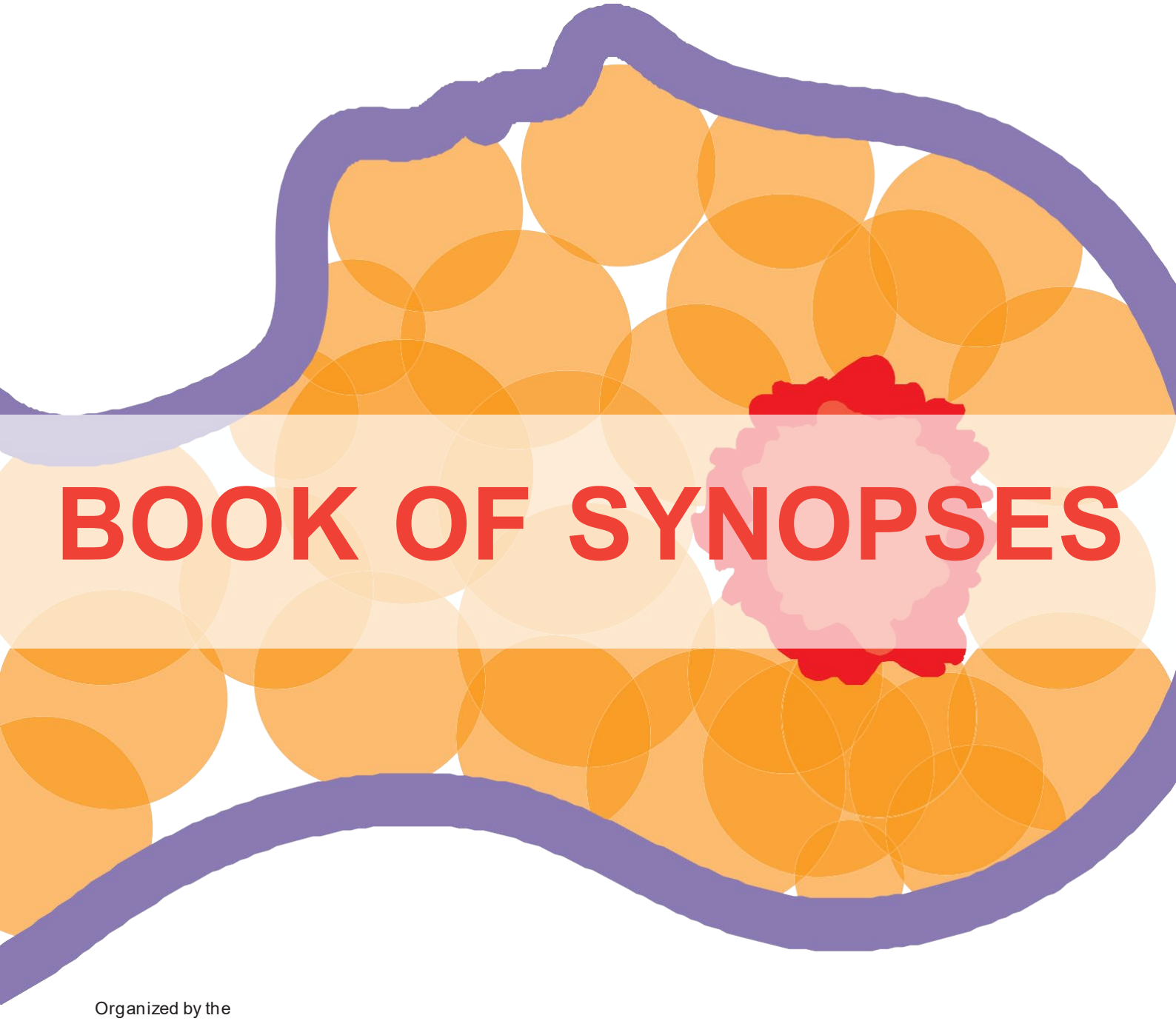
International Conference on

Advances in Radiation Oncology

Vienna, Austria 16–19 February 2021

#ICARO3



BOOK OF SYNOPSES

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International Atomic Energy Agency
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IAEA-CN-288
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In cooperation with the

European Society for Radiotherapy and Oncology

American Society for Radiation Oncology (ASTRO)

American Association of Physicists in Medicine (AAPM)

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International Commission on Radiation Units and Measurements (ICRU)

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Federation of African Medical Physics Organizations (FAMPO)

Global Clinical Trials RTQA Harmonization Group (GHG)

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Keynote

Opening Keynotes

From ICARO 2 to ICARO 3: Radiation Oncology

Eduardo Rosenblatt

The previous ICARO meetings took place in 2009 and 2017, fulfilling their promise of providing an international platform for presenting and discussing radiation oncology, radiobiology, and medical physics advances.
Some of the questions asked in the round-table discussions:
ICARO 1: Cobalt-60 RT: time to retire? IMRT: are you ready for it? Do we need proton therapy? ICARO 2: Should IMRT be the standard of care? Full automation in RT? Radical treatment for oligometastases? ICARO 3 – What is the role of Artificial Intelligence in RT? Is telemedicine here to stay? How to close the global technological gap?
The ICARO meetings focus on the needs of LMICs and how to deploy validated radiotherapy technologies. Radiotherapy centres are now coping with new realities imposed by the COVID-19 pandemic and will probably have to continue, in the "new normal" foreseeable future. A concerted global effort is needed to address the gap in radiotherapy technology.

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Keynote

Opening Keynotes

From ICARO 2 to ICARO 3: Physics

Geoffrey Ibbott
M.D. Anderson Cancer Center (MDACC)

Background and objective

ICARO3 will be held virtually in mid-February 2021, four years after ICARO2 and twelve years after the first ICARO conference, which was held in 2009. It is no understatement to say that the world has changed enormously in the past twelve years. The Covid-19 pandemic has been responsible for many recent changes, including the restrictions on mobility that have resulted in this meeting being held remotely. It is also true that radiation oncology has undergone an evolution in recent years as new treatment paradigms have emerged and been tested, including efforts to treat Covid-19 patients with radiation. The objective of this report is to review the changes that have taken place in the physics of radiation oncology over the course of three ICARO meetings.

Methods

A review was performed of the state of radiation oncology physics in 2009, in 2017, and in 2020. The changes that have taken place over the past twelve years were identified and an effort made to assess their significance.

RESULTS AND DISCUSSION

Radiation therapy (RT) continues to be a valuable modality in cancer treatment. The annual number of courses of RT globally has increased in recent decades, largely due to the increase in the world's population. According to UNSCEAR [1-4] in the period 1985–1990, approximately 4.0 million treatment courses were delivered annually. This number increased to 4.7 million per year in 1991–1996, to 5.1 million in 1997–2007, and to 6.2 million in 2008-2018. Most of the recent increase occurred in high-income countries and was attributed to the increase in number of linear accelerators in use. According to the IAEA's DIRAC database, there are currently more than 14,000 treatment machines in use worldwide [5]. An increase was also seen in the availability of particle beams, particularly proton beams. The number of brachytherapy treatments and afterloading brachytherapy units appeared to have changed very little in recent years.

Treatment techniques have advanced considerably. In the past two decades, stereotactic treatment has progressed from being an exceptional procedure available at only a few highly-specialized centres to widespread use especially in high- and middle-income countries. Intensity-modulated radiation therapy is used for at least half of the patients treated in centres in high-income countries and is being introduced in low- and middle-income countries.

Image-guided radiation therapy (IGRT) has similarly undergone a rapid increase in use, thanks to the availability of kV imaging equipment on virtually all new medical linacs sold today. IGRT techniques also are being introduced in low- and middle-income countries as treatment equipment is replaced or upgraded. The use of magnetic resonance imaging (MRI) for treatment guidance is currently being introduced at a few centres and at least 60 MRI-linacs are now installed and undergoing testing or early clinical use.

Medical physicists have been instrumental in these developments. Techniques for dosimetry and quality assurance of new modalities have been developed and substantial training efforts have been undertaken to bring these to diverse communities.

Conclusions

Radiation oncology has evolved over the time frame of three ICARO conferences. Medical physicists have contributed to numerous technical developments, and have developed new methods,

or refinements to existing methods, to calibrate the radiation beams from new devices and to assure the quality of treatments.

Acknowledgments and ethics clearance

The author is grateful to the IOMP for the nomination to this conference

References

[1] UNSCEAR. Sources, Effects and Risks of Ionizing Radiation. UNSCEAR 1988 Report. United Nations Scientific Committee on the Effects of Atomic Radiation, 1988 Report to the General Assembly, with annexes. United Nations sales publication E.88.IX.7. United Nations, New York, 1988.

[2] UNSCEAR. Sources and Effects of Ionizing Radiation. UNSCEAR 1993 Report. United Nations Scientific Committee on the Effects of Atomic Radiation, 1993 Report to the General Assembly, with scientific annexes. United Nations sales publication E.94.IX.2. United Nations, New York, 1993.

[3] UNSCEAR. Sources and Effects of Ionizing Radiation. Volume I: Sources. UNSCEAR 2000 Report. United Nations Scientific Committee on the Effects of Atomic Radiation, 2000 Report to the General Assembly, with scientific annexes. United Nations sales publication E.00.IX.3. United Nations, New York, 2000.

[4] UNSCEAR. Sources and Effects of Ionizing Radiation. Volume I: Sources: Report to the General Assembly, Scientific Annexes A and B. UNSCEAR 2008 Report. United Nations Scientific Committee on the Effects of Atomic Radiation. United Nations sales publication E.10.XI.3. United Nations, New York, 2010.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY. Directory of Radiotherapy Centres (DIRAC). IAEA. [Internet] Available from (https://dirac.iaea.org/Data/ CountriesLight) on 8 February 2019.

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Keynote

Technological Gap

Technological Gap - Clinical Perspective

Michael Barton
University of New South Wales, Sydney

This paper examines the gap between supply of and demand for radiotherapy globally. Models of optimal demand for radiotherapy estimate that about half of all cancer patients need radiotherapy at least once in their illness. There is a global deficit in radiotherapy facilities that is greatest in Low and Middle Income Countries and has increased over time as populations grow and age. Gross Domestic Product, urbanisation and health spending correlate with the availability of radiotherapy. Social factors include the political environment, advocacy, national planning and a sustainable funding model. Full supply of radiotherapy by2035 would save 1 million lives per year globally and return US$97 to US$184 billion on the investment in facilities and staff.

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Keynote

Technological Gap

Technological Gap - Physics Perspective

Jacob van Dyk
Western University, London, Ontario, Canada

Background and objective

The increasing burden of cancer and the corresponding shortage of radiation therapy (RT) services around the globe, especially in low-to-middle income countries (LMICs) has been well documented. The most comprehensive of these reports was produced by the Global Task Force on Radiotherapy for Cancer Control (GTFRCC) [1]. Several follow-up reports have described factors affecting cost considerations [2], the needs by geographic region and income level [3], and initiatives to increase access to treatment [4]. This review provides an update on the gap in RT technologies between what exists in 2020 and what is needed over the next 15 years.

The technological gap

While the technological gap is often described by the number of megavoltage machines required to treat the projected number of patients, in reality, the needs extend well beyond the physical machines. There has to be a political and organizational will at the government and institutional levels to develop new or expanded facilities. The machines are housed in bunkers in RT departments; these facilities are an essential component. Without professional and well-trained staff, the technology is useless. The essential staff include medical physicists, radiation oncologists and radiation therapists, in addition to support staff. Furthermore, the staff need to be trained to operate the technologies and to develop treatment protocols. The knowledge and skill developments are essential ingredient to the proper functioning of treatment procedures. The inter-relatedness of these issues is summarized schematically in Figure 1.

Radiation therapy is a complex process involving multiple steps and multiple technologies beyond megavoltage RT machines, including CT-simulators, radiation treatment planning systems, brachytherapy afterloading units, radiation oncology information systems, patient immobilization devices, dosimetry measurement systems, radiation safety devices, in addition to a number of related ancillary devices. Regarding megavoltage therapy machines, the GTFRCC indicated that in 2013, there were 13,100 machines available globally. From the IAEA DIRAC database [5], in 2020, there existed 14,300 machines representing a 9% increase in total and a 27% increase in LMICs. In its second Call for Action, the GTFRCC report targeted “an increase of 25% in the 2015 radiotherapy treatment capacity by 2025” for LMICs. These data are shown as the grey bars in Figure 2. The gap between what exists in 2020 and what is the projected need in 2035 is shown by the red numbers and arrows in Figure 2, corresponding to a total need of 7,300 machines. Since the average department includes two megavoltage machines, this implies that nearly 3,700 departments will have to be developed each with a CT simulator, a treatment planning system, a brachytherapy system, a radiation oncology information system in addition to ancillary equipment.

The people gap is more complex since medical physics education and training have a university academic component and a 2-year on the job training component (residency) – all of which can take 6-10 years. Once trained, on-going professional development is essential.

There are a few barriers in considering the people and knowledge gap. These barriers can be reduced by new enabling technologies along with partnerships of professional societies volunteer organizations as well as government and non-government organizations.

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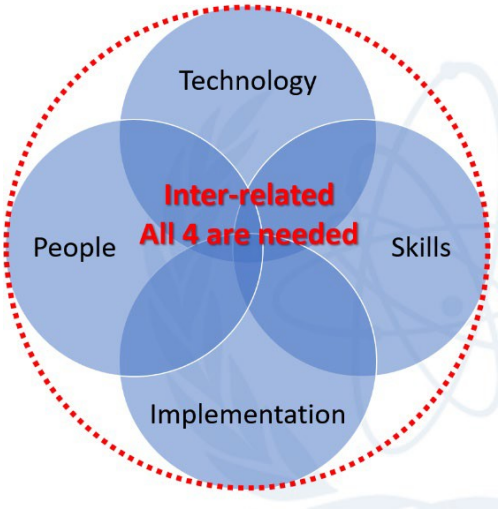

Figure 1. The technological gap is more than a lack of treatment technology.

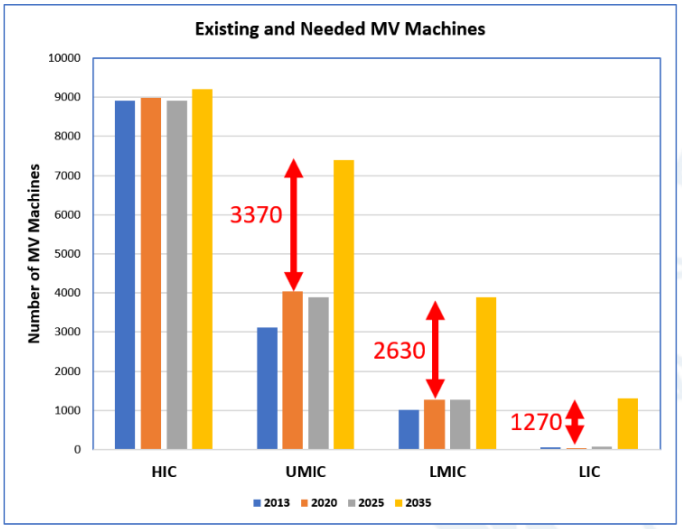

Figure 2. Existing and needed megavoltage machines. The 2013 data are from the GTFRCC report [1]. The 2020 data are from IAEA's DIRAC database [5]. The 2025 data represent the GTFRCC call for action of an increase of 25% in LMICs. The 2035 data represent the projected needs to provide access to RT globally. HIC=high-income countries; UMIC=upper middle-income countries; LMIC=lower middle-income countries; LIC= low-income countries. The numbers in red represent the gap between what exists in 2020 and what is need in 2035.

References

[1] ATUN R., JAFFRAY D.A., BARTON M.B., BRAY F., BAUMANN M., VIKRAM B., HANNA T.P., KNAUL F.M., LIEVENS Y., LUI T.Y., MILOSEVIC M., O'SULLIVAN B., RODIN D.L., ROSENBLATT E., VAN DYK J., YAP M.L., ZUBIZARRETA E., GOSPODAROWICZ M. Expanding global access to radiotherapy, Lancet Oncol, 16, (2015) 1153-1186.

[2] VAN DYK J., ZUBIZARRETA E., LIEVENS Y. Cost evaluation to optimise radiation therapy implementation in different income settings: A time-driven activity-based analysis, Radiother.Oncol, 125, (2017) 178-185.

[3] ZUBIZARRETA E., VAN DYK J., LIEVENS Y. Analysis of Global Radiotherapy Needs and Costs by Geographic Region and Income Level, Clin.Oncol.(R.Coll.Radiol.), 29, (2017) 84-92.

[4] RODIN D., HANNA T.P., BURGER E., ZUBIZARRETA E., YAP M.L., BARTON M.B., ATUN R., KNAUL F., VAN DYK J., LIEVENS Y., GOSPODAROWICZ M., JAFFRAY D.A., MILOSEVIC M. Global Access to Radiation Therapy for Cervical Cancer: The Cost of Inaction, Int J Radiat Oncol Biol Phys, 96, (2016) S14-S15.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA). Directory of Radiotherapy Centres, DIRAC (https://dirac.iaea.org/) Accessed 2021/01/09, IAEA . 2021.

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Keynote

Advanced Technologies

Artificial Intelligence in Radiotherapy

Ben Heijmen
Department of Radiation Oncology, Erasmus Medical Center, Erasmus University Rotterdam

Artificial Intelligence (AI) is an upcoming research field in radiotherapy, triggered by substantial recent successes in other fields. Actually, in a relatively simple form, AI is not new to radiotherapy. The much-applied logistic regression for response modelling is basically AI, in which a single artificial neuron is trained for performing predictions. The more advanced AI that is currently developed has much complexer modelling, e.g. using deep learning with artificial neural networks (ANN) consisting of hundreds or thousands of neurons. Currently, many researchers are exploring the new possibilities that advanced AI can offer radiotherapy to improve treatments or make the workflow more efficient. In this lecture, a brief overview will be provided of some basic technical aspects of AI in radiotherapy, and some applications with high potential clinical impact will be discussed in more detail. Lastly, challenges, hazards and legislative issues for using AI in radiotherapy will be briefly touched.

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Keynote

Radiobiology

Radiobiology of high dose per fraction

Mike Joiner
Wayne State University

We can now deliver radiation to a target volume with accuracy better than 1 mm. Given this accuracy, why fractionate? If we can put dose only on the cancer, never on critical normal tissue, then surely just give a high single dose to that cancer, and job done. Local tumor control is 100% with minimal toxicity. If only. Two linked issues keep Clinical Radiobiology in the game. First, imaging resolution does not yet correspond with this sub-millimeter accuracy of radiotherapy delivery. Second, even if that imaging resolution is reached it could still not detect occult disease. Consequently, unless the cancer is truly isolated, perhaps in early-stage prostate cancer, it is always necessary to "degrade" the treatment plan by defining a CTV and PTV into which the radiation delivery is expanded. This imposes a risk of normal-tissue radiotoxicity, therefore we use fractionation and/or brachytherapy to minimize that risk. In fractionation, the Linear-Quadratic (LQ) model describes the relationship between total dose and dose per fraction, for isoeffect. A hypothesis for the different α/β values for early- and late-reacting tissues in LQ, is that a naturally low α/β for a cell population is smoothed out to a higher value as the sum of the responses of different proliferative subpopulations. In some malignancies, notably human prostate, clinical data indeed indicate an α/β as low as 1.5, which might also reflect more uniformity in response perhaps more characteristic of lower proliferative or early-stage disease. Thus in prostate cancers, hypofractionation is becoming standard of care.

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Keynote

Radiobiology

New radiobiological concepts and their implications

Loredana Marcu[a,b]
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bCancer Research Institute, University of South Australia, Adelaide, SA 5001, Australia

Background and objective

The role of radiobiology is to elucidate the effects of radiation on cellular structures and on the tumour as a whole, in order to support the design of new radiotherapy protocols for an enhanced therapeutic index. Therefore, radiotherapy progress requires continuous radiobiological research that allows translation of results from pre-clinical to clinical studies. There are several aspects in clinical radiobiology that can tailor patients' treatment towards a more personalised approach. The aim of this work is to present some of the latest advances in radiobiology that have an impact on patients' response to treatment.

Methods

The Rs of radiobiology, both old and modern will be revisited and discussed in the context of novel therapeutic strategies and their impact on clinical practice.

Results and discussion

Reoxygenation requires fractionated doses in order to occur, which does not always happen in modern radiotherapy. Large fractions of doses in strongly hypofractionated radiotherapy, such as stereotactic body radiotherapy, shows less efficiency in tumour reoxygenation [1]. Repopulation is now known to be due to stem-like cancer cells that have the ability to produce the whole lineage of cells within a tumour, therefore this subgroup must be targeted for eradication [2]. Remote effects caused by radiation could trigger unwanted long-term and very-long-term consequences (increased risk of second cancer) [3]. The volume of the irradiated tissue in the context of today's molecular imaging and the long-term restoration of normal tissue are other critical aspects to be accounted for during treatment planning and radiation delivery [4].
Knowledge of radiation quality and advances in track structure studies in radiation biology led to better understanding of biological properties of ionizing radiation, thus to the clinical implementation of proton, heavy ion and targeted alpha particle therapies. While these new techniques offer several advantages, there are radiobiological questions regarding long-term effects that are yet to be answered.

Conclusions

For a long time, the main focus of radiotherapy was to uniformly target the tumour volume to achieve complete eradication. However, tumour subvolumes built of cellular subtypes with specific properties require a differential approach, due to different radiobiological properties. Hypoxic tumour subvolumes, cancer stem cells and inherently radioresistant tumour subpopulations are the main culprits for tumour recurrence, disease dissemination and treatment failure. The future of radiotherapy relies on the clinical implementation of radiobiological findings, and on an even stronger multidisciplinary approach that involves all players in the field of oncology.

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References

KELADA, O.J., DECKER, R.H., NATH, S.K., et al. High Single Doses of Radiation May Induce Elevated Levels of Hypoxia in Early-Stage Non-Small Cell Lung Cancer Tumors, Int J Radiat Oncol Biol Phys. 102 (2018) 174.

LI, F., ZHOU, K., GAO, L., et al. Radiation induces the generation of cancer stem cells: A novel mechanism for cancer radioresistance, Oncol Lett. 12 (2016) 3059.

MARCU, L.G., Photons - Radiobiological issues related to the risk of second malignancies. Phys Med. 42 (2017) 213.

DÖRR, W., Radiobiology of tissue reactions, Ann ICRP. 44 (1 Suppl) (2015) 58.

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Keynote

Education and Training

Competency Based Education in Radiation Oncology: Global Perspectives on the Assessment of Learning

Kim Benstead
Gloucestershire Hospitals NHS Foundation Trust

Assessments will vary between different countries because of national regulations. We can, however, reach a consensus on what it is valuable for trainees to learn in order to be good consultant radiation oncologists and express this in a curriculum. Curriculum frameworks such as CANMEDS identify the roles of a doctor aiding us in structuring a curriculum. Assessing the performance of trainees in all the roles requires workplace-based assessments. Using Entrustable Professional Activities (EPAs) to build a curriculum allows us to define the standard of proficiency required as a level of the EPA. This will vary between countries depending on the incidence of different cancers but should be explicit. Blueprinting assessments against the EPAs ensures that all areas of the curriculum are assessed. Working together to develop and share curricula and validated workplace assessment tools, and to evaluate each other's training programmes will enable standards to converge.

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Keynote

The RTT Profession

Mary Coffey
Discipline of Radiation Therapy, School of Medicine, Trinity Centre for Health Sciences, St. James's Hospital

The RTT profession must change and evolve as radiotherapy evolves. However we must first consider what it means to be a professional and to reflect on whether currently RTTs actually meet the criteria in this definition. When we consider the developments in radiotherapy over recent times many of the approaches considered innovative are already a part of routine practice. The future in terms of technology and technique will change the face of our radiotherapy departments and how we work within the new environment. Technological developments include the MR Linac and particle beams which are already in use in specialist centres and will become more and more mainstream over the coming decades. New technique approaches such as novel fractionation, FLASH and PART will enhance the patient outcome but will require greater care and skill on the part of the RTT. The greater use of immunotherapy coupled with radiotherapy will bring challenges in time scheduling and side effect management. The RTT in the future will have to rise to meet these challenges for the benefit of the patient and also the profession.

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Keynote

Clinical Research

Clinical Research

Jai Prakash Agarwal
Tata Memorial Hospital, Mumbai

Clinical research has helped in understanding the diseases particularly cancer and finding out the optimal solutions faced by the global community at each level . There are enormous challenges in doing the clinical research and varies with each region and local context but certainly which can be overcome dialogue and collaborations. Clinical research over the decades done at IAEA particularly with Low- and middle-income countries has shown and strengthened the global oncology with not only sparing of resources but has improved outcomes too. IAEA CRP and other programs helped in capacity building and strengthening the manpower to conduct international level high quality research.

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Keynote

Expanding Access to Radiotherapy

Health Systems Research

Yolande Lievens
Department of Radiation Oncology; Ghent University Hospital; Ghent University

Health systems research (HSR), is a broad multidisciplinary field of research studying aspects of the society and the healthcare system, affecting quality and cost of, and access to healthcare, ultimately impacting our health and well-being as individuals or as society. HSR has traditionally been insufficiently recognised in radiation oncology, but in recent years the interest has been increasing.
In order to guarantee maximal impact on the outcome of our patients, clinical research and health systems research should go hand in hand, so that innovations can be quickly and optimally implemented in clinical practice and made accessible to our patients. Providing optimal access to qualitative care is indeed a central theme in HSR.
Access is a broad concept covering different domains, determined not only by the health services, but also by human and economic factors. Delivering the right treatment in the right way can improve access to radiation services by avoiding the waste of resources in delivering low-value care. In addition, it can support the sustainability and resilience of our radiation practice, which by themselves are crucial in safeguarding access, in spite of chronic or sudden disturbances.

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Keynote

Paediatric Radiation Oncology

Radiotherapy in Teenagers and Young Adults with cancer: Providing Care and Improving Outcomes

Ed Smith
The Christie Hospital, University of Manchester

No longer children and not yet adults, Teenagers and Young Adults (TYA's) with Cancer can present a challenge to healthcare professionals and healthcare systems alike.
Management of their cancer as well as understanding behaviour and psychology are all important components of care for this group of patients.
At an age of physical and psychological transitions, management of this group of patients can challenging.
Delays in diagnosis, adherence to treatment, concerns around sexuality, fear of lagging behind educationally, being disadvantaged career wise, and fear of late effects can all be major issues.
Services and treatments have evolved to address many of these issues.

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Keynote

Radiotherapy in the National Cancer Control Plan

Radiotherapy in the National Cancer Control Plan

Lisa Stevens
Director, Programme of Action for Cancer Therapy (PACT), IAEA

Dr Lisa Stevens, Director of the Programme of Action for Cancer Therapy at the International Atomic Energy Agency (IAEA), presents on the role of radiotherapy in national cancer control planning. This presentation outlines how comprehensive cancer control assessments (imPACT Reviews) conducted by the IAEA, WHO and IARC provide a baseline situation analysis to guide cancer control planning and investments. imPACT Reviews cover the entire cancer control continuum. Recommendations from imPACT Reviews support key global WHO initiatives on cervical and childhood cancer and will support the forthcoming WHO breast cancer initiative. Specific country examples of Burkina Faso, Honduras, and Kazakhstan are discussed.

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Keynote

QUATRO

QUATRO:

Building National Quality Audit Programme for Radiotherapy: the Belgian experience.

Stefaan Vynckier[1], Aude Vaandering[1,2]
[1]UCL, Université catholique de Louvain, Imagerie Médicale, Radiothérapie et Oncologie (MIRO)
[2]Department of radiation oncology, Cliniques Universitaires St Luc, Brussels, Belgium

Background and objective

The International Atomic Energy Agency (IAEA) published in 2007 a document that proposes a methodology to carry out comprehensive clinical audits in radiotherapy [1]. Known as IAEA QUATRO (Quality Assurance Team in Radiation Oncology) audits, this audit methodology has been conducted in a significant number of radiotherapy departments located in Europe, Latin America, Asia and Africa [2]. This audit methodology has also been used in Belgium.

Methods

Under the auspices of the government, clinical audits were initiated and carried out in Belgium in all 25 radiotherapy centres using the IAEA QUATRO approach [3]. All departments were audited between 2011 and 2015.

Results

After the evaluation of the first cycle of audits, it was felt that a follow-up campaign was desired. It was deemed that it would be worthwhile to review the QUATRO document to adapt it to the Belgian context while also integrating into it the newer technologies that had emerged since the QUATRO publication. It was also decided to integrate within this revision a whole chapter focusing on the quality management systems underlying radiotherapy departments themselves. In 2017, a second cycle of clinical audits were initiated using the adapted document called B-QUATRO[4].

Conclusion

Clinical audits in Belgian radiotherapy departments were successfully implemented based on the IAEA QUATRO methodology.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Comprehensive Audits of Radiotherapy Practices: A tool for Quality Imrpovement, Vienna: IAEA, 2007.

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[2] J. Izewska, M. Coffey, P. Scalliet, E. Zubizarreta, T. Santos, I. Vouldis et P. Dunscombe, «Improving quality of radiation oncology: "10 years' experience of QUATRO audits in the IAEA Europe Region", Radiotherapy and Oncology, vol. 126, pp. 183-190, 2018.

[3] Scalliet, P. (on behalf of the Federal College of radiotherapy), "Clinical radiotherapy audits in Belgium 2011-2014. ", *Cancer/Radiothérapie*, vol. 19, pp. 621-623, 2015.

[4] A. Vaandering, Y. Lievens, P. Scalliet, Belgian College for Physicians in Radiation Oncology: "Feasibility and impact of national peer reviewed clinical audits in radiotherapy departments.", *Radiotherapy and Oncology,* vol. 144, pp. 218-223, 2020.

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Keynote

Strategies in Ensuring Continuity of Radiotherapy Services in the Context of COVID-19

Matthias Guckenberger
Department of Radiation Oncology, University Hospital Zürich, University of Zurich, Zurich, Switzerland

COVID-19 has been declared a pandemic by the WHO on March 11th . Since then, almost 100 Million people have been infected and more than 2 million people died of a CVID-19 infection. In addition, the pandemic has consequences affecting all components of our societies. From a health care perspective, cancer patients are at multiple and competing risks: due to COVID-19 directly by and iincreased risk of infection, hospitalization and death and by insufficient access to ICU; due to cancer by reduced access to diagnosis & treatment and by sub-optimal cancer care.
Despite radiation therapy is not associated with an increased risk of death due to COVID-19, radiation oncology needs specific preparations to cope with the challenges of the COVID-19 pandemic. These include strict hygiene rules, home office, tandem operational teams, postponement of low-risk indications, digital solutions for consultations, hypofractionation. All measures need adaptation to national, regional and local rules and regulations. And importantly, all measures need to balance the patient individual and society risks due to pandemic and the patient individual cancer risk.

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Keynote

Telemedicine

Telemedicine in Radiation Oncology

Iain Ward
Canterbury Regional Cancer and Blood Service, Christchurch Hospital

Telemedicine is not new in radiation oncology, but its uptake has been accelerated by the COVID-19 pandemic. Most patients and radiation oncologists have had positive experiences with telephone and video consultations, but difficulties with physical examination limit their use for a minority of patients. Virtual Tumour Boards help maintain physical distance for infection control, and they have also become established in the international setting to provide support for oncologists in Low and Middle Income Countries without local tumour boards. Electronic collection of Patient Reported Outcome Measures have the potential to better inform clinical assessment of toxicity and symptom response to radiotherapy. Telehealth standards and guidelines specific to radiation oncology need to be developed to ensure that risks to quality, equity and privacy are managed. If employed thoughtfully, there are many benefits that telemedicine can bring to our patients and to our nonclinical practice.

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Physics Thursday

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T: Advanced Technologies and Techniques in Radiation Oncology

Invited speaker:

MP-T1	Ferid Shannoun and Peter Thomas (UNSCEAR)	The UNSCEAR 2020 report on medical exposure: approach, trends and challenges in the field of radiation therapy
MP-T2	Oliver Jäkel (ICRU)	Prescribing, Recording and Reporting Proton and Light Ion Beam Therapy (ICRU 78 and 93)
MP-T3	Yolanda Prezado (EFOMP)	Spatially fractionated radiation therapy: from photons to charged particles
MP-T4	Geoffrey Ibbott (IOMP)	Out of field doses
MP-T5	Robin Hill	on kV therapy dosimetry: updates and challenges
MP-T6	Laurence (Edward) Court	Radiation Planning Assistant: Automated contouring and treatment planning

Profert paper presentations:

MP-TO1	Sonja Wegener	Effect of detector choice for commissioning measurements propagated trough beam modelling to final dose calculation
MP-TO2	Iqbal AL AMRI	Accuracy of an Eclipse treatment planning system for SRS
MP-TO3	Tania Filipa Sobrinho dos Santos	Characterization of helical tomotherapy plans complexity
MP-TO4	Abdelkader Toutaoui	Retrospective evaluation of portal dosimetry pre-treatment quality assurance for volumetric-modulated arc therapy (VMAT) and stereotactic radiotherapy (SRT) plans
MP-TO5	Hwee Shin Soh	A novel quantitative metrics for assessing IMRT plan complexity: A virtual phantom study
MP-TO6	Vibeke Hansen	Clinical implementation of the MRLinac in Odense, Denmark
MP-TO7	Andrea Mantuano	FRICKE DOSIMETRY FOR BLOOD IRRADIATORS

Poster presentations:

MP-TP01	Taweap Sanghangthum	Dosimetric comparison between volumetric modulated arc therapy and intensity modulated proton therapy for whole brain irradiation with hippocampal sparing
MP-TP02	MARIA DO CARMO LOPES	Independent verification of the pre-installed beam model in helical tomotherapy
MP-TP03	Božidar Casar	On the dose linearity of detectors for small field dosimetry
MP-TP04	ISMAIL ZERGOUG	TPS commissioning for IMRT/VMAT
MP-TP05	Ezequiel Larger	Simple method for evaluating flatness and symmetry based on EPID and MATLAB

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MP-TP06	Abdelkader Toutaoui	Dosimetric comparison between VMAT and dedicated stereotactic planning tool for single isocenter stereotactic radiotherapy for patients with multiple brain metastases
MP-TP07	Jonas Ringholz	Small field output correction factors at 18 MV
MP-TP08	Carla Mota	COMMISSIONING OF AN X-RAY BIOLOGICAL RESEARCH IRRADIATOR
MP-TP09	Nkosingiphile Maphumulo	Determination of field output correction factors in small static photon fields following TRS-483 CoP
MP-TP10	Tinnagorn Donmoon	Verification of two beam-matched linear accelerators using volumetric modulated arc therapy plans
MP-TP11	Aik Hao Ng	Assessing the target shift and its effect on dose distribution using deformable image registration method for head and neck patients undergoing IMRT
MP-TP12	Jamema Swamidas **Kishore Joshi**	Evaluation of Knowledge-based planning of Volumetric Modulated Arc Therapy (VMAT) for Nasopharyngeal cancer
MP-TP13	SADIA SADIQ	Dosimetric Comparison of VMAT and IMRT for NPC and Prostatic Carcinoma
MP-TP14	Reena Devi Phurailatpam	Total Marrow with Lymphoid Irradiation (TMLI) as a conditioning regimen using VMAT technique: Planning and dosimetry validation
MP-TP15	Maria Elena Grech	A Measure of the Target Reposition Errors for Lung Volumetric Arc Therapy as Observed on Three-Dimensional Cone-Beam Computed Tomography, in a Single Radiotherapy Department in Malta
MP-TP16	Ilya Lvovich and Tomer Charas	Bladder filling before radiation therapy treatments to the prostate – Evaluating volume, dose and reproducibility of constraints
MP-TP17	Claus Maximilian Baecker	Development of proton range verification by use of titanium implants and PET

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E: Education and Training

Invited speaker:

MP-E1	LORETI, Giorgia	IAEA Activities in Support of Education and Recognition in Medical
MP-E2	Geoffrey Ibbott (IOMP)	IOMP activities in medical physics education and training
MP-E3	Brendan McClean (through Prezado Yolanda)	EFOMP activities in education and training of medical physicists in Europe

Sub-Session: MP-E4. Global access to medical physics: challenges and opportunities

MP-E4.1	Jacob Van Dyk	Virtual mentoring in global medical physics education and training
MP-E4.2	Graciela VELEZ	Challenges in establishing a clinical training programme for MP
MP-E4.3	Parminder S. Basran (MPWB)	The "Open Syllabus" project – improving global access to radiation oncology medical physicist residency training content
MP-E4.4	LORETI, Giorgia	Monitoring and Evaluation of IAEA e-learning Courses in Medical Physics
MP-E4.5	Daniel Venencia	Experience as a remote supervisor under the IAEA Doctoral CRP Programme

Profert paper presentations:

MP-EO1	Sherisse De Four	Volumetric Modulated Arc Therapy (VMAT): The gold standard for the present and future of radiotherapy?
MP-EO2	Chi Do Duc	A study on the determination of relative output factors for very small fields in stereotactic radiosurgery
MP-EO3	Ignatius Komakech	Establishment of an Incident reporting and learning System as a tool for Quality Management in Uganda's radiotherapy services: A case of the low resource setting
MP-EO4	Nesrine Elamri	Evaluation of positionning and dosimetry uncertainties in patients treated with intensity modulation radiotherapy (IMRT) for nasopharyngeal cancers in Tunisia
MP-EO5	Bertha Gracia;Milagros garcia gutierrez	Determination and comparasion of output factors in small field for field square and rectangular field with 5 detectors for For 6 Mv.

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Poster presentations:

MP-EP01	Mwape Mofya	A comparative study of two treatment planning systems for IMRT optimization
MP-EP02	Saba Hussain	Small-field output factor determination for Versa HD flattened and flattening filter-free beams with various detectors
MP-EP03	Rosa Petit	Statistical Control Process in Tomotherapy pre-treatment QA
MP-EP04	Penabei samafou	Dosimetric verification and comparative analysis of Collapsed Cone Convolution (CCC) and Irregular Field (IF) algorithms for soft tissue, lung and bone region treatment sites using an anthropomorphic phantom
MP-EP05	Edith Villegas Garcia	Brain Radiotherapy during pregnacy: a dosimetric study for fetal dose with OSLD
MP-EP06	Mohammed Abujami	Confidence in 6 MV and 6 MV FFF VMAT EPID QA adopting the AAPM-TG119 approach

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A: Audits, Quality and Safety

Invited speaker:

MP-A1	Andy Nisbet	What is new in radiotherapy medical physics auditing?
MP-A2	Stephen F Kry	Enhancing quality in radiotherapy through dosimetry audits (the IROC experience)
MP-A3	Pavel KAZANTSEV	IAEA/WHO dosimetry audits: present and future
MP-A4	Stefaan Vynckier	Experience and skills for medical physics auditing under the IAEA QUATRO activity
MP-A5	Annette Wygoda	Designing a framework for improving Radiotherapy Safety and Quality
MP-A6	Ola HOLMBERG	Enhancing safety in radiotherapy: the IAEA Safety Standards for Medical Uses

Proffered paper presentations:

MP-AO1	Petri Sipila	Dose verification from imaging to delivery during site visits in radiotherapy
MP-AO2	Ilkka Jokelainen	Small field absorbed dose to water determinations in LINAC MV photon beams during site visit authority control of radiotherapy
MP-AO3	Alexis DIMITRIADIS	Introduction of the IAEA Electron Beam Dosimetry Audit Service
MP-AO4	Godfrey AZANGWE	Following up on radiotherapy dosimetry audit discrepancies (2018-2020): the IAEA experience
MP-AO5	Magali EDOUARD	Medical physics outsourcing in radiotherapy in France: services, practices, limits and points of vigilance

Poster presentations:

MP-AP01	Jerickson Abbie Flores	Safety in Radiation Oncology (SAFRON) Incident Learning System in the Philippines: Learning through Experience
MP-AP02	Jhonatan Riparip	Obstacles in Error Reporting System Among Radiotherapy Facilities: Basis for an Enhanced ILS Policy
MP-AP03	Jaffar Pineda	Failure Modes and Effects Analysis in Image Guided High-Dose-Rate Brachytherapy: A Single Institutional Study
MP-AP04	Eliana Quinteros	Implementation of a comprehensive verification program for 3D high-dose rate brachytherapy plans: "QA-Brachy"
MP-AP05	Arissa Pickler	ANALYSIS OF THE FRICKE-PMMA INTERACTION AND ITS EFFECTS IN FRICKE DOSIMETRY
MP-AP06	Manuel Castrillon	Comparison of monitor units and dose calculation between two independent second-check verification software
MP-AP07	Una Findlay	Optimising Learning from a National Incident Learning System in Radiotherapy: The PHE Experience

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MP-T1 The UNSCEAR 2020 report on medical exposure: approach, trends and challenges in the field of radiation therapy, F. Shannoun, P. Thomas and G. Ibbott

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BACKGROUND AND OBJECTIVE

Medical exposure reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) aim to determine annual frequencies of medical examinations and procedures involving the use of ionizing radiation and their associated radiation doses. Past reports of the Committee have encompassed exposure and practice in diagnostic radiology, nuclear medicine and radiation therapy. Data have been analyzed to deduce temporal trends and to evaluate the collective population dose due to medical exposure from imaging procedures. This paper will focus on the results obtained from the analysis of the radiation therapy data.

METHODS

Annual frequency and dose data were derived from two main sources: the UNSCEAR Global Survey and the comprehensive peer-reviewed scientific literature, supplemented by data from relevant international organizations [1, 2, 3, 4, 5]. Further, a comprehensive review of published literature related to medical exposure was conducted, covering the period 2005–2018, with inclusion of additional relevant recent articles and reports. Publications were deemed suitable for the evaluation if they demonstrated changes and updates in practice since the previous UNSCEAR 2008 Report [6].

UNSCEAR Global Survey data were received from 44 countries, covering about 50% of the total world population. Because the number of countries providing data was low, additional data from the IAEA, OECD and WHO were incorporated in the assessment [1, 3]. Data on radiation therapy treatment courses do not include radionuclide therapy treatments.

In the evaluation, mathematical models of procedure frequencies within seven broad classifications were developed to generate projections for those countries that did not provide data to the survey. The procedure categories used were: conventional radiology (excluding dental radiology), dental radiology, computed tomography, interventional radiology, diagnostic nuclear medicine, radionuclide therapy and radiation therapy. While it would have been desirable to include population demographics data in the modelling to account for possible variations in examination frequencies due to different age and disease distributions, it was not possible to adopt such an approach as only a limited number of countries were able to provide the necessary detailed data.

RESULTS AND DISCUSSION

The estimated total annual number of radiation therapy treatment courses was 6.2 million, with an uncertainty of ±25%. The total was derived by combining the assessment data with the predictions of a continuous model for countries that did not submit data to the survey. The UNSCEAR continuous model was a power-law fit to the treatment course frequencies in the assessment data as a function of physician density. The number of radiation therapy treatment courses estimated is shown in Table 1, with categorization by health care and income levels.

Table 1. f courses per annum by health care levels and income levels.

Category	Population (millions)	Estimated total number of treatment course (millions)[a]	Average treatment courses per million[a]

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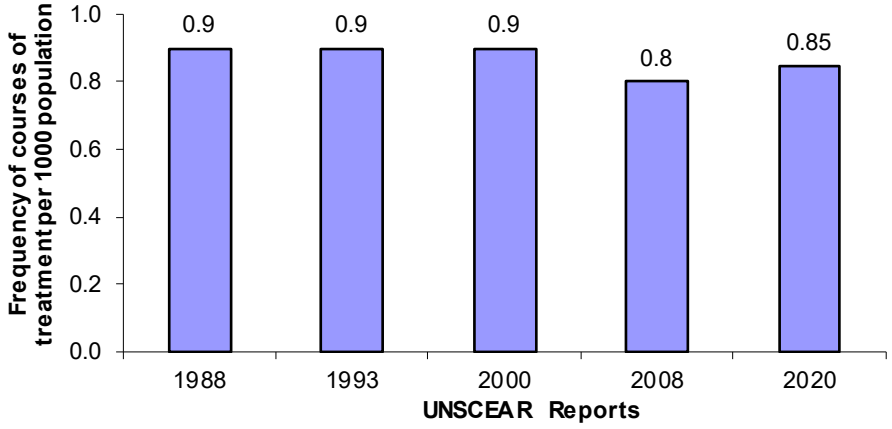
Categorization by health-care level			
I	3,908	5.8	1,480
II	2,256	0.38	168
III	622	0.05	85
IV	526	0.01	19
Categorization by income level			
High	1,149	3.0	2,620
Upper middle	2,619	2.6	1,000
Lower middle	2,882	0.50	172
Low	662	0.10	148
All	**7,312**	**6.2**	**853**

[a] *Values have been rounded.*

The current UNSCEAR survey indicates that, on average, brachytherapy accounts for 6.7% of all treatment courses. On this basis, an estimated total of number of 5.8 million patients were treated with external beam radiation therapy and around 0.4 million were treated with brachytherapy. The number of linac treatment units increased to more than 12,000 worldwide. A large increase was seen in health care level I countries. At the same time, the number of brachytherapy treatments and the number of after loading brachytherapy units appeared to have changed very little. Particle-beam therapy facilities have been developed worldwide, with the result that today there are 104 particle beam facilities in operation (counting carbon-ion facilities independently of proton beam facilities).

Radiation therapy has undergone an evolution in the past several decades. According to the IAEA's DIRAC database, the approximate number of treatment machines (linacs plus cobalt-60 units) available worldwide is 14,285 [1]. In many parts of the world, however, access to radiation therapy is extremely limited. The annual number of courses of radiation therapy treatment (excluding radionuclide therapy) is estimated to have increased from 800 to 850 per million since the previous UNSCEAR 2008 Report [6], however the overall global rate has remained constant in the past three decades [6, 7] (Figure 1).

Figure 1. Trend in global annual frequency of courses of radiation therapy treatment (excluding radionuclide therapy)



CONCLUSIONS

Radiation therapy treatments have increased in number and sophistication but access to radiation therapy continues to be varied worldwide. The estimated annual total number of treatment courses represents an increase of 22% compared to previous UNSCEAR reports [6, 7], however the overall global rate of treatment courses has remained constant in the past three decades.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY. Directory of Radiotherapy Centres (DIRAC). IAEA. [Internet] Available from (https://dirac.iaea.org/Data/ CountriesLight) on 8 February 2019.

← Back To Table of Contents

[2] INTERNATIONAL AGENCY FOR RESEARCH ON CANCER. Cancer Incidence in Five Continent. IARC [Internet] Available from (http://ci5.iarc.fr/Default.aspx) on 8 May 2019.
[3] ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT. Health equipment. OECD [Internet] Available from (https://data.oecd.org/ health.htm #profile-Health%20equipment) on 15 January 2020.
[4] WHO. Health statistics and information systems. World Health Organization. [Internet] Available from (https://www.who.int/healthinfo/statistics/en) on 3 October 2018.
[5] World Bank. World Bank Open Data. [Internet] Available from (https://data. worldbank.org) on 15 January 2018.
[6] UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION. Sources and Effects of Ionizing Radiation. Volume I: Sources: UNSCEAR 2008 Report to the General Assembly, Scientific Annexes A and B. United Nations sales publication E.10.XI.3. United Nations, New York, 2010.
[7] UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION. Sources and Effects of Ionizing Radiation. Volume I: Sources. UNSCEAR 2000 Report to the General Assembly, with scientific annexes. United Nations sales publication E.00.IX.3. United Nations, New York, 2000.

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MP-T2 Prescribing, Recording and Reporting Proton and Light Ion Beam Therapy (ICRU 78 and 93), Oliver Jäkel

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BACKGROUND AND OBJECTIVE

Proton beam therapy has been developed and pioneered in clinical studies already since 1954, when John Lawrence started to treat the first proton therapy patients at the Berkeley radiation laboratory. John's brother Ernest Lawrence, who invented the cyclotron, had built the first proton cyclotron, which was capable to reach energies sufficiently high to penetrate the human body. The idea to use protons for radiotherapy dates back to Robert Wilson, who published this idea in a seminal paper in 1946. After the first patients were treated, Helium ions were used in Berkeley and in 1977 in a new machine, the use of heavier ions (from (C to Ar) was explored. While protons are being used mainly because of their advantageous depth dose profile, heavier ions exhibit distinct radiobiological features, which seem beneficial for very resistant (e.g. hypoxic) tumors.
Proton therapy for many years was only available in a few research centres and a single clinical centre in Loma Linda University Medical Center (opening in 1990). When ICRU decided to form a committee to work on a proton therapy report (around 2000), there were only 7 facilities worldwide, treating patients with protons (3 with carbon ions) for deep seated tumours, but it was clear that many new facilities were underway (by the end of 2021, around 140 proton and ions centres will be operational, see www.prcog.ch). In 2004, a committee for a report on light ion beam therapy was formed (chaired initially by H. Tsujii and WT Chu, and from 2013 on by the author).

METHODS

The ICRU report 78 (chaired by Hermann Suit and Dan Jones) on *prescribing, recording and reporting proton therapy*, was published in 2007 and contributed significantly to a harmonization of proton beam radiotherapy. Three field were of special importance:
□ Dosimetry: it was recommended to base dosimetry on ionization chambers calibrated to absorbed dose to water, following the Code of practice published by the International Atomic Energy Agency (IAEA) as TRS 398 in 2000.

□ Radiobiology: it was recommended to use the same value for the relative biological effectiveness (RBE) of proton beams in all clinical applications. The value was kept fixed at 1.1, a value that is still being used at all clinical proton facilities.

□ For the product of absorbed dose and RBE, solely the term *RBE-weighted absorbed dose* should be used in proton therapy in combination with the unit Gy, however, denoted by the descriptor "(RBE)", i.e. "Gy (RBE)".

The ICRU report 93 on light ion beam therapy was published in January 2020 (although the publisher for internal reasons denoted the year 2016 on the cover). The report follows the format of former ICRU reports on prescribing, recording and reporting of new modalities and

extensively described the historical, physical, radiobiological and technical background of light ion beam therapy. A focus was put on the radiobiology, and it was deemed important to clearly describe the various models used for RBE calculation in clinical treatment planning. These models use quite different approaches to transfer doses from cell data to humans or from prior clinical experience with X-rays (or neutrons in case of Japan) to ion beams. The models therefore use very different assumptions and premises, which are not always clear, when comparing clinical data from publications.
In order to make the reporting of ion beam therapy very transparent, it is recommended to include further information on the treatment plans, going beyond RBE-weighted dose distributions.
The recommendations can be summarized as follows:
□ In contrast to ICRU 78, the use of the unit "Gy (RBE)" for RBE-weighted dose is strongly discouraged, as there are obviously concerns by the committee of the SI-system, concerning a modification of the unit Gray. Both absorbed and RBE-weighted dose have to be specified in units of Gray, without any further descriptor.

□ For plan reporting, detailed information on the RBE-model used and additional data on the absorbed dose distributions, as well as LET – and RBE-distributions should be included (depending on availability in the specific TPS).

□ Dosimetry recommendations were updated to be consistent with latest ICRU reports and the update of the TRS-398, which is under preparation.

RESULTS AND DISCUSSION

ICRU report 78 eliminated the formerly used *pseudo-units* Gray equivalent (GyE or Gy(E)) or Cobalt Gray equivalent (CGE) and introduced a consistent terminology for absorbed and RBE-weighted dose. ICRU report 93 closed a gap in harmonizing the clinical application of light ion beam therapy and includes an update on recent developments. The change in the nomenclature for RBE-weighted dose is being discussed controversially, as confusion of the different dose terms is expected.
Besides carbon ion beam therapy, currently also Helium beam therapy is about to be resumed in Heidelberg and it will be exciting to see if ICRU 93 can also consistently be applied to this new treatment modality. In the future, oxygen is another candidate to further exploit different ion beams in radiotherapy.

REFERENCES

[1] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENT, Prescribing, recording and Report Proton Beam Therapy, Report 78, Oxford University Press, Oxford (2007).
[2] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENT, Prescribing, Recording and Report Light Ion Beam Therapy, Report 93, Oxford University Press, Oxford (2016).

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MP-T3 Spatially fractionated radiation therapy: from photons to charged particles, Yolanda Prezado

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BACKGROUND AND OBJECTIVE
Despite remarkable advancements, the dose tolerances of normal tissues continue to be the main limitation in radiation therapy (RT). One possible solution could be to employ distinct dose delivery methods, activating different biological processes from those ones in standard RT. Along this line, the spatial fractionation of the dose, used in techniques such as minibeam radiation therapy (MBRT), has already demonstrated a significant improvement of the therapeutic index for radio-resistant tumours [1-6]. Spatially fractionated radiation therapy (SFRT) describes a radiotherapeutical approach that uses a strong spatial modulation of the dose to create alternating regions of high and low dose in order to increase the tolerance of normal tissue. In recent years, the exploration of the possible synergies between the advantages of SFRT and the benefits of charged particles for therapy has started [3-6]. A brief and general overview of the latest developments in SFRT will be provided.
METHODS
To perform those evaluations, developing adequate technical implementations, suitable dosimetry protocols for small field dosimetry and radiobiology experiments had to be carried out.
RESULTS AND DISCUSSION
Concerning technical implementation, solutions using mechanical collimators [7] or magnetic focusing [8] were assessed. SFRT has been explored with medical LINACs, large synchrotrons, as well as small animal irradiators, and at proton and heavy ions facilities [3].
Different dosimetry protocols adequate for the very narrow beams used were developed [9]. The radiobiology experiments and clinical trials performed showed a significant increase of the therapeutic index for radioresistant or bulky tumours [3].
CONCLUSIONS
SFRT is a promising approach in RT. The latest developments, especially the use of charged particles, allow for fully profiting from the advantages of the use of spatial fractionation of the dose in radiation therapy.

ACKNOWLEDGMENTS and ETHICS CLEARANCE
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REFERENCES
[1] Haring, W., Development of Grid therapy, Strahlentherapie 102 (1957) 479-82.
[2] Slatkin, D.N. et al, Microbeam radiation therapy., Med Phys. 19 (1992) 1395-400.
[3] Weisi, Y. et al., Spatially fractionated radiation therapy: History, present and the future. Clin. Transl. Radiat. Oncol. **20** (2020) 30–38.
[4] Prezado, Y. et al., Transfer of Minibeam Radiation Therapy into a cost-effective equipment for radiobiological studies: a proof of concept Sci. Reports 7, (2017) article number 17295.
[5] Prezado, Y. and Fois, G., Proton minibeam radiation therapy: a proof of concept. Med. Phys. 40 (2013) 031712, 1–8.
[6] Prezado, Y. et al., Proton minibeam radiation therapy widens the therapeutic index for high-grade gliomas. Scientific Reports 8 (2018) article number 16479.

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[7] Dilmanian, A.F., et al., Minibeam therapy with protons and light ions: Physical feasibility and the potential to reduce radiation side effects and to facilitate hypofractionation. Int J Radiat Oncol Biol Phys. 92 (2015) 469-474.

[8] Guardiola, C., et al., Optimization of the mechanical collimation for minibeam generation in Proton MiniBeam Radiation Therapy, Med. Phys. 44 (2017) 1470–1478.

[9] Schneider, T. et al., Advancing proton minibeam radiation therapy: magnetically focussed proton minibeams at a clinical centre. Scientific Reports 10 (2020) Article number: 1384.

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MP-T4 Out of field doses, Geoffrey Ibbott

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BACKGROUND AND OBJECTIVE

The benefits of radiation therapy (RT) for cancer treatment are realized from the carefully controlled and spatially accurate delivery of radiation doses to tumour volumes. Conversely, doses delivered to healthy tissue represent detriment and contribute to the toxicity of treatment. The development of intensity-modulated radiation therapy and image guidance have enabled more accurate delivery of radiation doses to anatomically complex and temporally changing tumour volumes, while simultaneously sparing surrounding healthy tissues.

METHODS

A review was conducted of recent publications describing methods of reducing the dose outside the target volume during RT.

RESULTS AND DISCUSSION

Radiation therapy for cancer treatment, unlike surgery or chemotherapy, is an extremely quantitative modality that must be delivered with great precision. Historically, treatment guidance consisted of x-ray imaging prior to the treatment using dedicated radiographic and fluoroscopic equipment. However, while such treatment simulators clearly demonstrated bony landmarks, they could not distinguish between tumour tissue and healthy organs. In the late 1970s, CT scanners brought the opportunity to identify organs and structures [1]. Software for CT-based radiation therapy simulation became available and was once known as 'virtual simulation' [2]. By the early 21st century, conventional simulators had largely been replaced with dedicated CT scanners and simulation software. A major step forward came with the introduction of electronic portal imaging detectors (EPIDs) which captured a portal image electronically, replacing radiographic film. A refinement allowed for the creation of CT images by acquiring transmission data from a kV OBI system [3, 4]. Their use has enhanced image-guided radiation therapy (IGRT) considerably [5].

From the early days of radiation therapy, it was recognized that patients changed over the course of treatment. Interfraction changes occur at infrequent intervals; these may be a result of tumour growth or regression, or patient weight loss. In the recent past, this was most often addressed by reducing the treatment field dimensions after several weeks of treatment, anticipating reduced tumour volume by that point in the treatment. Incorrect estimations of target volume size could result in irradiation of larger volumes of normal tissue, or under-treatment of the tumour.

Conversely, intrafraction changes occur during the delivery of radiation and may result from respiratory motion or patient movement. Such variations have been managed by increasing the treatment field size to keep the target volume within the high-dose region. In the case of respiratory motion, this could result in a substantial increase in irradiated normal lung.

IMRT and IGRT have enabled greater sparing of normal tissues [6] and addressed both inter- and intrafraction motion much more effectively. Clinical evidence indicates that image guidance has contributed to treatment management [7].

However, x-ray imaging for daily treatment guidance results in a small additional radiation exposure to a large volume that can include sensitive normal tissues [8]. Consequently, the benefits of x-ray-based IGRT should be weighed against possible detriment to the patient.

CONCLUSIONS

Image guidance in radiation therapy has undergone major advances in recent years. Clinical benefits of regular image guidance and adaptations in treatment plans have been demonstrated. The field is on the verge of several practice-changing advances in IGRT, with the development of hybrid MR and PET imaging systems and treatment devices.

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REFERENCES

[1] Goitein, M., et. al., 1983. Multi-dimensional treatment planning: II. Beam's eye-view, back projection, and projection through CT sections. Int. J. Radiat. Oncol. Biol. Phys. 9, 789–797.

[2] Sherouse, G.W., Chaney, E.L., 1991. The portable virtual simulator. Int. J. Radiat. Oncol. Biol. Phys. 21, 475–482.

[3] Jaffray, D.A., et. al., 1999. A radiographic and tomographic imaging system integrated into a medical linear accelerator for localization of bone and soft-tissue targets. Int. J. Radiat. Oncol. Biol. Phys. 45, 773–789.

[4] Jaffray, D.A., et. al., 2002. Flat-panel cone-beam computed tomography for image-guided radiation therapy. Int. J. Radiat. Oncol. Biol. Phys. 53, 1337–1349.

[5] Moseley, D.J., et al., 2007. Comparison of localization performance with implanted fiducial markers and cone-beam computed tomography for on-line image-guided radiotherapy of the prostate. Int. J. Radiat. Oncol. Biol. Phys. 67, 942–953.

[6] Kilburn, J.M., et al., 2016. Image guided radiation therapy may result in improved local control in locally advanced lung cancer patients. Pract. Radiat. Oncol. 6, e73–e80.

[7] de Crevoisier, R., et al., 2005. Increased risk of biochemical and local failure in patients with distended rectum on the planning CT for prostate cancer radiotherapy. Int. J. Radiat. Oncol. Biol. Phys. 62, 965–973.

[8] Hall, E.J., Wuu, C.S., 2003. Radiation-induced second cancers: the impact of 3D-CRT and IMRT. Int. J. Radiat. Oncol. Biol. Phys. 56, 83–88.

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MP-T5 on kV therapy dosimetry: updates and challenges, Robin Hill

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BACKGROUND AND OBJECTIVE

Kilovoltage (kV) x-ray beams have a well-established role in treating skin cancers, keloids and other related conditions. The dosimetry of kV beams can be challenging due to large dose gradients, a large energy response in some detectors at these energies and uncertainties in reference dosimetry [1, 2]. There has however been significant work completed in reference and relative dosimetry for kV beams including planned updates to the IAEA TRS-398 Code of Practice [3]. This presentation will assist in guiding clinical practice in the dosimetry of kV beams by providing an update on this work.

METHODS

Reference dosimetry for kV beams is performed using air-kerma or dose-to-water based calibration which vary according to x-ray beam energy and the code of practice [1,2]. While the TRS-398 COP provides a framework for dose-to-water based calibrations, there are limited PSDLs and SSDLs that can provide calibration data for radiotherapy dosimeters based on this methodology. In addition, correction factors used in the COPs such as the backscatter factor in water (B_w) and ionization correction factor (k), have been limited in scope and may not be consistent with the x-ray beams used in the clinic. A number of recent studies, amongst others, have overcome these issues to provide a more extensive data set for these factors [4, 5]. The determination of these factors has become necessary in order to take into account updated physics data as published in the ICRU Report 90 [5]. These studies have relied on both advanced measurement techniques and/or Monte Carlo methods.

There are many possible dosimeters that could be used for relative dosimetry of kV x-ray beams. While the Farmer type ionization chambers typically possess very good energy response at kV energies, their large volume poses practical issues when one is trying to measure the dose at the surface of within the first few mm of a water phantom [1]. A number of studies have investigated the use of cylindrical and parallel plate ionization chambers as well as solid state detector for depth dose and lateral profile measurements [6-8].

RESULTS AND DISCUSSION

The work of Bancheri *et al* provides new data for the overall ionization chamber correction factors as used for dose-to-water calibrations [4]. This will allow for more accurate dosimetry as well as the use of a wider range of ionization chambers which were not available at the time of the original published TRS-398 COP. The database of B_w values developed by Andreo considers an extensive number of x-ray beam spectra, field sizes and source-to-surface distances [5]. This new data will allow for more accurate air-kerma based calibrations for the local clinic.

The use of parallel plate ionization can be considered for depth dose measurements of kV x-ray beams with good agreement to reference data and Monte Carlo calculations [6, 8]. However, determination of the dose right at the water phantom surface may require care extrapolation techniques. Other dosimeters that have shown promise include diamond detectors and radiochromic film, but these should always be compared to suitable ionization chambers [1, 9].

CONCLUSIONS

kV x-ray beam dosimetry has many challenges, but this talk will provide an update on how these can be carefully managed in the clinic.

REFERENCES

[1] HILL, R., et al., *Advances in kilovoltage x-ray beam dosimetry.* Physics in medicine and biology, 2014. **59**(6): p. R183.

[2] NAHUM, A.E., *Perturbation effects in dosimetry: Part I. Kilovoltage x-rays and electrons.* Physics in Medicine and Biology, 1996. **41**(9): p. 1531-1580.

[3] ANDREO, P., et al., *Absorbed Dose Determination in External Beam Radiotherapy, An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water, Technical Report Series No. 398*. 2000, Vienna: International Atomic Energy Agency.

[4] BANCHERI, J., et al., *Monte Carlo and water calorimetric determination of kilovoltage beam radiotherapy ionization chamber correction factors.* Physics in Medicine & Biology, 2020. **65**(10): p. 105001.

[5] ANDREO, P., *Data for the dosimetry of low-and medium-energy kV x rays.* Physics in Medicine & Biology, 2019. **64**(20): p. 205019.

[6] HILL, R., et al., *An evaluation of ionization chambers for the relative dosimetry of kilovoltage x-ray beams.* Med Phys, 2009. **36**(9): p. 3971-3981.

[7] LI, X.A., C.M. MA, AND D. SALHANI, *Measurement of percentage depth dose and lateral beam profile for kilovoltage x-ray therapy beams.* Physics in Medicine and Biology, 1997. **42**(12): p. 2561-2568.

[8] MA, C.M., X.A. LI, AND J.P. SEUNTJENS, *Study of dosimetry consistency for kilovoltage x-ray beams.* Med Phys, 1998. **25**(12): p. 2376-2384.

[9] DAMODAR, J., et al., *A study on the suitability of the PTW microDiamond detector for kilovoltage x-ray beam dosimetry.* Applied Radiation and Isotopes, 2018.

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MP-T6 Radiation Planning Assistant: Automated contouring and treatment planning, Laurence (Edward) Court

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BACKGROUND AND OBJECTIVE

Contouring and planning for radiotherapy treatments can be time-consuming tasks. We are developing an online tool to support the creation of high-quality treatment plans at clinics across the world, focusing on those that cannot afford commercial tools.

METHODS

The user must upload a CT scan to RPA.mdanderson.org, and complete a service request (which includes information about the prescription and treatment approach). The contouring and/or planning then proceeds automatically. Once complete, the user downloads the DICOM files to their own treatment planning system for review, edit and final calculation.

The online tool uses a combination of in-house software and Eclipse to fully automate the treatment planning process, including contouring, field definition (3DCRT) and optimization (VMAT). All tasks are performed automatically using a primary algorithm for the treatment plan and a secondary independent algorithm to verify the primary algorithm. The only manual intervention is delineation of the GTV for head and neck (H/N).

For H/N VMAT cases, normal tissues and lymph node targets are automatically delineated using a deep learning approach. A deep learning approach is used for the segmentation verification algorithm. A second algorithm is used to verify the primary algorithm, with differences flagged to the user for further investigation. RapidPlan is used to create a VMAT plan.

The same approach is also used for cervix VMAT cases. For centres where VMAT is not available, it is also possible to create 4-field box treatments. Two 4-field box approaches have been developed: bony landmark based plans, where field apertures (jaw and MLC positions) are automatically calculated based on automatically delineated bony anatomy, and soft-tissue plans, where the field apertures are based on automatically delineated targets and pelvic nodes.

For post-mastectomy irradiation of the chest wall (tangents+SCV), the beams are set up and the dose is optimized using a combination of automatic delineation (using our in-house tool), beam setup algorithms using support-vector machines and deep learning to determine field borders, and automatic field-in-field optimization.

Other treatment sites which have been developed and are undergoing active testing include palliative plans (whole brain, spine and ribs).

RESULTS AND DISCUSSION

Algorithms have been developed and undergone quantitative testing and physician review for H/N, cervix, chest wall, as well as whole brain, spine and ribs. Several of these RPA tools are now in routine clinical use at MD Anderson (H/N contouring, female pelvis contouring). We expect to clinically deploy the automated contouring and planning tools in South Africa in 2021.

CONCLUSIONS

We have achieved full automation for H/N, cervix and chest wall. Clinical deployment at partner sites will start soon.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

This presentation represents the work of the Radiation Planning Assistant Project – a collaborative effort covering many clinics across the world.

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MP-TO1 #45 Effect of detector choice for commissioning measurements propagated through beam modelling to final dose calculation, Sonja Wegener

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BACKGROUND AND OBJECTIVE

Different small field detectors are available for commissioning measurements. For each task, i.e. depth dose curves, profiles and output factor measurements, the detector response depends on properties such as the active volume size, material composition and density relative to water. In the absence of an ideal detector, measurements are typically a compromise between detectors available and the need to address different measurement tasks correctly.

In the treatment planning system, a beam model is fitted to match the measured data. Beam characteristics, such as the photon energy spectrum, the focal spot size and electron contamination, are tuned to reproduce dose distributions that follow the measured data. The goal of this work was to investigate how changes in the measured data affect the final dose computation.

METHODS

The clinical beam model of a 6 MV Elekta Versa HD accelerator was copied in the Philips Pinnacle treatment planning system and eight alternative models were created, each differing from the initial reference model in one aspect. One model parameter was altered, such that the newly modelled curve deviated by an amount typical for choosing a non-ideal but reasonable detector, for example small ionization chambers of different sizes for profiles or different diodes for output factor measurements and depth dose curves. Detector response differences were taken from measurements and from literature data [1-3].

Three clinical VMAT plans per category: head and neck, prostate, vertebrae, breast step-and-shoot IMRT, 3D-conformal breast tangent plans and cranial stereotactic treatments, were recalculated using the alternative models. Representative dose parameters for target volumes or organs at risk (OAR) were evaluated.

Additionally, all plans were measured using the Sun Nuclear ArcCHECK cylinder phantom including a central dose measurement using a 0.125 cc ionization chamber. Measurements were compared with the calculated dose distributions of the original and alternative models using gamma analysis.

RESULTS AND DISCUSSION

Many of the implemented changes only led to minute changes in the dose calculation for DVH parameters representing the target volume prescriptions (often < 0.3 %). The magnitude of the observed deviations depended on the body region and technique. Modifications of the depth dose distribution became apparent for targets at large depths (prostate plans) and with vertebrae plans due to dense bone material (changes approximately 1-2%). Changes in the build-up region were generally not observable, even with surface-near target volumes (breast, head and neck). Changes in output factor tables influenced small stereotactic fields (up to around 6% change), and to a much smaller degree some of the VMATs (approximately 0.5% change). Modified penumbra did not affect the 3D-conformal breast plans, but introduced dose changes in most other plans, exceeding 1% in four of the VMAT plans. In particular, dose to the OAR adjacent to the target volume differed for this modification. Stereotactic treatments changed the most (3%-6% prescription dose changes). Results of the gamma analysis on the phantom differing from the body geometry did not always coincide with the changes in DVH. Modifications of the depth dose curve led to dose changes most apparent in prostate plans, but notably reduced gamma passing rates only for the 3D-conformal breast and the stereotactic plans. Changes of the electron contamination in the surface-near region

are not accessible for the detector array measuring at approximately 3 cm depth. Substantial reductions of the gamma passing rate for most treatment techniques were only observed for the modified penumbra, with the largest changes for the stereotactic treatment and hardly any changes for the prostate and head and neck plans.
The predicted central dose obtained with the ionization chamber changed by 1-2% for all plans for the depth dose modification and approximately 10% for the penumbra cases when the position of the ionization chamber corresponds to an organ at risk adjacent to the target volume.

CONCLUSIONS

In practice, choosing a non-optimal detector and consequently creating small errors of the beam model affects only dose calculations under certain conditions. However, lacking correlation between dose calculation errors and quality assurance metrics, poor modelling may go unnoticed. Critical modelling parameters for most plans are the penumbra, the depth dose curve for deep targets, and output factors especially for small targets. It seems necessary to validate a new beam model not only in one phantom geometry and not only with typical clinical plans (head and neck, prostate), but with dedicated or challenging plans to encompass typical errors (complex VMAT, 3D-conformal, small fields) independent of the treatment scope of the linac.

REFERENCES

[1] S. Wegener *et al.*, MedPhys 44, 1139-1148, 2017.
[2] S. Wegener *et al.*, Med Phys 45, 898-907, 2017.
[3] S. Wegener *et al.* Med Phys 47, 1327-1339, 2020.

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MP-TO2 #110 Accuracy of an Eclipse treatment planning system for SRS, Iqbal AL AMRI

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INTRODUCTION

The Royal Hospital in Muscat, Oman, obtained a Varian TrueBeam ver SRT linac in 2016. 6 MV and 6 FFF photon beams were commissioned on an Eclipse treatment planning system (Ver 13.7) using dosimetric data ranging from 40x40 cm2 to 4x4 cm2 as recommended by the vendor. Although a dedicated iPlan treatment planning system is routinely used for stereotactic radio-surgery (SRS) planning, we wanted to investigate the feasibility of using Eclipse treatment planning system in the dosimetry of treatment fields typically used in SRS treatments with dimensions smaller than those recommended by the vendor.

MATERIALS AND METHODS

PDDs, OARs and output factors were measured for 6 MV and 6 FFF photon beams using a pinpoint chamber for 3x3, 2x2 and 1x1 cm2 fields. Separate beams were configured in the planning system with one configured with beam data containing the vendor recommended dosimetric data (fields between 40 cm x 40 cm and 4 cm x 4 cm), and the other with dosimetric data for the small fields in addition to the vendor's recommended dosimetric data. To test the performance of the Eclipse treatment planning system, we first compared PDDs of 3x3, 2x2 and 1x1 cm2 field sizes to measurements. In addition, VMAT plans for single and multiple SRS type lesions were optimized and calculated. The optimized plans were then recalculated in a standard 30x30x15 cm3 QA Solid Water phantom. Using a small thimble ionization chamber, measured and calculated doses within the QA phantom were compared.

RESULTS

Measured PDDs for 6 MV and 6 MV FFF beams were compared to Eclipse-calculated PDDs for beams configured with small fields dosimetric data. The calculated PDDs for depths 5 and 10 cm and 3 x 3 cm^2 field size were less than 0.2% from measurements. For the 2 x 2 cm^2 field size however, the discrepancy increased to 2.0%.

Moreover, for plans optimized and calculated with 6 MV beams configured with small field dosimetric data, the calculated and measured doses in the QA phantom were in closer agreement with one another compared to plans optimized with 6 MV beams configured without including small fields dosimetric data. We also noticed that the agreement between calculated and measured doses improved when jaw-tracking is disabled in plan optimization.

CONCLUSION

It is important to include dosimetric data for small fields in treatment planning beam data when planning to treat small lesions. To further reduce discrepancies between calculation and measurements, we recommend using fixed-jaw positions when optimizing plans for small lesions.

REFERENCES

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[1] Ase Ballangrud et al. Institutional experience with SRS VMAT planning for multiple cranial metastases, Journal of applied clinical medical physics, 2018 Mar; 19(2): 176–183.

[2] Ans CC Swinnen et al. Influence of the jaw tracking technique on the dose calculation accuracy of small field VMAT plans, Journal of applied clinical medical physics, 2017 Jan, Volume18, Issue1: 186-195.

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MP-TO3 #16 Characterization of helical tomotherapy plan complexity, Tania Filipa Sobrinho dos Santos

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BACKGROUND AND OBJECTIVE

Complexity analysis has proven to be an important tool for treatment plan characterization and comparison, contributing to improve the quality, efficiency and safety of the planning and delivery processes [1]. The purpose of this work is to evaluate the complexity of helical tomotherapy (HT) plans using some indicators recently proposed [2] and assess their potential to predict the plan deliverability.

METHODS

One hundred head and neck HT clinical treatment plans generated with simultaneously integrated boost for two and three dose levels were retrospectively analysed. The prescribed dose per fraction to the high-risk planning target volume was either 2 or 2.12 Gy. All plans were created in the Tomotherapy treatment planning system v.5.1.1.6 and delivered by a Tomotherapy HD unit (Accuray Inc., Sunnyvale, CA, USA). For each plan, six complexity indicators have been calculated from the planned sinogram saved in the corresponding DICOM RT file, using a home-made MATLAB program (Mathworks, Natick, MA, USA). The computed parameters and indices included: the modulation factor (MF), the percentage of leaves with an opening time below 100 ms (%LOT < 100 ms), the percentage of leaves with an opening time close to the projection duration (%LOT > pT-20 ms), leaf open time variability (LOTV), plan sinogram time variability (PSTV) and modulation index (MI) recently adapted for HT [2].

To assess the plan deliverability, pre-treatment quality assurance (QA) verifications were performed. Plans were recalculated in the Tomotherapy phantom (Cheese phantom) and delivered in the HT unit with the couch out of the bore. Dosimetry Check software v.5.5 (LifeLine Software Inc., Austin, TX, USA) was used to reconstruct the measured dose distribution from the acquired sinogram. The agreement between the planned and reconstructed dose was evaluated using 3D global gamma analysis. The passing rate acceptance limit was 95% for a 3%/3 mm and 10% dose threshold (TH) criterion. In this work, more stringent criteria were also adopted, namely 3%/2 mm 10% TH, 2%/2 mm 10% TH and 2%/1 mm 10% TH.

The correlation between the complexity metrics and the pre-treatment verification results was investigated using Spearman's rank correlation coefficients r_s. The identified dependencies were classified as: $|r_s| < 0.4$ "weak", $0.4 \leq |r_s| < 0.6$ "moderate" and $|r_s| \geq 0.6$ "strong", for a significance level of 5%.

RESULTS AND DISCUSSION

The average values of the complexity indicators and corresponding standard deviation for the head and neck HT plans were: MF 2.096 ± 0.175, %LOT< 100 ms 27.792 ± 3.571, %LOT > pT-20 ms 8.658 ± 3.746, LOTV 0.931 ± 0.010, PSTV 5.406 ± 0.729 and MI 10.726 ± 0.895.

All plans were considered clinically deliverable, with an average passing rate of 98.6 ± 1.0% (3%/3 mm, 10% TH) for the entire group. The use of more stringent criteria for gamma analysis resulted in a wider spread in the obtained passing rates, as expected.

Only weak associations have been identified between the complexity indicators and the verification results, regardless of the adopted criteria, as shown in Table 1.

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Table 1 – Correlation coefficients (r_s) between the gamma passing rates for various criteria and the complexity indicators for the HT plans. Correlations were considered statistically significant for a p-value (p-val) < 0.05, in bold.

	3%3 mm 10%TH		**3%2 mm 10%TH**		**2%2 mm 10%TH**		**2%1 mm 10%TH**	
	r_s	p-val	r_s	p-val	r_s	p-val	r_s	p-val
MF	0.102	0.312	0.059	0.562	-0.072	0.474	-0.111	0.271
%LOT < 100 ms	-0.193	0.054	-0.193	0.055	-0.003	0.973	-0.022	0.831
%LOT > pT-20 ms	-0.272	**0.006**	-0.245	**0.014**	-0.075	0.459	-0.044	0.661
LOTV	0.366	**0.000**	0.346	**0.000**	0.178	0.076	0.154	0.125
PSTV	-0.347	**0.000**	-0.337	**0.001**	-0.139	0.169	-0.128	0.206
MI	-0.157	0.119	-0.162	0.108	-0.070	0.487	-0.103	0.306

The lack of correlations may be explained by the homogeneity of the considered set of plans, which led to a limited variation of both the complexity indicators and the deliverability results.

CONCLUSIONS

Despite the reported lack of correlations, the complexity indicators values can be taken as reference in our clinic to evaluate future plans, given that the pre-treatment QA results of the entire set included in this study were all clinically acceptable. Treatment plans with a complexity out of these limits for any of the computed metrics should be further evaluated and eventually be subjected to a more rigorous QA.

REFERENCES

[1] SANTOS, T., VENTURA, T., LOPES, M.C., Evaluation of the complexity of treatment plans from a national IMRT/VMAT audit – Towards a plan complexity score, Phys. Med. 70 (2020) 75-84.

[2] SANTOS, T., VENTURA, T., MATEUS, J., CAPELA, M., LOPES, M.C., On the complexity of helical tomotherapy treatment plans, J. Appl. Clin. Med. Phys. 21:7 (2020) 107-118.

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MP-TO4 #80 Retrospective evaluation of portal dosimetry pre-treatment quality assurance for volumetric-modulated arc therapy (VMAT) and stereotactic radiotherapy (SRT) plans, Abdelkader Toutaoui

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BACKGROUND AND OBJECTIVE

The purpose of this work was to evaluate the gamma passing rate (%GP), maximum gamma (g_{max}) and average gamma (g_{ave}) for various regions of interest using Varian's implementation of three absolute dose gamma calculation techniques of improved, local, and combined improved and local, as applied to VMAT and SRS treatments.

METHODS

We performed a retrospective re-evaluation of 782 EPID dosimetry pre-treatment QA measurements of 270 patients treated at our centre from September 2017 to June 2019. Integrated Varian solution (RapidArc planning, EPID and Portal dosimetry system) for planning, delivery and QA analysis was used. All patients' plans were delivered on Varian Clinac iX23 machines equipped with 120-leaf Millennium MLC and an aS1000 panel EPID.
We calculated several gamma parameters for each field and for different regions of interest (Field, Field + thresholds, multileaf collimator complete irradiation area outline (MLC CIAO)). We also investigated the influence of different gamma criteria: 3%/3 mm, 2%/2 mm and 1%/1 mm on the gamma passing rate.

RESULTS AND DISCUSSION

Area	Field				MLC
Threshold	0%	5%	10%	15%	0%
3%/3mm	99·9 ± 0·2 (98·1–100)	99·9 ± 0·4 (97·2–100)	99·8 ± 0·4 (96·6–100)	99·8 ± 0·5 (96·3–100)	99·8 ± 0·4 (96·5–100)
2%/2mm	99·2 ± 1·2 (91·3–100)	99·0 ± 1·6 (87·9–100)	98·9 ± 2·0 (85·6–100)	98·9 ± 2·1 (84·7–100)	98·8 ± 2·0 (85·6–100)
1%/1mm	87·4 ± 6·6 (56–98·6)	88·0 ± 7·7 (62·8–99·1)	87·6 ± 8·8 (58·3–99·2)	87·2 ± 9·0 (56–99·1)	87·5 ± 9·0 (50·2–99·2)

Table 1: Average gamma passing rate with 1 SD for improved gamma calculation techniques with different acceptance criteria and various regions of interest

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Tables 1 and 2 show the means, standard deviations (SD) and ranges of the gamma passing rate for three gamma criteria of 3%/3mm, 2%/2mm and 1%/1mm, for different regions of interest (Field, Field+5, 10, 15% and MLC CIAO), and for gamma calculation techniques of improved and local.

Area	Field				MLC
Threshold	0%	5%	10%	15%	0%
3%/3mm	87·8 ± 6·7 (56·8–99)	97·6 ± 3·2 (83·6–100)	99·5 ± 0·6 (95·9–100)	99·5 ± 0·7 (95·7–100)	99·5 ± 0·8 (95·7–100)
2%/2mm	75·9 ± 8·0 (44·9–94·5)	93·4 ± 4·8 (77·5–99·3)	96·9 ± 2·7 (82·4–99·6)	97·1 ± 2·8 (81·5–100)	97·0 ± 2·9 (82·9–99·7)
1%/1mm	49·7 ± 7·5 (26·7–67·8)	67·9 ± 9·6 (42·9–86·7)	72·4 ± 10·1 (40·8–91)	73·9 ± 11·0 (40·3–98·3)	73·1 ± 10·3 (40·9–92·2)

Table 2 : Average gamma passing rate with 1 SD for local gamma calculation techniques with different acceptance criteria and various regions of interest

Using the improved γ method, the mean %GP was above 99·8, 98·8 and 87·2% for the 3%/3 mm, 2%/2 mm and 1%/ 1mm criteria, respectively. The %GP does not seem to depend on the low- dose threshold values, irrespective of the gamma criteria used. This is because the normalization of dose difference in improved gamma calculation was with the maximum reference dose which is relatively higher than the dose difference in the low-dose region. The SD values increase by increasing the threshold and tightening the acceptance criteria from 3%/3 mm to 1%/1 mm. This is because the sensitivity becomes closer to the resolution of the detector.

The values of %GP are lower using the local gamma method compared with those obtained by the improved method. As the threshold increases from 0 to 15%, the mean %GP increases. This is due to the fact that the dose difference is normalized to the currently evaluated pixel for local gamma calculation and therefore, the pixels in low-dose regions usually fail the acceptance criteria. The SD values decrease by increasing the threshold from 0 to 10% for the 3%/3mm and 2%/2 mm criteria, respectively, while the opposite is observed for the 1%/1 mm criterion.

CONCLUSIONS

We have performed detailed gamma analysis on 782 portal dose images from 270 VMAT and SRT plans. We are using a 3%/3mm improved γ criterion with a γ passing rate of 95% for QA of all VMAT and plans. However, based on current data analysis, stricter g criteria with higher γ passing rates can easily be implemented for QA VMAT and SRT treatment plans.

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MP-TO5 #38 A novel quantitative metrics for assessing IMRT plan complexity: A virtual phantom study, Hwee Shin Soh

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BACKGROUND AND OBJECTIVE

In IMRT treatment planning, quantitative assessment is crucial in order to measure and improve the plan quality. A comprehensive metric is useful to provide information for the planners on the feasibility of achieving established planning goals and subsequently the possibility of tightening the planning goals for each patient. However, there has been little interest in defining parameters to assess the quality of the treatment plan using quantitative metrics.
This work was carried out for the first time to develop a series of virtual phantoms to assess the IMRT planning complexity. These phantoms were geometrically simple and simulated patient IMRT plans. They were then used to create patient plans utilising different IMRT techniques.

METHODS

A series of virtual phantoms were designed using MATLAB® software (MathWorks, Natick, MA, United States), simulating a cylindrical-shaped planning target volume (PTV) surrounded by two cylindrical-shaped organs-at-risk (OARs). The separation of PTV-OARs was designed to have variable distances. Three different IMRT techniques were investigated: step-and-shoot IMRT (SSIMRT), volumetric modulated arc therapy (VMAT) and helical tomotherapy (HT). Later, there were two complexity metrics being established to quantify the complexity of an IMRT treatment plan. The first was the "wiggliness" of dose profile for the treatment plan. This was chosen as an approach to represent the complexity of a treatment plan and it was quantified as spatial complexity matrix (SCM). Both the dose profile and 3-D surface plot for 120 IMRT plans were plotted and analysed by using MATLAB® software. The second, the metric of spatial frequency ratio (SFR), was established. The proportion of rapidly varying dose with distance in a treatment plan was used to predict the complexity of a plan. The 1-D power spectral density (1D PSD) for the dose surface was generated to characterise the high and low frequency components of the dose surface [1].

RESULTS AND DISCUSSION

For SCM analysis, the dose profiles and 3-D plots for 7-field SSIMRT plans presented a noticeable seven dose peak with higher value of maximum dose compared with VMAT and HT. The planning complexity in SSIMRT was decisive in the outcome of comparison against VMAT and HT. The calculated SCM value for SSIMRT was found to be higher than VMAT and HT. For SFR analysis, HT had the highest SFR, followed by VMAT and SSIMRT. The higher SFR indicated that the high frequency dose was varying rapidly with the distance. This was then considered a good surrogate to represent the level of complexity for a treatment plan.

CONCLUSIONS

This study has demonstrated the complexity assessments on all the IMRT plans generated using the virtual phantoms. The 3-D surface plots and 1D PSD plots generated in this study clearly presented a landscape view of the dose surface roughness and the spatial variation of high frequency dose component. The results of these studies have shown for the first time, the feasibility of using the self-developed metrics of SCM and SFR on virtual phantoms for assessing plan complexity.

ACKNOWLEDGMENTS

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REFERENCES

[1] Bosse, H., E. Sidick, B. Bodermann, and R.M. Silver. Power spectral density specification and analysis of large optical surfaces in Modeling Aspects in Optical Metrology II. Munich, Germany (2009).

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MP-TO6 #58 Clinical implementation of the MRLinac in Odense, Denmark, Vibeke Hansen

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BACKGROUND AND OBJECTIVE

At Odense University Hospital, a MRLinac (MRL) Unity, Elekta, was installed in 2018. The MRL provides the means of soft-tissue image contrast at the time of treatment to visualize the target and the surrounding normal tissue for MR-guided radiotherapy (RT). The MRL adapts the treatment based on the daily anatomical changes. This may lead to smaller margins and increased use of hypo-fractionation. The potential is to adapt the treatment not only based on anatomical changes, but also biological response, e.g. Diffusion-Weighted Imaging (DWI).

METHODS

The implementation is based on a multidisciplinary team of clinicians, physicists, and RTTs.

[1] Everyone has experience in conventional RT in a department where both CT and MR are used for RT planning. All patients treated at the MRL are treated within clinical protocols focusing on treatment outcome and side effects. CT and MR scans are acquired for pre- treatment planning. Contouring is based on the MR scan, while the electron density information is linked from the CT to the MR scan using deformable image registration. In addition to the standard target and organ at risk (OAR) volumes used for the treatment optimization, a set of MRL specific volumes are auto-generated:

- DelineationVolume: the volume, where OAR re-delineation is required on the MR scan to include the anatomical changes for the online plan adaptation.
- ActionVolume: the volume, which determines if second adaptation is required.
- TrackingVolume: the volume that the CTV should stay within during irradiation.

A reference treatment plan is optimised in the treatment planning system, Monaco, based on the planning MR scan. This plan is independently checked and verified, using the ArcCheck phantom. The reference-treatment plan is never used; it only serves as a starting point for the optimisation of the online-created adaptive treatment plans.

The Online workflow is used after the patient is set-up in the MRL including the MR-coil positioning. A 3D MR is acquired, which is automatically fused to the planning MR scan. Based on the daily anatomy of the patient, the target structures from the initial pre-treatment planning scan may be shifted and rotated or possibly re-delineated while the OAR structure may require daily adjustment within the DelineationVolume. Based on the adapted contours, a new plan and dose distribution are optimised, and this new treatment plan is checked independently prior to

delivery. While the delineation and re-planning are being performed, a DWI sequence is acquired in the background for research purposes. Prior to treatment, a fast 3D MR validation scan is acquired to evaluate whether the patient's anatomy has changed during re-delineation and re-planning. If part of the target is outside the ActionVolume, the treatment beams are repositioned, and a fast re-calculation of the delivered dose is performed. Finally, during patient irradiation, a 2D MR scan is run in cine mode to validate the target position within the TrackingVolume. At the very last part of the treatment delivery, an additional fast 3D MR scan is acquired for evaluation purposes. The total treatment time from the patient entering the room to leaving the treatment room is in the range of 21-60 min.

RESULTS AND DISCUSSION

Treatments on the MRL at OUH were initially in the pelvic region. However, currently, patients with abdominal cancers are also treated at the Unity system. Until 1st of July 2020, 129 patients have been treated on the Unity system – most of the treatments are based on either a hypofractionation or SBRT scheme. Figure 1 shows the different sites treated and related fractionations; only prostate cancer patients are treated with 20 fractions.

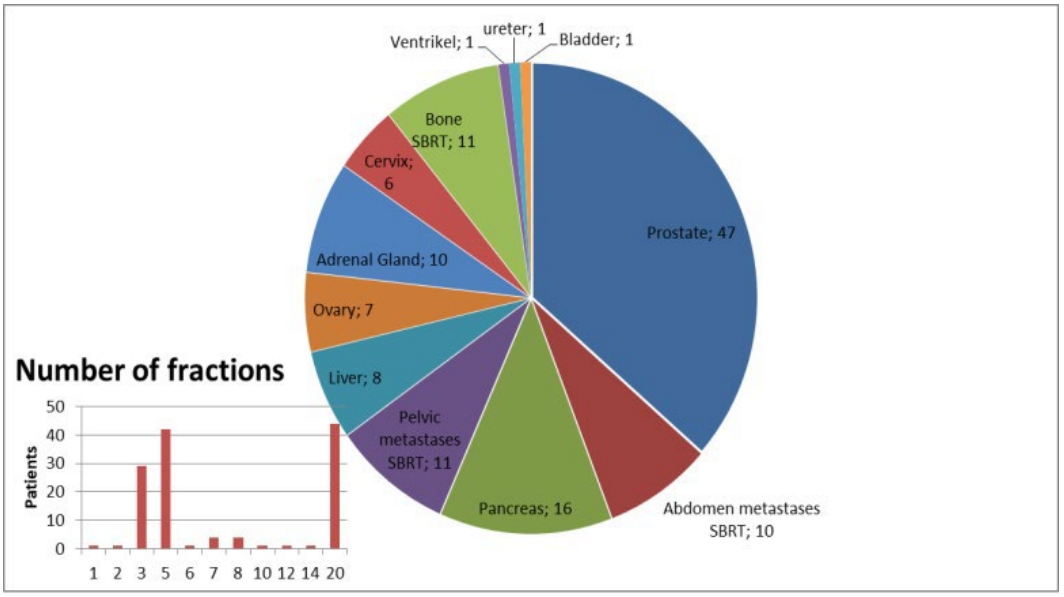

Figure 1 Distribution of the number of patients treated so far based on the target position and the fractionations used.

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CONCLUSIONS

Implementing the MRL in a clinical setting requires education of a multidisciplinary team. The MRL institutions are accumulating clinical data in a joint registration protocol, which may form the basis for selecting future patients for MRL treatment based on the possible gains relative to standard linac treatment. The MRL gives the RT community a new opportunity to "see what is being treated, while treating". This can be used to evaluate, not only what is treated on the MRL, but the knowledge can feed into margins and patterns of known anatomical movements during RT. The DWI research could provide biological response information, such that the treatments can be adapted based on the likely tumour and toxicity outcome of the individual patient.

REFERENCES

[1] BERTELSEN, A.S., SCHYTTE, T., MØLLER, P.K., MAHMOOD, F., RIIS, H.L., GOTTLIEB, K.L., AGERGAARD, S.N., DYSAGER, L., HANSEN, O., GORNITZKA, J. VELDHUIZEN, E., ODWYER, D.B., CHRISTIANSEN, R.L., NIELSEN, M., JENSEN, H.R., BRINK, C., BERNCHOU, U. "First clinical experiences with a high field 1.5 T MR linac", Acta Oncologica, 58:10, (2019) 1352-1357

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MP-TO7 #84 FRICKE DOSIMETRY FOR BLOOD IRRADIATORS, Andrea Mantuano

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BACKGROUND AND OBJECTIVE

Transfusion-associated graft-versus-host disease (TA-GVHD) is a possible transfusion reaction and can often be a fatal complication occurring in patients receiving cellular blood components. Inactivation of transfused lymphocytes by the use of ionizing irradiation of blood components remains the most efficient method for inhibiting lymphocyte blast transformation, hence preventing TA-GVHD. Chemical dosimetry using Fricke has shown potential in being a reliable standard of absorbed dose for blood irradiation and other applications. The linearity for this dosimeter and reproducibility tests have been investigated by this group [1,2]. Thus, considering all these issues, we propose the use of a Fricke dosimeter to perform blood irradiation dosimetry, and for this we have provided the dose distribution in the irradiator container.

METHODS

A specific phantom was constructed and patented by the Radiological Sciences Laboratory to perform the measurements. The phantom created by the authors consists of a cylindrical container made in a 3D printer using acrylonitrile butadiene styrene (ABS) with a density (ρ = 1.03 g.cm^{-3}) close to that of water. It has a design suitable for the Fricke solution to be placed in small polyethylene bags. The phantom has 19 cavities with dimensions of 4 x 4 x 0.4 cm^3, to accommodate the polyethylene bags with Fricke, that are spatially homogeneous distributed throughout the cylindrical volume [3].
Five bags were used as the control solution and submitted to the same conditions but were not irradiated. A Gammacell 3000 Elan (Best Theratronics) blood irradiator located at the Hemocenter in Rio de Janeiro, Brazil, was used for this work, which uses two ^{137}Cs sources for irradiation. The measurements were performed as a routine irradiation procedure, of 5 minutes and 49 seconds, with an expected dose of 25.7 ± 1.5 Gy in the centre of the cylinder.

RESULTS AND DISCUSSION

The cavities of the phantom can be grouped into three regions: the center, the top and the bottom. Five sets of measurements using 19 bags each were performed. The mean doses were calculated and were as follows: 29.28 Gy with a type A uncertainty of 1.06% for the bottom part, 30.40 Gy with a type A uncertainty of 1.10% for the central part, and 26.39 Gy with a type A uncertainty of 1.15% for the top part. Figure 1 shows the mean values for all measurements for each individual cavity. The increasing tendency shown in Figure 1 is due to the position within the cylinder. The dose is higher in the external part of the cylinder due to its proximity to the source.

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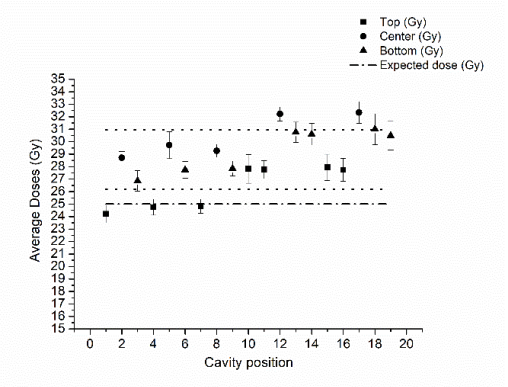

Figure 1. Average doses and standard deviation for all 19 cavities. The dashed dotted line indicates the expected dose (25.7 Gy) and the short dashed line indicates the standard deviation of average doses.

CONCLUSIONS

Fricke dosimetry provided a volumetric dose distribution evaluation with a final uncertainty of 2.07% (k=1). The obtained results showed that the setup, including the Fricke dosimeter and the phantom, is able to perform dosimetry for blood irradiators. Using the Fricke system reduces the uncertainty of the dose in the centre of the mid plane of the canister by about a factor of 4 compared to that achievable using EBT film.

We intend to implement a standard for absorbed dose to water based on Fricke chemical dosimetry and supply the need for hemocenters, hospitals and clinics to perform annual dosimetry for the irradiation of blood components as required by the Brazilian Health Regulatory Agency, American Association of Blood Bank and the Brazilian National Commission of Nuclear Energy.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

The authors acknowledge HEMORIO for carrying out the measurements, and the financial support of the Brazilian Government organizations (CAPES) and the Research Support Foundation of Rio de Janeiro State (FAPERJ).

REFERENCES

[1] Mantuano A, De Amorim GJ, David MG, Rosado PHG, Salata C, Magalhães LAG, et al. Linearity and reproducibility response of Fricke dosimetry for low energy X-Ray beam. Journal of Physics: Conference Series 2018;975. https://doi.org/10.1088/1742-6596/975/1/012052.

[2] Muñoz E, Peixoto JG, de Almeida CE. Uma revisão crítica dos processos de translação em radioterapia pre-clínica associada às limitações na dosimetria de irradiadores biológicos conformacionais. Brazilian Journal of Radiation Sciences 2019;7:01–18.

[3] Mantuano A, Salata C, Mota CL, Pickler A, de Castro Pacífico L, Magalhães LAG, et al. Technical Note: Fricke dosimetry for blood irradiators. Medical Physics 2020. https://doi.org/10.1002/mp.14487.

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MP-TP01 #5 Dosimetric comparison between volumetric modulated arc therapy and intensity modulated proton therapy for whole brain irradiation with hippocampal sparing, Taweap Sanghangthum

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BACKGROUND AND OBJECTIVE

Whole brain radiation therapy (WBRT) is a main treatment in cancer patients with brain metastasis. However, the standard treatment of right and left parallel opposing in 3D technique cannot spare the hippocampus organ. This organ is more sensitive to radiation than other organs in the brain, and this organ is related to cognition function and neurogenesis. Advanced techniques, including Volumetric Modulated Arc Therapy (VMAT) and Intensity Modulated Proton Therapy (IMPT), were introduced to reduce organs-at-risk (OARs) doses [1]. The purpose of this study was to compare the dosimetric effect between VMAT and IMPT techniques for WBRT with hippocampal sparing.

METHODS

Fifteen patients previously treated with WBRT with VMAT plans from a TrueBEAM linear accelerator (Varian Medical System, Palo Alto, CA) were re-planned with IMPT technique in Eclipse treatment planning system version 15.6. The 6 MV VMAT plans consisted of two full arcs with coplanar beams and two to three half arcs with non-coplanar beams. IMPT plans were generated from three multi-field optimizations for 45, 130 and 180 degree gantry angle with 270 degree couch angle for all fields, and the range shifter was also applied to all proton fields.

The prescribed dose to the whole brain planning target volume (PTV) was 30 Gy in 10 fractions. The dose constraints were matched to RTOG 0933 planning requirements [2], as shown in Table 1. The target coverage and homogeneity index (HI) was used to evaluate PTV, and the maximum and mean doses were reported for OARs.

Table 1. Dose constraints of PTV and hippocampus according to RTOG 0933.

Organs	Dose Constraints		
	Per Protocol	**Variable Acceptable**	**Deviation Unacceptable**
PTV	D2% ≤ 37.5 Gy	40 Gy ≥ D2% > 37.5 Gy	V30% < 90%
	D98% ≥ 25 Gy	D98% < 25 Gy	D2% > 40 Gy
Hippocampus	D100% ≤ 9 Gy	D100% ≤ 10 Gy	D100% > 10 Gy
	Max. dose ≤ 16 Gy	Max. dose ≤ 17 Gy	Max. dose > 17 Gy

RESULTS AND DISCUSSION

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The PTV $D_{95\%}$ was higher than the prescribed dose for all cases with no statistically significant difference between VMAT and IMPT. The compared dose distribution between VMAT and IMPT is presented in Figure 1. The PTV dose of VMAT was less homogeneous than for IMPT. The average HI of VMAT and IMPT was 33.7±13.0 and 17.6±5.0, respectively, as shown in Table 2. Moreover, IMPT technique presented significantly lower doses to all OARs including hippocampus, eyes and lens, compared to VMAT plans. The VMAT plans did not pass the dose criteria in several cases, especially D_{100} (Hippocampus). The maximum dose of hippocampus fromVMAT was reduced from 14.9±2.1 Gy for VMAT to 9.1±1.7 Gy for IMPT.

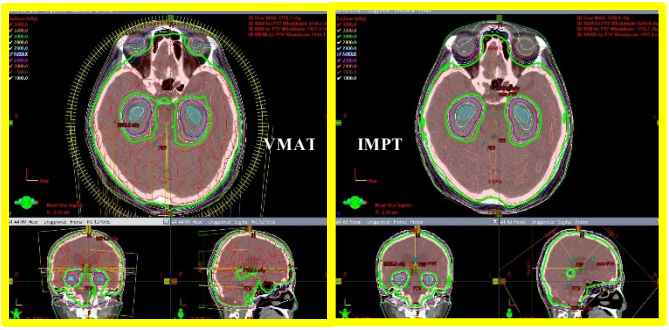

Figure 1. Dose distribution comparison between VMAT and IMRT for whole brain irradiation with hippocampal sparing.

Table 2. Average doses of PTV and OARs.

Parameters		Dose (Gy or GyE)		P-value
		VMAT	IMPT	
PTV	D_{98}	26.7 ± 2.9	27.1 ± 1.5	0.637
	D_{95}	30.1 ± 0.1	30.0 ± 0.1	0.458
	D_{50}	34.7 ± 2.4	31.4 ± 0.2	0.001
	D_{2}	36.8 ± 3.2	32.3 ± 0.3	0.001
	HI	33.7 ± 13.0	17.6 ± 5.0	0.004
OARs	D_{max} (Hippocampus)	14.9 ± 2.1	9.1 ± 1.7	0.001
	D_{mean} (Hippocampus)	12.6 ± 1.7	5.9 ± 1.2	0.001
	D_{100} (Hippocampus)	10.0 ± 1.0	3.7 ± 1.1	0.001
	D_{max} (Rt len)	9.5 ± 3.5	2.9 ± 1.0	0.004
	D_{max} (Lt len)	9.4 ± 3.3	2.6 ± 0.9	0.004
	D_{max} (Rt eye)	22.9 ± 7.1	14.5 ± 2.4	0.011
	D_{max} (Lt eye)	22.9 ± 7.3	14.0 ± 3.0	0.008

CONCLUSIONS

IMPT offers significant dosimetric advantages over VMAT in terms of both PTV dose and OARs sparing, which is expected to result in better tumour control and decreased toxicity for patients.

REFERENCES

[1] STOKER, J., VORA, S., PATEL, A., et. al. Advantages of intensity modulated proton therapy during hippocampal avoidance whole brain radiation therapy, Physics and Imaging in Radiation Oncology **8** (2018) 28-32.

[2] MEHTA, P.M., GONDI, V., KANNER, A., et. al., A phase II trial of hippocampal avoidance during whole brain radiotherapy for brain metastases. Radiation Therapy Oncology Group, RTOG 0922 (2011).

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MP-TP02 #6 Independent verification of the pre-installed beam model in helical tomotherapy, MARIA DO CARMO LOPES

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BACKGROUND AND OBJECTIVE

Helical Tomotherapy (HT) is a pre-commissioned equipment. The pre-installed beam model only needs to be verified by the customer as part of the commissioning process. With the aim of supporting medical physicists in this task, the AAPM Task Group 148 report was published in 2010 [1]. The joint IAEA and AAPM international code of practice (CoP) for small static fields dosimetry – TRS 483 [2] – builds on the established reference dosimetry and extends it to non-reference fields by introducing the concept of machine specific reference (*msr*) field.

To report the local procedures for independent verification of the pre-installed beam model – gold standard (GS) dosimetry in HT – was the aim of the present work.

METHODS

The standard HT quality assurance package includes: 2 ionization chambers Exradin A1SL, one TomoElectrometer with 8 channels and a 2D TomoScanner water tank, all from Standard Imaging. The longitudinal and transverse dose profiles as well as the percent depth doses for the three field sizes – 1, 2.5 and 5 cm length – are measured by Accuray during the installation process with the 2D TomoScanner water tank, and compared to the GS dosimetry corresponding to the pre-installed beam model. Beam adjustment is assessed through 1D gamma-function analysis where the Accuray tolerances are set at: i) 2% Dose Difference/1% Distance-To-Agreement (which converts to 0.25 mm for the 2.5 cm field size profile at isocentre, for instance) for longitudinal profiles at 15 mm depth; ii) 2%/1 mm for transverse profiles also at 15 mm depth and iii) PDD analysis is based on dose ratio with tolerance of 2% from 10 to 200 mm depth. Full width at half maximum (FWHM) of longitudinal profiles should also be within 1% of the correspondent length in GS. For transverse profiles, it is the full width at 25% (quarter) maximum (FWQM), also at 15 mm depth, that should be within 1% of FWQM of the corresponding GS profile.

The local dosimetry package includes an MP3-T motorized water phantom from PTW, with the aim of being independent from Accuray procedures. Using MP3-T with the beam data acquisition software MEPHYSTO mcc 3.2 and the standard A1SL ionization chamber, dose profiles measured at installation have been repeated and compared with GS curves. To further enhance independency, the measurement of the same profiles was repeated using the PTW 31016 PinPoint 3D chamber in orthogonal alignment and using the standard PTW detector holder for the MP3-T phantom.

For dose calibration, the *msr* concept has been used and an independent dosimetry audit was carried out by an IAEA expert.

RESULTS AND DISCUSSION

PDD results for the two data sets – using A1SL and PTW 31016 PinPoint 3D chambers with the PTW MP3-T motorized water phantom – were within 1% to the GS using the 2D TomoScanner, well below the required Accuray ratio criteria of 2% PDD ratios.

Longitudinal profiles for the three field sizes– 1, 2.5 and 5 cm – using both chambers complied almost everywhere with the 1% dose/1 mm distance-to-agreement gamma criteria when GS is taken as reference, except in a limited region outside the larger field, where the standard 2% dose criterion was required.

Transverse profiles exhibiting the FFF characteristic cone-shape were measured with all MLC leaves open which corresponds to 40 cm width at isocentre. FWQM of these profiles at 10 cm depth met 1% tolerance from GS for both measurement sets, even at a deeper depth than 15 mm as required by ATP for this parameter.

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For absolute dose calibration, the percent deviation from the external audit dosimetry system was 0.2%.

CONCLUSIONS

The installation of a helical Tomotherapy machine and the publication of the CoP TRS 483 motivated the presented work. Independent verification of the pre-installed beam model in HT was reported and proven to be in closer agreement than the Accuray acceptance tolerance levels. The independency from Accuray procedures was based both in a different water phantom, the PTW MP3-T with standard ionization chambers (Exradin A1SL) and using non-standard detectors like PTW 31016 PinPoint 3D.

These are the first dosimetry results presented for HT using the MP3-T, although other phantoms have also been tested [3].

REFERENCES

[1] LANGEN, K.M., et al., QA for helical tomotherapy: Report of the AAPM Task Group 148, Med. Phys. 37 (2010) 4817–4853

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry of small static fields used in external beam radiotherapy, Technical Reports Series No. 483, IAEA, Vienna (2017).

[3] PENG, J. L., ASHENAFI, M. S., MCDONALD, D. G., VANEK, K. N., Assessment of a three-dimensional (3D) water scanning system for beam commissioning and measurements on a helical tomotherapy unit, J. Appl. Clin. Med. Phys. 16 (2015) 51-68

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MP-TP03 #25 On the dose linearity of detectors for small field dosimetry, Božidar Casar

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BACKGROUND AND OBJECTIVE

The International Code of Practice (CoP) IAEA TRS-483 provides a formalism for dosimetry in small fields of MV photon beams. It includes specific guidance for suitable detectors, and summarizes their general characteristics, e.g., dose linearity, stability, dose rate linearity, and leakage. The guidance for dose linearity stipulates it to be *"better than 0.1% over an absorbed dose range of at least three orders of magnitude"*. The CoP did not provide any methodology for the measurement of dose linearity. The aim of our multicentre experimental study was to verify the guidance given in TRS-483 for dose linearity applying two alternative methods, using a large number of suitable detectors recommended in TRS-483 for small field dosimetry.

METHODS

All measurements for the determination of dose linearity were done following a strict study protocol, at each of the nine participating centres. Twenty different types of detectors (10 ionization chambers, 9 diodes, and 1 micro diamond detector) were used for testing the dose linearity, with 49 detectors in total. All measurements were performed using an isocentric set-up with SSD = 90 cm, a depth of 10 cm, gantry 0°, and field size of 4 x 4 cm^2 in 6 and 10 MV photon beams with (WFF) and without (FFF) flattening filter on either Elekta Versa HD™ or Varian TrueBeam™ linear accelerators. To minimize fluctuations in ion chamber readings from linac output variation, an ionization chamber having sufficiently large cavity volume (PTW Semiflex or IBA CC13) was utilized as a reference detector. Detectors were irradiated with 5, 10, 20, 30, 50, 100, 200, 300, 500, and 1000 MUs, covering an approximate absorbed dose range of three orders of magnitude. We analyzed the results by two alternative methods, considering a pass criterion of 0.1% as stated in TRS-483.

A. Dose Linearity A: Adapted formalism from "*IEC 60731 Medical electrical equipment – Dosimeters with ionization chambers as used in radiotherapy*"

Dose linearity was calculated as shown in Eq. (1), where $M_i = m_i/m_{i,ref}$; m_i denotes a single, *i-th* measurement (data point) performed at a particular centre, for a selected detector, energy, and number of MUs, while $m_{i,ref}$ stands for the corresponding measurement with reference ionization chamber done at the same time. M_{ref} was defined as shown in Eq. (2), where indices 50, 100, and 200 denote number of MUs.

$$\text{Dose Linearity A} = 100 \cdot \left(\frac{MM_{ii}}{MM_{rrrr}} - 1 \right) \quad (1)$$

$$MM_{mrr} = \frac{1}{3}(MM_{50} + MM_{100} + MM_{200}) \quad (2)$$

B. Dose Linearity B: Coefficient of determination R^2

R^2 indicates the proportion of the variation of the data explained by the best-fit linear function, where $m_{i,ref}$ and m_i were considered as the independent and dependent variables, respectively. We also considered that the pass criteria of 0.1% is satisfied if $R^2 > 0.999$.

RESULTS

Dose Linearity A: We found that the TRS-483 guidance on dose linearity (0.1%) was not met for the majority of the 1960 analyzed data points (Table 1). In particular, the dose linearity criterion was not satisfied for low number of MUs.

Dose Linearity B: The coefficient of determination R^2 was higher than 0.999 for all analyzed data sets (196) for the entire range of MUs investigated in this study.

Table 1. Percentage of analyzed data points that satisfy different dose linearity criteria/tolerances ranging from 0.1 to 2.0% using the approach "Dose Linearity A" as described in the Methods section.

	Dose linearity tolerances			
t[MU]	0.1%	0.5%	1.0%	2.0%
	Data within tolerances [%]			
5	10.2	41.3	64.8	86.2
10	13.8	51.5	81.6	92.3
20	21.4	69.9	92.9	95.9
30	30.1	87.8	94.4	98.0
50	49.0	96.4	99.0	100.0
100	82.7	99.0	100.0	100.0
200	63.3	97.4	99.5	100.0
300	44.4	95.4	98.5	100.0
500	41.3	93.4	98.0	100.0
1000	33.2	88.3	95.9	99.5

DISCUSSION AND CONCLUSIONS

We tested dose linearity for 49 detectors (20 different types) using two methods.

The present results show that the 0.1% tolerance for dose linearity cannot be met for the selected range of doses (MUs) if the first method is used (adapted methodology from IEC 60731) for the determination of dose linearity. A less stringent acceptability criterion is needed, especially for very small numbers of MUs. For instance, if the tolerance in linearity is set at 1.0%, then more than 90% of the data points with 20 or more MUs comply (Table 1).

Alternatively, if we assume that R2 = 0.999 corresponds to 0.1% linearity criterion from TRS-483, the dose linearity acceptability criterion can be met with 100% of the data points for the whole range of MUs investigated in this study.

In our opinion, method B is an acceptable method for the determination of dose linearity of detectors for small field dosimetry. Therefore, we recommend reporting dose linearity in terms of the coefficient of determination R2. To avoid any potential ambiguity, the methodology for the determination of dose linearity should be specified along with the corresponding acceptability criterion in an eventual update of the TRS-483.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry of Small Static Fields Used in External Beam Radiotherapy, Technical Reports Series No. 483, IAEA, Vienna (2017).

[2] INTERNATIONAL ELECTROTECHNICAL COMMISSION, IEC 60731 Medical electrical equipment – Dosimeters with ionization chambers as used in radiotherapy, IEC, Geneva (2011).

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MP-TP04 #28 TPS commissioning for IMRT/VMAT, ISMAIL ZERGOUG

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BACKGROUND AND OBJECTIVE

The study describes the methodology for Monaco TPS beam model validation on two Infinity linear accelerators for IMRT/VMAT techniques.

METHODS

One of the two linear accelerators was taken as a reference and the second one was matched in terms of PDDs and profiles for different field sizes and depths in a water tank using gamma analysis. For MLC calibration verification, 3 abutted fields were measured and analyzed with a 2D matrix array. An offset was applied to produce a best fit for both MLCs. After that, the ExpressQA package provided by Elekta was performed to fine-tune MLC parameters by comparing TPS calculated dose distributions with those measured at the linear accelerator.

For IMRT/VMAT verification, AAPM TG119 test cases were used. DICOM images from the AAPM website with structures sets were imported into Monaco 5.11 TPS. Planning was done for Prostate, Head and Neck, Multi Target and C-Shape for both IMRT and VMAT techniques following recommendations set in TG119 report. All treatment plans were created using 7-9 beams for IMRT and 1-2 arcs for VMAT for energy 6MV. For point dose measurement, IBA FC-65G (0.65cc) ionization chamber in a RW3 phantom (*Figure 1*) was used at CAX. For planar dose measurement, a 2D array (IBA Matrixx) positioned in a MultiCube phantom set to the isocentre was used (*Figure 2*). Planned and measured planar dose distributions were compared using gamma index criteria of 3%/2mm as recommended by AAPM TG218. For IMRT plans, gantry was kept at zero angle. IMRT and VMAT plans were delivered on both machines and a comparison was made.

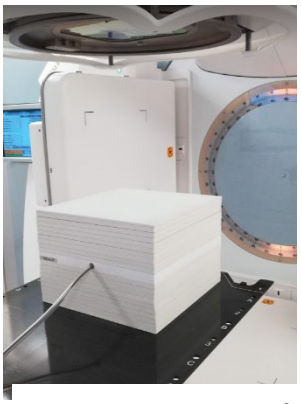

Figure 1. Setup of phantom for point dose measurement

Figure 2. Setup of phantom for planar dose measurement

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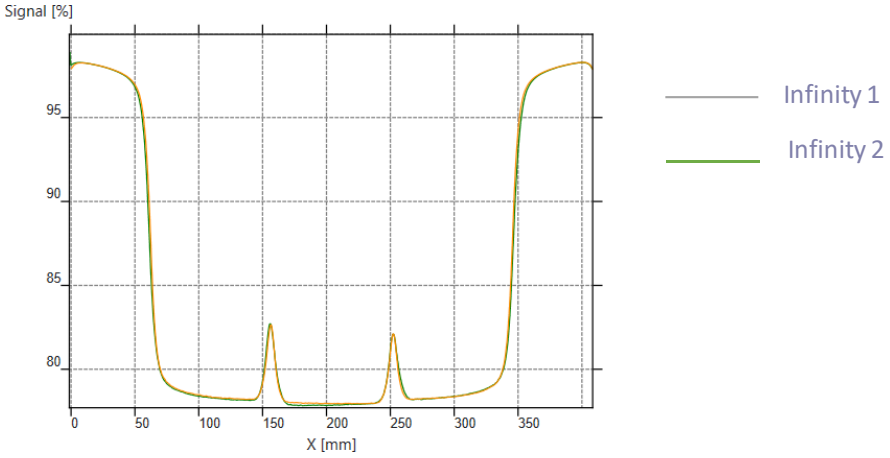
RESULTS AND DISCUSSION

The 3 abutted field profiles of the two machines showed a good match with gamma index of 99.6% using 2%/2mm criteria.



All plans reached the goals as per TG119 reports. In term of point dose measurement, an average difference of 0.1% and 0.4% were observed for IMRT and VMAT, respectively. For planer dose distribution, the mean gamma index values were 98.9% and 98.6% using 3%/2mm criteria with a mean confidence limit of 3.3 (i.e., 96.7% passing) and 3.9 (i.e., 96.1% passing) for IMRT and VMAT delivery on both linear accelerators, respectively.

CONCLUSIONS

The two Infinity linear accelerators were measured and MLC parameters were fine-tuned. The results showed good agreement between measured and TPS calculated dose distributions for IMRT/VMAT delivery techniques.

REFERENCES

[1] Monaco Technical Reference, Post Modeling Adjustment of MLC Parameters, LRMMON0003/4.0, 2014.

[2] Nainggolan et al.“Dosimetric Evaluation of Volumetric Modulated Arc Therapy (VMAT) and Intensity Modulated Radiotherapy (IMRT) Using AAPM TG 119 Protocol.” Journal of biomedical physics & engineering vol. 9,4 395-408. 1 Aug. 2019.

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MP-TP05 #43 Simple method for evaluating flatness and symmetry based on EPID and MATLAB, Ezequiel Larger

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BACKGROUND AND OBJECTIVE

The use of Electronic Portal Imaging Devices (EPID) for the evaluation of dosimetric parameters such as flatness, symmetry and radiant field size of the linear accelerator (LINAC) photon beam, requires a calibration method adapted to the requirements and equipment of the clinic. Currently, in our institution, these types of controls are carried out using detector arrays, but the limited spatial resolution, the error added during the positioning of the devices and the time it takes to mount them, generates the need to implement a more practical method. Faced with this situation, it is proposed to implement the use of EPID for the execution of these controls.
In this work, an empirical calibration method based on film dosimetry will be used, since this detector is superior in resolution and its calibration method and the curve optical density (OD) vs. dose has been validated in many studies.

METHODS

To achieve the conversion of pixel values to dose values, we propose acquiring two calibration curves. The first is a calibration curve that allows the film's OD values to be related to the delivered dose values. To obtain the calibration curve, EBT3 radiochromic films were irradiated, under the following conditions: isocentric technique, 5 cm deep in solid water and a field size of 10x10cm^2. Films with different MUs were irradiated from 0 to 500 UM, which were related to a dose value calculated in the MONACO® treatment planning system (TPS) from ELEKTA.

For the second calibration curve, 10x10cm^2 fields with the same MU values were irradiated on the EPID model iView GT AL type, from ELEKTA®, with no material interposed between the source and the detectors. The pixel values obtained in each image were related to a DO value of the irradiated fields on the radiochromic films.

Finally, it's necessary to perform a gain correction for the off-axis points; this is due to the non-homogeneous response present in the EPID detectors and the depth difference at which it is measured, compared to the 5 cm depth of the plane of reference dose. To solve this, the plane obtained from the EPID is calibrated with a reference plane obtained with an array of Octavius 1500 detectors from PTW® at a depth of 5 cm.

The values of the calibration curves are incorporated into an independent software programmed in numerical computation system MATLAB®, which allows the transformation of the image obtained from the ELEKTA® EPID iView GT to a dose plane in the determined depth, and automatically analyzes radiant field characteristics with respect to the reference values obtained from the TPS. These parameters, defined according to the IEC 60976 standard, include flatness, symmetry and radiant field size in the crossplane and inplane axes.

For this study, only the data obtained using an ELEKTA® SYNERGY linear accelerator for 6MV energy will be analyzed with an ELEKTA® EPID iView GT AL.

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RESULTS AND DISCUSSION

The following tables show the results of EPID measurements and Octavius 1500 PTW® measurements.

Table 1. EPID measurements.

Date	Flatness		Symmetry		Field Size	
	Crossplane	Inplane	Crossplane	Inplane	Crossplane	Inplane
May-20	103.2	102.4	100.5	100.4	19.7	19.8
June-20	103.1	102.4	100.6	100.2	19.7	19.8
Aug-20	103.3	102.6	100.5	100.2	19.8	19.9
Sep-20	103.4	102.4	100.7	100.2	19.7	19.8
Oct-20	103.4	102.4	100.5	100.3	19.7	19.8

Table 2. Octavius 1500 PTW® measurements.

Date	Flatness		Symmetry		Field Size	
	Crossplane	Inplane	Crossplane	Inplane	Crossplane	Inplane
May-20	102.8	101.9	101.4	100.8	20.2	20.1
June-20	102.5	102	101.5	100.6	20.2	20.2
Aug-20	102.8	102.1	101.2	100.6	20.2	20.2
Sep-20	102.4	101.9	101.6	100.7	20.3	20.1
Oct-20	102.2	101.9	101.2	100.7	20.3	20.3

CONCLUSIONS

The results indicate a consistency in the data obtained by the EPID, and this shows that the tool can be used for flatness and symmetry checks routinely. It is important to take into account however, that the EPID response becomes more inhomogeneous over time, and therefore it must be recalibrated after a certain period of time.

REFERENCES

[1] Van Elmpt W, McDermott L, Nijsten S, Wendling M, Lambin P, Mijnheer B. A literature review of electronic portal imaging for radiotherapy dosimetry. doi: 10.1016/j.radonc.2008.07.008. Epub 2008 Aug 14. PMID: 18706727.

[2] Mohammadi M, Bezak E. Two-dimensional transmitted dose measurements using a scanning liquid ionization chamber EPID. doi: 10.1088/0031-9155/51/11/019. Epub 2006 May 24. PMID: 16723778.

[3] International Electrotechnical Commission. Medical electrical equipment - Medical electron accelerators - Functional performance characteristics - IEC 60976. Edition 2 2007-10.

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MP-TP06 #67 Dosimetric comparison between VMAT and dedicated stereotactic planning tool for single isocenter stereotactic radiotherapy for patients with multiple brain metastases, Abdelkader Toutaoui

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BACKGROUND AND OBJECTIVE
Brain metastases are a very common and devastating complication of cancer. In the present study, we undertook a dosimetric study to compare two mono-isocentric approaches used for the treatment of multiple brain metastases. The Volumetric Modulated Arc Therapy (VMAT) implemented on the Eclipse TPS (Varian Medical Systems, USA) and the dedicated Elements Multiple Brain Mets SRS (MBM) (Brainlab AG, Germany).
METHODS
Ten patients with brain metastases were included in this study. Our work focused on the comparison of two treatment planning systems: Eclipse (Varian medical systems, USA) and Elements Multiple Brain Mets SRS (MBM) (Brainlab, AG, Germany) used for patient treatment planning. For treatment plans generated by Multiple Brain Mets SRS, a comparison between two dose calculation algorithms was also established: the pencil beam model (PB) and the Monte Carlo model (MC).Comparisons include target coverage (TC), conformity and homogeneity indexes (CI, HI), gradient index (GI) and Paddick indexes (PCI, IPCI) [1]. All plans were delivered on a Varian iX23 with millenium 120 MLC, Brainlab ExacTrac positioning system and 6D Robotics couche.

RESULTS AND DISCUSSION
Figure 1 illustrates the average values of the various indices used for the quantitative assessment and comparison of the VMAT (AXB) and DCAT (PB) plans. We note that for doses to OARs, the average and maximum dose values calculated by the two TPS are similar. The volume of the brain receiving 12Gy in single fractionation is smaller for DCAT(PB), and the volume receiving 50% of the prescribed dose is also smaller for DCAT.
The indices of coverage, homogeneity and sparing of OAR calculated by both TPS's are similar. Dedicated TPS (DCAT) shows noticeable superiority in gradient index, while VMAT is slightly higher than DCAT for compliance index due to intensity modulation.

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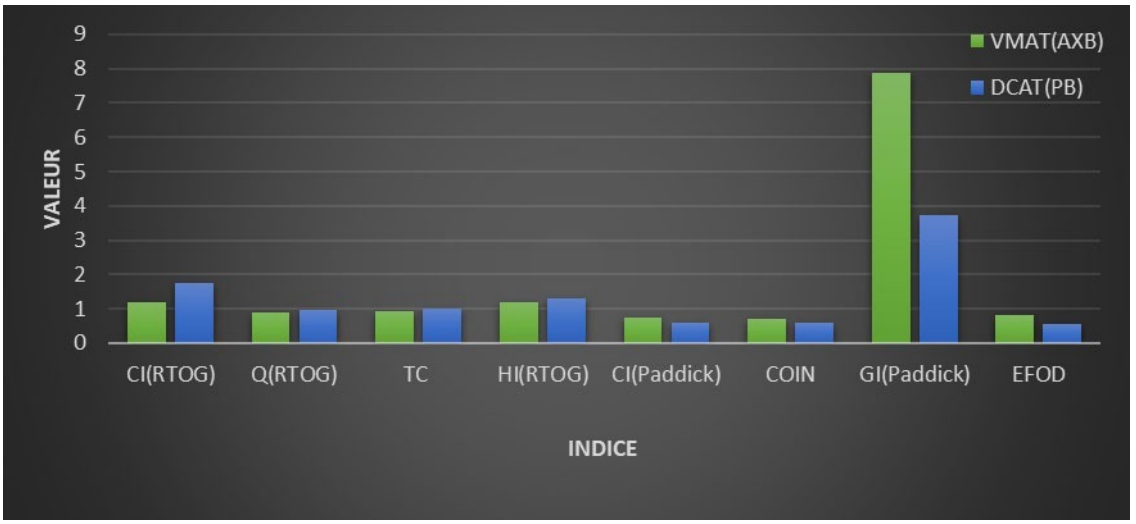

Figure 1: Histogram representing the different indices calculated in this study for the evaluation and comparison of the VMAT (AXB) and DCAT (PB) plans

The quality of PTV coverage with the prescription isodose, the homogeneity of the dose distribution and the preservation of the OARs was comparable for the two techniques, with a slight improvement for DCAT with regard to the HIRTOG which could increase the probability of local tumour control and reduce complications associated with treatment. Planning in VMAT had better results for indices indicating compliance due to the modulation of intensity which ensures more compliant processing. On the other hand, the values obtained for the GIPaddick and EFOD indices showed a significantly better dose gradient for planning in DCAT. This is due to the use of adaptive computing grid and dynamic MLC, which allows for more accurate dose calculation and treatment delivery with a lower scattered radiation rate.

CONCLUSIONS

The results obtained for these two comparisons led to the conclusion that the DCAT technique on MBM had overall better clinical results for treatment planning for multiple brain metastases. A dose calculation using a less precise algorithm with regard to taking into account the heterogeneities compared to MC made it possible to achieve the precision required for the administration of treatments under stereotaxic conditions in a considerably reduced calculation time.

REFERENCES

[1] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Prescribing, Recording, And Reporting Of Stereotactic Treatments With Small Photon Beams, Report 91, Journal of the ICRU **14** (2014).

MP-TP07 #71 Small field output correction factors at 18 MV, Jonas Ringholz

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BACKGROUND AND OBJECTIVE

The response characteristics and correction factors for detectors in small megavoltage photon fields are well studied and summarized in [1]. In this report, only accelerator energies up to 10 MV were considered, as these are the primary energies recommended for stereotactic treatments and intensity modulated radiotherapy. However, many facilities operate accelerators providing also energies up to 18MV, which still need to be characterized and commissioned. Literature data for detector response at such high energies is sparse. Therefore, in this work we compare the response characteristics of ten detectors for small fields at photon energies of 18 MV to extend the available data.

METHODS

The considered detectors contain the ionization chambers: PTW-Semiflex-3D-31021, PTW-PinPoint-31006, the diodes: PTW-60012, PTW 60008, Sun-Nuclear-EDGE, iba-PFD-3G-pSi and iba-SFD, the micro-diamond: PTW-60019, the EXRADIN scintillator: W2-1x3 and GAFChromic EBT-3 film.

The measurements were performed with an ELEKTA Versa HD accelerator at 18MV in water. The general measurement setup consisted of a PTW MP3 water-phantom at a source to surface distance (SSD) of 90 cm and the considered detector isocentrically at 10 cm depth with their effective points of measurement as stated by the manufacturers. The Semiflex chamber was positioned orthogonal to the beam with its central axis at 10 cm depth. The PinPoint chamber was positioned parallel to the beam. Prior to the measurement, detectors were centralized by scanning profiles in a small field. We measured relative signals for 100 monitor units for each detector for the following nominal fields: 10 x 10 cm^2, 6 x 6 cm^2, 4 x 4 cm^2, 3 x 3 cm^2, 2 x 2 cm^2, 1.4 x 1.4 cm^2, 1 x 1 cm^2, 0.9 x 0.9 cm^2, 0.8 x 0.8 cm^2, 0.7 x 0.7 cm^2, 0.6 x 0.6 cm^2 and 0.5 x 0.5 cm^2. All measurements started with the 10 x 10 cm2 field descending to the 0.6 x 0.6 cm^2 field, repeating this series three times.

The EXTRADIN scintillator W2-1x3 was oriented parallel to the beam. To correct for Cherenkov photons, it was calibrated following the small field water tank method described by the manufacturer, by irradiating the fiber in minimum and maximum configuration in a 10 x 10cm^2 field.

Film was calibrated using several filmstrips exposed to doses between 0 Gy and 5.4 Gy at the same beam quality. For the field measurements, a PMMA holder was used to position the film in the water tank. The monitor units for the GAFChromic EBT-3 Film were scaled to obtain a central dose of approximately 2 Gy for all field sizes. The single films were scanned centrally on an EPSON-Expression11000XL scanner at a resolution of 150 dpi. Optical density was converted into dose using FilmQAPro software (Ashland) and the three-color method. Darkening after multiple scans was corrected for. The dose down to 4 cm field size was calculated as the arithmetic average of the central 15 x 15 pixel region. For the small fields we used the sum of two sigmoid functions to fit each dose grit in x- and y-direction, followed by a fit to the maxima of both directions to get both the real field size (FWHM) and the maximum dose of the field.

For each detector, field output correction factor was calculated according to [1] using film as the dose reference.

RESULTS AND DISCUSSION

An increase of the correction factor was observed below the field size of 1 cm for all detectors with the most pronounced manifestation for the PFD diode.

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The values of the scintillator W2-1x3 deviated least from the film. As expected, the shielded diodes (PTW-60008, Sun-Nuclear-EDGE) showed the highest overresponse at small field-sizes. Also, the unshielded diodes (PWD-60012, SFD) over-responded at small fields. On the other hand, they also over-responded at large fields due to more low energy photons. The PFD and PTW microDiamond increasingly overresponded below field sizes of 3 cm resulting in corrections higher than for the unshielded but lower than for the shielded diodes. The ionization chambers show the known volume effects at small fields and their response decreases there up to 10% for the Pinpoint-chamber and up to 25% for the Semiflex-31021 detector.

There is very little difference between the corrections for PTW-60012 and PFD at 18 MV and the data provided in [1] for 10 MV. For PTW-60008 and SFD, the corrections in [1] increase from 6 MV to 10 MV. This trend continues also to 18 MV. MicroDiamond and EDGE-diode also require larger corrections at 18 MV.

CONCLUSIONS

Field output correction factors were determined for 18MV for quadratic fields between 10cm and 0.5cm side length. For most detectors, the corrections are larger than those tabulated for 6MV and 10MV in [1]. The use of beam quality specific field output correction factors will improve the accuracy of output data in small high-energy photon fields.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry of Small Static Fields Used in External Beam Radiotherapy, Technical Reports Series No. 483, IAEA, Vienna (2017).

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MP-TP08 #77 COMMISSIONING OF AN X-RAY BIOLOGICAL RESEARCH IRRADIATOR, Carla Mota

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BACKGROUND AND OBJECTIVE

The use of radiation is a recognized technique for cancer treatments, but the previous knowledge of its effect in different tissues and doses is highly desirable. Experiments that use specially designed biological irradiators for cells or small animals are becoming available using X-ray beams with kilovoltage in the range of 40–300 kVp. According to the Task Group 61 (TG 61) protocol from the American Association of Physicists in Medicine (AAPM), due to the increase in use of conventional and electronic x-ray machines in North America during the last few years, there is also a renewed interest in the radiotherapy treatment with superficial and orthovoltage x-rays. As result, it is necessary to accurately measure the quantity of interest, absorbed dose to water (D_w), for prescribing the tumor dose (Ma et al., 2001).
The Radiological Science Laboratory (LCR) is investigating the potential use of Fricke dosimetry as a standard for the absorbed dose in that energy range. The Fricke dosimetry depends on the oxidation of ferrous ions (Fe^{2+}) to ferric ions (Fe^{3+}) caused by interaction of the ionizing radiation with the solution. The increased concentration of ferric ions is measured at a wavelength of 304 nm in this case using a Varian Cary 50 Bio spectrophotometer. The Fricke composition is very close to water (96%), as well as its dosimetric properties; a dose range from 5 to 400 Gy and dose rates of up to 10^6 Gy/s are possible. The major disadvantage of Fricke dosimetry is its high sensitivity to impurities, which act as scavengers of the hydroxyl radicals generated by irradiation or as ferrous ion oxidants, resulting in a non-linear response and decreased system sensitivity when the oxygen present in the solution is depleted (Rosado et al., 2020). The RS 2000 X-ray biological irradiator was constructed with a sealed cabinet (420 × 440 × 390 mm^3) that produces x-rays with energies from 100 to 300 kV. In the cabinet, the samples can be irradiated at 6 different distances (from 168 to 486 mm) depending on the desired dose rate and sample dimensions (Colello, B. et al., 2017).
The half-value layer (HVL) was measured in combination with the tube potential, to characterize the photon fluence, i.e. the beam quality. Before irradiating the Fricke dosimeter, the commissioning of the irradiator was performed to investigate the accuracy of the beam calibration for the beam quality at each point of interest and the factors needed to convert the readings in dose. The radiation beam quality depends on several factors such as the tube potential, target angle, thickness and material of the target, tube window, monitor camera, filtration, the shape of collimation, the aluminum shelf and the distance between the source and the chamber.
The aim of this study was initially to perform the dosimetric calibration of the RS 2000 X-ray biological irradiator (Figure 1) using a NE 2571 Farmer type ionization chamber associated to a Keithley 6514 electrometer and compare the results with the Fricke solution.

METHODS

For this purpose, the measurement of HVL was done and the mean energy was obtained for this radiation beam. In this study, the shelf of the irradiator was fixed at (FSD 31 cm) for all exposures.

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All measurements were carried out with 150 kV and 20 mA (considering 0.8 mm of Be inherent filtration and an added filtration of 0.33 mm of Cu and 1.75 mm of Al).

Figure 1. RS 2000 X-ray biological irradiator.

RESULTS AND DISCUSSION

Results showed that the first HLV was 0.64 mm of Cu at the source detector distance (SDD) of 310 ± 5 mm, for a radiation field of 225.6 mm, and the mean energy of the beam was then defined as 73.2 keV. Further work is needed to determine all correction factors associated with the Fricke method for different beam qualities used in the radiobiology studies performed with this irradiator.

CONCLUSIONS

As the quality of a beam depends on many factors (tube potential, target angle, target material, window material, and thickness, monitor chamber material and thickness, filtration material and thickness, shape of collimation, and the source-chamber distance), a measurement of HVL was done. Further work is needed to determine all correction factors associated with the Fricke method for different beam qualities used in the radiobiology studies performed with this irradiator.

REFERENCES

[1] Ma, C-M., et al. "AAPM protocol for 40–300 kV x-ray beam dosimetry in radiotherapy and radiobiology." Medical physics 28.6 (2001): 868-893.

[2] Rosado, P.H., et al. “Determination of the Absorbed Dose to Water for Medium Energy X ray Beams Using Fricke Dosimetry.” MEDICAL PHYSICS, v. 47, p. 5802-5809, 2020.

[3] Colello, B. et al. "Biological X-ray irradiator characterization for use with small animals and cells." Brazilian Journal of Medical and Biological Research 50.3 (2017).

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MP-TP09 #91 Determination of field output correction factors in small static photon fields following TRS-483 CoP, Nkosingiphile Maphumulo

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BACKGROUND AND OBJECTIVE

The IAEA in collaboration with the AAPM, recently (2017) published an international code of practice for measurements in small static photon beams (TRS-483). The CoP provides methods and data on a range of detectors to ensure a systematic and unified approach to measurements in small static fields. The data available on TRS-483 CoP is on detectors that were commercially available for measurements in small static fields at the time of its publication. The aim of this study was to determine field output correction factors for a new micro detector (PTW 31021) designed for measurements in standard and small fields. The field output correction factors were determined using output factor measurements performed with detectors available on TRS-483 and the response of PTW 31021 in small static fields.

METHODS

The study was performed in a 6 MV flattened photon beam using two solid state detectors (Diode PTW-60012 and MicroDiamond PTW-60019), two air ionization chambers (Semiflex PTW-31010 and PinPoint 3D PTW-31016) and a liquid ionization chamber (PTW-31018). The PTW microDiamond detector was used to measure the lateral beam profiles used to define the equivalent square radiation field sizes (Sclin) from the set fields. The field output factors were measured using the selected detectors and field output factor correction factor data available in the TRS-483 CoP. The acquired field output factor data were then fitted using an analytical function proposed by Sauer and Wilbert. The function's fitting parameters were adjusted to produce the line of best fit for measured field output factors.

$$k_{Q_{clin},f_{ref}}^{f_{clin},f_{ref}} = \frac{\Omega_{Q_{clin}Q_{ref}}^{f_{clin}f_{ref}}}{\left(\frac{M_{Q_{clin}}^{f_{clin}}}{M_{Q_{ref}}^{f_{ref}}}\right)}$$

The above expression was then used to calculate the corresponding field output correction factors as a function of S_{clin} for the new micro reference class ionization chamber (PTW 31021) from its response when it was mounded parallel and perpendicular to the beam axis, where $\Omega_{QQ_{cccccc}QQ_{rrrrrr}}^{rrcccccrrrrrr}$ is the predicted field output factor obtained using the analytical function, and $MM_{QQ_{cccccc}}^{rrcccccccc}$ and $MM_{QQ_{rrrrrr}}^{rrrrrrrr}$ are the response of the PTW-31021 in the clinical and reference fields, respectively.

All detectors were irradiated under identical conditions using the same set up, and the measurements were repeated three times.

RESULTS AND DISCUSSION

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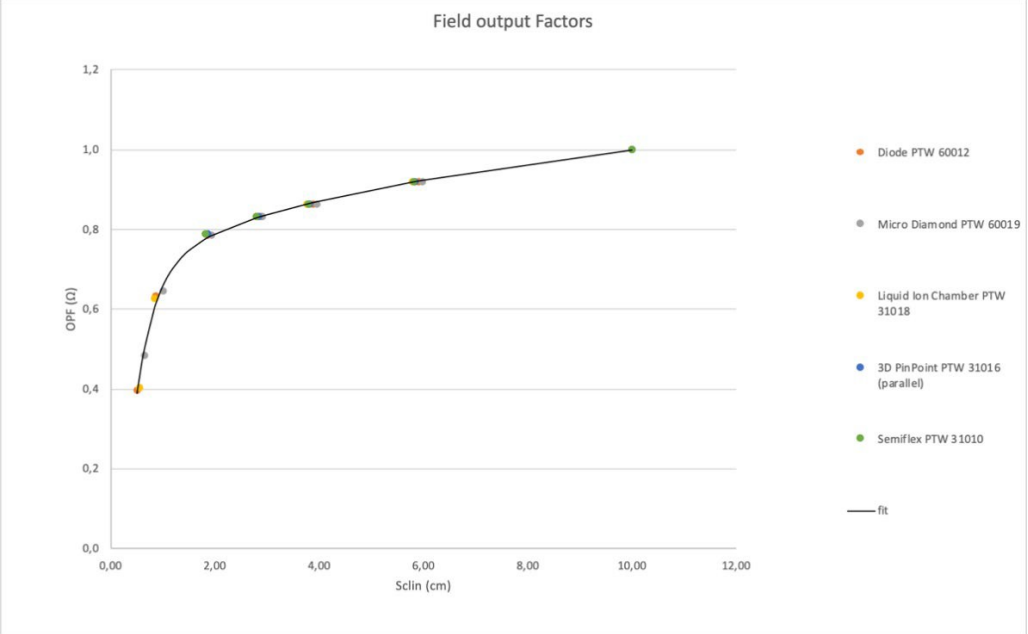

Field output factors were measured in small static fields using a relatively large selection of detectors. The field output factors were fitted to an analytical function as proposed by Sauer and Wilbert to produce the line of best fit represented by the solid black line.

$$\Omega(S) = P_{\infty} \frac{S^n}{l^n + S^n} + S_{\infty}(1 - e^{-bs})$$

The fitting parameters that produced the best fit on the data for the analytical function were: $P_{\infty} = 0.741$, $S_{\infty} = 0.41$, $l = 0.517$, $n = 2.433$ and $b = 0.099$.

The field output factor correction factors $k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ as a function of S_{clin} in a 6 MV beam with flattening filter for a selection of detectors were used in the study for measurement in small fields. The correction factors for the PTW-31021 were determined in this study and the correction factors for all the other detectors used in this study were obtained from the IAEA TRS-483 Cop.

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S_{clin}	Semiflex 3D PTW-31021 (perp)	Semiflex 3D PTW-31021 (parallel)	Diode PTW-60012	Micro Diamond PTW-60019	Semiflex PTW-31010	Pin Point 3D PTW-31016	MicroLion PTW-31018
8.0	1.000	1.000	1.005	1.000	1.000	1.000	0.997
6.0	1.000	1.000	1.010	1.000	1.000	1.000	0.994
4.0	0.999	0.999	1.015	1.000	1.000	1.000	0.991
3.0	0.999	0.999	1.017	1.000	1.001	1.001	0.989
2.5	1.000	1.000	1.017	0.999	1.002	1.001	0.988
2.0	1.002	1.001	1.016	0.997	1.008	1.004	0.988
1.5	1.012	1.010	1.010	0.993	1.025	1.013	0.987
1.2	1.033	1.029	1.003	0.989	-	1.025	0.987
1.0	-	-	0.996	0.984	-	1.039	0.987
0.8	-	-	0.985	0.977	-	-	0.990
0.6	-	-	0.970	0.968	-	-	0.999
0.5	-	-	0.960	0.962	-	-	1.011
0.4	-	-	-	0.955	-	-	1.033

CONCLUSIONS

When one compares the size of the sensitive volume to the field output correction factors, the result of this study was found to be in agreement with data published in the TRS-483 code of practice. The results of this study were compared to the findings of Casar et al and the results were in good agreement, which proved the MicroDiamond to be an effective detector for field size measurements. The Semiflex 3D (PTW-31021) ionization chamber was found to be usable to field sizes down to 1.2 cm x 1.2 cm.

ACKNOWLEDGMENTS

The University of the Witwatersrand is acknowledged for affording the opportunity to be part of this study and Charlotte Maxeke Johannesburg Academic Hospital is acknowledged for the use of their facilities.

REFERENCES

[1] H. Palmans, P. Andreo, M. S. Huq, J. Seuntjens, K. E. Christaki, A. Meghzifene, Dosimetry of small static fields used in external photon beam BIBLIOGRAPHY 60 radiotherapy: Summary of TRS-483, the IAEA–AAPM international Code of Practice for reference and relative dose determination. Medical Physics, 2018, 45: e1123–e1145.

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[2] International Atomic Energy Agency (IAEA), Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water. Technical Report Series 398, version 12, IAEA, Vienna, Austria, 2006.

[3] H. Palmans, P. Andreo, M. S. Huq, J. Seuntjens, K. E. Christaki, A. Meghzifene, Dosimetry of small static fields used in external photon beam radiotherapy: Summary of TRS-483, the IAEA–AAPM international Code of Practice for reference and relative dose determination. Med. Phys. 2018, 45

[4] B. Casar, E. Gershkevitsh, I. Mendez, S. Jurković, M. S. Huq, A novel method for the determination of field output factors and output correction factors for small static fields for six diodes and a microdiamond detector in megavoltage photon beams. Med. Phys. 2019, 46: 944-963.

[5] P. Papaconstadopoulos. On the detector response and the reconstruction of the source intensity distribution in small photon fields. PhD thesis, McGill University, Montreal, 2016.

[6] I. J. Das, G. X. Ding, A. Ahnesjö, Small fields: Nonequilibrium radiation dosimetry. Med. Phys. 2008, 35: 206-215.

[7] O. A. Sauera, J. Wilbert, Measurement of output factors for small photon beams, Medical Physics, 2007, 34: 1983-1991.

[8] PTW Freiburg, Detectors, Including Code of Practice. 2018/2019

[9] S. Wegener, A. O. Sauer, Energy response corrections for profile measurements using a combination of different detector types. Med. Phys. 2018, 45: 898-907

[10] B. Casar, E. Gershkevitsh, I. Mendez, S. Jurković, M. S. Huq, Output correction factors for small static fields in megavoltage photon beams for seven ionization chambers in two orientations-perpendicular and parallel. Med. Phys., 2020, 47: 242-259.

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MP-TP10 #120 Verification of two beam-matched linear accelerators using volumetric modulated arc therapy plans, Tinnagorn Donmoon

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BACKGROUND AND OBJECTIVE

Currently, our centre has two linear accelerators (LINACs), identical models and brands. Both are capable of volumetric modulated arc therapy (VMAT). The two LINACs were installed two years apart. The final goal of this work is to interchange patients between the two LINACs, without re-planning if there any malfunctions on one machine. Having two identical LINACs, it is our opportunity to try using beam-matching techniques. First, we followed the vender's criteria. However, these are insufficient to ensure the interchangeability of the patients. After completing the acceptance test and initial vendor-recommended beam-matching test, the extent of beam-matching was measured to confirm the level of beam matching in both LINACs. The photon beams of the original LINAC (LINAC1) were selected as the reference for beam tuning of the newer LINAC (LINAC2). This work aimed to verify the dosimetric accuracy of beam-matching by using VMAT plans after completion of the beam-matching.

METHODS

For planar dose measurement, thirty previously treated patients from our database were selected. Sites included were: head and neck, thorax, and pelvis, with ten patients for each site. The VMAT plans were generated in Monaco (version 5.11.02) Treatment Planning System (TPS) using the same 6 MV photon beam model. The doses were computed using the Monte Carlo algorithm with a calculation grid size of 0.3 cm. TPS doses calculated on LINAC1 was taken as a reference for all measurements. The LINAC1's verification plans have been beamed ON in all LINACs by doing the machine override option available in LINAC2 consoles. All the VMAT plans were measured using Octavius^{4D} phantom with Octavius detector 1500 and VeriSoft® verification software. Octavius measurement was compared with the TPS calculated planar doses through absolute dose gamma comparison using criteria of 3% dose difference and 3 mm distance to agreement (3%/3mm). The statistical significance of differences for gamma passing rates of Octavius measurements between two LINACs were analyzed using a t-test at a 95% confidence limit.

RESULTS AND DISCUSSION

For all thirty cases, the gamma passing rates of Octavius measurements on two beam-matched LINACs were higher than 95% with 3%/3mm gamma criteria, as shown in Figure 1. The average gamma passing rates of LINAC1 and LINAC 2 were 96.23±0.81% and 96.28±0.85%, respectively. There was no statistical difference in the gamma passing rates between LINAC1 and LINAC2, with a p-value of 0.463.

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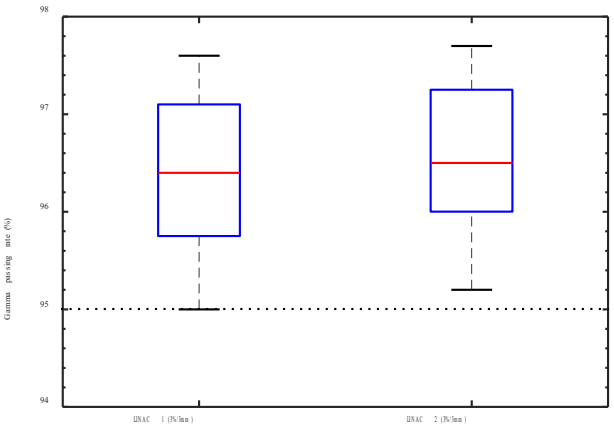

Figure 1. Distributions of absolute dose gamma passing rate of VMAT plans delivered on two beam-matched LINACs.

CONCLUSIONS

The beam-matched LINACs show good agreement between measurements and TPS calculations for VMAT plans. Small differences in gamma passing rates between two LINACs prove the viability of interchanging VMAT patients between two beam-matched LINACs without re-planning VMAT plans to manage the machine downtime.

ACKNOWLEDGMENTS

All authors would like to sincerely thank senior medical physicist Mr. Paisarn Suwannakorn for the professional advice and contribution during beam measurements. We would like to thank Dr. Arkom Chaiwerawattana, director of Mahavajiralongkorn Thanyaburi hospital, for granting permission to use the laboratory facilities and support during the entirety of this work.

REFERENCES

[1] SANGAIAH A, GANESH K.M, RAMALINGAM K, et al. Dosimetric validation of volumetric modulated arc therapy with three 6 MV beam-matched linear accelerators. Asian pacific journal of cancer prevention 18.12 (2017) 3439-44.

[2] ZHENGZHENG X, GREGORY W, SUYOUNG L, et al. Assessment of beam-matched linacs quality/accuracy for interchanging SBRT or SRT patient using VMAT without replanning. J Appl Clin Med Phys 20.1 (2019) 68-75.

[3] MARIUS T, PETRA M, CHRISTIAN G, et al. Linac twin in radiotherapy, doi: 10.5772/60427 (2015)173-186.

[4] JANHAVI R, SATHIYA NARAYANAN V.K., NAMTHA K, et al. Dosimetric analysis of beam-matching procedure of two similar linear accelerators. Journal of medical physics 36.1 (2011) 176-80.

[5] DAVID S, ULF B, WIVIANN O and CLAUS F. A beam-matching concept for medical linear accelerators. Acta Oncologica 48 (2009) 192-200.

[6] SANKAR A, AITANG X, TONY Y, et al. Three dimensional dose verification of VMAT plans using the Octavius 4D dosimetric system. Journal of Physics: Conference Series 573 (2015) 012081.

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MP-TP11 #65 Assessing the target shift and its effect on dose distribution using deformable image registration method for head and neck patients undergoing IMRT, Aik Hao Ng

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BACKGROUND AND OBJECTIVE

The objective of the study was to assess the target shift in relation to other structures during intensity modulated radiation therapy (IMRT) treatment and the effect on the dose distributions.

METHODS

The Eclipse treatment planning system (version 15.5, Varian Medical Systems, Palo Alto, California) was used to perform the deformable image registration using the planning CT (pCT) and cone beam computed tomography (CBCT). Head and neck patients who underwent IMRT treatment were included in the study retrospectively. Upon completion of radiotherapy treatment, deformed CTs (dCT) were deformed using the pCT and the weekly produced CBCT. The magnitude of target shift (x,y,z) for each dCT was computed by tracking any changes in the position of centre of mass (COM) of the planning target volume (PTV). Subsequently, the shift coordinates were used by the treatment planning system to execute dose recalculation on dCT, based on the initial IMRT treatment plan. Dose volume histograms of relevant organs-at-risk (OARs) were generated and compared.

RESULTS AND DISCUSSION

A series of dCT were successfully generated for each patient, enabling further quantification work to be carried out. Figure 1 shows an example of the dCT generated from pCT and CBCT of a patient with nasopharyngeal cancer (NPC). The preliminary result shows that the average target shift for the PTV was 0.05 ± 0.04 cm (ranged between 0.00 and 0.24 cm). For dosimetry analysis, no significant changes on OARs (brainstem, optic nerves, spinal cord and chiasm) were observed, and all were below tolerance limits as shown in Figure 2.

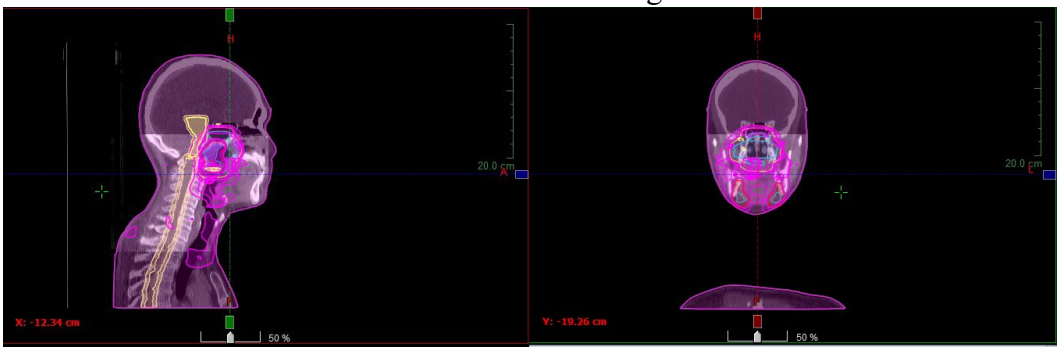

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Figure 1. The deformed CT images (sagittal and coronal view) around the PTV (volume of interest from brainstem to cervical level).

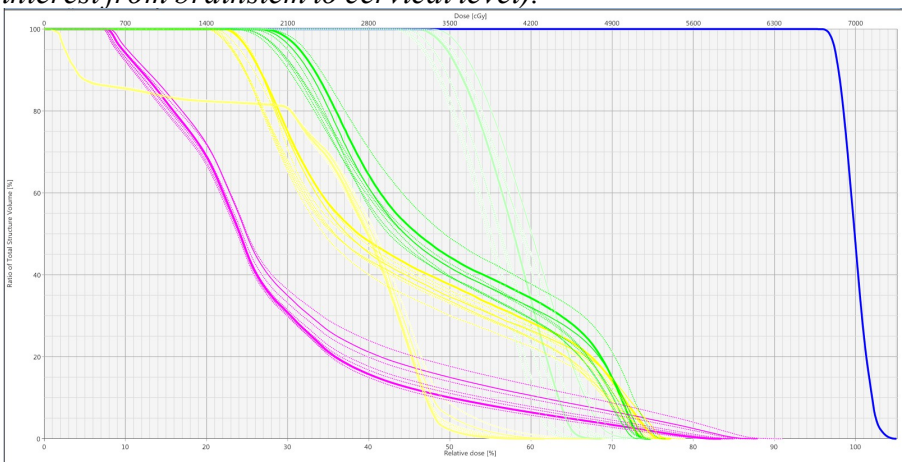

Figure 2. Dose volume histogram for PTV (blue) and dose uncertainty for pre-defined organs-at-risk (OARs) calculated by the treatment planning system.

CONCLUSIONS

This study demonstrates a quantitative method to assess target shift over fractionated treatment and to evaluate its effect on the dose distribution of OARs for head and neck patients undergoing IMRT. The generated data can serve as baseline data and would be useful in the future, particularly for adaptive radiotherapy.

ACKNOWLEDGMENTS

The authors would like to thank the Director General of Health Malaysia for his permission to publish this article.

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MP-TP12 #134 Evaluation of Knowledge-based planning of Volumetric Modulated Arc Therapy (VMAT) for Nasopharyngeal cancer, Kishore Joshi

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BACKGROUND AND OBJECTIVE

The aim of the current study was to investigate knowledge-based predictive models for treatment planning of nasopharyngeal cancer (NPC).

METHODS

105 previously treated NPC clinical treatment plans (CP) (Eclipse treatment planning system, Varian medical System v13.5) with dose prescriptions of 66 and 54 Gy in 30 factions were used to configure a knowledge-based model (Rapid Plan, Varian medical system v13.5)[1,2]. The OAR structures modelled were as follows: spinal cord, brainstem, planning risk volume (PRV) brainstem, PRV spinal cord, eyes, parotid glands, oral cavity, optical chiasm and optic nerves. Influential geometric and dosimetric outliers were removed by deleting certain OARs from a patient or the entire patient from the initial model, which resulted in a final model with 73 patients. Model quality was quantified by the coefficient of determination R^2, goodness-of-fit statistics χ^2 and by the goodness of estimation mean square error (MSE) between the original and estimate[2]. Finally, optimization objectives for the PTVs and OARs were generated and optimized iteratively. Model validation was carried out on a subset of 14 patients not included in the training database, by comparing the knowledge-based plans (KBP) using single optimization without any manual intervention during optimization and CP. Various dose-volume parameters were evaluated for both target and OARs to compare CP vs KBP (Table 1). Wilcoxon single rank test and paired t - test was used to establish the statistical significance between CP and KBP (SPSS v21).

RESULTS AND DISCUSSION

From the summary of the model quality parameters, the R^2, χ^2 and MSE, it was observed that the estimation capability of the model was good for optic nerves and optic chiasm (MSE = 0.012, R^2 = 0.89), and modest for mandible (MSE = 0.003, R^2 = 0.74), brainstem (0.008, 0.65) and eyes (0.007, 0.55). For other OARs, such as spinal cord (R^2 = 0.37), parotids (R^2 = 0.3) and midline structures (R^2 = 0.44), the prediction capability was poor. The overall observation about target coverage was that KB plans resulted in comparable plans for both target coverage and conformity as compared to CP. Most of the DVH parameters related to target structures were found to not be statistically significant comparing CP vs KBP (Table 1).

	Organ	Dose volume parameter	CP	KBP	p value
Target structures	PTV_66	D98 (Gy)	61.5 ± 0.85	61.4 ± 0.96	0.598
		D95 (Gy)	63.2 ± 0.89	62.9 ± 0.68	0.336

		Dmean (Gy)	66.5 ± 1.1	66.1 ± 1.1	**0.001**
		D2cm3 (Gy)	69.4 ± 1.2	69.3 ± 1.6	0.403
		HI	0.12 ± 0.02	0.12 ± 0.03	0.927
	PTV_54	D98 (Gy)	50.5 ± 0.84	50.7 ± 1.9	0.703
		D95 (Gy)	51.8±1.4	51.7±0.4	0.433
		D2cm3 (Gy)	57.9± 1.8	56.9 ± 1.6	**0.012**
		Dmean (Gy)	54.7 ± 1.03	54.1 ± 0.96	**0.015**
		HI	0.13± 0.06	0.12 ±0.04	0.3
OARs	Lt Parotid	Dmean (Gy)	50 ± 9.7	49 ± 9.7	0.263
	Rt Parotid	Dmean (Gy)	49 ± 11.6	48 ± 11.4	0.075
	Parotids total	D20cc (Gy)	54.7 ± 14.7	52.3 ± 15.0	0.055
	Spinal Cord	Dmax (Gy)	43.3 ±4.2	41.7 ±3.5	**0.035**
		D1cm3 (Gy)	38.6 ± 3.9	38.1 ± 3.6	0.668
	Brainstem	Dmax (Gy)	52.8 ± 2.6	52.2 ± 2.7	0.431
		D1cm3 (Gy)	49.6 ± 3.1	48.4 ± 3.3	0.108
	Optic Chiasm	Dmax (Gy)	35.8± 23.8	36.6± 26.7	0.124
		D1cm3 (Gy)	34.8 ±23.4	35.5 ±26.3	0.14
	Mandible	Dmax (Gy)	69.7 ± 3.8	68.9 ± 3.6	0.051
		D1cm3 (Gy)	66.7± 3.1	66± 3.5	0.272
	Midline Structures	Dmean (Gy)	41.3 ± 6.3	42.4 ± 6.3	0.448
	Lt Eye	Dmean (Gy)	14.7 ± 9	10.4 ± 5.6	**0.004**
	Rt Eye	Dmean (Gy)	18.9 ± 11.7	13.7 ± 9.1	**0.01**

CONCLUSIONS

A KBP model was built and validated for NPC, to be used for VMAT, for multi-target and dose prescription involving SIB technique. Based on the results, KBP was comparable, and for some OARs, even outperformed as compared to clinical plans, while producing conformal, homogeneous target coverage, in a time-efficient manner. Further validation studies to improve the scope of the model are underway.

REFERENCES

[1] Yuan L, Ge Y, Lee WR, Yin FF, Kirkpatrick JP, Wu QJ. Quantitative analysis of the factors which affect the interpatient organ-at-risk dose sparing variation in IMRT plans. Med Phys. 2012 Nov;39(11):686878. doi: 10.1118/1.4757927. PMID: 23127079.

[2] Eclipse Photon and Electron Reference Guide, Varian Medical Systems

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MP-TP13 #136 Dosimetric Comparison of VMAT and IMRT for NPC and Prostatic Carcinoma, SADIA SADIQ

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BACKGROUND AND OBJECTIVE

METHODS

This study was conducted in the Radiation Therapy Department of the Institute of Nuclear Medicine & Oncology Lahore (INMOL). Five patients with NPC and ten patients with prostate carcinomas were selected. All patients were of Stage 3/4 with tumour spread to adjacent lymph nodes. Their simulations were done with the help of the TOSHIBA AQUILON CT scanner. Radiation oncologist drew all target volumes of primary tumours and lymph nodes. All organs present near tumour sites were also delineated. Doses were prescribed to each target volume. For sparing of OARs, QUANTEC limits were followed.

For treatment Planning, ECLIPSE TPS (version 15.6.04) was used. For VMAT, 2.5 Arcs were applied for NPC cases and 1.5 Arcs for prostate cases (Figure 1a). For IMRT plans, 9 beams were planned for NPC cases, while 7 beams planned for prostate cases. (Figure 1b).

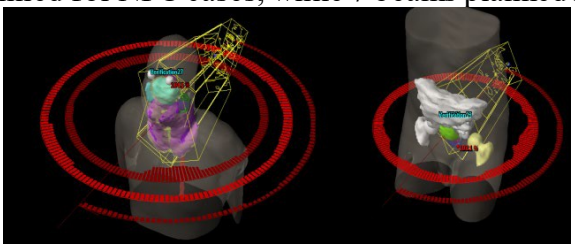

Figure 1a. VMAT planned Arcs for this stud.

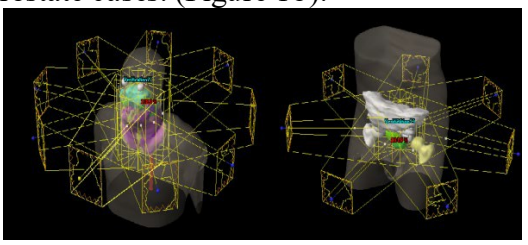

Figure 1b. VMAT planned Arcs for this study.

All plans were optimized using Inverse Planning technique. Initial beams were set and final goals were provided. These goals were achieved after performing multiple iterations by continuously changing priorities to targets/OARs. Figure 3 shows the optimization window. After optimization, dose was calculated. Plan evaluation was carried out using Conformity index (CI), Homogeneity Index (HI), Tumor coverage Factor (TCF), Monitor Units (MU) and dose to OARs as per QUANTEC.

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RESULTS AND DISCUSSION

Plans of both techniques achieved the same level of dose coverage as per ICRU 50 criteria. Figure 2 shows dose coverage of one of the NPC cases from this study.

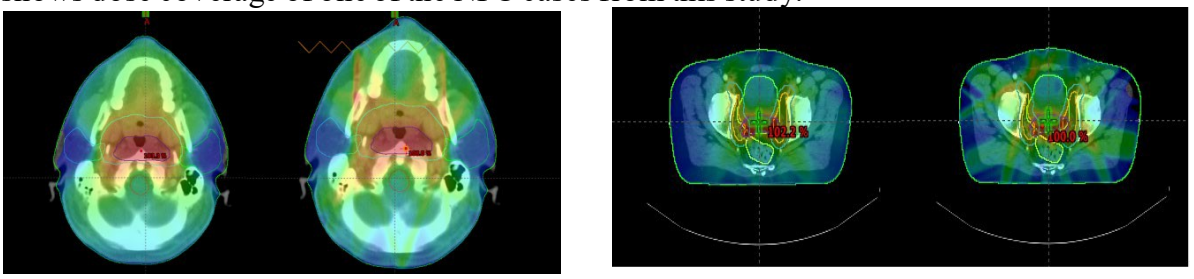

Figure 2: Dose Coverage of IMRT (right) and VMAT (left) in NPC and Dose Coverage of IMRT(right) and VMAT(left) in prostate carcinoma case.

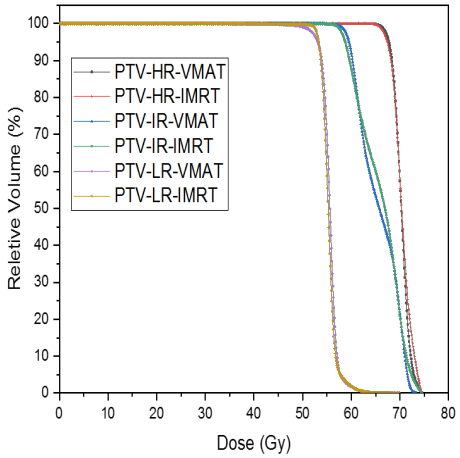

Figure 3: Average DVHs of PTV-HR, PTV-IR and PTV-LR in NPC Cases

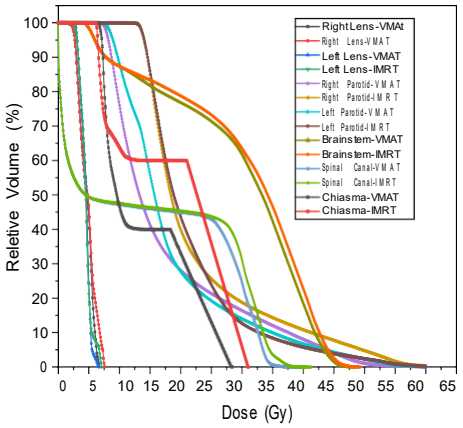

Figure 4: Average DVHs of Lenses, Parotids, Brainstem, Spinal Canal and Chiasma.

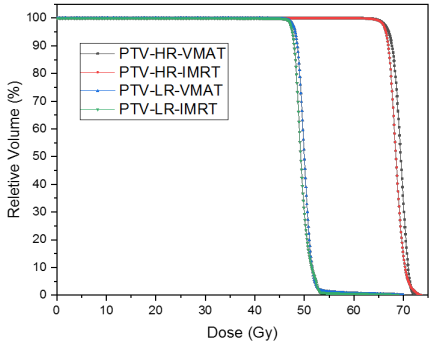

Figure 5: Average DVHs of PTV-HR, PTV-IR and PTV-LR in Prostate

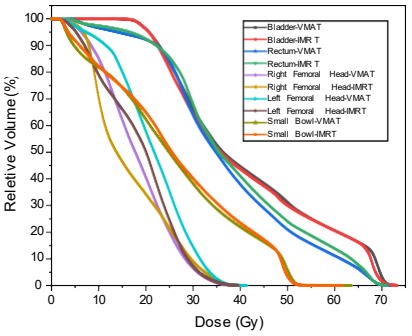

Figure 6: Average DVHs of Femoral Heads, Rectum, Small Bowl and Bladder.

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Figure 3 and Figure 5 compare average DVHs of PTVs, while Figure 4 and Figure 6 show comparisons of OARs DVHs.

The following Tables shows average values of some parameters evaluated for both techniques.

Parameter (NPC)	VMAT	IMRT
CI	1.25	1.30
HI	0.08	0.07
TCF(PTV-IR)	0.966	0.974
TCF(PTV-LR)	0.964	0.984
Brainstem (Dmax)	48.42 Gy	49.26 Gy
Right Lens (Dmax)	6.74 Gy	7.56 Gy
Left Lens (Dmax)	6.59 Gy	6.91
Right Parotid (Mean dose)	18.54 Gy	22.94 Gy
Left Parotid (Mean)	18.92 Gy	21.9 Gy
Chiasma (Dmax)	28.35 Gy	30.99 Gy
Spinal Canal (Dmax)	40.46 Gy	41.32 Gy
onitor Units	468.4	2325.8

Parameter (Prostate)	VMAT	IMRT
CI	1.16	1.24
HI	0.07	0.06
TCF(PTV-LR)	0.971	0.947
Bladder (V59,V68,V72)	(20.93,11.66,0.24) %	(21.38,8.09,0.25) %
Rectum (V45,V59,V68)	(29.07,12.26,2.55) %	(31.84,14.83,2.02) %
Right Femoral Head (Dmax)	40.1 Gy	39.77 Gy
Left Femoral Head (Dmax)	40.5 Gy	40.52 Gy
Small Bowl (mean)	25.79 Gy	26.58 Gy
Monitor Units	733.4	2149.1

CONCLUSION

VMAT showed better conformity of doses in target volumes. IMRT was superior in homogeneity indices. All organs received lesser doses from VMAT except for femoral heads. VMAT requires a fewer number of monitor units than IMRT. It was concluded that VMAT is superior than IMRT in terms of treatment efficiency and less scatter dose to patients.

REFERENCES

[1] A. Mundit and J. Roeske, Intensity Modulated Radiation Therapy : A Clinical Prospective, London, BC Decker lnc, 2005.

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[2] F. M. Khan and J. P. Gibbons, KHAN's Treatment Planning in Radiation Oncology, Wolters Kluwer, 2016.
[3] K. Otto, Volumetric Modulated Arc Therapy : IMRT in a single gantry arc, Medical Physics, Vol. 35 No. 1, pp 310-317, 2018.

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MP-TP14 #137 Total Marrow with Lymphoid Irradiation (TMLI) as a conditioning regimen using VMAT technique: Planning and dosimetry validation, Reena Devi Phurailatpam

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BACKGROUND AND OBJECTIVE

Planning and dosimetric feasibility of implementing TMLI (Total Marrow with lymphoid Irradiation) using Volumetric modulated arc therapy (VMAT) as a conditioning for bone marrow transplant was studied.

METHOD

Four patients who were planned to receive cyclophosphamide- TMLI based conditioning for allogenic transplant were accrued in the present study after institutional ethics committee approval. VMAT plans were generated on a TrueBeam Linac (Varian Medical Systems, USA) using Eclipse treatment planning system (TPS version 13.5). The plans were dosimetrically validated using Lithium fluoride thermoluminescent dosimeters (LiF TLD), Ionization chambers and ArcCHECK phantom (M/S SUN NUCLEAR CORPORATION). Clinical target volume CTV TMI encompassed marrow sites of skeletal bone, including ribs and sternum. Mandible was excluded as target region to minimize dose to the oral cavity. CTV TLI encompassed lymphatic sites. Mesenteric lymph nodes were excluded as target regions to minimize dose to the gastrointestinal tract. CTV_sanctuary sites were the brain and testes. PTV-TMLI encompassed the entire CTV TMI and CTV TLI and the sanctuary sites of brain and testes. Organs at risk (OAR) include lungs, heart, liver, kidneys, eyes, oral cavity, thyroid, parotids and bowels. The PTV dose prescription was 13.2Gy/8# delivered twice daily. VMAT plans were generated using 8 overlapping 360° coplanar arcs optimized simultaneously. 6MV photon at dose rate 600MU/min was used. The isocentre was placed at the overlapping area between the two adjacent arcs to eliminate the uncertainty in matching the two planes.[1]

Dosimetric validation TLD and Ionization chambers: A thorax phantom and a rectangular phantom (density 1.03 g/cm3) were strapped together to make a phantom of 100 cm length. CT scans with 2.5 mm slice thickness were taken with fiducials aligned with lasers. Twenty-five TLDs along with 3 ionization chambers were placed at different places of the phantom. Opaque markers were also kept at the planned positions of the TLDs so that TPS point dose at each location of 25 TLDs could be accurately compared with the measured dose. Three ionization chambers (0.125cc PTW) were inserted inside the phantom during the CT scan. The thorax phantom had lung inhomogeneity and two ionization chambers inserted with the proper holder at the cranial and thoracic sites. Another ion chamber was also inserted at the middle of the rectangular phantom. Each opaque markers was contoured and effective chamber volumes delineated. Fluence maps of the plans created were transferred to the phantom. Mean dose calculated by TPS at each marker and chamber were compared with the measured dose by TLD

and ionization chamber at the corresponding position. For planar dose validation, the Arc CHECK phantom was used. Dose distributions were analyzed using gamma criteria of 3% dose and 3 mm distance to agreement.

RESULTS AND DISCUSSION

The mean volume of PTV encompassed by 95% isodose line was 92% of the PTV volume, and D_2 (mean dose of 2cc volume of PTV) was 104% of prescribed dose. Conformity and homogeneity indices were 0.90 and 0.21, respectively. Doses to OARs are given in table 1. Percentage variation in point dose measurements with Ionization chambers were found to be within 5%. The mean TLDs reading was within 7% of the TPS calculated dose. Planer dose verification was passed within 95% of gamma index with 3%-3 mm criteria.

Table 1 OAR dose

OAR	Mean Dose Gy (Std deviation)
Right Eyeball	7.95(1.13)
Left Eyeball	7.80(1.14)
Oral cavity	6.9(1.32)
Lt Parotid	7.27(0.77)
Rt Parotid	7.03(0.61)
Thyroid	12.65(0.87)
Heart	6.9(0.77)
Left lung	8.25(0.82)
Right lung	8.63(0.95)
Liver	9.01(1.01)
Left Kidney	6.08(1.45)
Right Kidney	6.64(0.96)
Bowel	9.57(1.47)

CONCLUSION

Although resource intensive, the favourable dosimetry of VMAT based TMLI and its validation using two independent methods makes this technique robust enough to potentially replace the conventional TBI technique with adequate PTV coverage and better OAR sparing effect.

REFERENCES

[1] Mancosu P, Navarria P, Castagna L, et al. Anatomy driven optimization strategy for total marrow irradiation with a volumetric modulated arc therapy technique. J Appl Clin Med Phys. 2012;13(1):3653. Published 2012 Jan 5. doi:10.1120/jacmp.v13i1.3653

[2] Symons, Kirsty; Morrison, Colm; Parry, Jason; Woodings, Simon; Zissiadis, Yvonne (2018). Volumetric modulated arc therapy for total body irradiation: A feasibility study using Pinnacle treatment planning system and Elekta Agility™ linac. Journal of Applied Clinical Medical Physics,.doi:10.1002/acm2

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MP-TP15 #139 A Measure of the Target Reposition Errors for Lung Volumetric Arc Therapy as Observed on Three-Dimensional Cone-Beam Computed Tomography, in a Single Radiotherapy Department in Malta, Maria Elena Grech

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BACKGROUND AND OBJECTIVE

Delivering volumetric arc therapy (VMAT) to lung tumours is challenging due to their susceptibility to movement and change in position from planning to treatment. To be able to account for such changes, it is essential for these to be measured. These had not yet been measured in the department where this study took place. This research set out to measure the department-specific setup errors and tumour reposition errors (TRE) i.e., the shift in position of the tumour in relation to the surrounding anatomy from planning to treatment [1].

METHODS

20 patients who had previously completed a course of conventionally fractionated VMAT to the lung between December 2018 and November 2020 were recruited for this study. Each participant underwent a daily cone-beam CT (CBCT) using Elekta XVI® prior to treatment, resulting in 432 CBCTs. An automatic bone match was first performed to obtain the setup error. Then, a further manual match was applied to achieve a gross tumour volume (GTV) match. The values obtained from the bone match were subtracted from those of the GTV match to obtain the TRE. From these values, the mean, systematic and random errors were obtained for the individual participants and the population [2]. The individual and population error patterns were also analysed to understand whether an alternative imaging frequency may be used.

RESULTS AND DISCUSSION

The group mean setup errors ± standard deviations (SDs) were 0.00 cm ± 0.29, -0.02 cm ± 0.31 and -0.36 cm ± 0.22 in the left-right, superior-inferior, and anterior-posterior directions, respectively. The random setup errors recorded were 0.26 cm, 0.27 cm and 0.18 cm in the left right, superior-inferior, and anterior-posterior directions, respectively. A systematic posterior setup error of 0.36cm was found. It is recommended that the source of this error is investigated. This may be due to a mismatch in laser alignments between planning and treatment. Other than this, setup errors are comparable to other studies that used similar or more complex immobilization techniques [1,3-5], thus validating the current setup and immobilisation technique used for lung VMAT. The group mean TREs ± SDs were -0.04 cm ± 0.09, 0.01 cm ± 0.21 and -

0.02 cm ± 0.17 in the left right, superior-inferior, and anterior-posterior directions, respectively. The SDs of the random errors were 0.08 cm, 0.12 cm and 0.15 cm in the left-right, superior-inferior, and anterior posterior directions, respectively. The TREs were found to be very small and comparable to other studies that included participants undergoing stereotactic body radiotherapy (SBRT) [1,3-5]. The left-right TREs were the smallest while the anterior-posterior and superior-inferior TREs were similar. These results are very favourable for the introduction of SBRT. 51.3% of all treatment fractions had shifts that exceeded the 0.5 cm tolerance and reducing the imaging frequency was not found to be feasible due to the randomness of daily errors.

CONCLUSIONS

While further research is recommended to include more participants, the researchers concluded that the immobilisation technique used is adequate for lung VMAT as well as for the future implementation of SBRT. 4DCT planning is recommended for more accurate TRE measurements as well as to adapt margins to the individual patient through internal target volumes. Retaining daily IGRT and attempting to reduce planning target volumes is recommended to spare normal tissue.

REFERENCES

[1] WANG, L., FEIGENBERG, S., FAN, J., JIN, L., TURAKA, A., CHEN, L. ET AL., 'Target repositional accuracy and PTV margin verification using three-dimensional cone-beam computed tomography (CBCT) in stereotactic body radiotherapy (SBRT) of lung cancers.' Journal of Applied Clinical Medical Physics, (2012) 13(2), pp.41-54.

[2] HOSKIN, P., GAZE, M., GREENER, T., On target: ensuring geometric accuracy in radiotherapy. The Royal College of Radiologist, London. (2008):1-78

[3] GUCKENBERGER, M., MEYER, J., WILBERT, J., BAIER, K., MUELLER, G., WULF, J., et al., 'Cone-beam CT based image-guidance for extracranial stereotactic radiotherapy of intrapulmonary tumors.' Acta oncologica. (2006)1;45(7):897-906.

[4] LI, W., PURDIE, T.G., TAREMI, M., FUNG, S., BRADE, A., CHO, B.J et al., 'Effect of immobilization and performance status on intrafraction motion for stereotactic lung radiotherapy: analysis of 133 patients.' International Journal of Radiation Oncology* Biology* Physics. (2011) 1;81(5):1568-75.

[5] WORM, E.S., HANSEN, A.T., PETERSEN, J.B., MUREN, L.P., PRÆSTEGAARD, L.H., HØYER, M. 'Inter-and intrafractional localisation errors in cone-beam CT guided stereotactic radiation therapy of tumours in the liver and lung.' Acta Oncologica. (2010) 1;49(7):1177-83

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MP-TP16 #140 Bladder filling before radiation therapy treatments to the prostate – Evaluating volume, dose and reproducibility of constraints, Ilya Lvovich

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BACKGROUND AND OBJECTIVE

The volume of pelvic organs (such as bladder and rectum) can change significantly at the time of RT. In order to maintain constant bladder volume and potentially reduce urinary toxicity, our department adopted bladder filling protocol for all patients undergoing prostate radiotherapy. The aim of this study is to evaluate adherence to the bladder filling protocol and analyze the factors that might influence differences in the bladder volume (waiting time, disease stage, RT dose, etc.) and their effect on dosimetric parameters.

METHODS

Bladder filling was required prior to CT-simulation and each treatment fraction). After voiding, patients were requested to drink 4 cups of water (estimated to be 400cc) during a period of 30 minutes and to avoid any additional voiding until after CT-simulation or treatment. Treatment cone-beam CTs (CBCTs) were imported into the treatment planning system (Monaco® by Elekta), and the bladder was contoured on each CBCT. The original treatment plan was applied and each CBCT dose constraint for the urinary bladder, according to RTOG 0415, was re-calculated (figure 1). Demographic data (patient's age, Gleason score, etc.) and waiting time were extracted from the medical records. Correlation and regression tests between the demographic data and the calculated data were performed, analyzing change in volume, percentage of change, and adherence to the constraints.

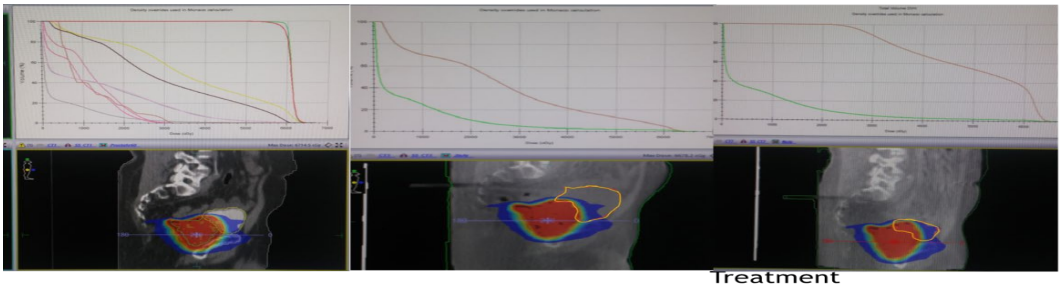

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Figure1

RESULTS AND DISCUSSION

A total of 326 CBCTs from 36 patients were analyzed. The average waiting time for treatment was 42 min [range: 9-158 min]. Analysis was done on 4 different groups according to waiting times (0-20, 20-35, 35-60, >60 min), on 41, 61, 116 and 103 CBCTs, respectively. Average bladder volume was 171.7 ml, while average measured volume changes were -25%, -6.8%, 20.2% and 33%, respectively (Graph 1). Calculated correlation between waiting time with change in

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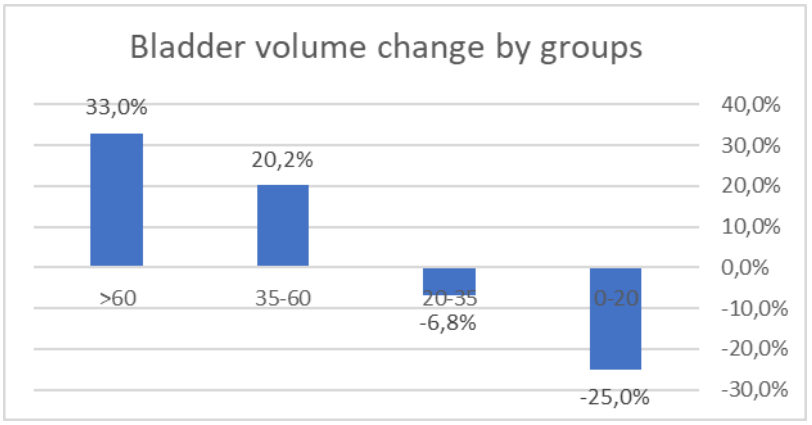
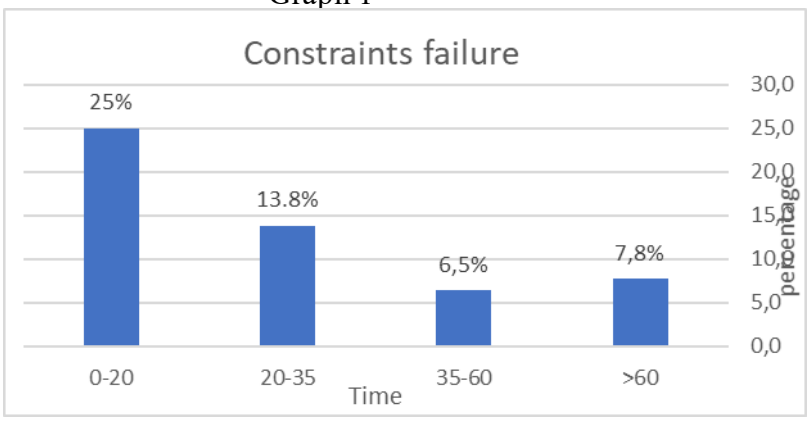
bladder volume and percentage was medium straight (r=0.48, *p<0.001* by regression test). Correlation after splitting waiting time into groups is strong (r=0.99, *p<0.001*). Constraint failures were seen in 25%, 14%, 6.5% and 7.8% of CBCTs, respectively.



Graph 1



Graph 2

CONCLUSIONS

There is a direct and strong relationship between waiting time and the change in bladder volume and dose delivered to the bladder. When radiation therapy is performed at 30 minutes of waiting (as indicated in the protocol), constraints are met, but if waiting time is shorter or longer, deviations might occur, more significantly at shorter waiting times. This highlights the importance of adhering to bladder filling and strict waiting times in prostate cancer patients undergoing radiation treatment.

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MP-TP17 #37 Development of proton range verification by use of titanium implants and PET, Claus Maximilian Baecker

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BACKGROUND AND OBJECTIVE

Proton beam range verification by positron emission tomography (PET) has been discussed in several publications in the past. The implementation as a so-called off-line method with a PET scanner outside of the treatment rooms is limited by transport processes of biological molecules, which is commonly known as biological wash-out [1]. Implanted markers have been proposed to avoid the wash-out, as they keep their position in the patient and are not subjected to the transport processes [2]. This study investigates the activation of titanium-based implants which are used in surgical resection prior to the proton therapy because of their biocompatibility and can be found especially in brain tumour patients.

METHODS

In the first step, a titanium sheet is placed diagonal in a PMMA phantom, which is called slanted angle phantom. This setup is irradiated with a monoenergetic proton field and later with a SOBP-like dose distribution. The activity distribution is calculated with cross sections known from the literature. From both irradiations, suitable positions of implants for range verification can be derived from the PET scans. In the second step, dedicated implants are placed in different phantoms to investigate the activation of small implants and absolute activity prediction. While the slanted angle phantom is taken from Ref. [3], this study aims to investigate the clinical feasibility featuring a clinical PET scanner and more realistic setups.

RESULTS AND DISCUSSION

Figure 1 shows the possibility to predict the distal fall-off induced by incident protons with cross sections from the literature. The distal fall-off of the activity distribution can be calculated with the cross sections from the literature for the several radionuclides produced from titanium. Furthermore, potential positions of the implants can be investigated with depth-activity distribution.

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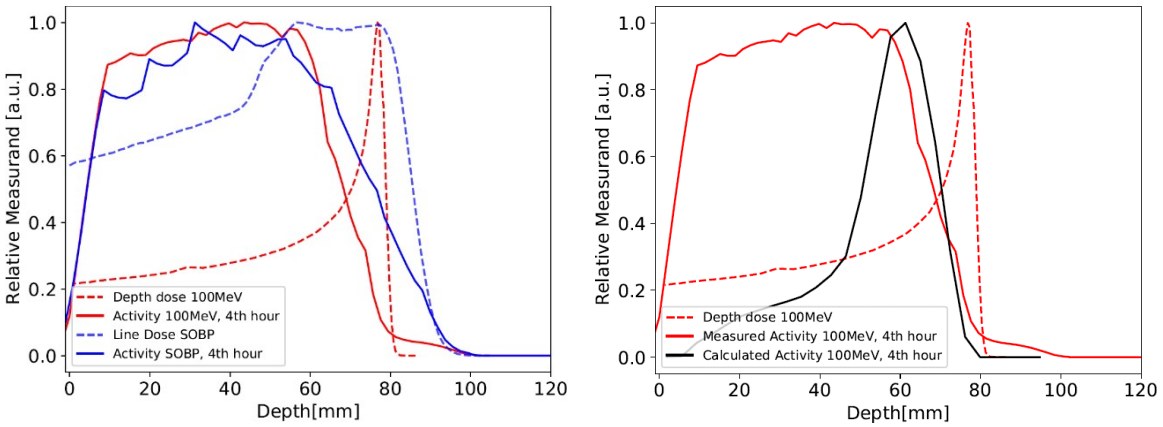

Figure 1. Left: Comparison of the depth dose curve (dashed) and the obtained activity (line). The monoenergetic field is red, the SOBP-like is blue. Right: calculated activity (black).

From the four hours of the PET scan, a suitable time window is estimated. The dedicated implants are placed at representative positions of SOBP-like dose distributions. The activity of the implants in a geometric PMMA phantom and an anthropomorphic phantom can be obtained in PET scan three hours after the irradiation.

CONCLUSIONS

The potential use of activated titanium implants is demonstrated with the transfer to realistic geometries. The PET scan should be taken more than one hour after the treatment to enhance the specificity of the PET scan for radionuclides produced from titanium. Useful positions of implants can be derived from the PET images. In further studies, the sensitivity of the method can be evaluated and Monte Carlo simulations of the produced activities should be investigated.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

The presented study was supported the MERCUR-Stiftung graduate school "Präzisionsprotonentherapie – Praxisbezogene Physik und Chemie an der Schnittstelle zur Medizin" (grant number St-2019-0007). The authors would like to thank the iba PT physics team Essen for their support regarding the target irradiation. Many thanks to Manuel Beck and Julian Kinne for the manufactured phantoms.

REFERENCES

[1] PARODI, K., BORTFELD, T., HABERER, T., Comparison Between In-Beam and offline Positron Emission Tomography Imaging of Proton and Carbon Ion Therapeutic Irradiation at Synchrotron- and Cyclotron-Based Facilities, Int J Rad. Oncol. Biol. Phys. **71** (2008) 945-956.

[2] CHO, J. et al., Feasibility of proton-activated implantable markers for proton range verification using PET, Phys. Med. Biol. **58** (2013) 7497-7512.

[3] BÄCKER, C.M. et al., Proton Beam Range Verification with Secondary Radiation from Titanium Implants, Proceedings of the 2019 IEEE Nuclear Science Symposium and Medical Imaging Conference, Manchester (2019).

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MP-E1 IAEA Activities in Support of Education and Recognition in Medical, Giorgia Loreti

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BACKGROUND AND OBJECTIVE

Medical Physics has been included among the healthcare professions by the International Labour Organization (ILO) since 2008 [1]. Despite this, the recognition of medical physicists has been sparse in many countries, negatively affecting the access to education and training programmes aligned to international best practices [2-6]. This can ultimately threaten the safety, quality and effectiveness of radiation medicine. For this reason, the IAEA supports medical physics through helping Member States establish or enhance education programmes and promoting the certification of medical physics as a health profession.

METHODS

An established health profession is constituted of different components:
- well-defined education and training pathways;
- national system that recognizes and identifies the professionals that graduated from such paths;
- healthcare system adequately recognizing the clinical competence of the profession;
- established continuous professional development mechanisms, to ensure standards of practice are maintained over time.

RESULTS AND DISCUSSION

The IAEA supports Member States in establishing medical physics academic and clinical training programmes, typically through dedicated national and regional Technical Cooperation projects. When such programmes do not exist in-country, the IAEA can offer support to individuals to receive education through fellowships mechanisms. In some instances, fellows are accepted in the Master of Advanced Studies in Medical Physics (MMP), jointly run by the ICTP and the University of Trieste. The programme is supported by the IAEA and based on the regional AFRA guidelines [7]. To ensure the MMP fulfils its role, the IAEA closely follows up on the graduates through comprehensive surveys and consultation with Member States and stakeholders.

The application of best practices in education can also be achieved through regional coordination. For instance, in the Asia and Pacific Region, an IAEA online tool, AMPLE (acronym for Advanced Medical Physics Learning Environment), has been developed to help residents in all specialties of medical physics acquire the needed competencies. The tool

facilitates combining local and remote mentoring and allows documentation of the progress of residents through online portfolios and assignments.

When medical physicists are clinically qualified and working in a hospital, they should maintain and expand their competencies. This is typically done through continuous professional development (CPD) activities which are often not offered to medical physicists, especially where the profession is not recognized. To address this lack, the IAEA offers to its Member States national, regional and international training courses in all medical physics specialties. E-learning courses based on IAEA guidelines and established training materials have also been developed, to reach a wider audience. At the same time, the IAEA encourages regional approaches to solutions in providing regular access to CPD activities. For instance, a platform to host regionally developed CPD activities is currently under development for the region Africa (Medical Radiation Physics NET-Africa).

Video tutorials, as well as other multimedia training material, have also been made available on the IAEA Human Health Campus to complement and aid the dissemination of IAEA guidelines.

To ensure the quality of the educational material provided and its successful outreach, regular follow ups are performed by the IAEA and the results analyzed to identify corrective actions.

In parallel, the IAEA works on supporting the recognition of medical physics as a healthcare profession, as this will underpin and enhance all other efforts and help ensure radiation medicine is performed at the highest standards of quality, efficiency and safety for the ultimate benefits of patients.

CONCLUSIONS

The IAEA works simultaneously on providing access to adequate education and training in medical physics and professional development opportunities to medical physicists already working in the clinic. To ensure these efforts are sustainable and effective, professional recognition and certification of medical physics as health professionals should be pursued in parallel.

REFERENCES

[1] SMITH, P. H. S., NUSSLIN, F., Benefits to medical physics from the recent inclusion of medical physicists in the international classification of standard occupations (ICSO-08), Med. Phys. Int. J. 1 (2013) 10-14.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, IAEA Human Health Series No. 25, IAEA, Vienna (2013)

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Postgraduate Medical Physics Academic Programmes, Training Course Series No. 56, IAEA, Vienna (2014).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Clinical Training of Medical Physicists Specializing in Diagnostic Radiology, Training Course Series No. 47, IAEA, Vienna (2011).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Clinical Training of Medical

Physicists Specializing in Nuclear Medicine, Training Course Series No. 50, IAEA, Vienna (2011).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Clinical Training of Medical Physicists Specializing in Radiation Oncology, Training Course Series No. 37, IAEA, Vienna (2010).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Academic and Clinical Training Programmes and Portfolios for the Regional Training in Medical Physics, IAEA, Vienna (2019).

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MP-E2 IOMP activities in medical physics education and training, Geoffrey Ibbott

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BACKGROUND AND OBJECTIVE

The International Organization for Medical Physics (IOMP) was founded in 1963 with the mission to advance medical physics practice worldwide by disseminating scientific and technical information, fostering the educational and professional development of medical physicists, and promoting the highest quality medical services for patients. The IOMP represents more than 27,000 medical physicists worldwide. There are 87 National Member Organizations (NMOs) and six Regional Organizations (ROs). The ROs are federations of NMOs and facilitate regional meetings that attract large numbers of registrants and exhibitors. The IOMP Council consists of the IOMP officers, Committee chairs, the Editor of Medical Physics World, and representatives of each the six ROs.
This report will focus on the education and training activities of the IOMP.

METHODS

The IOMP maintains a committee on Education and Training, chaired by one of the authors of this report (AC). The goals and activities of the committee and those of the IOMP as a whole were reviewed and summarized.

RESULTS AND DISCUSSION

The goals of the IOMP Education and Training Committee are, in part, to improve medical physics worldwide by disseminating systemized knowledge through education and training of medical physicists especially in developing countries, to advance the practice of physics in medicine by fostering the education, training and professional development of medical physicists, and to promote international education and training programs sponsored or endorsed by IOMP, its National Member Organizations and its Regional Organizations.
These goals are met through the development and presentation of a number of educational programs, sponsored events, and the accreditation of education programs.

- IOMP School
  The IOMP hosts educational programs that are presented at regional or international meetings including the triennial IOMP/IUPESM World Congresses, the intervening International Conferences on Medical Physics, and regional conferences sponsored by IOMP.
- IOMP Webinars
  The IOMP organizes a series of webinars, offered on a monthly schedule, featuring a variety of topics of interest to medical physicists. Speakers are volunteers from IOMP member countries, and the topics are often requested by participants in the series. Some webinars are taken from the IOMP Schools, and others are tied to events such as the International Medical Physics Week. Yet others are collaborations with the IAEA.
- The International Day of Medical Physics
  The IDMP is held each year on November 7, the birthdate of Marie Curie. Many IOMP National Member Organizations hold educational seminars as part of a celebration of the IDMP. The IOMP encourages Regional Organizations to nominate members, one of which from each region is recognized with the IDMP Award.

- Sponsored Events
  The IOMP sponsors educational programs organized by a wide variety of National Member Organizations, Regional Organizations, and collaborations.
- Accreditation
  The IOMP Accreditation Board has been set up to ensure that accredited medical physics programs satisfy the highest standards established by IOMP in collaboration with other international organizations. The Board accredits medical physics masters programs and residency programs, medical physics education and training institutions/centres and education and training events for continuing professional development.
- Resources
  The IOMP maintains a number of resources for medical physicists including references, an encyclopaedia, teaching resources, and links to graduate training programs in all regions.
- Certification
  The IOMP is a supporting organization of the International Medical Physics Certification Board. The role of the IMPCB is to establish the infrastructure, requirements and examination procedures for the certification of medical physicists in accordance with the requirements of IOMP guidelines. IMPCB certification is available to medical physicists in countries without national or regional certification boards.

CONCLUSIONS

The IOMP conducts a number of programs intended to further the education and training of medical physicists worldwide. These programs provide needed support to medical physicists and trainees in regions without the resources to conduct their own training and supplements the programs that exist elsewhere.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

The first author acknowledges the support of the IOMP to participate in this symposium.

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MP-E3 EFOMP activities in education and training of medical physicists in Europe, Brendan McClean

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BACKGROUND AND OBJECTIVE
EFOMP facilitates and promotes education and training of medical physicists in Europe with the aim to increase the quality of physicists working in a healthcare environment. This presentation will summarise the range of EFOMP activities in pursuit of these aims.
METHODS
EFOMP has been instrumental in developing a clear roadmap for the qualifications required for Medical Physics Experts (MPE) in Europe. This has been supported by policy statements, together with practical guidelines for implementation, on roles and responsibilities of the MPE, education and training pathways, and continuous professional development processes. Education and training has been achieved through partnership (for example EUTEMPE-Rx, EANM, ESR and ESTRO), directly through conferences and congresses [1] (1987-2018), the European School for MPE (ESMPE) [2] and the European Journal of Medical Physics (EJMP) [3].
ESMPE has delivered webinars, Master Classes and school editions in a range of areas including nuclear medicine, radiotherapy, diagnostic and interventional radiology, and statistics. The schools are accredited by the European Board for Accreditation in Medical Physics (EBAMP), an independent organization for accreditation. A recently implemented e-learning platform provides medical physicists with invaluable access to recorded presentations and documentation from the ESMPE schools and other EFOMP educational activities. Development of an EFOMP Examination Board further facilitates harmonization of education and training standards.
CONCLUSIONS
EFOMP continues to build on previous experience and develop an ambitious programme for educating and training of medical physicists in Europe. The significant and increasing number of attendees at Congresses and ESMPE events testify to the need for such further education. The collaborative approach of EFOMP provides an efficient approach to optimize education activities in Europe.
REFERENCES
[1] https://www.efomp.org/index.php?r=pages&id=ecmp.
[2] https://www.efomp.org/index.php?r=pages&id=esmpe-upcoming-editions
[3] Home Page: Physica Medica: European Journal of Medical Physics

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MP-E4.1 #29 Virtual mentoring in global medical physics education and training, Jacob Van Dyk

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BACKGROUND AND OBJECTIVE

Medical Physics is a highly specialized profession. The education and training of a medical physicist can take multiple years (6-10 years, university and residency) to become a Clinically Qualified Medical Physicist (CQMP). This training can be particularly challenging in low-to-middle income countries (LMICs) which often have limited educational resources both from the perspectives of personnel (available educators and their scope of knowledge and experience) and of the technologies available for appropriate training. A possible mechanism to assist with the education, training, and on-going medical physics support of medical physicists in LMICs could be through established and supported mentoring programs. Unfortunately, experienced mentors may not be available in local settings but rather only from a distance. This could foster remote "virtual mentorship" by which the participants meet via information communications technologies (ICTs) rather than face-to-face. The objective of this paper is to provide a structural framework and overview for the development of effective mentorship programs.

CONCEPTUAL FRAMEWORK

Mentoring is the collaborative relationship between two people with the goal of professional development. The mentor is the person with more experience who provides the guidance to the mentee. Virtual mentoring is the process whereby the mentor and mentee meet via internet tools, such as e-mail, Skype, Zoom, other video-conferencing tools, or social media. A general conceptual framework describing the factors influencing mentorship is summarized by the schematic diagram in Figure 1 [1]. The immediate factors potentially influencing the relationship between mentor and mentee could relate to gender, age, language, religious congruencies, cultural backgrounds, ethnicities, vulnerabilities, resources and world view. The main consideration relates to how well the mentor and mentee connect. At the next level are the institutional influences. These relate to how the superiors, both in the mentee's and the mentor's institutions, support and encourage or discourage such mentorship activity. At the next level are the societal influences which relate more broadly to cultural, socio-political, and economical factors. Finally, at an even broader level are the global influences including the global economy and sociopolitical factors that may affect global health work. These could play a role in influencing funding of projects, priorities and deadlines.

FACTORS AFFECTING SUCCESS AND SATISFACTION

Figure 2 addresses the dimensions of "success" and "satisfaction" and the distinction between "coaching" and "mentoring". Success is task oriented and relates to skill acquisition. It is very

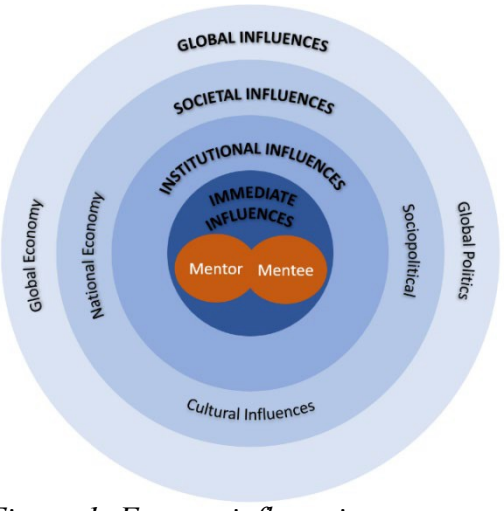

Figure 1. Factors influencing mentor and mentee relationships. Adapted from [1].

Figure 2. Success and satisfaction factors in mentor and mentee relationships. Adapted from [1].

much performance driven. Satisfaction relates to internal feelings and personal rewards. Thus, moving from "job" to "mission" provides greater satisfaction but does little to improve performance, whereas moving from "job" to "career" improves performance but gains little satisfaction. In this context, "coaching" is task- and skill-oriented. Mentoring includes a person-oriented component which is development driven and rooted in relationships. These considerations are important in addressing a successful mentoring relationship.

A great resource for implementing a successful mentoring process is provided by the *Mentoring Handbook* produced by The Afya Bora Consortium [2]. However, it does not address the specific challenges associated with virtual mentoring. These include issues related to the impact of different time zones, cultural backgrounds, sufficiency of internet availability and internet bandwidth, issues related to technical proficiency in terms of software utilization and also technological differences in the clinical context. Added to this is that the mentor may not have a full grasp of the mentee's local circumstances, which may well be significantly different from the mentee's situation. Finally, there are also considerations in terms of availability of time both for the mentor and mentee.

CONCLUSIONS

Understanding the overall conceptual framework of mentoring helps inform the creation of structures and processes for the development of effective mentorship programs. In general, the onus is on the mentee to initiate, maintain and use mentorship interactions to benefit one's career and the quality of work. It needs to be emphasized that mentoring is bidirectional and provides benefits to both the mentor and mentee [2].

REFERENCES

[1] PRASAD S., SOPDIE E., MEYA D., KALBARCZYK A., GARCIA P.J. Conceptual Framework of Mentoring in Low- and Middle-Income Countries to Advance Global Health, Am.J Trop.Med.Hyg., 100, (2019) 9-14.

[2] AFYA BORA CONSORTIUM. Mentoring Handbook. Available at: http://www.afyaboraconsortium.org/materials/Mentoring%20Handbook.pdf, Afya Bora Consortium,2018.

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MP-E4.2 Challenges in establishing a clinical training programme for MP, Graciela Velez

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BACKGROUND AND OBJECTIVE
Establishing clinical training programmes for Medical Physicists is complicated in many countries due to the lack of appropriate structure in the clinical setting, and mainly due to the shortage of professional qualified personnel to undertake this task.
METHODS
A detailed analysis of the situation in countries of different regions was carried out from surveys submitted, as well as personal involvement in some of the programmes currently running. The data were insufficient in some areas, but this could be a secondary indicator of the situation.
RESULTS AND DISCUSSION
In regions like Latin America, the urgent need to have Medical Physicists working in the clinical field, mainly in Radiation Oncology because of the incorporation of modern technologies, had led some countries to the decision to organize graduate programmes instead of the recommended postgraduate education and training.
On the other hand, there are some postgraduate programmes offered with contents just in theoretical basis with absolute absence of clinical training. This divorce between the theoretical contents of training and clinical practice in the different fields of application of medical physics leads to unwanted situations.
Few institutions have been able to bridge these differences by offering comprehensive Residency Programmes in Medical Physics; however, the major difficulties lie in the shortage of qualified staff to deal with the education and training without neglecting the specific functions and responsibilities in the clinic. These troubles are being faced by emulating the well-established programmes for physicians' residencies and promoting agreements between clinical facilities and universities. Additionally, the shortage in qualified personnel to achieve the goal is being sorted out with external professors clinically qualified and with broad experience in different fields of medical physics until the gap can be bridged.
Another point to be addressed is the infrastructure installed in the regions due to limitations in existing technologies in some areas.
CONCLUSIONS
The consolidation of programmes to achieve the recommended level to harmonize the background knowledge as well as the proper clinical training of medical physicists is still a difficult task.
The inequality in installed capacities also generates another problem, although this is a dynamic process continuously growing.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Human Health Series Nº 25, Roles and Responsabilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, lAEA, Vienna 2013.

← Back To Table of Contents

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Training Course Series Nº 37: Clinical Training of Medical Physicists Specializing in Radiation Oncology, IAEA, Vienna 2010.
[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Training Course Series Nº 47: Clinical Training of Medical Physicists Specializing in Diagnostic Radiology, IAEA, Vienna 2011.
[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Training Course Series Nº 50: Clinical Training of Medical Physicists Specializing in Nuclear Medicine, IAEA, Vienna 2011.
[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Training Course Series Nº 56: Postgraduate Medical Physics Academic Programmes, IAEA, Vienna 2014.

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MP-E4.3 #41 The "Open Syllabus" project – improving global access to radiation oncology medical physicist residency training content, Parminder S. Basran

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BACKGROUND AND OBJECTIVE

A major challenge in the training of medical physicists in resource-limited environments such as low- and middle-income countries (LMICs) is access to high quality and timely educational medical physics resources. The learning objectives and assessed competencies for mastering medical physics practice have been well defined by national and international professional organizations, such as the IAEA and CAMPEP. There are also many reputable online and freely accessible educational resources which help facilitate these educational needs, such as those on the IAEA, AAPM, and i.TreatSafely websites. However, connecting learning objectives and competencies directly with specific online content remains a challenge. Furthermore, there remain challenges in ensuring the online content is scientifically accurate, relevant, and practical.

Medical Physics for World Benefit (MPWB) is a not-for-profit organization whose mission is to support activities which will yield effective and safe use of physics and technologies in medicine through advising, training, demonstrating, and/or participating in medical physics-related activities, especially in LMICs. To address the unmet need of connecting core medical physics learning objectives and competencies with freely available educational resources, MPWB has created and commenced the "Open Syllabus" project.

The goal of the Open Syllabus project is to develop a generalized freely accessible syllabus that consists of common core-learning objectives from various medical physics educational curricula specifically geared towards medical physics residents in resource limited environments. The Open Syllabus is a 'living document' that is flexible enough to adapt to the latest best-practices and available technologies, yet practical enough such that it could be delivered within the timeframe (2 years) of a typical medical physics residency.

OBJECTIVES AND DELIVERABLES

The specific objectives of the project include:

- Create a modified or adapted radiation oncology medical physics residency syllabus that reflects the educational needs of medical physics residents;
- Curate, define, select and/or collect high quality, accurate and timely digital assets and materials that can be used in achieving the learning objectives;
- Publish a platform for connecting learning objectives with freely available digital assets and materials;
- Partner with organizations in development of the Open Syllabus when and where it is possible.

The core deliverables of the project are:

- Open Access website whose content is licensed through the creativecommons.org framework (attribution, non-commercial 4.0);
- Sustainable workflow where changes to the syllabus can be easily made as new technologies, techniques, and practices emerge.

- Guidance for medical physics trainees by prioritizing the educational value in digital content which will help them with core competencies in a systematic fashion.

DISCUSSION

We have chosen to use the IAEA Training Course Series 37 report: Clinical Training of Medical Physicists Specializing in Radiation Oncology, as a template for the first medical physics speciality for the project. The steps for creating the Open Syllabus are as follows. The IAEA-TCS 37 syllabus contains multiple modules, e.g., as brachytherapy, treatment planning, quality assurance, and many others. First, each module is reviewed for accuracy and completeness to reflect modern clinical medical physics practice. Each module, and the sub-modules contained therein, is transcribed into a spreadsheet format where specific learning objectives are identified. For each learning objective within a module (or sub-module), a link to internal (hosted on the MPWB website) or external digital content is then provided. Linked content could include publicly accessible AAPM reports, PDFs or power-point presentations, online videos, or content on a website. For a specific module spreadsheet, the learning objectives and associated linked content are processed through HTML and java scripting such that the content on the spreadsheets can be actively displayed on a web page. This workflow enables the webpage of a specific module (or submodule) to be easily modified and updated.

To address challenges with licensing, we adopt the creativecommons.org framework and encourage contributors to license their work using the 4.0 licensing category. This license condition entitles someone to freely share and modify their material provided they are attributed and so long as it is for non-commercial purposes. An online Google form has been created to obtain and track licensing from contributors. For all other content, such as those freely accessible on the internet, only material which has a 4.0 licensing category - or a less restrictive one- is referenced.

CONCLUSIONS

It is important to stress that while the Open Syllabus Project aims to provide access to digital content and connect them with learning objectives and competencies, it does not provide a means for delivering or evaluating the progress of a resident. The Open Syllabus is designed to supplement -not replace- the training and education of a resident. The open access nature of the syllabus enables it for use for programs in not only LMICs, but for programs in developed countries as well.

ACKNOWLEDGMENTS

We would like to acknowledge the following in volunteering their energy and time for this project: Anna Rodrigues, Surendar Rao, Curtis Caldwell, Mirel Palmaru, Shannon O'Reilly, Stephano Peca, Garry Grogam, Deivis Errada, Satish Jaywant, Tomas Janssen, Stephani Marcie, Courtney Mauger, Jenny Bertholet, Ferny Diaz Molina, Radim Barta.

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MP-E4.4 #59 Monitoring and Evaluation of IAEA e-learning Courses in Medical Physics, Giorgia, Loreti

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BACKGROUND AND OBJECTIVE

In providing Member States freely accessible, quality educational material in the field of medical physics, the IAEA has developed e-learning courses based on IAEA guidelines and hosted on the IAEA e-learning platform CLP4NET. The medical physics courses are freely available online, self-paced and include video lectures, slides, mandatory intermediate knowledge assessments and a final test. Upon successful completion, the user can download a proof thereof, which can then be used for obtaining local continuing professional development credits, where applicable. This study describes a method to monitor participation in IAEA e-learning courses in medical physics, with the objective of exploring quality assurance in e-learning. The regular evaluation of the data extracted from the e-learning platform allows for data-driven analysis of the dissemination of best practice in medical physics. The analysis of such data also informs the continuous improvement of the e- learning packages.

METHODS

The study investigates the outreach of the educational material, the professional profile of the users and the benefit to the target group. Three e-learning courses focused on: small field dosimetry [1], image-guided radiotherapy (IGRT) [2], and nuclear and radiological emergencies (NRE) [3]. Data has been extracted and analyzed at regular intervals. The number of enrolled users and their progression through the intermediate knowledge assessments has been analyzed. The average time to complete the course is examined and compared to the minimum duration estimated during the design of the e-learning course.

Cyclically, users' data from the participants' forms and feedback forms are also analyzed.

RESULTS AND DISCUSSION

As of December 2020, the IGRT (released in February 2019) has reached 531 participants, the NRE course (released in 2016) reached 417 and the small field course (released in September 2020) reached 338. The access to the three e-learning courses [1-3], albeit only available in the English language, shows that the educational material has reached every region, as shown in Figure 1 (comparison of data extracted in October and November 2020) for the e-learning on small fields dosimetry [1].

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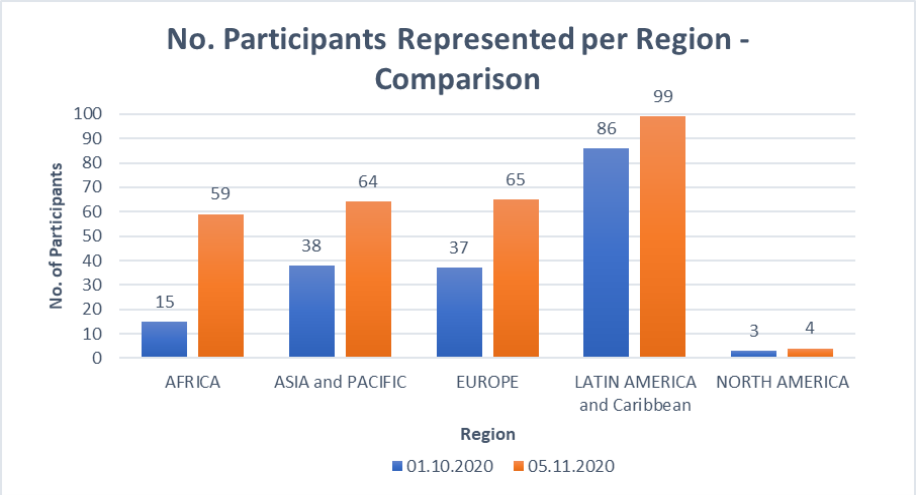
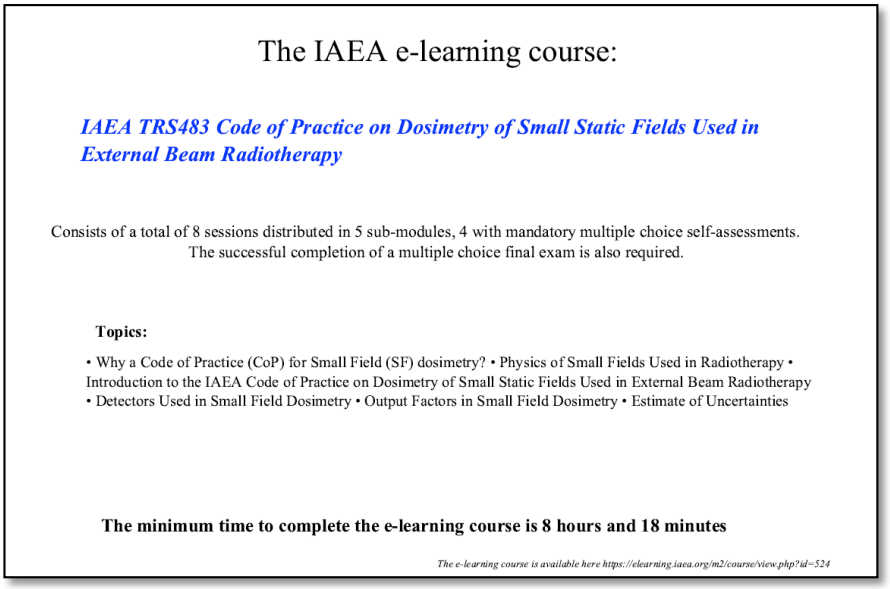


Figure 1. Participants in the small field e-learning course.

Clinically qualified medical physicists or medical physics students are the main target learners and were indeed the core beneficiaries: more than 80% medical physicists or clinical medical physicists completed the small field course, more than 60% the IGRT course and more than 50% the NRE course.

The average time to complete the courses was found to be higher than the minimum time estimated. For instance, the small field e-learning reached an average of approximately double the anticipated duration (> 17.5 hours). This is an indication that the e-learning participants use the e-learning platform as a study instrument, go through the material several times and attempt the mandatory self-assessments until they succeed. At the end of the e-learning courses, a final exam must be successfully completed to be able to download the proof of completion (sample in Figure 2).


The IAEA e-learning course:

IAEA TRS483 Code of Practice on Dosimetry of Small Static Fields Used in External Beam Radiotherapy

Consists of a total of 8 sessions distributed in 5 sub-modules, 4 with mandatory multiple choice self-assessments.
The successful completion of a multiple choice final exam is also required.

Topics:

• Why a Code of Practice (CoP) for Small Field (SF) dosimetry? • Physics of Small Fields Used in Radiotherapy • Introduction to the IAEA Code of Practice on Dosimetry of Small Static Fields Used in External Beam Radiotherapy • Detectors Used in Small Field Dosimetry • Output Factors in Small Field Dosimetry • Estimate of Uncertainties

The minimum time to complete the e-learning course is 8 hours and 18 minutes

The e-learning course is available here https://elearning.iaea.org/m2/course/view.php?id=524

Figure 2. Sample of one of the pages of the proof of completion.

The proof of completion includes information on the content of the course and the minimum foreseen duration, in order to facilitate its use as evidence of continuous professional development (CPD) [4]. Feedback forms provided useful information on the users' evaluation of the course content, structure, and their overall satisfaction with the learning experience.

CONCLUSIONS

The time the registrants spend online in the e-learning courses provides an indication that the e-learning's fruition is aligned to its design and purpose. To encourage feedback, consideration is being given to making the questionnaires mandatory. Continuous monitoring and evaluation of data extracted from the e-learning platform is necessary to ensure that the efficacy, level and relevance of the e-learning is maintained over time. Monitoring of specific indicators such as the number of participants taking the entry test and the average time to complete the e-learning, have been identified.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, E-learning course on IAEA TRS483 Code of Practice on Dosimetry of Small Static Fields Used in External Beam Radiotherapy, IAEA CLP4NET.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, E-learning course on IAEA guidelines on IGRT, IAEA CLP4NET.

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, E-learning course on Nuclear and Radiological Emergencies, IAEA CLP4NET.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, Human Health Series No. 25, IAEA, Vienna (2013).

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MP-E4.5 Experience as a remote supervisor under the IAEA Doctoral CRP Programme, Daniel Venencia

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BACKGROUND AND OBJECTIVE

In 2019, the IAEA began a new Coordinated Research Project (CRP) with the objective to support the PhD level research of clinically qualified medical physicists from low- and middle-income countries [1]. Each PhD student has a local and a remote supervisor. The remote supervisor provides guidance and ensures a high-quality research project. The objective of this presentation is to share the first-year experience as a remote supervisor of Bertha Garcia from Peru on the research "Preparation of an audit program for high technology radiotherapy".

METHODS

The CRP Programme is vitally important in the world and especially in regions where the number of PhD graduates in medical physics is few. I personally had the opportunity to be a PhD student under an IAEA Doctoral CRP from 2008 to 2012. The IAEA gave me a unique opportunity and Dr. Yakov Pipman, my remote supervisor, was fundamental in the development of my work, without whom I would not have been able to achieve my goal.

As remote mentor of Ms Garcia, we had to work on the dosimetry of small fields, audits, stereotactic radiosurgery phantom manipulation, 3D printing, film dosimetry and others. There are no Radiosurgery audits in Latin America, and at least five Hospitals had shown interest to implement the audits proposed by this research in their Institutions.

The CRP Programme also gives the students the opportunity to share their experiences with other students and supervisors, from other regions.

CONCLUSIONS

Remote supervision is an important responsibility. Working together with the local supervisor and other supervisors is critical. The support of the student's Institution, especially if they are performing their research work in a clinical environment, is necessary to sustain the PhD project. The IAEA doctoral CRP provides a great research platform, a collaborative environment to engage globally and some funding to raise the level of medical physics in the world.

REFERENCES

[1] https://www.iaea.org/newscenter/news/new-crp-doctoral-crp-on-advances-in-radiotherapy-techniques-e24022

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MP-EO1 #34 Volumetric Modulated Arc Therapy (VMAT): The gold standard for the present and future of radiotherapy?, Sherisse Hunte (De Four)

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BACKGROUND AND OBJECTIVE

Cancer is the second leading cause of death globally and radiotherapy used alone or in conjunction with chemotherapy and surgery has been used for over one hundred years and has been proven effective for the treatment and management of cancer. With approximately fifty percent of all cancer cases able to benefit from radiotherapy, [1] advancements in techniques would prove beneficial to patient outcomes.

Although introduced more than three decades ago, IMRT has continued to evolve and its use has remained constant in many departments. A survey in Australia and New Zealand revealed that many facilities (46%) utilize both photon modulated techniques and some facilities (27%) use IMRT only [2]. Additionally, Peng et al. observed a decline in 3DCRT usage for Non-small cell lung cancer (NSCLC) from 67.5% in 2009 to 4.3 % in 2017 and an increase in VMAT usage from 0% in 2009 to 54.8% in 2017. Though [3] research was only on NSCLC this trend has been seen in various treatment sites.

Previously there have been two review papers on the clinical use and of VMAT [4] and its outcomes [5] assessing VMAT at the start of its implementation (2000-2010) and the other looking at the clinical outcomes of its implementation (2009-2016). This paper seeks to review the current treatment techniques used in radiotherapy (2017-2020) and assess the role of VMAT in the future while examining six clinical sites.

METHODS

Searches were done through google scholar and advance search engines of Medical Physics journals: National Library of Medicine -PubMed subsequent analysis followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

Publications were selected for inclusion if they were published within the above timeframe, English language only, full text articles which reported clinical outcomes (survival and toxicities) or dosimetric outcomes after modern radiotherapy schemes. Exclusion criteria included any case reports, comment abstracts, and duplicate publications.

RESULTS AND DISCUSSION

Current research recommends adoption of hypofractionated radiotherapy schemes (HRT) and simultaneous integrated boost (SIB-VMAT) towards the enhanced management of prostate [6] ([7] [8] and cervical [9] [10] [11] cancer patients due to improved tumour control. Cases of advanced cervical cancer where brachytherapy is not feasible SIB-VMAT and sequential boost VMAT are effective treatment options as they reduce dose to OARs, 91% local control for stage II cases, 67% local control for stage III cases and good three-year overall survival rates: 100% stage II and 85% stage III.

Most anorectal case studies advocate for VMAT to be adopted as the gold standard owing to the sparing of the anal sphincter [12], reduction in hot spot doses, better conformity, and homogeneity indices [13], toxicity reduction and successful treatment results. Patients who require more bone marrow protection VMAT is preferred and patients who require intestinal protection IMRT is preferred.
Breast radiotherapy have widely used 3DCRT as the gold standard however, many centers have adopted modern techniques from the outcomes of mainly dosimetric investigations. VMAT for breast radiotherapy increases dose homogeneity and conformity [15]- with one main drawback, the generation of low-dose baths specifically to the contralateral breast and lung and heart which exceed that of 3DCRT [16]. Long-term clinical trials are required to determine the effects of the low-dose baths on the healthy tissue but whole breast hypofractionated VMAT is feasible and well tolerated [17] Wide retrospective studies [3] revealed longer overall survival rates with IMRT and VMAT compared with 3DCRT for NSCLC and as such VMAT and IMRT are recommended for the management of patients with stage III NSCLC.
Many studies regarding nasopharyngeal cancer (NPC) reveal IMRT and VMAT plans do not differ vastly, both techniques meet the clinical requirements [19] and survival and quality of life metrics are comparable [20]. VMAT has been widely adopted for head and neck cancers (HNC). Prospective proton therapy studies [23] revealed clinical benefits for oropharyngeal cancer with reduced rates of PEG-tube replacement, acute hospitalization and narcotic requirements compared to VMAT. Although longer follow up is needed to determine long-term effects, initial findings show a reduction in acute toxicity and hence improved quality of life.

VMAT SRS has been used for both single and multiple metastatic lesions with a known drawback of statistically significant low-dose spillage compared with the other SRS options. VMAT for brain metastases reveal lower mean OARs doses and better conformities and the feasibility of hippocampal avoidance while maintaining target conformity and homogeneity.

CONCLUSIONS

VMAT has been widely adopted throughout many centres and clinical sites. Proof of this adoption can be seen in its use to evaluate the effectiveness of other techniques (SIB, FFF, SBRT, IGRT and hypofractionation) and the application of outcomes in dose fractionation gained through static IMRT studies seamlessly applied to VMAT. The generation of the low dose baths produced with VMAT is of concern for brain irradiation and also breast radiotherapy. Most study designs are retrospective in nature and assess small patient cohorts therefore the need is evident for multicenter prospective clinical trials to adequately answer our research question.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

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REFERENCES

[1] S. J. ,. J. S. ,. K. W. ,. S. R. T. ,. T. P. H. 1. G. P. D. Michael B Barton, "Estimating the Demand for Radiotherapy From the Evidence: A Review of Changes From 2003 to 2012," *Radiotherapy and Oncology: Journal of the European Society for Therapeutic Radiology and Oncology,* 2014.

[2] P. V. ·. P. W. N. M. Jeffrey Barber, "A survey of modulated radiotherapy use in Australia & New Zealand," *Australasian College of Physical Scientists and Engineers in Medicine 2017,* p. 813, 2017.

[3] M. G. P. P. E. D. M. M. E. M. P. A. S. M. Peng, "A Comparison of Radiation Techniques in Patients Treated with Concurrent Chemoradiation for Stage III Non Small Cell Lung Cancer," *International Journal of Radiation Oncology Biology Physics,* 2019.

[4] M. F. C. H. C. M. P. W. F. M. W. F. D. A. N. M. P. M Teoh, "Volumetric modulated arc therapy: a review of current literature," *The British Journal of Radiology,* 2011.

[5] F. D. S. C. S. C. A. G. M. F. G. S. Gabriella Macchia, "Volumentric modulated arc therapy for treatment of solid tumours: current insights," *Onco Targets and Therapy ,* 2017.

[6] A. A. F. A. Daoud, " Clinical outcome and toxicity evaluation of simultaneous integrated boost pelvic IMRT/VMAT at different dose levels combined with androgen deprivation therapy in prostate cancer patients," *Onco Targets and Therapy,* 2017.

[7] Y. N. A. O. A. Shimizu, "Long-term tumor control and late toxicity in patients with prostate cancer receiving hypofractionated (2.2Gy) Soft-tissue-matched Image-guided Intensity-Modulated radiotherapy," *Anticancer Research,* 2017.

[8] N. C. v. K. M. Vassis, "Moderately HRT vs CRT for localized prostate cancer using image-guided VMAT with SIB: evaluation of acute and late toxicities," 2019.

[9] S. L. T. Sukhikh, "Dosimetric and radiobiological comparison of simultaneous integrated boost and sequential boost of locally advanced cervical cancer," *European Journal of Medical Physics,* 2020.

[10] R. F. G. L. F. P. R. A. Mazzola, "Weekly Cisplatin and Volumetric-Modulated Arc Therapy with Simultaneous Integrated Boost for Radical Treatment of Advanced Cervical Cancer in Elderly Patients: Feasibility and Clinical Preliminary Results," *Technology in Cancer Reserach and Treatment,* 2017.

[11] C. Cho, "Management for locally advanced cervical cancer: new trends and controversial issues," *Radiation Oncology Journal,* 2018.

[12] R. M. P. B. C. a. H. Dapper, "Impact of VMAT-IMRT compared to 3D conformal radiotherapy on anal sphincter dose distribution in neoadjuvant chemoradiation of rectal cancer," *Radiation Oncology,* 2018.

[13] T. C. L. L. Lin, "Compared planning dosimetry of TOMO, VMAT and IMRT in rectal cancer with different simulated positions," *Oncotarget,* 2017.

[14] M. W. K. Meier, "Dosimetric comparison of intensity-modulated proton therapy and volumetric-modulated arc therapy in anal cancer patients and the ability to spare bone marrow," *International Journal of Particle Therapy,* 2017.

[15] S. M. G. Karpf, "Left breast irradiation with tangential intensity modulated radiotherapy (t-IMRT) vs tangential volumetric modulated arc therapy (t-VMAT): trade-offs between secondary cancer induction risk and optimal target coverage," *Radiation Oncology,* 2019.

[16] A.-H. H. F. C. T. Byrne, "Comparison of semiautomated tangential VMAT with 3DCRT for breast or chestwall and regional nodes," *Radiation Oncology Physics,* 2018.

[17] G. M. F. R. S. G. R. F. N. M. C. A. Fiorentino, "Intensity-modulated radiotherapy and hypofratcionated volumetric modulated arc therapy for elderly patients iwth breast cancer: comparison of acute and late toxicities," *Radiotherapy,* 2019.

[18] H. X. S. L. L. D. H. Chen, "Prospective matched study on comparison of volumetric-modulated arc therapy and intensity-modulated radiotherapy for nasopharyngeal carcinoma:dosimetry, delivery efficiency and outcomes," *Journal of Cancer,* 2018.

[19] T. C. C. L. T. F. Huang, "Quality of life and survival outcome for patients with nasopharyngeal carcinoma treated by volumetric-modulated arc therapy versus intensity-modulated radiotherapy," *Radiation Oncology,* 2020.

[20] L. R. H. P. S. M. H. A. A. P. G. H. M. N.-W. M. F. W. F. Manzar, "Comparative analysis of acute toxicities and patient reported outcomes between intensity-modulated proton therapy (IMPT) and volumetric modulated arc therapy (VMAT) for the treatment of oropharyngeal cancer," *Radiotherapy and Oncology,* 2020.

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[21] The International Agency for Research on Cancer (IARC), "Latest global cancer data:," WHO, 2018.

[22] S. H. M. Pokhrel, "Potential reduction of lung dose via VMAT with jaw tracking in the treatment of single-isocentre/two-lesion lung SBRT," *Radiation Oncology Physics,* 2018.

[23] Z. M. C. X. T. L. S. Zhao, "Patterns of failure and clinical outcomes of definitive radiotherapy for cervical esophageal cancer," *Oncotarget,* 2017.

[24] L. Xi, "Recent advances in intensity modulated radiotherapy and proton therapy for esophageal cancer," *Expert Review of Anticancer Therapy,* 2017.

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MP-EO2 #44 A study on the determination of relative output factors for very small fields in stereotactic radiosurgery, Chi Do Duc

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INTRODUCTION

Small field dosimetry provides many challenges which are still being resolved so that radiotherapy services can have accurate radiation dosimetry. For small radiation fields, there are various physical conditions that occur including a lack of lateral charged particle equilibrium on the beam axis, the size of the detector is comparable or larger than the field size, there is partial occlusion of the primary photon source by the collimators, and differences in the radiological water equivalence of the water. The IAEA TRS-483 Code of Practice (COP) provides advice on how to measure small field dosimetry data as well as correction factors for commonly used detectors for a range of field sizes and beam energies. However, the COP does not include data for recently released detectors such as the IBA Razor diode, and there is minimal data for very small fields with dimensions less than 5 mm. This provides a challenge for clinical radiation oncology departments which have a stereotactic radiosurgery (SRS) program using cones with beam diameters down to 4 mm as defined at the isocentre. The purpose of this work was to determine relative output factors (ROFs) for SRS cone defined fields and determine correction factors for the IBA Razor diode using the TRS-483 COP framework.

METHODS

All of the radiation dose measurements were performed on Varian TrueBeam STx for 6X-WFF and 6X-FFF with SRS cone sizes ranging from 4 to 17.5 mm diameter. The detectors used were the IBA Razor diode, IBA Razor ionization chambers and Gafchromic EBT3 film. The Razor diode is p-type unshielded silicon diode, which was introduced by IBA as a replacement for their earlier model, the IBA SFD diode. Both of the IBA diodes are customized for measurements in small radiation fields, having an active area of 0.6 mm in diameter with a chip size of 0.95/0.4 mm (side/thickness). For comparison, the Gafchromic EBT3 film was taken as the reference dosimeter. The EBT3 film were scanned using an Epson Scanner XL11000 with 1200 dpi resolution 24 hours after exposure to radiation to allow the film to completely develop. Gafchromic EBT3 film is nearly energy-independent, has almost radiological water-equivalence, gives high spatial resolution and has been shown not to need any corrections for small field dosimetry provided a suitable methodology for the film is applied. All measurements were performed in an IBA Blue Phantom2 scanning water tank at a 5 cm depth with a source-to-surface distance of 95 cm. This geometry was selected to be consistent with the geometry of the radiotherapy treatment planning system. All ROFs were normalized to a 5 × 5 cm2 field for both 6X-WFF and 6X-FFF beams, and k correction factors for the IBA Razor diode were determined using the TRS-483 COP.

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RESULTS

A plot of the ROFs for the 6X-FFF beams is shown in figure 1 along with comparisons with other published data. There was good agreement between our measurements of the ROFs with the IBA Razor diode as compared to data provided by Cheng *et al* which was measured with the earlier IBA SFD. There was a maximum difference of about 1.5% for the 4 mm diameter cone. However, there are larger differences between the ROFs measured with the Razor diode in comparison to the representative data provided by Varian. The maximum difference is 4.7% for the 5 mm diameter cone and 2.6% for the 7.5 mm diameter cone for 6X-WFF and 6X-FFF beams, respectively. The comparison with Peyton Irmen *et al* for 6X-WFF beam showed generally a good agreement of most of the SRS cones sizes with less than 1% difference. However, there were differences of up to 5.8% for the smallest cone and 2.5% for the largest cone. A similar pattern was found for the 6X-FFF beam where there was a maximum difference of 5% for the smallest cone.

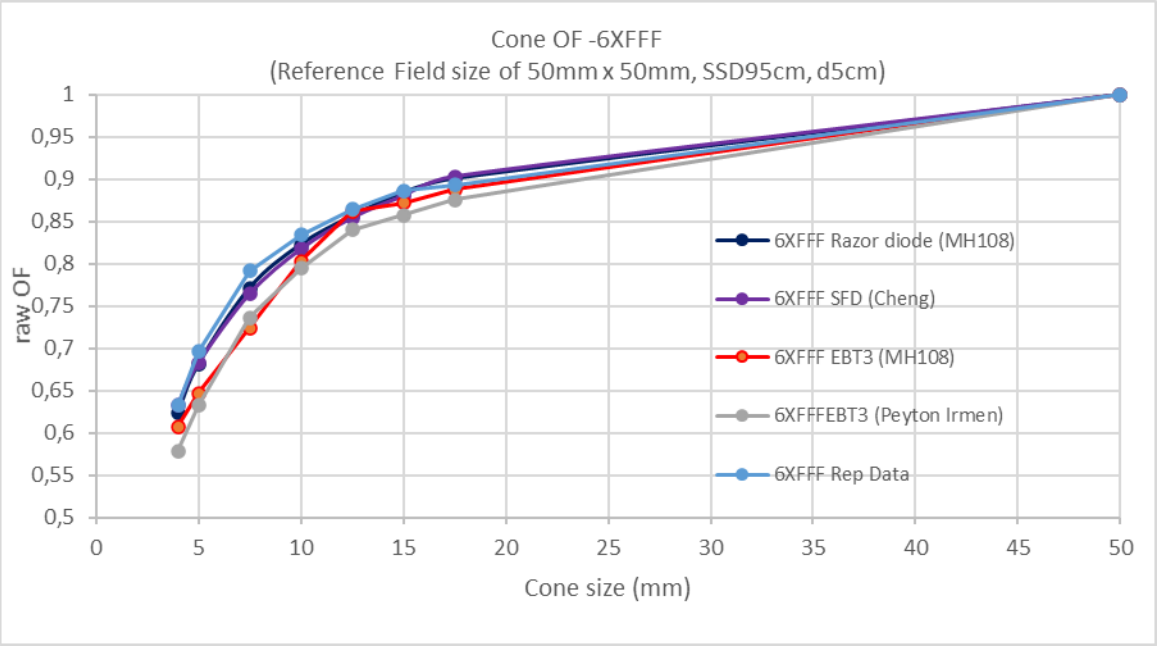

Figure 1. ROFs determined for the Varian SRS cones for the 6MV FFF x-ray beam.

CONCLUSIONS

This work has demonstrated that the IBA Razor diode is suitable for the dosimetry of very small radiation fields as found in SRS and consistent in response to the earlier IBA SFD. There is however, the need for additional work to determine suitable correction factors for this detector within the methodology of the TRS-483 COP in order to provide accurate radiation dosimetry.

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MP-EO3 #46 Establishment of an Incident reporting and learning System as a tool for Quality Management in Uganda's radiotherapy services: A case of the low resource setting, Ignatius Komakech

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BACKGROUND AND OBJECTIVE
The quality and safety of radiotherapy (RT) services in Sub-Saharan Africa has been a subject of major concern, as highlighted in several reports [1-2]. As for Uganda, it has been practicing 2D RT since the establishment of the service in 1995. In 2016, the only available cobalt-60 teletherapy machine broke down [3]. With the support of IAEA, the service was restored in 2017 with the installation of a new cobalt unit. In a bid to reduce reliance on a single machine, another cobalt unit was acquired, and a linear accelerator (linac) installed. The introduction of the linac will induce a move from 2D treatments to more advanced techniques. In order to make the move safer, it was agreed to evaluate the current quality and safety of the RT treatments delivered. The main objective of this study was therefore to identify errors/incidents that happened in the last 3 years (2018-2020) and develop a reporting and learning system, the first step of a broader Quality Management system.
METHODS
To identify the errors/incidents that happened in RT department, records of 1072 patients of the 4760 treated between January 2018 and December 2020 were randomly selected and reviewed. Several parameters were checked: prescribed total and daily doses, number of fractions, normalization depths, treatment times, completeness of treatment charts, setup instructions, etc. Treatment times were recalculated and compared with the values in the treatment chart and in the record and verification system (R&V).
RESULTS AND DISCUSSION
Errors found ranged from under-dosing (leading to recurrences) to overdosing (causing toxicities) of the patients and were in different categories: dosimetry and procedures.
Dosimetry: Dose errors were mainly due to omission of the block tray factor in the treatment time calculation (47), alteration of field sizes (20), incorrect normalization depths (17), omission of the bolus in treatment time calculation (14), incorrect beam weighting (9), failed second calculation checks (7), etc.
Procedures: Issues that were identified of great concern were: incomplete setup instructions, treatment plans not signed by RTT, calculations not signed by physicist, missing patient data in R&V, etc. The average waiting period from planning to start of treatment was 15.4 days, increasing from an average of 12.5 days in 2018 to 15.8 days in 2019 and to 16.6 days in 2020. This increase is attributed to the reduction in the number of staff, machine breakdowns and the introduction of payment of 3.2$ fraction.

A total of 1312 treatment sites were calculated. Of these, 86.7% were within ±5% of the prescribed dose [4]. There was an increase in the accuracy of dose calculation within ±5% along the years from 81% in 2018, 84.3% in 2019, and 93% in 2020. This is attributed to an increase in

staffing which was coupled with the introduction of a compulsory second calculation check in January 2020. Of the 2579 treatment fields used to treat these patients, 9.8% had their sizes altered either in the chart or in the R&V system. Alterations were due to non-reproducibility of some plans on machine, especially those during the simulator breakdown. Some were as a result of not considering wedge orientations while planning. Of the 1327 total treatment courses, only 44.7% were recorded in the R&V system. This was mainly due to the palliative cases such as single fractions being treated manually.

CONCLUSIONS

These results show evidence of gaps in the delivery of quality radiotherapy services in Uganda. If the underlying issues are addressed, the quality and safety of the radiotherapy services can improve. Several near misses and incidents were detected at early stages since the start of this study.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions from the Medical Physicists, Radiation therapists, and Oncologists of UCI. We sincerely appreciate the financial support provided by IAEA towards this study.

REFERENCES

[1] Peter, D., Recommendations for Safer Radiotherapy: What's the message? (2012).

[2] Jacob, V. D., Ahmed, M., Radiation Oncology Quality and Safety Considerations in Low Resource Setting: A medical Physicist Perspective. Semin Radiat Oncol November (2016) 27:124-135.

[3] Shekinah, N. E., Roshan, V. S., Awusi, K., Daniel, M. K., Broken Machines or Broken Systems – The Ugandan Experience, on Accessing/ Maintaining Radiotherapy Services, in Low and Middle-Income Countries, (2017) 3(5) 438 - 440.

[4] International Commission on Radiation Units and Measurements (ICRUI), Determination of absorbed dose in a patient irradiated by beams of X and Gamma rays in radiotherapy procedures, ICRU Publication Report 24, Washington D. C. (1976).

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MP-EO4 #79 Evaluation of positioning and dosimetry uncertainties in patients treated with intensity modulation radiotherapy (IMRT) for nasopharyngeal cancers in Tunisia, Nesrine Elamri

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BACKGROUND AND OBJECTIVE

The success of the IMRT treatment for nasopharyngeal patients is hampered by many sources of geometric errors and imprecision that can potentially deviate the delivered dose from the planned one, of which positioning errors are essentially noted [1-2]. In fact, the radiotherapy treatment is spread over several weeks while the ballistics of the treatment are defined on a single fixed CT scan acquired during the preparation of the treatment. The reproducibility of this planned position during irradiation sessions is then of critical importance [3]. An error in positioning or placement may be responsible for an underdosing and/or an overdosing of the target volume and the organs at risk [4-5]. The aim of the work was to detect potential setup and dosimetry errors using daily kilovoltage images and EPID measurements of repeatability of the dose distribution during irradiation of IMRT patients.

METHODS

A Varian Clinac iX, equipped with an amorphous-silicon EPID aS1000 was used in this study. We evaluated nine nasopharyngeal patients treated with IMRT. The dose prescribed was 60-70 Gy in 30-35 fractions. Immobilization of the patient was taken with 5 points masks [6]. During the treatment, two orthogonal kilovoltage images were obtained and compared with reference bone anatomy using automatic fusion to DRR images. The result of comparison gave the setup uncertainty in 3 directions (vertical, lateral and longitudinal) [7-8]. Deviations generated in the translational coordinates were analyzed and expressed in terms of mean values and their standard deviations. Additionally, portal imaging is often used for pre and during treatment anatomical setup verification. Images were collected with an EPID device for each IMRT subfield daily and compared to reference images (the first fluence treatment map) using the gamma method (DTA 3 mm, DD3%) [3-9].

RESULTS AND DISCUSSION

A total of 610 KV images and 2622 portal images were acquired over the course of the study. Setup errors were characterized by their mean values and standard deviations: 0.2 ± 2 mm in the vertical direction, 0.7 ± 5.1 mm in the longitudinal direction, and -0.4 ± 5.4mm in the lateral direction. For the dosimetry part, the average gamma index results were about 95.2% ± 3%. For 66% evaluated subfields, gamma index values were above 97% of analyzing fields. Only 2% of all evaluated data were with the Gamma index below 70%.

The magnitude of the random, systematic, and overall errors was quantified. A systematic error may be understood as an average variation that occurred during the treatment. A random error on the other hand, can be defined as the dispersion of systematic errors over time of treatment.

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CONCLUSIONS

This study emphasizes the importance of daily imaging in order to reduce setup errors and daily verification of the fluence map in order to provide extra information about day-to-day repeatability of treatment.

REFERENCES

[1] NOBLE, D.J, et al., Anatomical change during radiotherapy for head and neck cancer, and its effect on delivered dose to the spinal cord. Radiother Oncol (2018) 32–38.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Accuracy Requirements and Uncertainties in Radiotherapy, IAEA Human Health Reports No. 31, IAEA, Vienna (2016).

[3] KRUSZYNA-MOCHALSKAA, M., EPID-based daily verification of reproducibility of patients' irradiation with IMRT plans (2018) 309–314.

[4] LAM, J. C., et al., A comparison of dose and set-up accuracy between flexed and extended neck positions in Helical Tomotherapy of nasopharyngeal carcinoma. Medical Dosimetry (2020) 235-240

[5] RCR, IPEM et SCoR: On target: ensuring geometric accuracy in radiotherapy. London: The Royal College of Radiologists, Society and College of Radiographers, Institute of Physics and Engineering in Medicine (2008) 76pp.

[6] ZEFKILI, S., et al., Recommendations for a head and neck IMRT quality assurance protocol, Cancer/Radiothérapie 8 (2004) 364–379.

[7] VAN HERK, M., Errors and Margins in Radiotherapy. Seminars in Radiation Oncology; (2004) 52-64.

[8] VAN KRANEN S,, et al., Setup uncertainties of anatomical sub-regions in head-and-neck cancer patients after offline CBCT guidance, Int J Radiat Oncol Biol Phys. (2009)1566-73.

[9] POON, M., et al., Evaluation of deformed image-based dose calculations for adaptive radiotherapy of nasopharyngeal carcinoma. Medical Dosimetry (2017) 273–281.

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MP-EO5 #111 Determination and comparison of output factors in small field for field square and rectangular field with 5 detectors for 6 MV, Bertha Gracia

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BACKGROUND AND OBJECTIVE

This is a preliminary work of the comparisons of output factor measurements for small fields in different equipment. It is work in process and measuring small field factors turns out to be a challenge since the ideal detector does not exist. It is important to take this factor into account because it contributes very significantly in the calculation of delivery doses in patients.

METHODS

To analyze the response of each detector in relation to the square and rectangular field shape, 5 different detectors (Pinpoint 31016, Diode E 60012, Diode P 60008, Diode SRS 60018 and Diamond 60019) were measured on an Elekta 6MV accelerator (Infinity with Agility head, 5mm MLC). The results were then compared.

The measured fields were a total of 48 fields per chamber and the diode detector that was used. Table 1 shows the elongated (rectangular) fields that were measured.

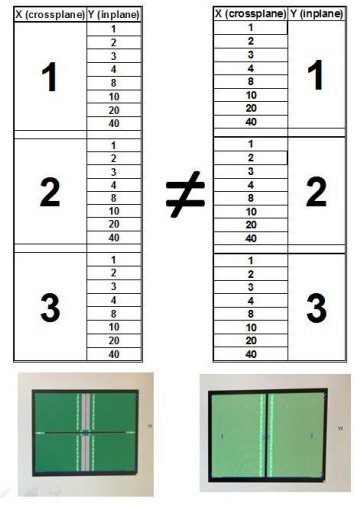

Table 1: Fields used for measurement in crossplane and inplane

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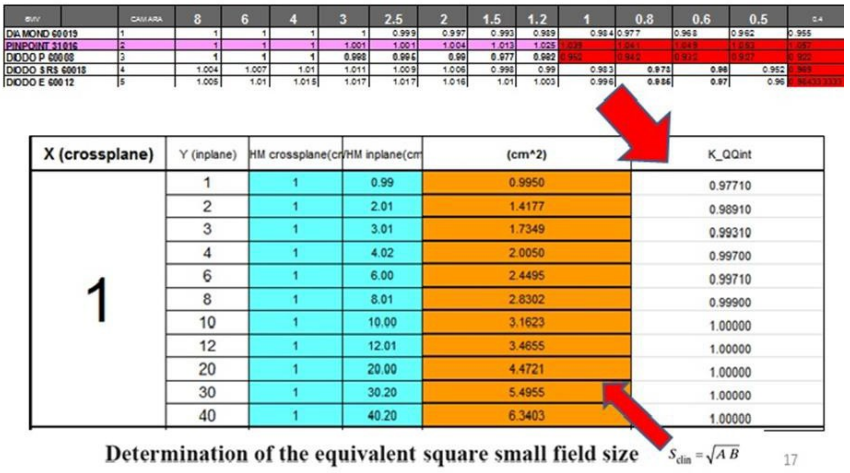
The equivalent square was found, and the $K_{Q,Qint}$ was calculated for each field taking into account the field formed by the accelerator and the type of detector used, by interpolating with the output corrections factor tables of the IAEA TRS 483 (Table 2).

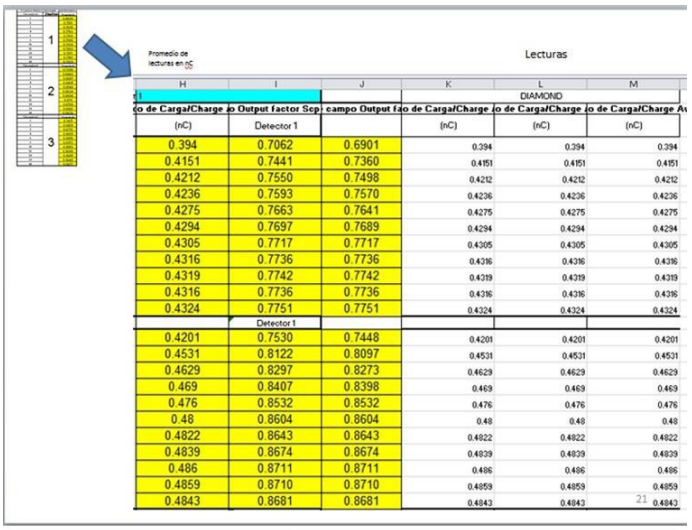


X (crossplane)	Y (inplane)	HM crossplane(cm	HM inplane(cm	(cm^2)	K_QQint
1	1	1	0.99	0.9950	0.97710
	2	1	2.01	1.4177	0.98910
	3	1	3.01	1.7349	0.99310
	4	1	4.02	2.0050	0.99700
	6	1	6.00	2.4495	0.99710
	8	1	8.01	2.8302	0.99900
	10	1	10.00	3.1623	1.00000
	12	1	12.01	3.4655	1.00000
	20	1	20.00	4.4721	1.00000
	30	1	30.20	5.4955	1.00000
	40	1	40.20	6.3403	1.00000

Determination of the equivalent square small field size $S_{clin} = \sqrt{A\,B}$ 17

Table 2: show the value K_{QQint} calculated using table N°26 and N°27 of the IAEA TRS-483.

The readings were performed ten times under the conditions in which the equipment was commissioned, i.e. SSD 90 cm and depth 10 cm. (Table 3).



Lecturas					
			DIAMOND		
(nC)	Detector 1		(nC)	(nC)	(nC)
0.394	0.7062	0.6901	0.394	0.394	0.394
0.4151	0.7441	0.7360	0.4151	0.4151	0.4151
0.4212	0.7550	0.7498	0.4212	0.4212	0.4212
0.4236	0.7593	0.7570	0.4236	0.4236	0.4236
0.4275	0.7663	0.7641	0.4275	0.4275	0.4275
0.4294	0.7697	0.7689	0.4294	0.4294	0.4294
0.4305	0.7717	0.7717	0.4305	0.4305	0.4305
0.4316	0.7736	0.7736	0.4316	0.4316	0.4316
0.4319	0.7742	0.7742	0.4319	0.4319	0.4319
0.4316	0.7736	0.7736	0.4316	0.4316	0.4316
0.4324	0.7751	0.7751	0.4324	0.4324	0.4324
	Detector 1				
0.4201	0.7530	0.7448	0.4201	0.4201	0.4201
0.4531	0.8122	0.8097	0.4531	0.4531	0.4531
0.4629	0.8297	0.8273	0.4629	0.4629	0.4629
0.469	0.8407	0.8398	0.469	0.469	0.469
0.476	0.8532	0.8532	0.476	0.476	0.476
0.48	0.8604	0.8604	0.48	0.48	0.48
0.4822	0.8643	0.8643	0.4822	0.4822	0.4822
0.4839	0.8674	0.8674	0.4839	0.4839	0.4839
0.486	0.8711	0.8711	0.486	0.486	0.486
0.4859	0.8710	0.8710	0.4859	0.4859	0.4859
0.4843	0.8681	0.8681	0.4843	0.4843	0.4843

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Table 3: The measurements obtained are shown

This study provides information on the effect of the orientation of the detectors, as well as the difference in the equivalent square fields using various square and rectangular fields. The results were based on the formalism of TRS 483.

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RESULTS AND DISCUSSION

In Figures 1 - 6, the graphs show that the smaller fields have a greater dispersion of data; the black lines are the average values. It is observed in the fields of side 1 cm (figures 1 and 4) that the dispersion increases as the field increases, however in the fields of side 2 cm and 3 cm (figures 2, 3, 5 and 6), the dispersion is smaller and it is observed that the data are almost the same. In the blue graphs, the variance was not used because the data did not have a normal distribution. The non-parametric analysis was used (tables below figures 3 and 6), where the significance values are the difference from the mean between the 5 detectors. We considered "significance" wherein values less than 0.05 represented a significant difference, and values around 1.0 represented no difference. In the case of fields of side 1 cm, the lowest value was at 0.05, and the significance value is greater for the wider fields. For the case of fields of side 1 cm, there is a significant difference in relation to diodes E and P as well as the diamond detector.

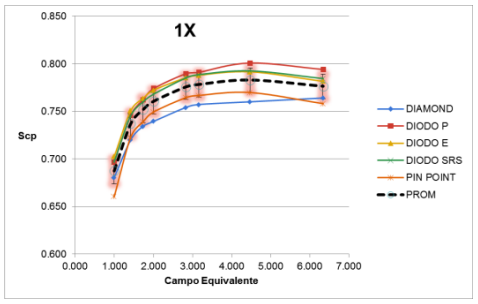


Fig.1

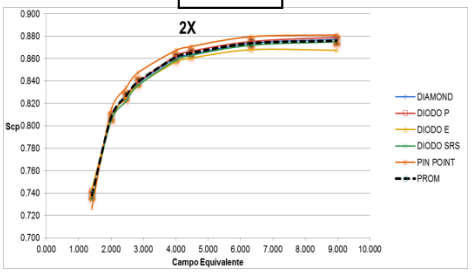
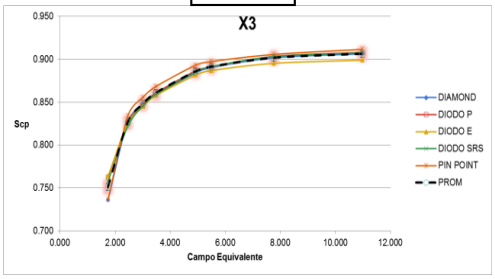


Fig.2



CAMPO	SIGNIFICANCIA
1X	0.046
2X	0.925
3X	0.961

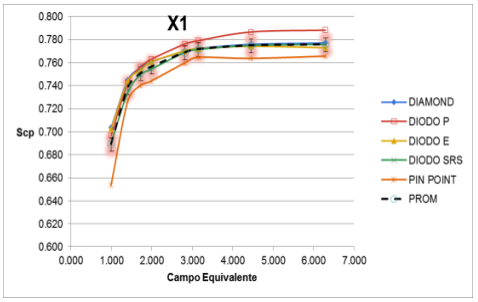


Fig.4

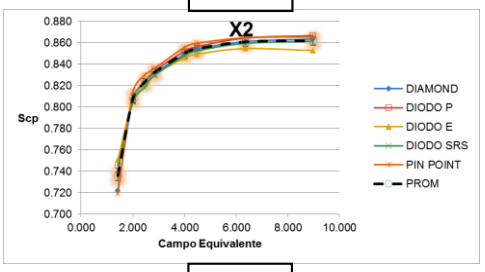


Fig. 5

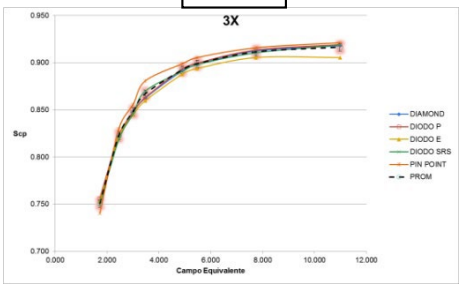


Fig.6

CAMPO	SIGNIFICANCIA
X1	0.382
X2	0.878
X3	0.958

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CONCLUSIONS

1. It is important to establish average reference values of output factor, for different fields and different accelerators.
2. The second phase is to compare the values obtained with other teams using the same equipment type.
3. Film dosimetry will be used to compare the values of the diodes and ionization chambers.
4. As can be seen, the difference occurs in very small fields, and these factors are used for radiosurgery treatments where high doses of treatment are used.

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I thank Dr. Alberto Gago, Dr. Daniel Venencia, and Dr. Gustavo Sarria for all their support and teaching.

REFERENCES

[1] TECHNICAL REPORTS SERIES NO. 483. DOSIMETRY OF SMALL STATIC FIELDS USED IN EXTERNAL BEAM RADIOTHERAPY.TRS 483. An International Code of Practice for Reference and Relative Dose Determination.2017.

[2] TECHNICAL REPORTS SERIES No. 398. Absorbed Dose Determination in External Beam Radiotherapy An International Code of Practice for Dosimetry Based on Standards of Absorbed Dose to Water. AIEA-Vienna 2000.

[3] BO ZIDAR CASAR. ET AL. A novel method for the determination of field output factors and output correction factors for small static fields for six diodes and a microdiamond detector in megavoltage photon beamshttps ://www.researchgate.net /publication/329457676. 2018.

[4] DOSIMETRY FOR SMALL FIELD. PTW. Guide of the aplication.

[5] IPEM 103. REPORT NUMBER 103, Small Field Mv Photon Dosimetry. Institute of Physicis and Engineering in Medicine 2010.

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MP-EP01 #70 A comparative study of two treatment planning systems for IMRT optimization, Mwape Mofya

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BACKGROUND AND OBJECTIVE

The Eclipse™ treatment planning system is in routine use at Istituto Nazionale Tumori Regina Elena, Italy, to generate individualized treatment plans. The institute recently purchased the research version of the Pinnacle^3 treatment planning system. The Pinnacle^3 treatment planning system incorporates the Auto-Planning® optimizer that automates many processes of the manual optimization [1-6]. The aim of this study was to compare, based on the institute's protocol, the plan quality among plans manually optimized both in Eclipse™ and Pinnacle^3, and plans generated by the Pinnacle^3 Auto-Planning® engine.

METHODS

Nine cases including three breast, three head and neck, and three prostate, were selected for this study. Forward IMRT plans were generated using the field in field (FiF) technique for the breast cases, fixed gantry inverse planning IMRT for the head and neck cases, and VMAT for the prostate cases. Two plans were manually optimized for each case. The first plan was optimized using EclipseTM and the second plan was optimized using Pinnacle3. A third plan was generated using Pinnacle's Auto-Planning® optimizer for the prostate and the head and neck cases. The target coverage, dose homogeneity, dose conformity, organ at risk sparing, and delivery efficiency were evaluated. The PQM% and the APQM% scores calculated using the plan quality algorithm in the PlanIQ [7,8] software provided a measure of the overall achieved plan quality of the plans. Statistical analyses were performed using paired t-tests with a level of significance at 5%.

RESULTS AND DISCUSSION

There were no significant differences between the FiF plans created in Eclipse™ and Pinnacle^3 treatment planning systems. Similar DVHs were obtained from the IMRT plans. On average, dose conformity was better in the Eclipse™ IMRT plans, but with significantly increased monitor units. The Auto-Planning® IMRT plans provided better sparing of the OARs. The PQM% scores were slightly higher in the Eclipse™ IMRT plans, but the differences with the manual Pinnacle^3 and the Auto-Planning® IMRT plans were not significant. VMAT plans optimized with Auto-Planning® had better target coverage, dose homogeneity, OAR sparing, and higher PQM% scores than the manually optimized Eclipse™

and Pinnacle^3 VMAT plans. The monitor units obtained from Eclipse^{TM}, Pinnacle^3 manual planning and Auto-Planning® VMAT optimization were comparable.

CONCLUSIONS

While the optimization algorithms, optimization tools, and dose computation algorithms differ in the Eclipse^{TM} and Pinnacle^3 treatment planning systems, IMRT plans of similar quality can be created. Auto- Planning, with manual intervention, could increase the quality of IMRT and VMAT plans. Auto-Planning® could be used as a starting point. Manual improvements to the dose distribution could then be made starting from the Auto-Planning® solution.

ACKNOWLEDGMENTS

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REFERENCES

[1] Batumalai, V., Jameson, M. G., Forstner, D. F., Vial, P., Holloway, L. C., "How important is dosimetrist experience for intensity modulated radiation therapy? a comparative analysis of a head and neck case", Practical radiation oncology, **3** (2013) 99-106.

[2] Cotrutz, C., Xing L., "Imrt dose shaping with regionally variable penalty scheme", Medical physics, **30** (2003) 30(4):544–551, 2003.

[3] Kusters J., Bzdusek, K., Kumar P., van Kollenburg P. G. M., Kunze-Busch, M. C., Wendling, M., Dijkema, T., Kaanders, J., "Automated imrt planning in pinnacle", Strahlentherapie und Onkologie, **193** (2017) 1031-1038.

[4] Nawa, K., Haga, A., Nomoto, A., Sarmiento, R, A., Shiraishi, K., Yamashita, H., Nakagawa, K., "Evaluation of a commercial automatic treatment planning system for prostate cancers", Medical Dosimetry, 42 (2017) 203-209.

[5] McConnell, K. A., Marston, T., Zehren, B. E., Lirani, A., Stanley, D. N., Bishop, A., Crownover, R., Eng, T., Shi, Z., Li, Y., et al., "Dosimetric evaluation of pinnacle's automated treatment planning software to manually planned treatments", Technology in cancer research & treatment, 17 (2018).

[6] Ouyang, Z., Shen, Z. L., Murray, E., Kolar, M., LaHurd, D., Yu, N., Joshi, N., Koyfman, S., Bzdusek, K., Xia, P., "Evaluation of auto-planning in imrt and vmat for head and neck cancer. Journal of applied clinical medical physics", **20** (2019) 39-47.

[7] Nelms, B. E., Robinson, G., Markham, J., Velasco, K., Boyd, S., Narayan, S., Wheeler, J., Sobczak, M. L., "Variation in external beam treatment plan quality: an inter- institutional study of planners and planning systems", Practical radiation oncology, **2** (2012) 296-305.

[8] Ahmed, S., Nelms, B., Gintz, D., Caudell, J., Zhang, G., Moros, E. G., Feygelman, V., "A method for a priori estimation of best feasible dvh for organs-at-risk: Validation for head and neck vmat planning", Medical physics, **44** (2017) 5486–5497.

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MP-EP02 #78 Small-field output factor determination for Versa HD flattened and flattening filter-free beams with various detectors, Saba Hussain

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BACKGROUND AND OBJECTIVE

The increased use of advanced radiation treatment techniques has improved the quality of radiation treatment by enabling precise positioning of the patients and targeting of tumours with minimising doses to normal healthy tissues [1]. With the adoption of these advanced techniques in modern radiotherapy, there is an increasing interest in the small field dosimetry of photon beams with both flattening filter (FF) and flattening-filter-free (FFF). Nowadays, the use of the FFF beams allows a higher dose rate with a minimum time duration to treat small lesions [2]. The present study evaluates the performance of various detectors for the determination of field output factors (OF) in small field dosimetry with FF and FFF beams.

METHODOLOGY

In this study, the linear accelerator VERSA HD (Elekta, Stockholm, Sweden) of 6 MV FF, 6 MV FFF and 10 MV FF energies was used to obtain the OFs with five different detectors (PTW microDiamond 60019 (mD), PTW Diode 60018, PTW PinPoint 31014, Sun Nuclear EDGE detector 1118 and Exradin W1 plastic scintillator). The dose rate of 6 MV FF and 6 MV FFF can reach 600 MU/min and 1900 MU/min, respectively. OF measurements were performed for field sizes from 0.6 × 0.6 cm^2 to 3 × 3 cm^2 by using all energies. The correction factors from IAEA TRS 483 [3] and from literature data (correction factors from De Coste et al [4] and Looe et al [5] to mD for 6 MV FF and correction factors from Francescon et al [6] with Monte Carlo (MC) to PinPoint detector for 6 MV FF and FFF) were applied to measured OFs in order to make a useful comparison between detectors and to evaluate their accuracy. The differences between measured and corrected OFs were investigated in this work.

RESULTS AND DISCUSSION

The standard deviation (SD) calculated on the measured OFs ranged from 0.2% to 3.7%. The application of the IAEA correction factors resulted in a reduced SD, ranging between 0.2% and 2.7%, considering all field sizes and energies. Higher differences in OF values before and after the correction were observed in FFF beams than in FF beams as well as in the smallest field (0.6×0.6 cm^2) for all detectors, as reported by other studies [7, 8]. The PinPoint detector under responded for the smallest fields (especially for 0.6×0.6 and 1×1 cm^2) for all energies due to its higher active volume compared to those of the other detectors. The OFs calculated using the

IAEA correction factors were found consistent with those obtained applying the imbalance correction factors for mD detector [4, 5], with differences within 0.7%. The corrected OFs differences between IAEA and MC for PinPoint detector were within 3% for both 6 MV and 6 MV FFF.

CONCLUSION

The outcome of this study demonstrated that all the investigated detectors are suitable for small field dosimetry. The differences in dose response between the detectors used in this study were reduced significantly by implementing the correction factors reported in IAEA TRS 483 and in literature for all investigated small fields and energies. However, further studies are needed to provide correction factors derived from an accurate beam modelling, which may improve the treatment results with enhanced patient safety.

REFERENCES

[1] GOYAL S, et al. "Image guidance in radiation therapy: techniques and applications". Radiology research and practice. (2014).

[2] SCORSETTI, M, et al. "Feasibility and early clinical assessment of flattening filter free (FFF) based stereotactic body radiotherapy (SBRT) treatments." Radiation oncology 6, (2011) 113.

[3] PALMANS, H, et al., "Dosimetry of small static fields used in external photon beam radiotherapy: Summary of TRS-483, the IAEA–AAPM international Code of Practice for reference and relative dose determination." Medical physics 45.11, (2018) e1123-1145.

[4] DE COSTE, V., et al. "Is the PTW 60019 microDiamond a suitable candidate for small field reference dosimetry? " Physics in Medicine & Biology 62(17), (2017) 7036.

[5] LOOE, H.K., et al. "The role of radiation-induced charge imbalance on the dose-response of a commercial synthetic diamond detector in small field dosimetry". Medical physics 46(6), (2019) 2752-2759.

[6] FRANCESCON, P., et al. "Calculation of k Q_{clinc}, Q_{msr} f_{clinc}, f_{msr} for several small detectors and for two linear accelerators using Monte Carlo simulations". Med. Phys. (2011) 6513.

[7] NARAYANASAMY G, et al."Commissioning an Elekta Versa HD linear accelerator". Journal of applied clinical medical physics 17, (2016) 179–191.

[8] MONASOR DENIA, P, et al. "Comparison of detector performance in small 6 MV and 6 MV FFF beams using a Versa HD accelerator". PloS one 14.3, (2019) e0213253.

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MP-EP03 #105 Statistical Control Process in Tomotherapy pre-treatment QA, Rosa Petit

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BACKGROUND AND OBJECTIVE

Intensity Modulated (IM) techniques, both static and dynamic, include a variety of uncertainties that make it more prone to errors during dose planning and delivery. That is why patient-specific QA is essential in identifying abnormal discrepancies between the calculated dose and the delivered one.

In IM patient specific pre-treatment QA, it can be useful to introduce statistical control processes (SPC), which can be defined as quality control methods that use statistical analysis of the information to track and inspect a process over time.

We applied the SPC methodology to gamma γ analysis results in helical Tomotherapy™ (Accuray) pre-treatment verifications, using ArcCheck™ (Sun Nuclear) as a QA tool, to establish tolerance limits and action thresholds for different anatomical sites (abdominal area, head & neck, breast plus supraclavicular nodes (SVC) and prostate). The final purpose of this research is both to promote detection of eventual delivery problems before the treatment dose and to monitor the system performances over time.

METHODS

The parameters selected to determine the tolerance and action limits in pre-treatment QA measurements using ArcCheck™ were the γ-index passing rate obtained with two criteria: 3%, 3 mm - local normalization (γ33L) and 3%, 2 mm - global normalization (γ32G). The calculation of the patient plan on ArcCheck™ was carried out with Tomotherapy "Delivery Quality Assurance" method available in the planning station, which also allows for absolute dose calculation in the center of the phantom, where an ionization chamber can be placed.

Tolerance limits at the institution's local level were evaluated with the method proposed in AAPM TG218[1] report, a guide that specifies patient safety standards for measurements prior to treatment. AAPM TG218 proposal requires a minimum of 20 pre-treatment QA measurements. Here, absolute dose measurement and γ33L analysis were evaluated on 623 cases (abdominal 145, breast + SVC 141, head & neck 93, and prostate 244); γ32G analysis was performed on a subset of 241 measurements (abdominal 50, breast + SVC 55, head & neck 40, and prostate 96).

RESULTS AND DISCUSSION

The tolerance and action limits that were established according to the anatomical area can be seen in Table 1:

Table 1: Averages, standard deviation, lower control limits, upper control limits and action limits of γ 3%, 3 mm, γ 3%, 2 mm and dose difference percentage.

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Test	Area	Average (%)	Standard deviation (%)	LCL (%)	UCL (%)	AL (%)
γ 3%, 3 mm Local	Abdominal	93.84	0.44	76.85	--	72.87
	Breast + SVC	88.71	0.48	75.35	--	60.29
	Head & Neck	96.95	0.09	90.69	--	87.25
	Prostate	95.89	0.17	88.40	--	82.45
γ 3%, 2 mm Global	Abdominal	98.54	0.04	96.12	--	92.36
	Breast + SVC	96.67	0.16	90.04	--	84.50
	Head & Neck	96.92	0.17	89.99	--	84.44
	Prostate	97.77	0.06	93.21	--	90.19
Dose difference test	Abdominal	0.94	0.03	-2.95	5.02	5.56
	Breast + SVC	1.06	0.89	-22.04	26.09	28.52
	Head & Neck	0.76	0.01	-1.83	4.00	4.27
	Prostate	0.93	0.03	-2.27	4.73	5.53

Different tolerance and actions limits were found for different anatomical locations. The highest Lower Control Limit (LCL) for the γ33L criterion were for head & neck (90.96 %) and prostate (88.40%), indicating that they are a very stable process in helical Tomotherapy. The lowest LCL were found for breast + SVC (75.35 %) and abdomen (76.85 %). These treatments generally involve large volumes, and it may be difficult to position the ArcCheck in order to efficiently sample the dose distribution with the diodes while preserving suitable positioning of the central ionization chamber in a full dose, low gradient region.

The action limits determined for γ33L also followed the same pattern described above, that is, head & neck (87.25 %) and prostate (82.45 %) as the highest values, with breast + SVC (60.29 %) and abdomen (72.87 %) as the lowest values.

For the γ32G criteria, the highest LCLs were observed for abdominal site (96.12 %) and prostate (93.21 %); the lowest LCLs were breast + SVC (90.04 %) and head & neck (89.99 %). The same happened with the action limits, with abdomen (92.36 %) and prostate (90.19 %), followed by breast + SVC (84.50 %) and head & neck (84.44 %).

The γ results for breast + SVC are not surprising; these treatments involve a large volume of very low doses and gradients where local γ always gives suboptimal results if a high threshold is not applied (10% in our analysis).

As far as the percentage difference of the absolute dose measured with the ionization chamber is concerned, the smallest values were those with the highest LCL and Action Limits: head & neck (average difference of 0.76%) and prostate (average difference of 0.93 %). The high variability and control levels for breast + SVC are due to the fact that ArcCheck positioning in these cases often results in the ionization chamber placed in a low dose and/or high gradient region.

CONCLUSIONS

Tolerance and action limits for different anatomical sites were successfully established. Following the protocol described in AAPM TG 218[1], the tolerance limits were compared with

the action limits, concluding that the tolerance limits are within the action limits. This indicates that the process can continue to be monitored under current conditions.

Setting tolerance and action limits locally helps to understand and validate the performance of IMRT QA over a period of time. In this way, negative results that may affect patients can be avoided and prevented.

An interesting side result of this study is that comparing results between the "historical" parameters γ33L and the new AAPM suggested γ32G, the gamma passing rates are definitively better with the latter. This denotes how important it is to know the behaviour of both parameters when changing from one focus to the other.

REFERENCES

[1] Moyed Miften, Arthur Olch, Dimitris Mihailidis, Jean Moran, Todd Pawlicki, Andrea Molineu, Harold Li, Krishni Wijesooriya, Jie Shi, Ping Xia, Nikos Papanikolaou, Daniel A. Low. Report No. 218 - Tolerance Limits and Methodologies for IMRT Measurement-Based Verification QA: Recommendations of AAPM Task Group No. 218, Medical Physics, (2018), https://dx.doi.org/10.1002/mp.12810

[2] Pawlicki T, Whitaker M, Boyer AL. Statistical process control for radiotherapy quality assurance, *Med Phys. 2005 Sep;32(9):2777-86. doi: 10.1118/1.2001209. PMID: 16266091.*

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MP-EP04 #113 Dosimetric verification and comparative analysis of Collapsed Cone Convolution (CCC) and Irregular Field (IF) algorithms for soft tissue, lung and bone region treatment sites using an anthropomorphic phantom, Penabei Samafou

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BACKGROUND AND OBJECTIVE

Treatment Planning Systems (TPSs) have proven to be indispensable tools in radiation therapy treatment. The accuracy of any TPS to calculate dose is largely dependent on the mathematical algorithm used and can be well verified using a dedicated phantom. The purpose of this work was the dosimetric verification and comparative analysis of two algorithms (Collapsed Cone Convolution (CCC) and Irregular Field (IF)) implemented in three different TPSs (Precise PLAN R2.15, Pinnacle^3 9.8 and Monaco 5.11.03) for soft tissue, lung and bone region treatment sites using an anthropomorphic phantom, based on the IAEA-TECDOC-1583 report.

MATERIALS AND METHODS

The study was executed with a CIRS 002LFC IMRT Thorax phantom made of plastic water, lung and bone sections with holes to hold interchangeable rod inserts and an ion-chamber port. The phantom was simulated using a computed tomography (Philips brilliance Big Bore, multi slices) scanner and three TPSs (Precise PLAN R2.15, Pinnacle 3 and Monaco 5.11.03) for application of beam setup parameters. Treatment plans were generated for three megavoltage photons energies (X4, X6 and X10) from an Elekta Precise Clinical Linear Accelerator Treatment System. A Pinpoint 3D ion-chamber (TW3101) was used to perform dosimetric verification placed at appropriate locations in the CIRS 002LFC IMRT Thorax phantom. The ionization chamber was coupled to a PTW-UNIDOSE-E electrometer which measures the charge collected during irradiation. For each test case, measurements were acquired and the deviations between measured and calculated TPS doses were analyzed using agreement criteria mentioned in IAEA-TECDOC-1583 report [1].

RESULTS AND DISCUSSION

Eight tests (reference field; oblique incidence, lack of scattering and tangential fields; significant blocking of the field corners; four field box; automatic expansion and customized blocking; oblique incidence with irregular field and blocking the center of the field; three fields, two wedge-paired, asymmetric collimation; non coplanar beams, couch rotation and collimator rotation) were modelled to evaluate the performance of CCC and IF algorithms to calculate the dose in media with homogeneities and heterogeneities for three nominal energies of photons 4, 6 and 10 MV.

The deviations (error%) obtained for the three TPSs, in comparison with the experimental measurements, are reliable in most cases with an error in the calculation of the absorbed dose of less than 2% in a homogeneous water-type medium, with the exception of the IF algorithm values corresponding to case 4, at 270° gantry angle (P5) for the nominal energies of 4 and 6MV which are slightly outside the confidence recommended limit. Good correspondence of the mean deviations of the calculated doses with respect to the measured doses are observed for all energies regardless of the algorithm considered. This testifies to the precision of the algorithms implemented in the 3 TPS to calculate doses in the homogeneous water-type medium. However, the deviations in the bony and lung insert regions depend largely on the

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algorithm. The results appear to be better for the CCC algorithm. The overall results in heterogeneous lung and bone inserts were 66.66% and 88.88% for PrecisePLAN, 100% and 95% for Pinnacle, and 100% and 100% for Monaco, respectively.

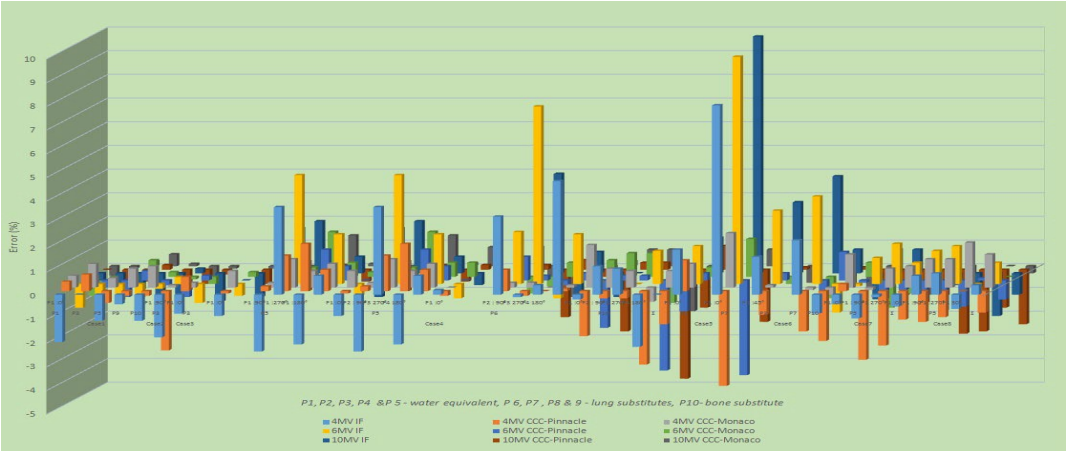

Figure 1: The deviation (Error %) between the measured and the calculated doses based on the CCC and IF algorithms for three nominal energies 4, 6 and 10 MV.

CONCLUSIONS

The dose prediction capacity of the Irregular Field algorithm appears to be comparable to the Collapsed Cone Convolution algorithm in soft tissue medium and was found to be 98 % within the agreement criteria. The most significant differences between the two algorithms were found in the bony and lung regions. This comparison shows good performance on the part of both the Monaco and Pinnacle TPS, in particular when taking into account the lack of diffusing volume and good modelling of the lateral electronic transport.

REFERENCES

[1] Assurance, Q. & Calculations, D. Commissioning of Radiotherapy Treatment Planning Systems : Testing for Typical External Beam Treatment Techniques Commissioning of Radiotherapy Treatment Planning Systems : Testing for Typical External Beam Treatment Techniques. At. Energy (2008).

[2] Sharpe, M. B. IAEA Technical Reports Series No. 430: Commissioning And Quality Assurance Of Computerized Planning Systems For Radiation Treatment Of Cancer. Med. Phys. 33, 561–561 (2006).

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MP-EP05 #115 Brain Radiotherapy during pregnancy: a dosimetric study for fetal dose with OSLD, Edith Villegas Garcia

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BACKGROUND AND OBJECTIVE
Radiotherapy during pregnancy must be carefully considered, as the fetus is extremely sensitive to radiation and fetal doses as low as 100 mGy can have serious effects [1]. One of the challenges is accurately determining fetal dose, as often it is far from the treatment target and special considerations must be taken into account [2]. The objective of this study is to compare doses calculated with the Varian Eclipse TPS to doses measured with OSLDs and radiochromic film.
METHODS
A batch of Landauer nanoDots OSLD was calibrated in a 6 MV field on a Varian TrueBeam linac, both in in-field and out-of-field locations. The reader used was the Landauer microStar ii. OSLDs were irradiated in a phantom made of solid water slabs and Rando Alderson Phantom slabs, with a high enough number of MU to achieve sufficient signal even in out-of-field positions. A custom PMMA grid was built to precisely position the OSLDs and avoid air gaps. The response of the OSLD was verified in-field at 8 different depths and out-of-field at depths of 5 cm, 10 cm and 15 cm, at distances between 30 cm and 42 cm from the central axis of a 10 cm x 10 cm field. A Farmer chamber was used as the reference detector for calibration, due to its small energy dependence. A batch of Gafchromic EBT3 film was also calibrated in the 6 MV energy in-field.
3DCRT and a VMAT plan were made for breast and brain tumors on a CT Scan of the Rando Alderson Phantom plus a solid water slabs (Fig.1). Plans were calculated on TPS Eclipse and Acuros algorithm. PMMA grids with OSLDs and EBT3 film were placed at a distance of 30 cm from the isocenter for the breast case and 42 cm for the brain case. A total of 60 Gy was irradiated to obtain a higher signal. The results of the measurements with OSLDs and EBT3 film were compared to the dose calculated by the TPS.
RESULTS AND DISCUSSION
The response of the nanoDots had a coefficient of variation of around 1.5%, with a maximum difference between one OSLD and the other of less than 4%. The coefficient of variation for the calibration factor of the OSLD in different out of field conditions was 5.5%.
The measured dose at a depth of 10 cm and a distance of 30 cm from the isocenter was 2.5 cGy for the breast plan, for a total dose of 60 Gy. This is in the same order of magnitude as the 3.9 cGy dose found by Antypas et. Al [3] at a distance of 29 cm from the edges of the field, with 46 Gy for the tumor.

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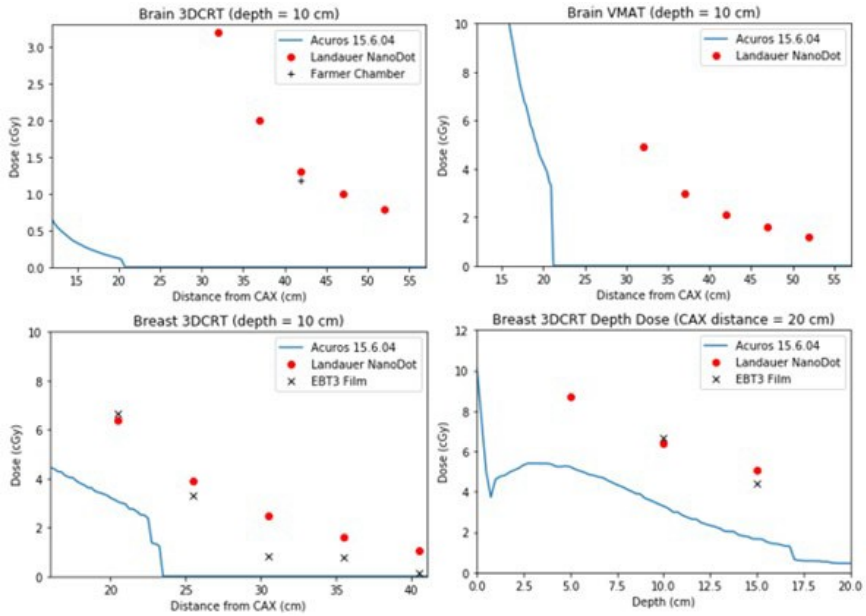

Figure 1. Comparison of the dose calculated by the TPS and the dose measured with the OSLDs and the radiochromic film for the breast and brain plans.

For the brain plans, the dose at a distance of 52 cm from the isocenter was 0.78 cGy for the 3DCRT plan and 1.12 cGy for the VMAT plan, at a depth of 10 cm. AAPM TG 36 reports 2.5 cGy at a distance of 52 from the field edges for a glioblastoma treatment.

For the 3DCRT breast plan at a distance of 20 cm from the isocenter, the dose calculated by the TPS differed from the measured dose by 40% at a depth of 5 cm, 48% at a depth of 10 cm and 67% at a depth of 15 cm, taking the OSLDs as reference. As shown in Figure 2, Gafchromic measurements confirm OSLDs measurements.

CONCLUSIONS

The Acuros calculation algorithm in Eclipse greatly underestimates the out of field dose and can be used only for a rough estimation in positions not so far to the field edges. For fetal dose, evaluation measurements before treatment should be done to avoid large errors.

REFERENCES

[1] STOVALL, Marilyn, et al. Fetal dose from radiotherapy with photon beams: report of AAPM Radiation Therapy Committee Task Group No. 36. Medical physics, 1995, vol. 22, no 1, p. 63-82.

[2] KRY, Stephen F., et al. AAPM TG 158: measurement and calculation of doses outside the treated volume from external-beam radiation therapy. Medical physics, 2017, vol. 44, no 10, p. e391-e429.

[3] ANTYPAS, Christos, et al. Fetal dose evaluation during breast cancer radiotherapy. International Journal of Radiation Oncology Biology Physics, 1998, vol. 40, no 4, p. 995-999.

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MP-EP06 #124 Confidence in 6 MV and 6 MV FFF VMAT EPID QA adopting the AAPM-TG119 approach, Mohammed Abujami

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BACKGROUND AND OBJECTIVE

The objective was to evaluate the dosimetric accuracy of VMAT for a new Versa HD linear accelerator (Elekta, Stockholm, Sweden) for 6 MV and 6 MV FFF (flattening filter-free) photon beams. All measurements were done according to the American Association of Physicist in Medicine (AAPM) Task Group (TG) 119 report [1], adapting it to the VMAT technique using EPID dosimetry and comparing the results obtained with a 3D cylindrical dosimetric phantom.

METHODS

VMAT plans were calculated and optimized following the AAPM TG-119 dose prescriptions and planning objectives, using the Monte Carlo based Treatment Planning System (TPS) Monaco 5.51 (Elekta, Stockholm, Sweden) for 6 MV and 6 MV FFF photon beams. The set of cases of the report consists of the following five tests called: Multitarget, Prostate, Head-and-Neck, C-Shape easy, and C-Shape hard. All the plans were delivered with a LINAC Versa HD and were measured with an integrated iViewGT™ EPID MV panel (Elekta AB, Stockholm, Sweden) with a distance from the source of 160 cm and an active imaging area of 41x41cm^2. The EPID image matrix is constituted of an array of 1024x1024 photodiodes with a pitch of 400 µm. EPIDose software (SunNuclear, USA) was used to convert EPID images in terms of dose maps.

Delta^4 Phantom+ with 1069 p-Si detectors was used as reference and to obtain a 3D dose distribution. Each p-type diode has a sensitive volume of 0.04 mm^3 with 5 mm spacing in a central region of 6 x 6 cm^2 and 10 mm outside up to 20 cm from the centre. The global gamma index of the 2D dose distribution obtained with the EPID system and the Delta^4 Phantom+ 3D dose distributions were compared with TPS calculations using global gamma criteria of 3%/3 mm.

Confidence Limits (CL = |100 – mean| +1.96*SD) were also calculated as suggested by TG119. In this study, we also used the pass criteria 2%/2mm in order to have a stricter acceptance criterion.

RESULTS AND DISCUSSION

The overall combined passing rates with 3%/3 mm and with 2%/2 mm for 6 MV obtained with EPID were 98.30 and 93.34 respectively; and the results with Delta^4 were 99.05 and 92.27, respectively.

The overall combined passing rate with 3%/3 mm and with 2%/2 mm for 6 MV FFF obtained with EPID were 96.29 and 86.56 respectively; the results with Delta^4 were 98.82 and 96.87, respectively. The obtained passing rates with 3%/3 mm for the 6 MV plans are higher than that reported in TG-19 (93.50), which is also the case for the 6 MV FFF beam. However, the results for 6MV FFF and the 2mm/2% passing rate are not mentioned in the TG 119 work.

As seen, passing rates for EPID are generally lower than the same for Delta^4; this is also due to the fact that Delta^4 measures the actual dose distribution. On the contrary, the EPID obtains the dosimetric information indirectly and measures the dose condensed in a single plane, thus

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condensing all the delivery inaccuracies in a single image. Moreover, the EPID has a higher spatial resolution than Delta^4 and it is also more sensitive to beam dose accumulation.
Gamma index analysis was compared between EPID and Delta^4 and TG 119 in Figure 1. All gamma evaluation results show more than 96% of data points pass the criteria of 3%DD and 3 mm DTA, and the result is acceptable for Delta^4 and EPID on both 6 MV and 6 MV FFF beam energy compared with TG 119. Both results were satisfied with TG-119 confidence limit of 7.33.

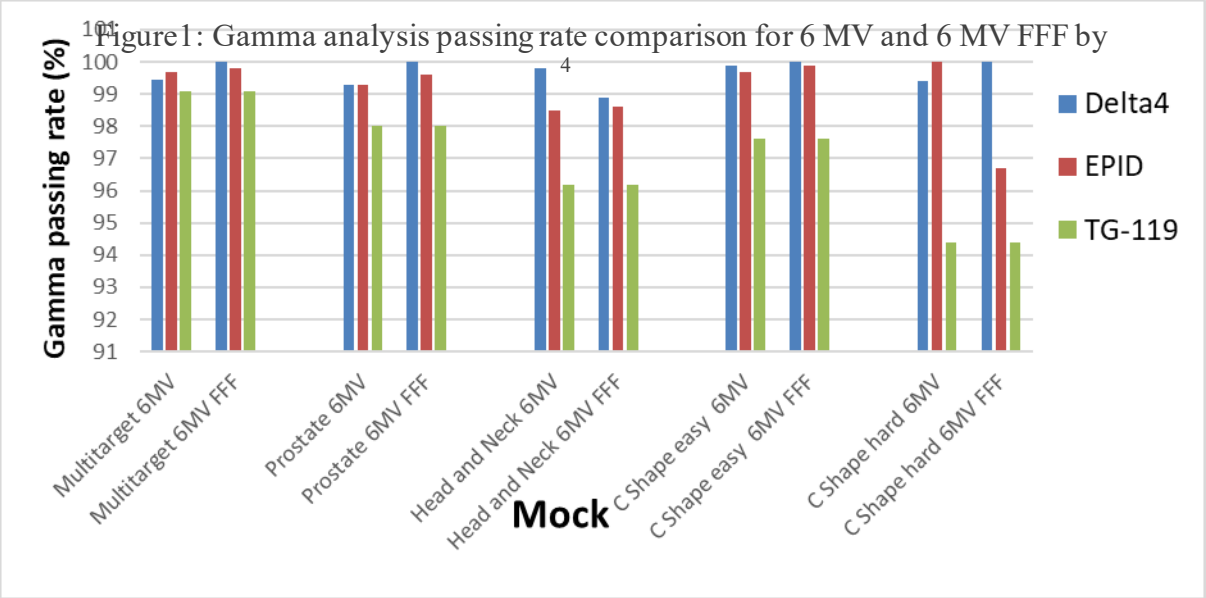

Figure1: Gamma analysis passing rate comparison for 6 MV and 6 MV FFF by

CONCLUSIONS

- TG-119 methodology has successfully been used to evaluate the commissioning accuracy of VMAT on a Versa HD linear accelerator via EPID Dosimetry.
- Local institutional CLs were established which can be used as benchmarks for future measurements and as a baseline for future patient-specific pre-treatment quality assurance.

REFERENCES

[1] Ezzell GA, Burmeister JW, Dogan N, LoSasso TJ, Mechalakos JG, Mihailidis D, Molineu A, Palta JR, Ramsey CR, Salter BJ, Shi J, Xia P, Yue NJ, Xiao Y. IMRT commissioning: multiple institution planning and dosimetry comparisons, a report from AAPM Task Group 119. Med Phys. 2009 Nov;36(11):5359-73. doi: 10.1118/1.3238104. PMID: 19994544.

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MP-A1 What is new in radiotherapy medical physics auditing? , Andy Nisbet

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BACKGROUND AND OBJECTIVE

Radiotherapy medical physics auditing is acknowledged as a cost-effective method for ensuring quality in radiotherapy treatment delivery. With advances in technology, and as treatment techniques continue to develop, the methods employed to audit advanced radiotherapy are required to evolve. This talk considers what is new in radiotherapy medical physics auditing.

METHODS

A number of literature reviews of radiotherapy medical physics auditing have been carried out to provide an overview of the development, benefits and current best practice in auditing advanced radiotherapy techniques through either site visits or remote auditing. These have covered brachytherapy [1], external beam radiotherapy [2] and more advanced radiotherapy techniques [3]. The IAEA have also reported on 50 years of IAEA / WHO postal dose audits [4]. Recent reported dosimetry audits have covered applications ranging from small animal irradiators to intracranial stereotactic radiosurgery [6].

RESULTS AND DISCUSSION

Analysis of the reported studies make clear the benefits derived from dosimetry audits [7] in terms of improved consistency between centres, and learning and training opportunities; and attempts have been made to quantify the subsequent potential clinical benefits that may arise. The currently achievable consistency in radiotherapy dosimetry, including for advanced radiotherapy techniques, may also be implied on national, regional or international scales. The benefits to clinical trials are also clear in terms of improved quality assurance and subsequent outcomes from trial arms.

CONCLUSIONS

Methodologies have been developed for most advanced radiotherapy technologies and techniques. Global availability of dosimetry audits is ever increasing. As radiotherapy techniques and technologies continue to evolve, further developments in dosimetry audit methodology will be required.

REFERENCES

[1] PALMER, A. L.; BRADLEY, D. A.; NISBET, A, Dosimetric Audit in Brachytherapy *British Journal Of Radiology* (2014) 87 (1041)Doi: 10.1259/Bjr.20140105

.

[2] CLARK CH, AIRD EG, BOLTON S, MILES EA, NISBET A, SNAITH JA, THOMAS RA, VENABLES K, THWAITES DI. Radiotherapy Dosimetry Audit: Three Decades of Improving Standards And Accuracy in UK Clinical Practice And Trials *Br J Radiol.* 2015 Sep 2:20150251

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[3] PASLER M, HERNANDEZ V, JORNET N AND CLARK CH Novel Methodologies for Dosimetry Audits: Adapting to Advanced Radiotherapy Techniques. *PHIRO* Vol 5, Jan 2018, 76-84

[4] IZEWSKA J, BOKULIC T, KAZANYSEV P, WESOLOWSKA P and VAN DER MERWE D. 50 Years of the IAEA / WHO Postal Dose Audit Programme for Radiotherapy: What Can be Learned From 13756 Results? *Acta Oncol* 2020 May: 59 (5): 495-502

[5] GRONBERG MP ET AL A Mail Audit Independent Peer Review System for Dosimetry Verification of a Small Animal Irradiator. *Radiation Research* Vol 193 (4), 341-350, 2020

[6] DIMITRIADIS A, TSANG Y, THOMAS RAS, PALMER AL, EATON D, LEE J, PATEL R, PATALLO IS, GOULDSTONE C, SNAITH JAD, KIRKBY KJ, NISBET A and CLARK CH. Multi-institutional dosimetric delivery assessment of intracranial stereotactic radiosurgery on different treatment platform. *Radiother. Oncol.* 147, 153-161, 2020

[7] THOMAS R, BOLT M, BASS G, NUTBROWN R, CHEN T, NISBET A and CLARK CH. Radiotherapy Reference Audi in the UK by the National Physical Laboratory: 20 Years of Consistency and Improvements. PHIRO. 2017, 3, 21-27

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MP-A2 Enhancing quality in radiotherapy through dosimetry audits (the IROC experience), Stephen F Kry

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BACKGROUND AND OBJECTIVE
This presentation explains the need and benefit of dosimetry audits, including the benefit to the patient as well as the importance in providing accurate data for clinical trials. This need is presented in the context of experiences from the Imaging and Radiation Oncology Core (IROC) dosimetry audit programs, the results of IROC's programs, and lessons learned.
METHODS
IROC monitors more than 2300 institutions worldwide and provides clinical trial quality assurance support for the USA's National Cancer Institute. IROC's primary dosimetry audit tools are: 1) machine calibration output verification (20,000 beams per year); 2) On-site dosimetry audits (30 institutions per year); 3) Anthropomorphic phantom audits of advanced radiation therapy techniques (750 phantoms per year).
RESULTS AND DISCUSSION
IROC's output verification program showed 0.7% of beams as outside a 5% criterion. IROC's site visit program showed 3% or larger errors in relative dosimetry at most institutions. IROC's phantom program showed 10-20% of institutions fail to irradiate the phantom within 7% and 3-5mm. These errors are frequent and substantial in magnitude.
Through the application of systematic dosimetry audits, IROC has also found broad shortcomings in radiation oncology. These include inadequate dose calculation by pencil beam algorithms for proton beams in the lung, as well as dramatic shortcomings in pre-treatment patient specific IMRT QA.
CONCLUSIONS
Dosimetry audits continue to uncover a high frequency of relatively large shortcomings in current radiotherapy practice. As such, audits provide valuable feedback to improve the quality of radiation therapy at individual institutions. Additionally, broad, systematic issues affecting radiation oncology in general have also been uncovered through uniform dosimetry audits, revealing areas for the entire field to improve. Through these pathways, dosimetry audits benefit the patients treated at institutions receiving an audit, the advancement of science when those patients are part of clinical trials, and the overall optimization of radiation oncology.

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MP-A3 IAEA/WHO dosimetry audits: present and future, P.Kazantsev

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BACKGROUND AND OBJECTIVE

The International Atomic Energy Agency (IAEA) jointly with the World Health Organization (WHO) has operated the dosimetry audit service for hospitals and secondary standards dosimetry laboratories (SSDLs) for over 50 years [1]. Advances in radiotherapy technology over time have dictated the need for more complex audit approaches, and the IAEA has developed a series of remote and on-site methodologies allowing for checking the physics related part of such treatments [2, 3, 4, 5]. In parallel, an extension of IAEA audits to cover the clinical part of radiotherapy treatments led to development of the Quality Assurance Team for Radiation Oncology (QUATRO) approach, which became widely accepted [6]. Here we summarize the historical activities of the IAEA in the field of radiotherapy dosimetry audits and outline the direction we are moving to in the foreseen future.

CURRENT SITUATION

The only audit for radiotherapy the IAEA Dosimetry laboratory (DOL) provides to Member States (MSs) as a regular service, is the reference output check for photon beams of medical linear accelerators (linacs) and ^{60}Co units using radiophotoluminescent dosimeters (RPLDs). An optically stimulated luminescence dosimetry (OSLD) system is used for radiation protection level audits of ^{137}Cs irradiators of SSDLs. Different audit methodologies were developed in the period of 1995-2017 through Coordinated Research Projects (CRPs) and technical expert meetings, with the aim of preparing internationally verified and ready to implement audit packages for national dosimetry audit networks (DANs) [5]. Fifteen DANs benefited directly from participation in CRPs and the subsequent application of the remote audit methodologies, which were developed [7]. Eight MSs participated in the multi-national on-site treatment planning system audit [8]; seventeen MSs expressed interest in implementing the on-site audit methodology for intensity modulated radiotherapy (IMRT) treatments [4], seven of them have successfully organized the national audit run. Just over a hundred QUATRO missions have been conducted in fifty-three MSs through numerous national, regional and interregional Technical Cooperation (TC) projects [6].

FUTURE DIRECTIONS

As of 2021, DOL will start accepting applications for electron beam reference output audits of newly commissioned radiotherapy machines. The methodology became available after extensive testing of different parameters of the RPLDs using the DOL linac and the development of a new holder. Publication of TRS 483 [9] and subsequent CRP on its implementation stimulated the work on small field audit methodology. Different dosimetry systems (RPLDs, OSLDs, films) and several holder designs were tested for feasibility, and the final design allows for the verification of both small field output factors and profiles. Currently, the audit methodology is available for TC/CRP participants only. This year will also mark the beginning of a new CRP in dosimetry audits; the 5-year project will cover three increasingly complex approaches for remote testing of brachytherapy treatments.

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Dosimetry audits became an invaluable part of quality assurance programs in hospitals around the world, mandatory in some countries [10]. The IAEA is planning to increase its role in harmonizing audit practices through organizing regular technical meetings of DANs. Additionally, DOL is planning to broaden its services for DANs by providing linac-based blind and reference irradiations, and offering a platform for audit feasibility testing.

CONCLUSIONS

The IAEA has actively contributed to establishing and maintaining high standards of radiotherapy dosimetry worldwide for many years, including provision of audit services and support of national DANs. Current developments aim at strengthening and diversifying the services provided as well as facilitating the professional knowledge exchange amongst the international DAN community.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

The authors would like to acknowledge the efforts of previous IAEA DMRP staff for their contributions in dosimetry audits.

REFERENCES

[1] IZEWSKA, J., et al., 50 Years of the IAEA/WHO postal dose audit programme for radiotherapy: what can we learn from 13756 results?. Acta Oncol 59 (2020) 495-502.

[2] LECHNER, W., et al., A multinational audit of small field output factors calculated by treatment planning systems used in radiotherapy, Phys Imag Rad Oncol 5 (2018) 58–63.

[3] WESOLOWSKA, P., et al., Testing the methodology for a dosimetric end-to-end audit of IMRT/VMAT: results of IAEA multicentre and national studies, Acta Oncol 58 (2019) 1731-1739.

[4] KAZANTSEV, P., et al., IAEA methodology for on-site end-to-end IMRT/VMAT audits: an international pilot study, Acta Oncol 59 (2020) 141-148.

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, National Networks for Radiotherapy Dosimetry Audit, IAEA, Vienna (2021, in press)

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement: Quality Assurance Team for Radiation Oncology (QUATRO), IAEA, Vienna (2007).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, SSDL Newsletter No. 70, IAEA, Vienna (2019).

[8] GERSHKEVITSH, E., et al., Dosimetric interinstitutional comparison in European radiotherapy centres: results of IAEA supported treatment planning system audit, Acta Oncol 53 (2014) 628-636.

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry of Small Static Fields Used in External Beam Radiotherapy, Technical Reports Series No. 483, IAEA, Vienna (2017).

[10] IZEWSKA, J., LECHNER, W., WESOLOWSKA, P., Global availability of dosimetry audits in radiotherapy: The IAEA dosimetry audit networks database. Phys Imag Rad Oncol 5 (2018) 1–4.

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MP-A4 Experience and skills for medical physics auditing under the IAEA QUATRO activity, Stefaan Vynckier

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BACKGROUND AND OBJECTIVE

The International Atomic Energy Agency (IAEA) published in 2007 [1] a document entitled "Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement". This document proposes a methodology to carry out comprehensive clinical audits in radiotherapy. As this clinical audit should be comprehensive, it focuses on the entire radiotherapy process and evaluates different aspects in a radiotherapy department, such as the organisation and infrastructure as well as the clinical and physical aspects underlying a radiotherapy department. This audit is a peer review process carried out by a team composed of:

- a radiation oncologist (RO),
- a medical physicist (MP) and
- a radiation therapist (RTT).

Known as the IAEA QUATRO (Quality Assurance Team in Radiation Oncology) audits, this audit methodology has been conducted across a various number of radiotherapy departments located in Europe, Latin America, Asia and Africa [2]. Training on the methodology has been organized in different countries such as Thailand, Indonesia, Pakistan etc. The methodology has also been imported as a national audit in some countries such as Belgium [3, 4].

Performing a QUATRO audit consists of different phases:

- Preparation: the audit team should be familiar with aspects of the institution in advance, such as:
  - Equipment;
  - Number and type of patients;
  - Age of the facility;
  - Role in the country;
  - Research and education.

Moreover, the experts should be informed about the radiotherapy practice in the country of the institution and identify any specific requirements and interests of the facility.

- *Site Visit*: 3-4 days on-site visit to assess the different practices of the institution. Assessment can be done by observations, interviews, review and practical implementation of different practices and procedures;
- *Measurements*: a special kit met dosimetry equipment is sent in advance to the center. The medical physics expert will perform local dosimetry measurements following the prescriptions in reference [1] or IAEA TECDOC 1543 [5].
- *Reporting:* A full report is drafted by the auditing team that will be submitted to the IAEA and sent afterwards to the center. A preliminary view is given by the experts the last day at the exit briefing. The report also include the results of the dosimetric measurements.

This keynote lecture will briefly shed light on my experience as a medical physics expert with previous QUATRO missions.

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REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Comprehensive Audits of Radiotherapy Practices: A tool for Quality Imrpovement, Vienna: IAEA, 2007.

[2] J. Izewska, M. Coffey, P. Scalliet, E. Zubizarreta, T. Santos, I. Vouldis et P. Dunscombe, «Improving quality of radiation oncology: "10 years' experience of QUATRO audits in the IAEA Europe Region", *Radiotherapy and Oncology,* vol. 126, pp. 183-190, 2018.

[3] Scalliet, P. (on behalf of the Federal College of radiotherapy), "Clinical radiotherapy audits in Belgium 2011-2014. ", Cancer/Radioth érapie, vol. 19, pp. 621-623, 2015.

[4] A. Vaandering, Y. Lievens, P. Scalliet, Belgian College for Physicians in Radiation Oncology: "Feasibility and impact of national peer reviewed clinical audits in radiotherapy departments.", *Radiotherapy and Oncology,* vol. 144, pp. 218-223, 2020.

[5] IAEA-TECDOC-1543: "On-site visits to Radiotherapy centres: Medical Physics procedures", 2007.

[6] IAEA-TECDOC-1583: "Commissioning of Radiotherapy Treatment pPlanning systems:Testing for Typical External Beam Treatment Techniques", 2008.

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MP-A5 Designing a framework for improving Radiotherapy Safety and Quality, Annette Wygoda

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BACKGROUND AND OBJECTIVE

From its inception, the Israeli Health System has allowed all citizens free access to Radiotherapy (RT) treatments, given in centers equipped with up to date and sophisticated machines and operating according to international guidelines by board certified physicians often trained abroad. Medical Physicists (MP) and Radiation Technologists (RTT) have been historically trained on the job. However, the combination of the explosion in the development of new Radiotherapy technologies, with the rapid increase in the Israeli population and the subsequent need for opening new centres has led the Israeli Health Authorities to recognize that National guidelines, regulation and control had to be established in the rapidly evolving field of Radiotherapy. In this context, the Ministry of Health (MOH) engaged into an ongoing process of establishing a framework for addressing all aspects of Radiotherapy, aiming at improving patients' safety and treatment quality.

METHODS

Upon request of the MOH, a mandatory QUATRO audit [1] was carried out in 2010 in all Radiotherapy departments by IAEA teams, in order to provide a complete picture of the RT status, and enable the setting of priorities for action.

The main findings of the audits pertained to a lack of formal training of RT professionals and to staffing shortages. Therefore, the auditors strongly suggested to:

- Improve the training of the RTTs.
- Establish a training program for MPs including specific academic education and clinical training.
- Train radiation oncology residents in a structured program.

Consequently, the MOH restructured its Radiation Control Unit, establishing a dedicated position for Radiotherapy Safety and Control, which led to important measures being taken, many with the support of the IAEA:

1. Training improvements:
   - Creation of The National School of Radiotherapy, a well-equipped framework for continuous education of RTTs, Medical Physicists and Radiation Oncologists.
   - Establishment of a mandatory comprehensive program for RTTs, complementing their on-the-job training.
   - Organization of series of lectures and hands-on trainings for Residents.
2. Establishment of National Safety and Quality Standards by:
   - Updating the Directives for installing RT treatment equipment. [2]
   - Publishing a Directive for operating RT departments. [3][4][5]

3. Modernization of the National Secondary Standard Dosimetry Laboratory (SSDL) for calibration of dosimetry equipment.
4. Starting mandatory participation in annual postal dosimetry audits (level I).

RESULTS AND DISCUSSION

The newly issued directives have been well accepted by the RT departments that now find an open communication channel with the MOH Radiotherapy specialists.
The professional level of the RTT teams has clearly improved, as a result of their participation in the course at the National School of Radiotherapy.
The level I dosimetry audits showed highly accurate results, demonstrating the excellence of the physicists' knowledge of calibration protocols.
Several other initiatives have recently been taken, the more significant being:
- An IAEA-supported project of establishing a training track for medical physicists, including the creation of a master's degree in medical physics, and the organization of a two-year clinical training programme in hospitals. [6][7].
- A national level III dosimetry audit is currently in the design phase: it will allow for the assessment of the quality of the overall radiation treatment process in all RT departments. [8][9]
Finally, consideration is currently made for the establishment of a National QUATRO type audit. This would provide the RT departments and the MOH with an accurate picture of the Radiotherapy field at regular intervals and help setting priorities for action. However, creating and training an audit team represent a big challenge that will have to be addressed in the near future.

CONCLUSIONS

The process engaged by the Israeli MOH to establish a framework for safer radiotherapy has demonstrated its efficacy and the need for its continuation and further development.

REFERENCES

[1] Comprehensive Audits of Radiotherapy Practices: A Tool for Quality Improvement. Quality Assurance Team for Radiation Oncology (QUATRO). IAEA, Vienna, 2007
[2] NCRP REPORT No.151. Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities
[3] Setting Up a Radiotherapy Programme: Clinical, Medical Physics, Radiation Protection and Safety Aspects. IAEA, Vienna (2008).
[4] ACR-ASTRO Practice Parameter for Radiation Oncology. Revised 2018.
[5] Safety is No Accident. A Framework for Quality Radiation Oncology Care. ASTRO (2019).
[6] IAEA HHS 25 - Roles and Responsibilities and Education and Traning (2013).
[7] IAEA-TCS-56 Postgraduate MP Academic Programmes (2013).
[8] IAEA-TECDOC-1583. Commissioning of Radiotherapy Treatment Planning Systems. Testing for Typical Expernal Beam Treatment Techniques (2008).
[9] J. LEHMANN & al. Dosimetric end-to-end tests in a national audit of 3D conformal radiotherapy. Physics and Imaging in Radiation Oncology 6 (2018).

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MP-A6 Enhancing Safety in Radiotherapy: The IAEA Safety Standards for Medical Uses, Ola Holmberg

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BACKGROUND AND OBJECTIVE

The IAEA has a statutory role in accelerating and enlarging the contribution of atomic energy, which is interpreted to include medical and other uses of radiation, to peace, health and prosperity in the world. The statutory role also includes establishing international safety standards in this field, and to provide for the application of these standards, which means to assist Member States implement the standards. The IAEA does this work together with other United Nations organizations such as the World Health Organization, as well as with other international organizations.

METHODS

Developing international safety standards, involves drafting by groups of experts, formal addressing of comments by Member States, professional bodies and other organizations, and coordinating discussions and approvals by the IAEA safety standards committees and commission, and the IAEA publications committee. The jointly sponsoring organizations also have formal procedures, so the whole process takes several years.

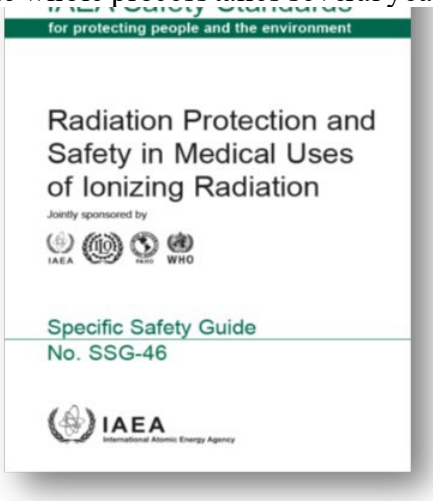

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Figure 1. Safety guide on radiation protection and safety in medical uses of ionizing radiation

RESULTS AND DISCUSSION

In order to provide recommendations and guidance on fulfilling the requirements of the international basic safety standards [1] (BSS) for ensuring radiation protection and safety of radiation sources in medical uses of ionizing radiation with regard to patients, workers, carers and comforters, volunteers in biomedical research, and the public, the IAEA published the

specific safety guide [2] (SSG-46) on radiation protection and safety in medical uses of ionizing radiation in October 2018.

SSG-46 covers radiological procedures in diagnostic radiology (including dentistry), image guided interventional procedures, nuclear medicine, and radiotherapy. Recommendations and guidance are provided on applying a systematic approach to ensure that there is a balance between being able to utilize the benefits from medical uses of ionizing radiation and minimizing the risk of radiation effects to people. It is aimed primarily at end-users in medical radiation facilities, responding to "What do I need to do to ensure that my facility's medical uses of radiation are in compliance with the BSS?", and at radiation regulatory bodies, responding to "What does the government need to do to ensure that the facilities in the country meet the requirements of the BSS?".

CONCLUSIONS

Aiming for global strengthening of radiation protection in medicine, and in the current context, in particular radiation protection and safety in radiotherapy, the focus is now on assisting countries to implement this new safety guide. Implementation will ensure better protection of patients, workers and the public when ionizing radiation is used in radiotherapy.

REFERENCES

[1] EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety in Medical Uses of Ionizing Radiation, IAEA Safety Standards Series No. SSG-46, IAEA, Vienna (2018).

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MP-AO1 #48 Dose verification from imaging to delivery during site visits in radiotherapy, P.Sipilä

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BACKGROUND AND OBJECTIVE

A lightweight, portable and water filled phantom was developed in STUK for radiotherapy site visits to verify the dose from imaging to delivery, especially for VMAT and IMRT beams, but suits for conventional beams as well. The phantom has been manufactured in the STUK mechanical workshop from PMMA and it is light to transport when empty and easy to fill and set up in a hospital. Different type of detectors can be fitted in the phantom easily. Most measurements are done as point measurements with a waterproof 0.6cc chamber or Semiflex ionization chamber (IC). A micro-IC, diamond detector or semiconductor are seldom used. If a dose distribution is needed, a piece of Gaf-Chromic radiochromic film EBT3 can be inserted into the phantom. Normally the phantom is used without any inhomogeneities, but different types of inhomogeneities can be inserted in several positions when needed. The inserts most used are lung and bone, but e.g. a hip replacement prosthesis can also be inserted. In order to avoid artefacts and calculation errors from the IC chamber, a plastic dummy IC is placed in the phantom during CT scanning.

METHODS

The phantom has been in regular use since 2014 and about 2400 photon beams have been measured during site visits. The phantom has been measured with all accelerators in Finland more than three times and has also been used in some clinics abroad. The phantom has been scanned in each hospital with the local CT scanner, i.e. the same scanner which is used for cancer patients. If there was a need to verify the image quality parameters, a CT-quality insert is added inside the phantom. This allows for the verification of HU values, image and contrast resolution. After analyzing image parameters in the CT scanner, the images are transferred to the planning station and several types of treatment beams will be planned. If conventional beams are verified, usually only a point dose at the isocenter is calculated and measured. If VMAT or IMRT beams are verified, a CTV is drawn of the detector volume, and a PTV introduced and some OAR according local procedures to either mimic the pelvis area if no inserts are used, or to mimic a lung tumour if a lung insert is used. The phantom and Farmer type chamber on the patient tabletop is shown in Figure 1.

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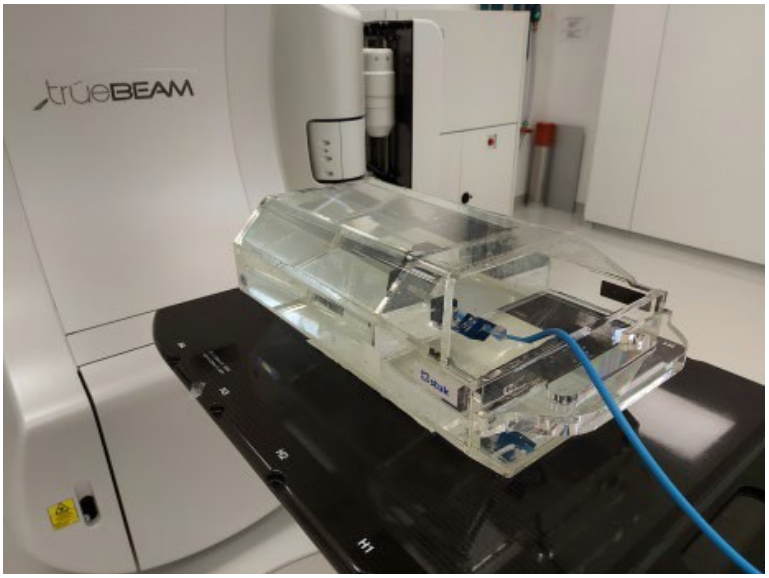

Figure 1. The Phantom.

RESULTS AND DISCUSSION

Most of the measured beams were in excellent agreement. The difference between calculated and measured dose between 2017 to 2020 has been less than 1% with 75% of the beams. The rest of the beams have been in good agreement to within 3%. Only 22 plans exceeded our tolerance limit of 3% but were still within 5%. Single cases with a larger dose deviation of over 5%, and up to 12% were found before 2017, during commissioning and the dose error could be corrected before patient treatments.

CONCLUSIONS

Portable, water filled phantom with interchangeable inhomogeneities, and online measurements has been found to be a very suitable instrument for verifying the correct dose to radiotherapy patients. If too large a deviation is found, the root cause for the discrepancy can be solved on site. The measurements should be done first without any inhomogeneities and if agreement for the dose is within tolerances, inhomogeneities can be used.

REFERENCES

[1] SIPILA, P., Gafchromic EBT3 film dosimetry in electron beams — energy dependence and improved film read-out. Journal of Applied Clinical Medical Physics (2016) 17(1):360

[2] OJALA, J., et Al. The accuracy of Acuros XB algorithm for radiation beams traversing a metallic hip implant — comparison with measurements and Monte Carlo calculations. Journal of Applied Clinical Medical Physics (2014) 15(5):162

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MP-AO2 #76 Small field absorbed dose to water determinations in LINAC MV photon beams during site visit authority inspection of radiotherapy, I. Jokelainen

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BACKGROUND AND OBJECTIVE

Use of radiotherapy in Finland is controlled by Radiation and Nuclear Safety Authority (STUK). The use of radiotherapy must fulfil requirements of national legislation and orders given by STUK. An effective method to verify the fulfilment of the acceptance criteria for radiotherapy equipment in use and the requirements for radiation safety of personnel and patients is an on-site inspection. Absorbed dose to water measurements in reference geometry and treatment planning system (TPS) verification by determination of the TPS-calculated patient doses in LINAC beams, are considered routine methods of authority control for radiotherapy in Finland. As radiotherapy treatment techniques focus on VMAT and IMRT treatments, the need for TPS verification of small fields has increased in authority control.
During the period 2015 – 2019 STUK verified the TPS-calculated small field patient doses by a total of 1500 absorbed dose to water determinations, which were performed as part of authority site visit inspections of 45 linear accelerators in 13 Finnish radiotherapy LINAC photon beams with different field sizes shaped with collimator jaws or multileaf collimator (MLC).

METHODS

The absorbed dose to water determinations were made in Varian and Elekta accelerator conventionally filtered beams (WFF: 6MV, 10MV, 15MV and 18MV) and in beams without flattening filter (FFF: 6MV and 10MV). The absorbed doses to water were determined by ionization measurements using ionization chambers and synthetic diamond as the detectors following the IAEA TRS398 absorbed dose determination protocol [1]. The calibrations of 0,6cm^3 Farmer-type ionization chamber PTW30013 and the used electrometer PTW UNIDOS E are traceable to the calibration laboratory SSDL-Helsinki. The small volume (0,03 cm^3) PinPoint-type ionization chamber PTW31015 and diamond detector PTW60019 (0,004 mm^3) were cross calibrated in reference geometry (SSD 100 cm, FS 10 x10 cm^2, depth 10 cm) during the inspections, with each hospital LINAC MV photon quality using the Farmer chamber as a reference instrument. For the Farmer- and PinPoint-chamber the recombination corrections (k_{rec}) were determined for every accelerator photon quality and the beam profile specific chamber volume averaging correction factors (k_{vol}) [2] were determined for every accelerator FFF photon qualities. All dose determination and dose plans were made with SSD 100 cm and in depth of 10 cm in hospitals water phantoms (50 cm x 50 cm x50 cm). Dose plans were calculated for field sizes from 30 x 30 cm^2 to 2 x 2 cm^2. A Farmer-type chamber was used for dose determinations in fields from 5 x 5 cm^2 to 30 x 30 cm^2, PinPoint chamber and diamond detector in fields from 2 x 2 cm^2 to 10 x 10 cm^2.

RESULTS AND DISCUSSION

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Most of the dose plans were in good agreement with doses measured by STUK to be within ±2 %. In one hospital the dose deviation exceeded the STUK acceptance criteria (±3 %) with field sizes 4 x 4 cm^2, 3 x 3 cm^2 and 2 x 2 cm^2 in 6 MV beam and with 2x2 cm^2 field size in 15 MV beam, having max. deviation of 7 % in 6 MV 2x2 cm^2 field. After updating the hospital dose planning system algorithm and the input data the deviation decreased below 4 %. The agreement with doses measured with cross calibrated diamond detector and PinPoint chamber was within 0.5 %, except for 2 x 2 cm^2 field size were the deviations of 1 % were found. The deviation in the calibration factors of cross calibrated diamond detector PTW60019 and ionization chamber PTW31015 in different LINAC beams having the same nominal energy were within ±0.6 %.

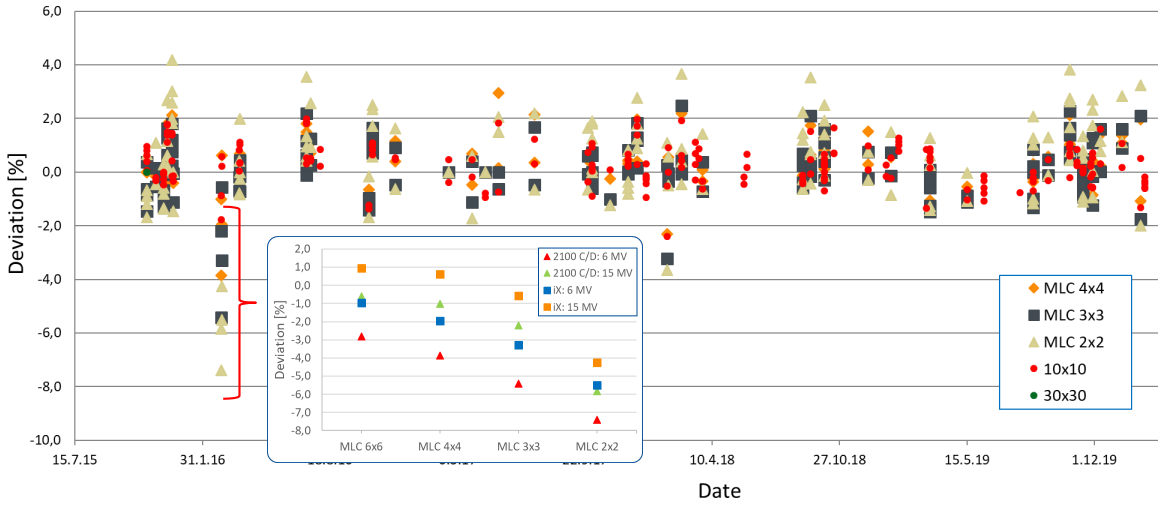

Figure 1. Deviation of TPS-calculated and measured point doses of rectangular treatment fields in LINAC MV photon beams.

CONCLUSIONS

For verification of the input data of a hospital' TPS, the absorbed dose to water measurements in LINAC MV beams with field sizes below 10 x 10 cm^2, has been found to be a useful authority control method. The synthetic diamond detector having high spatial resolution and small energy dependence has been found to be suitable as a cross calibrated detector for small field dosimetry for field sizes down to 2 x 2 cm^2, and the PinPoint ionization chamber PTW31015 for field sizes down to 3 x 3 cm^2.

REFERENCES

[1] IAEA, INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed dose determination in External Beam Radiotherapy. An international code of practice for Dosimetry Based on Standards of Absorbed Dose to Water. Technical Reports Series no. 398, V12, 05 June 2006.

[2] IAEA, INTERNATIONAL ATOMIC ENERGY AGENCY, Dosimetry of Small Static Fields Used in External Beam Radiotherapy. An international code of practice for Reference and Relative Dose Determination. Technical Reports Series no. 483, November 2017.

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MP-AO3 #60 Introduction of the IAEA Electron Beam Dosimetry Audit Service, A. Dimitriadis

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BACKGROUND AND OBJECTIVE

The International Atomic Energy Agency (IAEA) together with the World Health Organization (WHO) have been providing dosimetry audits for radiotherapy facilities primarily in low- and middle-income countries around the world for over 50 years [1]. Until recently, the regular audit service was limited to checking high energy photons. A new electron beam audit service has been tested and soon will be launched as a routine service.

METHODS

The IAEA/WHO audit service employs radiophotoluminescent glass dosimeters (RPLDs) for determining absorbed dose to water. During a photon beam audit, RPLDs are irradiated in reference conditions following TRS-398 using the standard IAEA holder (10 cm depth in water, 10×10 cm^2 field, SSD or SAD geometry). Upon return to the IAEA, the dose (D) is calculated using the following equation:

$$D = M \cdot N \cdot SCF \cdot f_{energy} \cdot f_{holder} \cdot f_{non\text{-}linearity} \cdot f_{fading}$$

Where M is the counts of photoluminescence corrected for readout magazine position, N is the calibration coefficient of the RPLD system, SCF is the sensitivity correction factor for the RPLD used and f are the associated correction factors for the stated subscripts.

The reference depth for electron beams depends on the beam energy, thus a special RPLD holder was developed to allow for a precise dosimeter positioning at any depth. The holder comprises of a 1 cm disk made of PMMA with a mid-plane hollow channel, which has a variable diameter so the RPLD can be tightly positioned in the middle of the disk. The disk can be mounted on top of a Roos or Markus chamber holder using two adapter rings. The audit participants would be expected to perform measurements in a water tank with a calibrated chamber to determine the absorbed dose to water in the electron beam audited, replace the chamber with the RPLD holder, insert RPLDs and irradiate them in the same conditions.

Commissioning tests for the audit methodology were conducted at the IAEA Dosimetry Laboratory using a Varian TrueBeam linac with eight electron beams with energies ranging from 6 MeV to 22 MeV. These tests were performed to evaluate the electron beam specific energy (f_{energy}) and holder correction factors (f_{holder}) for RPLDs. The energy correction factor was measured as the ratio of the RPLD responses in a ^{60}Co beam to each of the other eight electron energies. The holder correction factor was determined as the ratio of a detector's response in water without and with the holder in the same irradiation geometry. The measurements were done using an Exradin W1 plastic scintillation detector and an IBA Razor diode. The experimental setup was established in a PTW MP3 water tank with the detectors positioned at the reference depths for each energy using a 10 × 10 cm^2 applicator, 100 cm SSD. Reference depths were determined using a Roos chamber through PDD curve measurements.

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Additional developments were performed on an organizational level to facilitate the execution of electron beam audits. These included the preparation of instructions, datasheets and database developments. Finally, several blind dose irradiations following the developed methodology were conducted to test it internally, in preparation for a multi-centre pilot study and international service roll out.

RESULTS AND DISCUSSION

The results of the holder and energy correction factor determination are shown in Figure 1. The holder correction factor values are based on the results of 10 measurement sessions per energy for each of the two detectors used and the type A relative standard uncertainty $u_r(f_{holder})$ of the factors measured is 0.1%. The energy correction factor values are based on the response of 20 RPLDs per beam energy and the associated type A $u_r(f_{energy})$ is 0.5%. For the electron beam energies used, the product of the two correction factors described ranges between 1.04 and 1.05, compared to photons where it ranges from 1.01 to 1.04 in the therapeutic energy range. While holder corrections are of comparable magnitude for both modalities, energy corrections are substantially larger for electron beams and do not exhibit a linear dependence like for photon beams.

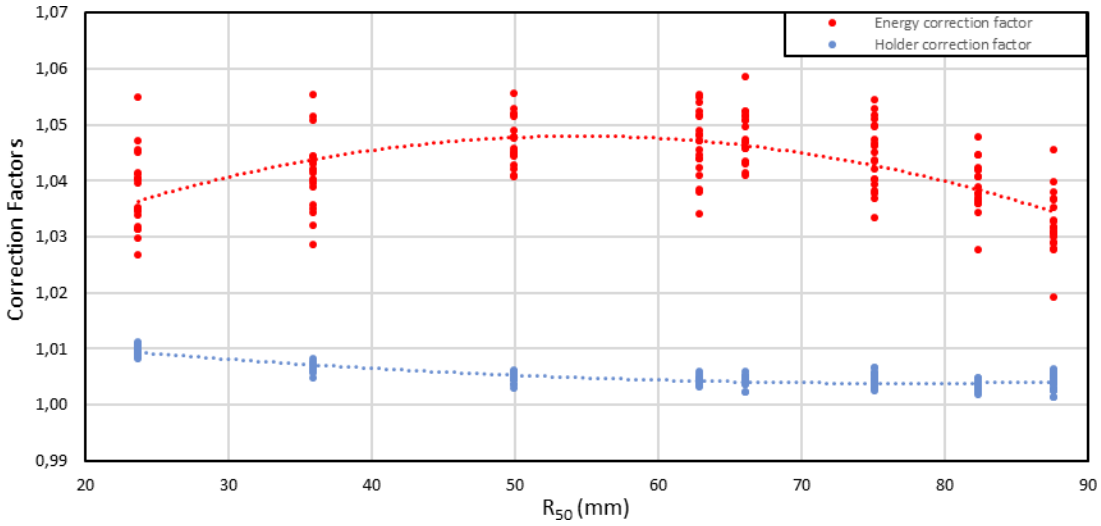

Figure 1. Holder and energy correction factors against electron beam quality (R_{50} in mm).

CONCLUSIONS

A new RPLD holder was developed and the required correction factors specific for electron audits were measured. In combination with the administrative developments described, they will enable the new service for auditing electron beams to be available in 2021, following a multi-centre pilot audit.

REFERENCES

[1] IZEWSKA, J., et al., 50 Years of the IAEA/WHO postal dose audit programme for radiotherapy: what can we learn from 13756 results?. Acta Oncol 59 (2020) 495-502.

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MP-AO4 #282 Following up on radiotherapy dosimetry audit discrepancies (2018-2020): the IAEA experience, G. Azangwe

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BACKGROUND AND OBJECTIVE

The International Atomic Energy Agency (IAEA) has operated a service to validate the calibration of radiotherapy beams through the IAEA/WHO TLD postal dose service since 1969 [1]. The service provides an independent verification (a quality audit) of the dose delivered by radiotherapy treatment machines using thermoluminescent dosimeters (TLDs) (1969-2016) and radiophotoluminescent dosimeters (RPLDs) (2017 onwards). The IAEA is responsible for all the technical aspects of the service with the assistance of PAHO and WHO in distributing the dosimeters in some countries. The IAEA's dosimetry audit services are coordinated with national dosimetry audit networks (DANs) where available, and supported by reference irradiations provided by the Bureau International des Poids et Mesures (BIPM), primary standards dosimetry laboratories and reference institutions. This study aims to analyse the reasons for audit results to be out of tolerance during checks that were performed during the period 2018-2020.

METHODS

Currently, three dosimetry systems are available at the IAEA Dosimetry Laboratory (DOL) for auditing purposes (TLD, OSLD and RPLD systems). The RPLD system is the one that is used for dosimetry audits of radiotherapy beams. The system is customized to include waterproof dosimeter capsules which fit the standard IAEA holder [2]. During a dosimetry audit run, the participating institutes receive a package with dosimeters, irradiation instructions (including a video demonstration for RPLD irradiations), a standard holder [2] and a datasheet. After the irradiation with Co-60 or linac beams (with flattening filter (WFF) or flattening filter free (FFF)), the institutions return the dosimeters and datasheets to the IAEA for evaluation. Once the dosimetrists have been readout, evaluations are generated in an IAEA comprehensive audit database [1], followed by a review by the Audit Officer. Once this first review is completed, certificates are signed and passed on to the Head of the Dosimetry and Medical Radiation Physics (DMRP) section for a second review and final signature. The signed certificates are then dispatched to the participating institutions.

Any results that deviate from accepted criteria of ±5% for radiotherapy hospitals and ±3.5% for SSDL (radiotherapy) are followed up by sending another set. In addition, the provided datasheets are reviewed by a Radiotherapy Physicist from DMRP with support of DOL staff to possibly identify any source of error that might have caused the high dose discrepancy.

RESULTS AND DISCUSSION

During the period 2018-2020, 1970 dosimeter sets were sent to 669 radiotherapy centres in 94 countries. Audited beams were 145 Co-60 and 1825 from linacs (1651 WFF and 174 FFF). The relative number of FFF beams has increased in the last 2 years, whereas the one of Co-60 has decreased. Of the 1970 dosimeter sets, 1893 were within the 5% acceptance criteria, with no significant difference between WFF and FFF beams. Of the 77 beams that were followed up, 22 were rectified resulting in 97% of beam checks being within acceptance criteria after followup. 55 follow up sets are still pending with many of them in the current 2019-2020 cycle (48). Our experience, mainly based on the investigation of the possible sources of error in collaboration with the participating institutions, has shown that that typical reasons for discrepancies were those reported in Table 1.

Table 1. Typical dosimetry issues that were identified during the review of the datasheets.

RPLD setup:	• Wrong RPLD setup • RPLD displacement during the irradiation procedure
Dose calculation:	• Application of the beam output (i.e. cGy/MU or Gy/min) to the wrong depth / confusion between the conditions for beam output specification and measurement • Confusion between SSD and SAD techniques • Confusion between PDD and TPR and their wrong application
Reference dosimetry:	• Errors in the calculation and application of the correction factors, mainly $k_{T,p}$ and k_Q

CONCLUSIONS

The majority of the dosimetry audits follow-up actions have been successful and have supported Member States to improve the quality of radiotherapy services. This has helped improve dosimetry practice over the years with most participating institutions showing good compliance with TRS-398 and other national/international dosimetry protocols (e.g. AAPM TG51, IPEM, DIN 6800-2).

ACKNOWLEDGMENTS and ETHICS CLEARANCE

The authors would like to acknowledge the efforts of previous IAEA DMRP staff for their contributions in dosimetry audits.

REFERENCES

[1] IZEWSKA, J., BOKULIC T., KAZANTSEV P., WESOLOWSKA P., VAN DER MERWE, D. 50 Years of the IAEA/WHO postal dose audit programme for radiotherapy: what can we learn from 13756 results?. Acta Oncologica 59 (2020) 495-502.

[2] HULTQVIST, M., FERNANDEZ-VAREA J.M., IZEWSKA, J. Monte Carlo simulation of correction factors for IAEA TLD holders. Phys. Med. Biol. 55 (2010), N161-6.

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MP-AO5 #17 Medical physics outsourcing in radiotherapy in France: services, practices, limits and points of vigilance, Magali Edouard

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BACKGROUND AND OBJECTIVE
The practice of radiotherapy includes medical physics activities prior to patient treatments (acceptance and commissioning of medical devices), during the care of each patient (dosimetry planning) and concomitantly with clinical activities (quality control). These activities, which guarantee the quality and effectiveness of the treatment delivered to each patient, are partly or totally distinct from clinical activities, temporally and/or materially. Consequently, radiation therapy departments are exploring the possibility of outsourcing some of these activities. In France, medical consulting companies and physicists, who are either independent or employees of medical establishments, offer occasional services for the commissioning of medical devices or the deployment of new techniques, and recently, routine services linked to clinical management and individual patients. Outsourcing could offer equity in access to care, the fact remains that the benefits / risks balance induced by these practices must be assessed.
In this study, the IRSN performed a review of the practices of outsourcing in radiotherapy in France and has evaluated the limits, points of vigilance from the technical, organizational and human points of view to ensure patient safety related to radiation protection issues.
METHODS
This study is based on a survey analysis. Three questionnaires were sent to external service providers identified as working in France, radiation therapy departments and manufacturers. The questionnaires were defined in order to perform a review of the services currently provided for medical physics activities in radiotherapy in France and to collect information on the reasons for outsourcing, the staff involved, interactions between stakeholders, supervision and controls, the responsibilities and stakeholders feedback.
RESULTS AND DISCUSSION
In France, the services provided by the external providers are machine commissioning, clinical implementation of advanced treatments (VMAT, stereotactic treatment or other advanced techniques), clinical “routine” task (quality control, treatment planning, medical physicist support), audit and consulting. The two main reasons for outsourcing a medical physics activity are saving time and providing an expertise. The only long-term activity subject to outsourcing is the quality control of linacs. Other "routine" activities are treatment planning and medical physicist replacement. All these routine activities request local practice knowledge for service providers. To verify qualification and skills of service providers, radiation therapy departments need to differentiate between academic knowledge and competencies, and knowledge coming from training provided by the manufacturers. For local medical physicists, education and training (academic and from manufacturers) remains mandatory in cases of outsourcing.
There is a level of satisfaction in the exchanges between on-site medical physicists and service providers, even if the availability of on-site medical physicists is sometimes not sufficient. Half of the radiation therapy departments found it necessary to interact with the manufacturer for activities such as commissioning.

From external provider's and medical physicists questionnaires, one point of vigilance is about the need of interactions between each other during all the process: providers need a framework to be able to work properly with on-site physicists, transmit the necessary information and provide the necessary skills. These interactions may be insufficient without a framework dedicated to outsourcing, or in case of conflict, for situations in a radiation therapy department willing to outsource activities.
Most of feedbacks from the survey pointed out a blurred responsibility in case of outsourcing due to unclear role and mission definition.
Risk level variability appears depending of the outsourced activities. The most critical points are:

- the difficulties in sharing responsibilities for the activities that are an integral part of patient care such as treatment planning
- the risk of losing local knowledge and know-how in the case of long-term outsourcing
- the difficulties for medical physicists to integrate the work done for short-term intervention such as commissioning
- the risk of non-detection of a systematic error for short-term outsourcing such as commissioning

CONCLUSIONS

There is no specific regulation for radiotherapy outsourcing in France. The service provider's practices are heterogeneous. This IRSN's survey has started to highlight points of vigilance which should be proceed either with regulation or good practice guidance. One of the most important results is the need to anticipate having sufficient and systematic required human resources in radiation therapy departments to supervise, control and integrate outsourced activities. At a national level, a visible, known and shared document that can gather all the identified needs for radiation therapy centres, service providers and manufacturers could be relevant. The perspective of this study is to provide a broad analysis on organizational and human factors regarding the consequences of outsourcing.

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MP-AP Poster Presentations

MP-AP01 #18 Safety in Radiation Oncology (SAFRON) Incident Learning System in the Philippines: Learning through Experience, J. Flores

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BACKGROUND AND OBJECTIVE

SAFRON is a database of error reporting and incident learning system (ILS) on radiotherapy developed by the International Atomic Energy Agency (IAEA) in December 2012. Identifying and analyzing safety-related events is a proven way to enhance the quality of cancer care and radiation delivery. Adapting SAFRON will help to assist our institution in promoting safety culture and to improve patient safety through analysis of incidents and formulate action plans to minimize errors in the future. This study will present a descriptive analysis about the radiotherapy events and near misses in our institution utilizing the SAFRON database.

METHODS

This study utilized SAFRON database of incidents (July 2017 – June 2019) reported by the Department of Radiotherapy, Jose R. Reyes Memorial Medical Center, Manila, Philippines. Data were analyzed based on the following: 1.) who discovered the incidents; 2.) how the incident was discovered; 3.) reachability to patients; 4.) process phase; 5.) clinical severity, 6.) failure of safety barriers. The results were analyzed using descriptive methods.

RESULTS AND DISCUSSION

There were 167 reported incidents to the SAFRON database by our institution, majority of which were reported by radiation therapist (74%). Most of the incidents were discovered during chart checks (81%). More than two-thirds of the incidents occurred during the treatment phase.When based on clinical incident severity, 80% were minor incidents and around 18% were classified as near miss with potential serious consequences.

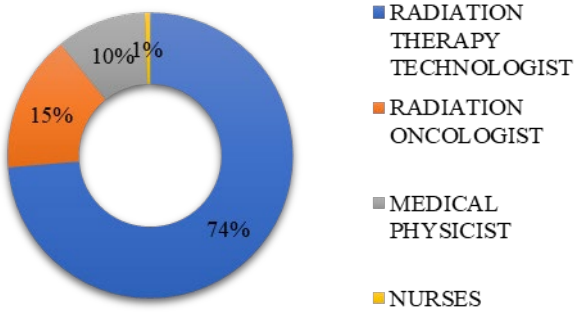


Figure. 1. Distribution of Radiotherapy Staff in Reporting

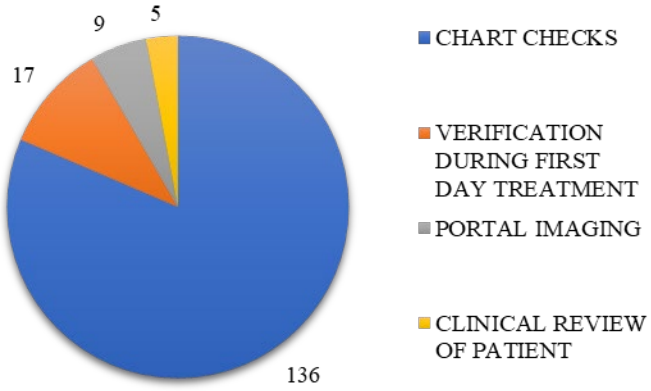
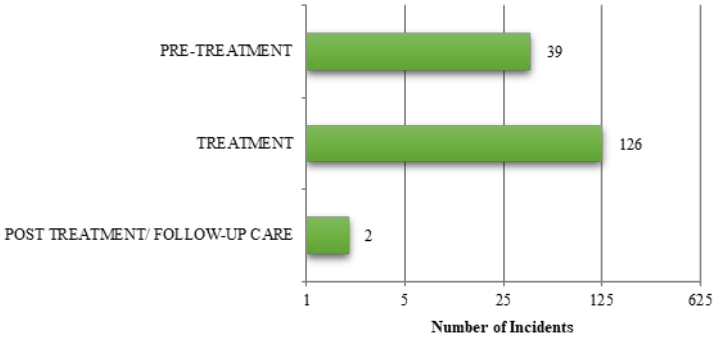


Figure. 2. Distribution of Events by Method of Detection



Figue. 3. Distribution of Events by Process Phase

We further investigated which safety barriers were breached, and these included failure to do time-outs, failure to review treatment plan and inability to do independent confirmation of dose, and absence of record verifying system.

CONCLUSIONS

SAFRON demonstrated that ILS will promote and reinforce the safety and quality of radiotherapy. Our institution's participation with SAFRON has led to increased awareness of safety culture and reporting of treatment errors through regular chart checks and clinical review of treatment plans. This includes the strengthening the identification of errors and near misses especially during the treatment phase, the detection of its clinical severity and transferability to our patients, and the identification of safety barriers which need improvement and modifications.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

The authors would like to thank the staff of the Department of Radiotherapy, Jose R. Reyes Memorial Medical Center, Manila, Philippines. This paper is dedicated to all cancer patients who deserve quality and safe radiotherapy and care.

REFERENCES

[1] British Institute of Radiology, Institute of Physics and Engineering in Medicine (2008). Towards Safer Radiotherapy. Retrieved April 18, 2017, from https://www.ipem.ac.uk/Portals/0/Images/Towards%20Safer%20Radiotherapy.pdf

[2] I.TreatSafely (2016). Retrieved April 18, 2017, from www.itreatsafety.org
[3] IAEA (2007). *Comprehensive Audits of Radiotherapy Practices. A tool for Quality Improvement by Quality Assurance Team for Radiation Oncology*. Vienna: International Atomic Energy Agency.
[4] The American Association of Physicists in Medicine. Retrieved April 8, 2017, from http://spa.aapm.org/
[5] Flores, J. A. S. et.al. Adaptation of the ASTRO Framework for Quality Radiation Oncology and Care on Treatment Error Reporting: A Single Institution Experience on Error Reporting Culture and Factors. Paper submitted at ASTRO 2017 Annual Meeting.
[6] American Society for Therapeutic Radiation Oncology (2012). Safety Is No Accident: A Framework for Quality Radiation Oncology and Care. Retrieved April 8, 2017, from https://www.astro.org/uploadedFiles/_MAIN_SITE/Daily_Practice/Accreditation/Content_Pieces/SafetyisnoAccident.pdf
[7] Radiation Protection for Patients (2013). Safron. Retrieved April 8, 2017, from https://rpop.iaea.org/RPOP/RPoP/Modules/login/safron-faq.pdf

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MP-AP02 #21 Obstacles in Error Reporting System Among Radiotherapy Facilities: Basis for an Enhanced ILS Policy, J. Riparip

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BACKGROUND AND OBJECTIVE

To identify the major obstacles in error reporting and the level of communication of radiotherapy personnel among radiotherapy facilities, in order to promote a better treatment error reporting and to enhance the incident learning system policy of the department.

METHODS

This study conducted a survey of 79 radiotherapy personnel that includes radiation oncologists, medical physicists, radiation therapy technologists, oncology nurses, and administrative staff from selected hospitals with radiotherapy facility. The survey focused on obstacles in error reporting and overall communication of personnel.

RESULTS AND DISCUSSION

Radiotherapy personnel were involved in the study from selected hospitals in Metro Manila, Philippines, and completed the surveys. Data were summarized using descriptive statistics. To determine the level of communication among radiotherapy personnel in terms of personal and interdisciplinary, the Weighted Mean was used. Further, Cramer's V was used to determine the level of association between the demographic profile in terms of profession, years of service, level of education, level of communication of the radiotherapy personnel in terms of personal and interdisciplinary, and the major obstacles to error reporting.

Major obstacles encountered were fear of reprimand with a frequency of 50 and a percentage of 63.3%, poor communication with a frequency of 44 and a percentage of 55.7%, hierarchical structure with a frequency of 35 and a percentage of 44.3%, lack of error reporting with a frequency of 27 and a percentage of 34.2%, and my personality with a frequency of 11 and a percentage of 13.9%.

Oncology nurses perceived the interdisciplinary communications as excellent, with mean rating of 4.61, while other personnel gave a mean rating ranging from 4.28 to 4.45. Radiation oncologists, medical physicists, oncology nurses, and administrative staff have excellent personal communication with a mean rating ranging from 4.50 to 4.63, while radiation therapy technologists gave a good personal communication with a mean rating of 4.42.

The demographics showed a very weak relationship with the interdisciplinary and personal communication of personnel and the major obstacles in reporting errors.

CONCLUSIONS

Radiotherapy personnel identified fear of reprimand, poor communication and hierarchical structure as the major obstacles. The majority of the personnel have good to excellent

communication. The relationship between the demographic profile and the level of communication and the major obstacles in error reporting, showed very weak association.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

We would like to acknowledge Jose R. Reyes Memorial Medical Center, Radiotherapy Department for the support and funding, and the University of Makati for their valuable comments, suggestions, insight and guidance that have made this research project possible.

REFERENCES

[1] CHURCH, J. A., ADAMS, R.D., HENDRIX, L. H., HOLMES, J. A., MARKS, L. B., CHEN, R. C. (2013).National Study to Determinethe Comfort Levels of Radiation Therapist and Dosimetrist. *Practical Radiation Oncology (2013) 3, el65-el70.*

[2] CLARK, B.J., BROWN, R.J., PLOQUIN, J., and DUNSCOMBE, P. (2013). Patient Safety Improvements in Radiation Treatment Through Five Years of Incident Learning. *Pract Radiat Oncol. 2013 Jul-Sep; 3(3): 157-63. DOI10.1016/j.prro.2012.08.001.*

[3] FLORES, J. S., CALAGUAS, M. J., RODRIGUEZ, L. V., GALINGANA, J.J. P., YU, C. C. C., CHIONG, E. L., TAVAS, M.A., RIPARIP, J.B., VALES, D.J.V. (2017). Adaptation Of ASTRO Framework For Quality Radiation Oncology and Care on Error Reporting: A Single Institution Experience on Error Reporting Culture and Factors. *International Journal of Radiation Oncology, Biology, and Physics. E550-3308 (2017).*

[4] RODRIGUEZ, L., FLORES, J., et al. (2017). Rewards and Challenges in Promoting Radiation Treatment Error Reporting Culture-A Single Institution Experience. *IAEA-RPOP (2017).*

[5] SAFETY IS NO ACCIDENT, A FRAMEWORK FOR QUALITY RADIATION ONCOLOGY AND CARE. *American Society for Radiation Oncology (ASTRO), 2012*

[6] RADIOTHERAPY RISK PROFILE, *World Health Organization (WHO) 2008.*

Halperin, E. C., Wazer, D. E., Perez, C. A., Brady, L. W. (2013). *Principles and Practice of Radiation Oncology, (6th ed.).* Wolters Kluwer/Lippincott Williams and Wilkins. Philadelphia, PA 19103USA.

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MP-AP03 #30 Failure Modes and Effects Analysis in Image Guided High-Dose-Rate Brachytherapy: A Single Institutional Study, J Pineda

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BACKGROUND AND OBJECTIVE
Image Guided Brachytherapy (IGBT) in the Philippines is a relatively new approach for delivering brachytherapy. A risk assessment should be conducted to recognize potential hazards, ascertain their causes, and formulate mitigation schemes. The purpose of this paper is to improve current practice by analyzing the potential risk for each step in Image Guided Brachytherapy using the application of Failure Modes and Effects Analysis and create necessary adaptations in the workflow that will provide an efficient and safe environment for patients and staffs.

METHODS
A multispecialty team which includes Radiation Oncology Residents, Medical Physicists, Radiation Therapy Technologists, and Oncology Nurses participated in this activity. Detailed problem lists were created for each IGBT treatment process. The team was able to identify failure modes for each process and score all failure modes using the ten point scale risk priority number (RPN) scoring method, based on the product of severity (S), occurrence (O), and detectability (D) scoring. Scores were ranked and stratified for each of the sub-processes. As already applied in previous FMEA studies in RT, the value RPN = 125 was considered as a threshold below which the risk can be considered acceptable.

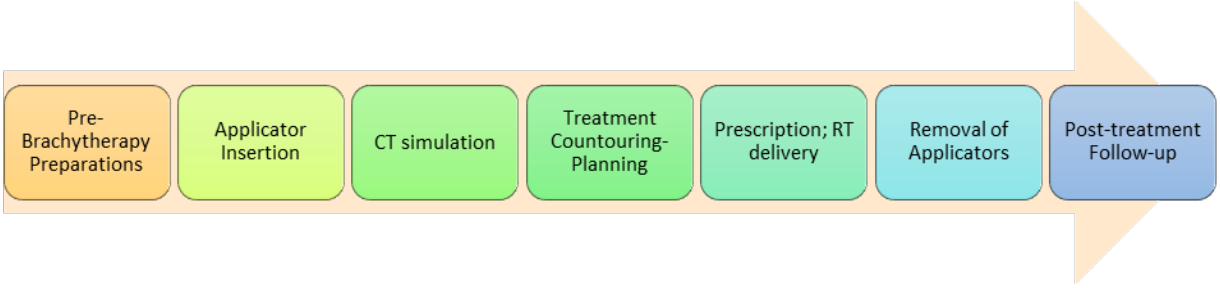

Figure 1. IGBT Treatment Process

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RESULTS AND DISCUSSION

The study was able to generate an average of 12 failure modes per sub-process, namely Patient Evaluation, Pre-Brachytherapy Preparations, CT Simulation, Treatment Contouring, Prescription and Treatment Delivery, Removal of Applicators, and Post-Treatment Follow-up. We stratified each failure mode and will report top 3 for each sub-process.

Table 1. IGBT Problem List & Risk Priority Number

Problem List	S	O	D	RPN	Rank
Patient Evaluation					
Prolonged time-interval	9	9	6	486	1
Delay in scheduling	8	8	2	128	2
Incomplete requirements	9	7	2	126	3
Pre-Brachy Preparations					
Improper sterilization	6	6	8	288	1
Incomplete materials	7	7	4	196	2
Inadequate patient preparation	6	5	5	150	3
Applicator Insertion					
Uterine Perforation	10	4	5	200	1
Blood contaminating open-ended catheter	8	5	4	160	2
CT Simulation					
Improper immobilization	9	8	10	720	1
Incorrect CT sim protocol	9	6	8	432	2
Unavailable CT simulator	10	7	2	140	3
Treatment Contouring and Planning					
Incorrect contour of volumes	9	8	9	648	1
Mislabeling of needles/applicators	8	6	7	336	2
Prolonged treatment planning	8	7	4	224	3
Treatment Delivery					
Emergency preparedness	7	9	7	441	1
Transfer tube near patient skin	5	8	9	360	2
Incomplete dose delivery	9	5	6	270	3
Removal of Applicator					
No radiation survey	8	5	5	200	1
Failure to secure tube caps	9	6	3	162	2
Source stuck-up	9	3	5	135	3
Post Treatment Follow-up					
Insufficient patient instruction	9	8	7	504	1
Lost to follow-up	8	6	4	192	2
Incomplete laboratories	7	5	4	140	3

Legend: S-Severity, O-Occurrence, D-Detectability, RPN-Risk Priority Number

CONCLUSIONS

The application of FMEA from the Patient Evaluation to the Post-treatment Follow-up has led to deeper investigation of various failure modes. Utilizing the ten-point scale in assessing the potential risk for each event permitted stratification of these failure modes in order of importance and the ability to define priorities for future risk mitigation, with the goal of optimizing quality management system. Based on the results obtained in this study and of the experience accrued by the Multispecialty Team, further investigation on safety barriers to promote risk mitigation using Fault Tree Analysis (FTA) are proposed in the near future.

REFERENCES

[1] FREWEN, H. et al. (2018). Failure mode and effects analysis in a paperless radiotherapy department. *Journal of Medical Imaging and Radiation Oncology Volume 62*(5). https://doi.org/10.1111/1754-9485.12762

[2] WADI-RAMAHI, S., MOFTA, B. (2016). Failure modes and effects analysis in image-guided high-dose-rate brachytherapy: Quality control optimization to reduce errors in treatment volume. *Brachytherapy Volume 5*(5) , 669-678

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[3] JOHNSON, J. (2014). Hands-on FMEA. 2014 AAPM Spring Clinical Meeting, Denver, CO

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MP-AP04 #42 Implementation of a comprehensive verification program for 3D High Dose Rate Brachytherapy plans: "QA-Brachy", E. Quineteros

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BACKGROUND AND OBJECTIVE

The objective of this work is to design a pre-treatment software that not only performs an independent dosimetric calculation of the dwell times of the High Dose Rate Brachytherapy (HDR BQT) planner, but also allows the verification of other important parameters involved in the process, such as: patient identification, applicator model, channels and catheters, medical prescription, treatment date and session, among others.

In order to provide safe and quality treatment, it is essential to establish control points in each of the stages of the HDR BQT workflow, to minimize possible errors in the process.

METHODS

After the first year of experience with the HDR BQT 3D service using Flexitron (Elekta) as the treatment unit and the source of Co-60, the need to establish control points to avoid possible errors that could slow down the workflow and, above all, to increase security in the delivery of the treatment has become evident.

A program was designed in the numerical computer system MATLAB, in which fundamental data from the treatment plan were imported from the planner Oncentra Brachy (Elekta) in csv (comma-separated values) format and a template created in Excel in xlsx format. It performs the independent dosimetric calculation using the formalism defined by the TG-43 of the AAPM. In addition, it executes various controls on the administrative information of the plan concerning the above-mentioned parameters, which automatically detects if the user has omitted or made any error in the information management process in the planner.

Once all the parameters have been checked, the program will indicate the results and will allow the incorporation of the Dose Volume Histogram (DVH) extracted from the planner in txt format. Once the information has been processed, it will automatically return the structured report with a level 3 approach according to the recommendations of ICRU 89, in pdf format.

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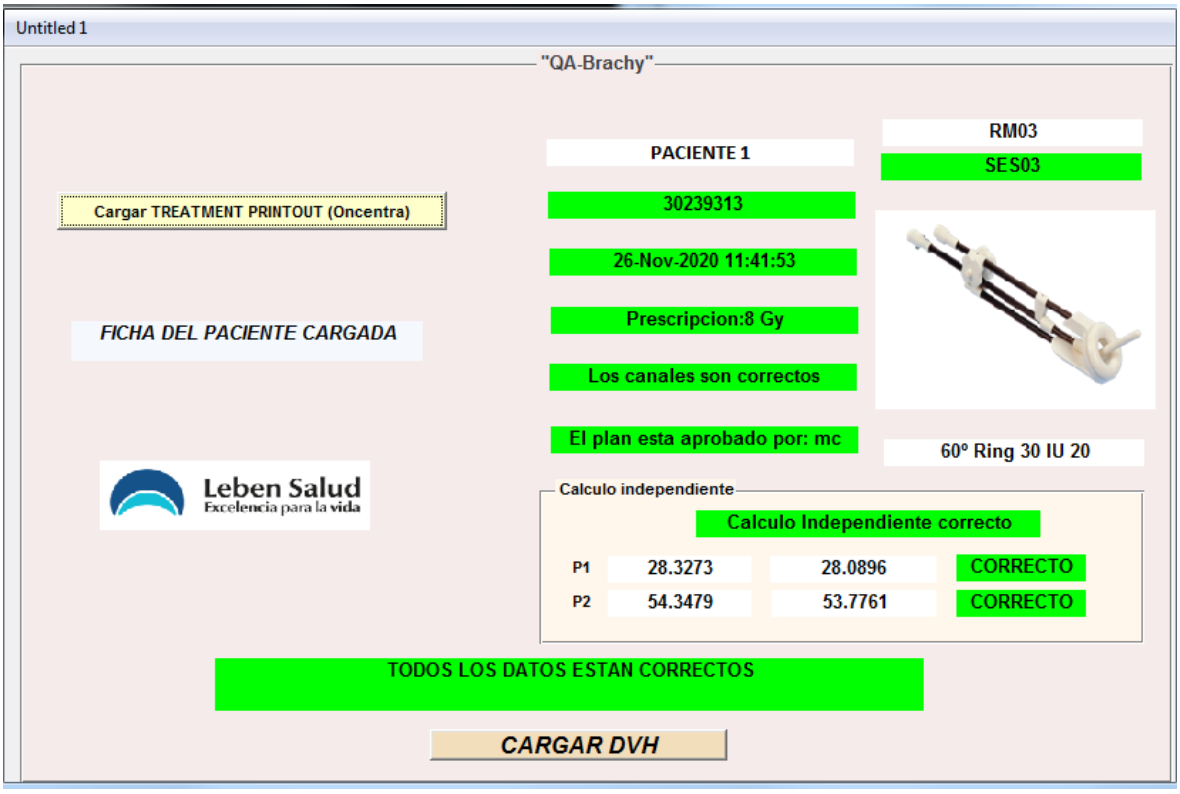

Figure 1. Graphical interface of the program "QA-Brachy".

RESULTS AND DISCUSSION

The program is used in the Brachytherapy clinic, and is performed with each patient before applying the treatment.

The impact of using the program was evident in the speed of detection of human errors during treatment planning that can impact the patient, not only in dose delivery but also in terms of pre-treatment times. It is a simple and intuitive tool, which allows faster data processing and automatic reporting per treatment session.

CONCLUSIONS

- The automation of the comprehensive treatment verification by means of software is a guarantee of safety for the patient.
- The incorporation of "QA-Brachy" reduces time and provides security to the patient, when verifying all the control points in the stages of the workflow.
- In addition, the program, by avoiding errors and reducing time, allows redirecting all efforts in the process of optimizing the workflow, allowing for continuous improvement.

REFERENCES

[1] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Prescribing, Recording and Reporting Brachytherapy for Cancer of the Cervix. Report No. 89. Oxford University Press. GEC-ESTRO. (2016)

← Back To Table of Contents

[2] Update of AAPM Task Group No. 43 Report: A revised AAPM protocol for brachytherapy dose calculations. Med. Phys. 31 (3). (2004)

[3] Report of the Brachytherapy Working Group of the Spanish Society of Medical Physics. Magnetic Resonance based planning in cervix gynecological brachytherapy, practical aspects. Spanish Society of Medical Physics Brachytherapy Task Group Report. Scientific article. Spain (2018)

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MP-AP05 #62 ANALYSIS OF THE FRICKE-PMMA INTERACTION AND ITS EFFECTS IN FRICKE DOSIMETRY, A. Pickler

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BACKGROUND AND OBJECTIVE

Fricke dosimeter is a chemical dosimeter based on the oxidation of ferrous ions (Fe^{2+}) to ferric ions (Fe^{3+}) present in the solution by the interaction of ionizing radiation. The Fricke dosimeter is 96% water by weight; therefore, its dosimetric properties are very similar to those of water. This dosimeter is used in a dose range of 5 to 400 Gy and for dose rates of up to 106 Gy/s. Due to its properties, the dosimetry using Fricke solution has been shown to be an effective method to overcome clinical and laboratory difficulties of dosimetry, which had previously required the use of ionization chambers. The Radiological Science Laboratory (LCR/UERJ) has been implementing the Fricke dosimeter in different areas in order to compare and improve dosimetry in institutions around Brazil.

High dose rate brachytherapy (HDR-BT) is a non-permanent type of brachytherapy in which a high activity source is placed near the tumor for treatment. HDR ^{192}Ir is the most common source used in clinical practice due to its high specific activity, small dimensions and desirable mean photon energy of around 380 keV. One of the challenges associated with the use of ^{192}Ir sources is related to how one can measure it in an absolute way. The bare source emission spectrum is complex as there is an additional scatter contribution of the source encapsulation as well as other smaller scatter effects, which makes modeling of its dosimetry difficult.

The National Research Council Canada (NRC) in Ottawa, Canada, and the LCR, Brazil, have studied the use of Fricke dosimetry as a possible method to obtain a primary standard of the absorbed dose to water for ^{192}Ir sources. Though there are some differences in the approach taken by each group, including preparation of the Fricke solution, the irradiation geometry (specifically the holder for the solution) and the Monte Carlo code used to derive the necessary correction factors, the results were in fairly close agreement. To minimize the differences, the LCR has redesigned its PMMA IAEA- XXXX holder to match the geometry of the NRC holder. The design of the new LCR holder allows the dose to be measured at 1 cm from the centre of the source, which is the distance recommended by the AAPM TG 43 protocol.
The chemical oxidation of Fe^{2+} to Fe^{3+} in Fricke solution can occur even without the presence of the ionizing radiation. This reaction also occurs, in a lower scale, due to the presence of oxygen, light or with direct contact with any material. The new holder is smaller, contains approximately 2 cm^3 of Fricke solution, which leads to a higher surface/volume ratio, compared to the previous holder.

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METHODS

The aim of this paper, therefore, was to study the possible interactions of the PMMA holder and its effects on the Fricke solution over time, and the reliability of using the PMMA holder without affecting the end results or the dosimetry measurements. In order to evaluate possible effects due to the interaction of the Fricke solution with the PMMA, the optical density (or ABS) of the Fricke solution was measured after exposed to the PMMA holder for different periods of time. The new PMMA holder was carefully filled with Fricke solution to avoid any air bubbles inside the vessel for each measurement. The ABS readings were performed at 1, 2, 4, 24, 48 and 96 hours after the PMMA vessel was filled. The vessel was kept filled with Fricke solution during the period in which there were no readings and the solution inside the vessel was changed for a new one in each reading. This procedure was repeated at least five times for each period over approximately three months.

RESULTS AND DISCUSSION

The results showed that there is a considerable interaction between the PMMA vessel and the Fricke solution. This interaction causes a significant increase in the absorbance measurements of the Fricke solution over time by 3.4% in the first hour and 25.8% in 96 hours of Fricke-PMMA contact. In fact, these interactions between the PMMA and Fricke solution can result in a wrong dose measurement when using the Fricke dosimeter. However, in this work, it was verified that the PMMA holder adapts to the acid solution and the reaction is stabilized in about 3 months of continuous use. After the reaction was stabilized, the behaviour of the vessel during Fricke solution irradiation was tested. The repeatability test showed that 89% of the absorbed doses to Fricke measurements were within one standard deviation. It is important to note that after the period of adaptation of the holder, the uncertainty contribution to the results is less than 3%, ranging from 2.4% to 2.8% during the periods tested. Taking into account the period required for the reaction stabilization, the authors suggest a period of adaptation, greater than 3 months, before using a PMMA vessel for Fricke dosimetry.

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MP-AP06 #135 Comparison of monitor units and dose calculation between two independent second-check verification software, M. Castrillon

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BACKGROUND
The independent calculation software is designed to verify the calculations of monitor units (MU) and doses computed in a treatment planning system (TPS). The independent calculation is important within the quality assurance process of the treatment plans that will be delivered to the patients, since the configuration data may be incorrect in the TPS, leading to incorrect MU and dose calculations. It is recommended that this process be carried out before starting the first treatment session, together with other quality control procedures, such as: dose measurements with ionization chamber, dose distribution with detector arrays, in vivo dosimetry, etc., thus guaranteeing that the delivered dose is within the recommended range of ±5% [1-3].
METHODS
In this work, two commercial software for independent calculation of MU and dose are compared, MuCheck v.8.4.0 (*Oncology Data Systems*) and RadCalc v.7.1 (*LifeLine Software*), using 3D conformal and IMRT treatment plans calculated in Eclipse v.11.0 (*Varian Medical Systems*) treatment planning system (TPS) with AAA algorithm, which were delivered with an Oncor Impression Plus linear accelerator (*Siemens Healthineers*). IMRT plans were isocentric with 6MV photons and step&shoot mode. Conformal plans were isocentric, except in some breast plans that were non-isocentric in which a calculation point to evaluate MU and dose were created, using 6 and 18MV photons and virtual wedge of multiple angles. Seventy treatment plans of different anatomical locations were compared, including pelvis (whole pelvis, cervix, prostate and rectum): 12, lung: 6, head & neck: 6, whole brain: 3, mediastinum: 3, esophagus: 2, spine metastases: 1, IMRT plans and breast: 21, spine metastases: 9, whole pelvis: 3, soft tissue: 2, breastbone: 1, eye orbit: 1, 3D conformal plans. Two hundred fifty-two IMRT fields and one hundred sixty-eight 3D conformal fields were analyzed. To perform the dose and MU calculation, both software require a calculation point that is located in the isocenter for isocentric plans, and for non-isocentric plans, it coincides with the calculation or normalization point.
RESULTS
Figure 1a shows the percentage deviations of the MU calculation performed by both software with respect to that calculated by TPS for all fields analyzed. For the MU independent calculation performed with RadCalc software: 33% of the calculated fields are within ±1% of deviation, around 80% between ±3%, 99% between ±5% and 1% greater than ±5% when compared with the calculation made by TPS. For the MU calculation with MuCheck software: 25% of the calculated fields are between ±1% deviation, around 60% between ±3%, 85% between ± 5% and almost 15% greater than ±5% when compared with the calculation made by TPS. Figure 1b shows the percentage deviations of the dose calculation performed by both software with respect to that calculated by TPS for all plans analyzed. For the independent dose calculation performed with RadCalc software: 45% of the calculated plans are within ±1% of

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deviation, around 95% between ±3% and the total of the analyzed plans between ±5% when compared with the calculation performed by TPS. For the dose calculation with MuCheck software: 33% of the calculated plans are between ±1% deviation, around 85% between ±3%, 95% between ±5% and 4% greater than ±5 % when compared with the calculation made by TPS.

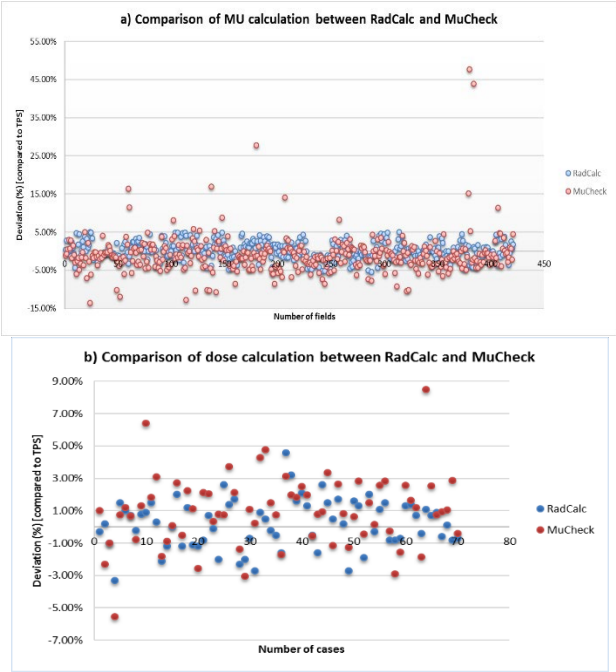

Figure 1. Comparison of a) MU and b) dose calculation between RadCalc and MuCheck with respect to TPS.

The anatomical locations that present the most differences greater than ± 5% in MU calculation are pelvis and head & neck for IMRT plans, and breast for conformal 3D plans calculated with both software using a single normalization point. However, the fields calculated with RadCalc software that do not meet this uncertainty limit only achieve ± 6% deviation in the MU calculation, while MU calculation deviation in the performed with MuCheck software for some fields reaches up to 40%. In the case of doses calculation, only MuCheck software presents differences greater than ± 5% in three treatment plans.

CONCLUSIONS

It is important to know how software works, whether commercial or in-house, calculate MU and doses and what is the uncertainty regarding the TPS, in addition to complementing it with other quality controls, such as those mentioned above, according to the expected deviations.

ACKNOWLEDGMENTS

We especially thank to *LifeLine Software* and *Biomundo Chile* companies for the opportunity to loan RadCalc software for testing.

REFERENCES

[1] STERN, R.L., et al., Verification of monitor unit calculations for non-IMRT clinical radiotherapy: Report of AAPM Task Group 114, Med Phys 38 (2011) 504-530.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Lessons learnt from Accidental Exposures in Radiotherapy, Safety Reports Series 17 (2000).

[3] RAVICHANDRAN, R., et al., Need of patient specific quality assurance and pre-treatment verification program for special plans in radiotherapy. J Med Phys 36 (2011) 181–183.

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MP-AP07 #143 Optimising Learning from a National Incident Learning System in Radiotherapy The UK Experience, Ú. Findlay

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BACKGROUND AND OBJECTIVE

The Incident Learning System (ILS) informs Safer Radiotherapy publications[1], written for professionals to mitigate radiotherapy incidents. PHE clinical staff work with National Health Service Improvement, medical societies, radiotherapy institutions and patient representatives to achieve this. The ILS is well established with participation of public radiotherapy institutions at 100% and regular publication of analysis and shared learning. However, some incident trends persist, and further work is required to minimise the probability of these incidents.

METHODS

Taxonomies used for analyses are nationally agreed upon in Towards Safer Radiotherapy[2] and Development of Learning from Radiotherapy Errors[1]. They include a description of the incident, incident severity, failed and effective safety barriers, and causative factors.
Most of the effort associated with ILS was focused on data collection, QA, analysis and publication. These were streamlined and automated where possible to create capacity to focus on development of learning from incidents.
Three key areas for development were identified: development of case studies of significant incidents; data linkage with other datasets; use of incident data to inform studies of risk and adoption of learning from excellence principles.

RESULTS AND DISCUSSION

Following a review of persistent incident trends, peer reviewed case studies of significant incidents were introduced in the Safer Radiotherapy Triannual Analysis[1]. These included a detailed synopsis of the incident, identification of root cause, contributory factors effective and failed safety barriers. Recommendations for remedial and corrective actions and shared Learning from Excellence were also included. These case studies are now included as a regular feature of the Safer Radiotherapy Triannual Analyisis[1].

Incident data was linked with the Radiotherapy Dataset[3], which measures activity including number of patient attendances and radiotherapy prescriptions. Aggregate activity data was used to estimate reported error rates.

An estimated reported incident rate of 4 per 1,000 attendances or 45 per 1,000 prescriptions was calculated. This was estimated at 0.4 per 1,000 prescriptions for incidents notifiable to the relevant reporting authority. Estimated reported rates are now included in Safer Radiotherapy Triannual Analyisis[1].

Incident analysis was used to inform a study of risk in thematic areas identified as part of incident trend analysis. This has been completed for brachytherapy associated incidents

(November 2020) and for the 'unseen pathway', which includes incidents associated with infrastructure, room design, new equipment, routine machine QA, mould room activities and equipment malfunction (February 2021).

A simple risk matrix approach is used which identifies specific area of risks with initial scoring of consequence and likelihood applied and associated mitigations identified in incident reports and through Learning from Excellence. A study of the risk will now be incorporated into the case studies included in the Safer Radiotherapy Triannual Analyisis[1].

Reported error rates and trends will be monitored to measure the efficacy of these measures to address persistent error trends.

CONCLUSIONS

Radiotherapy is ever evolving; the safety of existing and new techniques and technologies can be monitored using an incident learning system. However, incident learning systems need to evolve to maximise learning opportunities so incidents can be effectively mitigated.

ACKNOWLEDGMENTS and ETHICS CLEARANCE

This work in undertaken in association with NHS England and Improvement, Institute of Physics & Engineering in Medicine, Royal College of Radiologists, Society and College of Radiographers, & UK NHS Radiotherapy providers and service users.

REFERENCES

[1] https://www.gov.uk/government/collections/medical-radiation-uses-dose-measurements-and-safety-advice#radiotherapy
[2] https://www.rcr.ac.uk/publication/towards-safer-radiotherapy
[3] https://www.cancerdata.nhs.uk/

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Refresher Courses

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Multimodality imaging and deformable image registration

Vincenzo Valentini
Gemelli, Universita Catolica del Sacro Cuore

Deformable image registration (DIR) plays today a relevant role in the modern Radiotherapy (RT), as it allows to combine digital images acquired with different imaging modalities containing complementary information, such as Computed Tomography, Magnetic Resonance Imaging and Positron Emission Tomography.
In this first part of the lecture the physical principles of a DIR algorithm will be introduced and the main steps characterising the DIR process (image pre-processing, deformation and quality assurance) will be explained in detail.
In the second part of the presentation, the most common fields of application of the DIR in RT (target delineation, contour propagation, electron density map generation and dose accumulation) will be presented and properly discussed, considering the challenges and opportunities of each application.

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Automated target volume / organs at risk delineation and treatment planning

Vincent Gregoire
Centre du Lutte Contre Le Cancer, Centre Léon Bérard

This lecture will emphasize on evidences validating homogeneous and automated target volumes & organs at risk delineation for a better patient outcome.

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Management of interfraction motion (IGRT, Adaptive RT)

X. Allen Li
Medical College of Wisconsin

During the multi-fraction radiation therapy (RT) delivery process, the location, shape, and size of tumors and/or organs at risk change significantly on a daily basis. These large variations among treatment sessions, commonly referred to as interfraction variations, have hindered the effectiveness of RT. Image-guided RT (IGRT) has been introduced to address interfraction variations and has become the standard of care. However, IGRT can only address translational errors and, therefore, cannot fully account for all interfraction changes. To overcome this problem, research groups including us have introduced adaptive RT (ART), which offers both offline and online schemes. online ART is the most effective solution that can fully address interfraction variations. With the recent introduction of MRI guided ART, online ART is being practiced in the clinic. This presentation will provide an overview of these developments.

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Advanced Technologies: Beyond 3D

Advances in Dose Delivery Systems

Saiful Huq
Department of Radiation Oncology, University of Pittsburgh School of Medicine and UPMC Hillman Cancer Center
Pittsburgh, Pennsylvania

In recent years there have been many publications in the literature that suggest that novel technologies and treatment techniques combined with molecular imaging and/or immunotherapy may change the radiotherapy paradigm and open a new frontier for the treatment of localized and metastatic disease. For example, there is considerable literature that shows that stereotactic body radiotherapy (SBRT) has become the standard of care for medically inoperable early stage non-small cell lung cancer (NSCLC). For oligometastatic disease, various phase II clinical trials show that the addition of SBRT or surgery to all metastatic sites is associated with better overall survival and progression- free survival. Novel technologies such as MRI linac, Ethos, Flash therapy and biology guided radiotherapy have the potential to revolutionize the field of external beam radiotherapy. This presentation will provide a brief overview on how some of the advanced radiotherapy technologies work and their potential impact on clinical outcome.

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Current Status of RTT Education

Michelle Leech
Discipline of Radiation Therapy, Trinity College Dublin, Ireland

This presentation reviews the current status of the education of Radiation Therapists (RTTs) internationally. Even within regional areas, there is wide variation in the role, responsibilities and scope of practice of RTTs. The presentation will focus on the challenges of implementing both entry level and advanced curricula for RTTs internationally. Such curricula are already in existence but their routine implementation is overall lacking. Challenges faced in the implementation of entry level curricula include role recognition, support from Ministries of Health and Education and third level institutions. At advanced education level, support from government and availability of suitable educational programmes remain a challenge together with the development of a suitable career structure for RTT advancement.

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The advancing and changing role of the RTT

Aidan Leong
University of Otago, New Zealand

Despite the diversity in RTT responsibilities internationally, there are shared challenges in the constant evolution of technology that underpins so much of RTT practice. As the technical complexity of radiation therapy continues to increase, it is important to consider the drivers behind this, and whether this has fundamentally changed our role as RTTs. RTTs are key not only to the utilisation of advanced technology, but as educators and innovators in its application to the clinical workplace. Alongside this, advanced practice roles represent an important pathway of RTT progression beyond their traditional scope of practice. Such roles are of urgent relevance in the context of the global cancer burden and growing shortages in the oncologist workforce.

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Where are we going? Future Directions for the RTT profession

Mary Coffey
Discipline of Radiation Therapy, School of Medicine, Trinity Centre for Health Sciences, St. James's Hospital,

The RTT is one of the key members of the radiotherapy team. Together with the radiation oncologist and physicist they ensure that safe and accurate treatment is delivered to all patients. The RTT is ultimately responsible for the correct interpretation and application of the treatment prescription and plan. Radiotherapy is changing and evolving with technological developments and technical innovation. The RTT can use their knowledge and skills to introduce new technologies based on their unique hand-on experience with the equipment used to prepare and deliver treatment. They can take additional responsibility for daily patient care and support and in the overall management of the RTT staff and the wider radiotherapy department structure. As members of the radiotherapy team they can contribute to the future successful development and implementation of new innovations in radiotherapy.

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Challenges in Expanding Access to Radiotherapy

Surbhi Grover
Hospital of University of Pennsylvania
Department of Radiation Oncology

In this presentation, challenges associated with delivery of radiation therapy in LMICs will discussed specifically in sub-Saharan Africa. Challenges will be discussed in the context of larger oncology care in a low-resource setting. In addition, several examples of potential solutions that are being tried and worked on in specific settings (Botswana) will be discussed.

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Translating incidence into needs

Michael Barton
University of New South Wales, Sydney

Summary

There will be 24 million new cases of cancer annually by 2040 globally. An understanding of the size of the demand for radiotherapy for a population is needed to assess the adequacy of existing services and to estimate future requirements. The numbers and types of cancers vary considerably from country to country as does the distribution of stages at presentation due to differences in risk factors and the availability of diagnostics resources and screening programs.

Various methods can be used to estimate the number of people who will need radiotherapy range from expert opinion through to complex modelling techniques including evidence-based approaches, Monte Carlo techniques and benchmarking in well-resourced settings. Ideally a model should be evidence-based, have transparent assumptions and be readily adaptable to different populations.

Model results can be used to calculate the staff and equipment required based on assumptions about throughput. Local control, survival benefits and costs can also be derived.

Comparisons of all models with the actual supply of radiotherapy shows that there is a shortfall in most countries.

Useful references

[1] Clinical Oncology Special Issue: Evidence Based Demand for Cancer Therapy 27(2): 67-132(February 2015) https://www.sciencedirect.com/journal/clinical-oncology/vol/27/issue/2

[2] Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, Hanna TP , Knaul FM, Lievens Y, Lui TYM, Milosevic M, O'Sullivan B, Rodin DL, Rosenblatt E, Van Dyk J, Yap ML, Zubizarreta E, Gospodarowicz M. Expanding global access to radiotherapy. Lancet Oncol 2015; 16:1153-86

[3] MB Barton, S Jacob, J Shafiq, K Wong, SR Thompson, T Hanna, G Delaney. Estimating the demand for radiotherapy from the evidence: a review of changes from 2003 to 2012. Radiotherapy and Oncology 112 (2014) 140-144Malthus

[4] T Hanna, J Shafiq, GP Delaney, SK Vinod, SR Thompson, MB Barton. The Population Benefit of Evidence-based Radiotherapy: 5-year Local Control and Overall Survival Benefits. Radiotherapy and Oncology 2018 Feb, 126(2):191-197

Wong, Karen, Geoff P. Delaney, and Michael B. Barton. "Estimation of the optimal number of radiotherapy fractions for breast cancer: A review of the evidence." Radiotherapy and Oncology 116.2 (2015):174-178.

[5] Round C, Mee T, Kirkby NF, Cooper T, Williams MV, Jena R. The Malthus Programme: developing radiotherapy demand models for breast and prostate cancer at the local, regional and national level. Clin Oncol (R Coll Radiol). 2013 Sep;25(9):538-45. doi: 10.1016/j.clon.2013.05.006. Epub 2013 Jun 19. PubMed PMID:23791157.

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[6] Barbera L, Zhang-Salomons J, Huang J, Tyldesley S, Mackillop W. Defining the need for radiotherapy for lung cancer in the general population: a criterion-based, benchmarking approach. Med Care. 2003 Sep;41(9):1074-85. PubMed PMID: 12972847.
[7] M Barton, GS Gabriel, G Delaney. Testing criterion-based benchmarking for the appropriate use of radiotherapy. Radiotherapy and Oncology Radiotherapy and Oncology Radiotherapy and Oncology 128 (2018):406-410.

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Delivering Paediatric Radiotherapy within Multidisciplinary team care

Karen Marcus
Harvard Medical School, USA

When a child presents with evidence of cancer, there needs to be prompt participation from paediatric oncology, diagnostic radiology, surgery, and pathology. As radiation oncologists, we too, need to become involved early in the process. We participate in multidisciplinary tumor boards to determine the management and timing of interventions and treatment. As radiation oncologist we decide when radiotherapy is indicated. Many children will also receive chemotherapy during the course of radiotherapy, emphasizing the need for collaborative multidisciplinary care. After completion of cancer treatment, follow-up for recurrence and monitoring late effects continues by paediatric oncology, radiation oncology and other specialists as indicated. The radiation oncologist is part of the multidisciplinary care team in childhood cancer treatment and survivorship.

Radiotherapy plays a key role in the cure of many childhood cancers but can also provide excellent palliation when cure is no longer possible.

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Updates in Paediatric Radiation Oncology: CNS Tumours

Sahaja Acharya
St. Jude Children's Research Hospital, USA

This talk provides a review of paediatric CNS tumours from a radiation oncology perspective. The objectives of the talk are to: (1) provide an overview of the multidisciplinary management of paediatric CNS tumours, and (2) to highlight challenges in contouring and planning paediatric CNS tumours. The following tumours are included: ependymoma, medulloblastoma, low-grade glioma and germinoma. Case presentations and contouring examples of each are provided.

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Refresher Course

Paediatric Radiation Oncology

Updates in Paediatric Radiation Oncology - Non-CNS Tumours

Susan Hiniker
Stanford University Medical Center, USA

This presentation serves as a refresher and updates for two of the most common pediatric non-CNS tumors treated with radiotherapy: rhabdomyosarcoma and Ewing sarcoma. In rhabdomyosarcoma, we focus on a review of staging, workup, and timing of local therapy, in addition to radiation therapy volumes and current issues of local control as well as the currently enrolling Children's Oncology Group (COG) intermediate-risk study ARST1431. In Ewing sarcoma, we review epidemiology and prognostic factors, workup, value of PET scan, and selection of appropriate local control therapy. We further discuss the most recent COG nonmetastatic and metastatic studies for Ewing sarcoma, as well as radiation therapy guidelines and preliminary results.

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Management of late effects and follow up of the child into adulthood

Stephanie Perkins
Washington University School of Medicine in St. Louis

With modern therapies, over 80% of pediatric cancer patients will become long-term survivors of their disease. However, it is known that these patients are at high risk of secondary cancers, chronic medical health conditions, as well as neurological and psychological issues following therapy. Many of these patients would benefit from specialized follow-up care that recognizes the unique monitoring and care for pediatric cancer survivors. Fortunately, survivorship clinics are increasing in availability and helpful resources for management of this challenging patient population are available.

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Planning Quality Radiotherapy Services: A City Approach - the C/Can model

Diogo Neves
City Cancer Challenge Foundation

Launched by the Union of International Cancer Control in 2017 at the World Economic Forum, City Cancer Challenge (C/Can) responds to the call to translate the NCD targets of the sustainable development goals into concrete action at the local level. C/Can proposes a model of working with cities in a multisectoral way and involving multi-governmental levels (local, regional, and national), civil society and the private sector. Cities contain a pool of expertise, services and technology for cancer care and are a good start point to test service delivery models and ensure the health system functions as a network to produce the best health benefits possible in a particular population. In this talk, the progress and the lessons gathered by C/Can since its launch will be explored, with an emphasis on planning radiotherapy services through a stepwise participatory and consensus-building process towards policy adoption and improvement of access to quality cancer care.

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Demand and supply analysis: a city framework

Rodolfo Alfonso
University of La Habana

The purpose of the presentation is to propose a methodology for guiding a City´s Radiotherapy Expert Team in designing a Radiotherapy Development Plan (RDP), in the framework of a C/Can Initiative.
The main components of the RDP are examined; the required baseline information and the recommended benchmarks for equipment and staff requirement are discussed and tools for estimating their demand are proposed.
For the implementation phase, a stepwise approach in the form of intervention packages is suggested, from the most urgent needs and the available resources, to a level of completeness that reduce gaps in accessibility and ensure coming near to recommended international standards.

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Medical Physics Issues in Proton Therapy: Changing from 2 phases to single phase simultaneous integrated boost (to better use the optimiser) and use of EUD for plan assessment

Matthew Clarke, Gillian Whitfield and Neil Burnet
The Christie PBT Centre, University of Manchester

his work considers the use of a single-phase SIB approach to the planning of proton beam therapy treatments for adult base of skull (BoS) chordoma and chondrosarcoma patients. The proximity of BoS tumours to critical organs at risk (OAR) makes it challenging to create a treatment plan that delivers a curative dose (73.8Gy or 70.2Gy) to the target volume. Traditional planning approaches use 2 sequential phases but combining 2 separate plans makes it difficult to optimise the steep dose gradients that are required to create optimal plans. An SIB approach allows the optimiser to generate a sharp dose fall-off close to OARs to maximise the dose to the target. The equivalent uniform dose (EUD) is used to represent the inhomogeneous dose distribution as a single parameter and SIB plans show an increased EUD compared to the 2 phase approach which we have estimated could lead to an improvement in tumour control probability (TCP) by up to 5%

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The patient-centred Proton Beam Therapy pathway

Vicky Hughes
The Christie NHS Foundation Trust

The Christie NHS Trust Manchester is the first NHS provider of proton bean therapy in the UK. During development of this service it was extremely important to have the patients at the heart of everything we do. Proton Beam therapy has many technical complexities but also complexities from a patient pathway perspective. This presentation is going to illustrate the patient's journey in the proton service in Manchester from the referral anddecision process through to treatment completion. At every step of the way careful consideration has been given to the patients care and wellbeing throughout their proton journey.

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Image Guidance in proton therapy

Katja Langen
Emory University, Proton Therapy Center,

In proton therapy rooms the standard image guidance in-room technology is x-ray based. Newer treatment rooms are equipped with cone beam CT capabilities.
QA systems to test treatment and imaging isocenter alignment can be film based but two commercial devices exist to facilitate this test.
Proton ranges are based on the water equivalent densities as presented on the planning CT. Any differences in the water equivalent thickness at time of treatment can change the shape of the dose distribution. This makes it, at times, difficult to evaluate the optimal patient alignment. This is fundamentally different from photon therapy, where a geographic alignment of the target is sufficient.
In the future, fast and accurate dose calculation methods in CBCT should be developed to facilitate optimal patient alignment in proton therapy.

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FLASH proton therapy?

Jack Aylward
University of Manchester

The FLASH effect is a normal tissue sparing induced by ultra-high dose rate irradiation. This effect has the potential to create a step change in the therapeutic ratio, however the exact parameters which induce normal tissue sparing are unknown. Protons are an excellent modality for the clinical translation of FLASH due to the dept of penetration and the availability of ultra-high dose rate sources already in clinical use. The FLASH effect will be introduced in this talk, and considerations for clinical translation of proton FLASH will be discussed.

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Global health competencies in radiation oncology education

Meredith Giuliani
Princess Margaret Cancer Centre - University Health Network

Global health provides a framework to address issues such as inequities in health, cultural competency, globalization of health care, and social and environmental determinants of health crucial to modern medical education. Despite growing interest from trainees in radiation oncology to engage in global health training and the clear morale mandate to better align training priorities with the needs of patients, families and the health system current training in global health in radiation oncology is inadequate. This talk explores the mandate to integrate global health training into core radiation oncology training, how educational networks are essential to realizing these curricular changes and finally the need to critically reflect on power and representation in curricular design and delivery.

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Integrating radiation oncology education and research

Miriam Mutebi
Aga Khan University, Kenya

Using breast cancer therapy as a paradigm this talk explores various innovations, strategies and considerations to have while thinking about strategic approaches to disseminating education around radiation oncology and fostering research in radiation oncology. Developing multi-disciplinary/sectoral approaches would be key alongside strengthening the role of primary care practitioners. Innovations like telemedicine and telehealth are promising but are not a panacea for dysfunctional health systems.

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Interprofessional Education

Michelle Leech
Discipline of Radiation Therapy, Trinity College Dublin, Ireland

This presentation explains the role of interprofessional education in underpinning interprofessional collaboration in the clinic. Educational literature suggests that interprofessional collaboration is best learned at undergraduate level. This is feasible for RTTs together with those who also specialise at undergraduate level in the wider multidisciplinary team but is more challenging for radiation oncology-specific disciplines. Specific examples of previous interprofessional education activities from the field of radiation oncology literature are presented. A framework for the development of interprofessional learning opportunities is given along with an example of interprofessional education at undergraduate level from the presenter's own institute, involving final year RTT students.

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Radiation Oncology Education in the Interconnected World - Perspectives: HIC

Daniel Golden
The University of Chicago Medicine

Radiation oncology scholarship of education in high-income countries faces multiple challenges. These include a fragmented educational system, lack of formal training in methods of education scholarship, lack of funding to support rigorous education scholarship and curriculum development, and that scholarship of education is not a traditional academic pursuit. To address these challenges, it is important to understand the goal of scholarship of education; to conduct curriculum inquiry and improve radiation oncology education. Types of curricula and curriculum inquiry models are discussed. Additionally, models to lead change including Rosabeth Moss Kanter's 6 keys to leading positive change and John Kotter's 8-step process for leading change are reviewed. Lastly, the Radiation Oncology Education Collaborative Study Group (ROECSG) is discussed as a collaborative group model to facilitate robust multi-institutional curriculum development, facilitate deliberative curriculum inquiry, and create spaces for presentation and dissemination of education scholarship.

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Radiation Oncology Education in the Interconnected World - Perspectives: LMIC

Lotfi Kochbati
Hopital Abderrahman Mami, Ariana

Summary

In LMIC in general and particularly in Africa, cancer is becoming a silent crisis with increased incidence and mortality. Clinical decision-making in radiation oncology is a critical action that requires knowledge, experience and carries responsibility towards patient's health and life. But limited resources in equipment and education are noticed in the region which affects communications, access to medical literature and networking.

In this context, many initiatives raised to close this gap and several groups have established telemedicine network discussions in Africa with various levels of success:

- AFRONET: the Applied Radiation Biology and Radiotherapy Section (ARBR) of the IAEA in collaboration with a group of oncologists from the African region, started in June 2012, a teleconferencing platform network for clinical consultation in radiation oncology. The aim of this initiative was to assist participating centres in strengthening their clinical decision-making process. It contributed to bringing awareness of the application of evidence-based medicine in routine clinical practice. The project helped to establish a network platform for discussion contributing to harmonize and improve patient care in participating centres
- Other networks explored by different national societies focus on the review of radiotherapy treatment plans (chartround Africa) or training in contouring treatment volumes with application of international consensus guidelines (ESTRO Falcon platform or ASTRO Educase…)

These experiences have shown that online meetings taking advantage of current available video conferencing resources proved a useful platform to improve radiation oncology decision-making as well as an education tool in LMICs. It should be strengthened and expanded to other regions with other languages. Support from higher learning institutions (ESTRO/ASTRO…) and international organisms (IAEA/WHO..) may contribute to its dissemination and continuation.

References:

1. E Rosenblatt , RR Prasad , K Hopkins, A Polo, N Ndlovu, M Zaghloul, G Paris, L Kochbati. Africa radiation oncology network (AFRONET): an IAEA telemedicine pilot project JISfTeH. Volume 6, 2018
2. Abdel-Wahab M, Bourque JM, Pynda Y, et al. Status of radiotherapy resources in Africa: an International Atomic Energy Agency analysis. Lancet Oncol 2013;14:e168–175.
3. Zubizarreta, E.H, et al. Need for radiotherapy in low and middle-income countries: the silent crisis continues. Clin Oncol 2015;27(2):107-114

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Radiobiology - Radiobiological advances in Radiation Medicine

Marjan Boerma
University of Arkansas for Medical Sciences,

This presentation provides a brief summary of recent work in four areas of research related to normal tissue injury from conventional radiation therapy: 1) Recent reviews and meta-analyses show us the current state of development of assays that may predict which cancer survivors will develop normal tissue toxicity after chemoradiation; 2) we have learned more about the role of the immune system in abscopal effects on normal tissues; 3) several recent studies have focused on the role of the microbiome in both local and distant radiation injuries; and 4) pre-clinical studies have found promising pharmacological and dietary interventions that improve radiation-induced tumor control while simultaneously reducing normal tissue injury, and these approaches have been moved into clinical trials.

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Refresher Course

Radiobiology

Personalised Radiotherapy – From Bench to Bedside

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Background and objective

Despite significant advances in radiotherapy over the last decade, for various anatomic sites tumour response to treatment is often suboptimal. This is partly due to the lack of identification of those patient subgroups that are likely to benefit the most from a specific treatment [1]. Personalized radiotherapy is one of the main themes of today's oncology and represents a step towards optimum treatment planning and delivery.

Methods

Personalized radiotherapy can be achieved via a number of avenues which include the whole treatment chain: from diagnostic imaging to treatment delivery and follow-up. This talk will discuss some of the more common tools used in personalized radiotherapy such as imaging biomarkers, and also some less common ones: gender-dependent radiotherapy and chrono-oncology.

Results and discussion

Identification of tumour particularities and their subsequent targeting is one of the key factors for optimum treatment delivery. The uncovering of various tumour markers and the possibility of their specific in vivo targeting led to the development of imaging biomarkers. Biomarkers for generic tumour characteristics and molecular pathways such as oxygenation status, proliferation, stemness, apoptosis, immune response and so on, are being continuously developed and trialed to guide personalized therapies [2].

Studies have shown that gender plays an important role in treatment outcome after radiotherapy [3]. Although the difference in radiosensitivity between genders has been well documented, most radiotherapeutic guidelines are based solely on population averages rather than demographic subgroups. Clinical results show a small but significant difference in response to radiotherapy between sexes, therefore both prospective and retrospective studies are encouraged in order to evaluate gender-specific differences as a next step in personalized medicine.

Over the last years the oncology community has put more emphasis on the management of adverse events and the improvement of patients' quality of life. The evidence-based fact that certain chemotherapeutic agents induce fewer side effects when administered at a certain time of day should be sufficiently convincing to take the necessary steps to regard chronotherapy as the fourth dimension of oncological treatment [4]. Given that most solid tumour are managed via combined chemo-radiotherapy, the effect of timing between radiation and drug could dictate not only tumour response but also normal tissue toxicity.

Conclusions

While the traditional predictive assays for tumour characteristics (hypoxia, proliferation and radioresistance) have generally failed, tumour-specific imaging biomarkers are promising components of personalized radiotherapy. Furthermore, to account for better normal tissue protection, chrono-oncology is being rediscovered and successfully used in combined treatment approaches.

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References

[1] DOMINA, E.A., PHILCHENKOV, A., DUBROVSKA, A. Individual Response to Ionizing Radiation and Personalized Radiotherapy, Crit Rev Oncog. 23 (2018) 69.

[2] EUROPEAN SOCIETY OF RADIOLOGY (ESR). Medical imaging in personalised medicine: a white paper of the research committee of the European Society of Radiology (ESR), Insights Imag. 6 (2015) 141.

[3] DE COURCY, L., BEZAK, E., MARCU, L.G. Gender-dependent radiotherapy: The next step in personalised medicine? Crit Rev Oncol Hematol. 147 (2020) 102881.

[4] CEDERROTH, C.R., ALBRECHT, U., BASS, J., et al. Medicine in the Fourth Dimension, Cell Metab. 30 (2019) 238.

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A changed set up?: Implementation of surface guided radiation therapy

Kenton Thompson
Peter MacCallum Cancer Centre

The goal of radiation therapy treatment delivery is to ensure the dose is delivered as planned. Surface guided radiation therapy (SGRT) is a non-radiographic, non-invasive imaging modality used for patient setup and monitoring. It provides real-time feedback of patient's position with respect to a reference surface. This information can then be used to evaluate and readjust the patient's setup without the use of ionizing radiation.
SGRT can reduce interfraction and intrafraction target localisation errors. Additional benefits of surface imaging include the use of setup and immobilization techniques that confer greater comfort to patients, reduced need for imaging, and improvements to the efficiency and safety of clinical workflows. SGRT is becoming a routine tool for specific clinical indications in many clinics. It has not yet gained its full potential in terms of widespread adoption, as routine habits must be unlearned and replaced by new knowledge and routines.

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Advancing and changing practices: bringing the MRI-linear accelerator into clinical reality

Veronica Pollutri
Agostino Gemelli University Policlinic (Policlinico Universitario "Agostino Gemelli")

Magnetic Resonance guided Radiotherapy can play a significant role in daily clinical routine, specially in online adaptive workflow. Several aspects of this new useful technology will be discussed, in order to give an idea of fields of applications, recent clinical and technical evidences, but also a point of view of changings about the role of RTT, who can become a key player in this stimulating scenario.
The reality becomes evident and new technologies help us to better visualize the target in real time and in real view, bringing the patient deeply into the process.

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Proton therapy- new directions in treatment delivery for RTT

Sharon Wong
Singapore Institute of Technology

Proton therapy (PT) is a new technology for delivering conformal beam radiation with positively charged particles. The physical characteristics (Bragg peak) of proton allow escalation of tumor doses and greater sparing of normal tissues, thus potentially improving local control and survival while at the same time reducing toxicity and improving quality of life. PT is a growing radiotherapy modality and RTTs will have to be prepared to embrace this new technology with new knowledge and experiences. All RTTS will need to have a good understanding of protons, especially the uncertainties associated with treatment planning and delivery that have a huge impact on the treatment outcomes of proton therapy.

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Session: Clinical Research

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Contribution ID: 57 **Type: Proffered Papers**

Is Watch and wait approach feasible for patients with complete response post neoadjuvant therapy in Low Middle Income Countries?

Reena Engineer[1], Ashwin Desouza[1], Avanish Saklani[1], Debanjali Dutta[1], Prachi Patil[1], Supreeta Arya[1], Supriya Chopra[1]

[1]Tata Memorial Centre, Mumbai, India

Background

Neoadjuvant chemoradiation (NACTRT) followed by surgery and adjuvant systemic therapy remains the management option for locally advanced (T3-T4N+) rectal tumours.

APR remains the surgery of choice for distal rectal tumours which leads to permanent colostomy , loss of urinary and sexual functions and altered quality of life. This colostomy also leads to stigmatization of patients who are relatively young (median age 47 years) especially in the Low Middle Income Countries leading to a dropout rate or refusal for APR in more than 20% of the patients [1-2].

For patients achieving good and complete clinicoradiological response the Watch and Wait strategy was proposed by Habr-Gama and hence been implemented and reported in many studies [3-4]. However, this strategy involves strict follow up schedule and doing surgery at the time of regrowth. Can this strategy be implemented in LMIC's where the understanding of this approach and adherence to follow up schedule may be difficult. Also is it more economical compared to the patients undergoing surgery. In this study we retrospectively analyzed the outcomes of patients managed by wait and watch approach in terms of organ preservation rate, recurrence rate and survival. We also looked at the compliance and cost benefit compared to the patients undergoing surgery at our institution.

Methods and materials

Patients with rectal tumours, clinically T2-T4 N+ tumours, were included in the study. All the patients were staged with MRI pre and post 6 -8 weeks of NACRT.

All patients received NACTRT – EBRT to a dose of 45-50Gy in 1.8-2Gy/# with concurrent capecitabine.

All patients were assessed at end of radiation for response.

Twenty-two (40%) patients with near complete or complete clinical response (cCR) on DRE, escalated dose of radiation were given in form of endorectal brachytherapy mostly 8Gy/2# or EBRT 5.4Gy/3# (if DRE was painful).

Further response evaluation was done at 6th week and 12th week post treatment completion.

Patients with near complete or cCR response at 12th week were given option of immediate surgery vs wait and watch, and patients refusing surgery, after obtaining consent, were observed with 3 monthly with DRE, MRI pelvis and sigmoidoscopy.

Here we present the results of the patients attaining near complete or cCR at 12th week and kept on wait and watch.

Results

55 patients were followed up from December 2013 to December 2019, among which 39 had cCR (71%) while 16 had nCR(29%) post NACTRT.

Majority (80%) were distal rectal tumours (0-5 cm from anal verge) and 74.5% were T3 tumours. Tweny-two (40%) of the patients received brachytherapy boost.

61.5% of patients had achieved cCR at 12th week post NACTRT and rest continued to have nCR.
At a median follow-up of 33 months, overall 11(20%) patients have local regrowth; six patients with nCR and 5 with cCR.
Out of the 11 patients who had local regrowth, seven underwent surgery (4 APR, 2 ISR and 1 LAR), 4 refused surgery and is still alive with disease. Overall compliance rate to the protocol was 92.7%.
The overall organ preservation rate was 87%.
Six (11%) patients developed distant metastasis (3 along with local regrowth and 3 without). Three patients had metastasis in liver , 2 lung and 1 leptomeningeal.
Five of 6 patients with DM underwent metastatectomy and are disease free till follow up, whereas only one patient in the entire cohort died of leptomeningeal metastasis.
The 3 year colostomy free survival, non regrowth recurrence free survival, and OAS was 92.7%,94.5% and 98%.
On performing cost benefit analysis patients on W&W approach mean cost per patient in the W&W group was 1.4 Lacs INR (1854 USD) where as it was 4.5 Lacs (5960 USD) in patients undergoing routine NACRT followed by surgery.

Conclusions

This study has shown wait and watch approach is a possible alternative management option for patients attaining cCR after NACTRT with local regrowth risk being 20% but majority of which is surgically salvageable. This leads to excellent survival with added benefit of organ preservation in majority.
It is acceptable and feasible with a good compliance and economically 3 times cost effective compared to patients undergoing surgery. This is very relevant for patients in Low Middle Income Countries where expertise is available.

References

1. Patil PS, Saklani A, Gambhire P, et al. Colorectal Cancer in India: An Audit from a Tertiary Center in a Low Prevalence Area. Indian J Surg Oncol. 2017;8(4):484-490.
2. Shinde RS, Katdare N, Kumar NAN, Bhamre R, Desouza A, Ostwal V, Engineer R, Saklani A. Acta Oncol. 2018 Dec;57(12):1721-1723 Impact of histological subtype on treatment outcomes in locally advanced rectal adenocarcinoma treated with neoadjuvant chemoradiation

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Contribution ID: 9 **Type: Proffered Papers**

Modern possibilities of nuclear medicine in the treatment of patients with recurrence prostate cancer after radical prostatectomy

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[1]Federal State Budgetary Institution (N.N. Blokhin National Medical Research Center of Oncology) of the Ministry of Health of the Russian Federation

Purpose or Objective
The aim of our study is to analyze the long-term results of salvage radiation therapy (SRT) for patients with recurrence of prostate cancer (PCa) after radical prostatectomy (RP) using modern diagnostic capabilities of nuclear medicine.
Material and Methods
Biochemical recurrence after radical prostatectomy – subsequent detectable PSA level after radical prostatectomy that increases on 2 or more subsequent laboratory determination. Clinical recurrence – is a type of biochemical recurrence in which a substrate of a locoregional recurrence tumor is detected by modern high-tech diagnostic capabilities, including multiparametric MRI (mp-MRI) and positron emission tomography/computed tomography (PET/CT) with 68Ga-PSMA. Using this diagnostic approach, among all this group of patients, locoregional recurrence tumor was visualized in 261 (63.5%) patients: 53% - in prostate bed, 10.5% - in regional pelvic lymph nodes.
In 2009 we developed and implemented in clinical practice variant of SRT in classical fractionation, which consists in irradiating the regional pelvic lymph nodes to 44 Gy, the fossa of prostate gland to 66 Gy and the area of recurrence to 72 Gy. In 2013 we created and patented the technique of hypofractionation SRT. Radiotherapy have been prescribed to the pelvic lymphatic nodes to 46.8 Gy of 1.8 Gy per fraction, to the prostate bed - 61.1 Gy of 2.35 Gy per fraction and clinical recurrence - 65 Gy of 2.5 Gy each, in 26 fractions using simultaneous integrated boost. Some patients receive combination SRT and hormonal therapy (HT) (6-8 months (agonists LHRH).
Results
411 patients were treated from March 2009 to December 2018. Median of follow up – 48 (18-131) months. 42 (10.2%) of 411 patients were treated by classic fractionation SRT, 369 (89.8%) - by hypofractionation SRT. Survival rates were 3-year and 5-year disease free survival (DFS) - 81.3% and 77.6%, respectively. Locoregional control - 100%. The results of our study indicate two main negative factors in the prognosis of the efficacy of SRT – the period of prostate specific antigen (PSA) doubling time less than 6 months ($p = 0.035$) after RP and a higher PSA level, especially more than 0.5 ng/ml before SRT ($p = 0.037$). In our study, 247 (60.1%) of 411 patients were treated by combination SRT and HT. It was found that 5-year DFS among patients who received a combination of SRT and HT, is higher rates - 81%, compared with patients who were treated by monotherapy SRT - 73.5% ($p = 0.5$). However, retrospectively analyzing, we noted that patients who were treated by combination SRT and HT had more unfavorable prognosis factors: pT3a-b, pN1, Pn1, PSA level > 1 ng/ml at time the beginning of treatment, the period of PSA doubling time less than 6 months, the presence of regional relapses after RP, the size of the recurrent tumor more than 10 mm. We also have found that pN1 is a reliable adverse prognosis factor effectiveness of SRT. So, a 5-year DFS is significantly ($p=0.012$) lower in patients with pN1 than with pN0, it is 52% and 83%,

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respectively.

Conclusion

Excellent survival rates and locoregional controls of disease is the result of combination nuclear medicine advanced diagnostic approaches and high-precision radiation therapy in the treatment of patients with prostate cancer recurrence after radical prostatectomy

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Contribution ID: 92 **Type: Proffered Papers**

Survival benefits of adding palliative whole brain radiotherapy in non-small cell lung cancer with brain metastases unsuitable for resection or radiosurgery: A clinical prediction rule

Kyrhatii Trikhirhisthit[1], Kullathorn Thephamongkhol[1], Jiraporn Setakornnukul[1]

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Introduction

The QUARTZ trial demonstrated heterogeneous survival benefits of whole brain radiotherapy (WBRT) in non-small cell lung cancer (NSCLC) patients with brain metastases inappropriate for surgery or stereotactic radiosurgery/radiotherapy (SRS/SRT) which showed a favourable survival outcome with WBRT for those who were younger than 60 years old and potential benefits in patients with good Karnofsky Performance Status (KPS); ≥70%, no extra-cranial metastases and controlled primary NSCLC. The National Institute for Health and Care Excellence (NICE) guideline (NG99) recommends omission of WBRT for NSCLC patients with brain metastases who are not suitable for surgery or SRS/SRT with KPS<70%, while the National Comprehensive Cancer Network guideline (NCCN Version 2.2020) states that it is reasonable to hold on WBRT in selected NSCLC patients with extensive brain metastases if available CNS active agents exist. A question regarding proper selection of these patients to receive WBRT is to be solved. The objective of this study is to evaluate the added survival benefits of WBRT by developing and internal validating the individual survival prediction model for NSCLC patients with brain metastases inappropriate for surgery or SRS/SRT by using WBRT as a main prognostic factor.

Methods

We retrospectively collected 479 NSCLC patients with brain metastases treated with either WBRT or optimal supportive care (OSC) from January 2004 to December 2019 from Siriraj hospital database using clinical characteristics as potential predictors, previously established elsewhere. The primary outcome was overall survival. By the time of analysis, 452 patients found dead. According to the rule of thumb of 10 events per predictor, 45 predictors were adequately examined in our model. The Cox proportional hazard regression was used for survival analyses. Linearity of continuous variable was checked using Martingale residuals. The Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis (TRIPOD) statement was followed. To handle with missing predictors, multiple imputation by chain equations (MICE) with thirty imputations performing on the complete data set of all participants using identical known information generated primary analysis model. A backward elimination method was used to decide which of the potential predictors should be included in our reduced model based on Akaike information criterion (AIC), keeping predictors with a p-value of less than 0.157. The bootstrap procedure, a random resampling with replacement was performed for optimism-correction model. We combined the estimates across imputed data sets using Rubin's rules to produce final parameter estimates for the final model including baseline survival and slope. The model performance included Harrell's C-index and

calibration plot. Finally, the nomogram and web-based individual calculator were generated. All the above analyses were carried out using Stata version 14 and R.

Results

Of 479 patients, 389 (81.2%) received WBRT. There was less female gender in WBRT group, they had better KPS; ≥70% (65.5% vs 38.5%), presented with milder symptoms (39.8% vs 25.3%), had greater number of measurable lesions (87.4% vs 63.8%), were more likely to receive further systemic treatment (35.7% vs 15.2%) and had better prognosis by Graded Prognostic Assessment for Lung Cancer Using Molecular Markers (Lung-molGPA). Genetic mutation was not tested in three-quarters of the whole cohort. Better survival in WBRT group was observed (5.1 vs 2.3 months). Median follow up time was 4.3 (1.0-8.4) months. Potential predictors included age, gender, KPS, histology, EGFR/ALK status, neurological symptom, extracranial disease, previously received systemic treatment, presence of measurable lesions, received further systemic treatment and WBRT. Extra-cranial disease status and presence of measurable lesions were critical missing values. After MICE and dropping the candidate predictors step wise based on AIC, the following predictors were included in the reduced survival model: gender, KPS, neurological symptom, extra-cranial disease, previously received systemic treatment, received further systemic treatment and WBRT. WBRT exhibits a negative score, a good predictor. The final optimism-correction model was generated using shrinkage factor generated by bootstrapping with a C-index of 70.9% (69.1-73.8%) and an acceptable calibration. A model-transformed nomogram and web-based calculator were generated and available online at https://siriraj.cloud:9001/survival/. To put it simply, there were two characteristics demonstrated greatest benefit of WBRT: (1) patients who had controlled primary NSCLC and no extra-cranial metastases and (2) those who received further systemic treatment.

We also did a separate analysis for 117 patients with known genetic mutation status. The final model included only three predictors: extra-cranial disease, received further systemic treatment and WBRT. The genetic status variable was dropped out of the model in the same fashion as we did for the whole cohort. There was only ten percent of the patients received further targeted drug which could obscure the strength of genetic mutation variable. We are planning on updating our model in the modern era database and external validating thereafter.

Conclusion

This nomogram is able to help clinicians to make decision making for whole brain radiotherapy in the tough situation. Further external validation is encouraged to be performed.

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Contribution ID: 97 **Type: Proffered Papers**

Evolution and Prognosis Of Juvenile Nasopharyngeal Carcinoma: results from of a study on 68 children in Salah Azaiz Institute in Tunisia

Semia Zaraa[1], Safia Yahyaoui[1], Noubbigh Ghaiet el Fida[1], Souheil Jebali[1], Said Gritli[1], Chiraz Nasr[1]

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Background and objective

Juvenile nasopharyngeal carcinoma (NPC) is relatively common in Tunisia. The classification and treatment of NPC have been impacted by the increased rate of early diagnosis and advances in imaging techniques over time. The objective of our work was to study the epidemiological, clinical, therapeutic and evolutive aspects of juvenile NPC during the period between January 2004 and December 2014.

Methods

Our study was retrospective done on 68 patients younger than 18 years old with a CNP treated at Salah Azaiez Institute between January 2004 and December 2014. Patients with histological cavum cancer other than undifferentiated carcinoma (UCNT type) or poorly differentiated carcinoma were excluded. All our patients had a clinical and paraclinical assessment allowing staging of the tumor according to the TNM 2010 classification. The study of survival and prognostic factors was done after a descriptive analysis. These prognostic factors were studied in uni and multivariate analysis. The chosen significance level was 0,05.

Results and discussion

The median age of our patients was 14,7 years with a sex ratio of 2. The average consultation delay was 4 months. Rhinological signs were the most frequent reason for consultation. According to 2010 TNM classification, T3-T4 tumors accounted for 78% of all cases and nodal involvement was classified as N2-N3 in 63% of patients. Non-metastatic patients had radiotherapy (on the cavum and lymph nodes areas) associated (differently) with chemotherapy in 97% of cases. For metastatic patients, the treatment consisted of radiotherapy contracted on bone metastasis and first chemotherapy and radiotherapy (+/- concomitant chemotherapy) on the primitive and lymph nodes areas. After an average follow-up of 94 months, 78% of our patients were alive and in complete remission, 19% were in therapeutic failure with 16% of metachronous metastases. The overall survival at 5 years in the absence of therapeutic failure was 95% and that in the presence of therapeutic failure was 30%. Late toxicity was dominated by hyposialia and dystrophic complications.

Conclusions

Treatment of NPC is based on the combination of chemotherapy and radiotherapy. However, metastatic relapses are a common mode of failure. High radiotherapy doses are associated with excellent local control rates with increased late sequelae. Innovative radiotherapy techniques, including conformal radiotherapy with or without intensity modulation, are promising and could overcome toxicity problems while maintaining an excellent local control rate.

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References

1. Abdallah MB. Registre des cancers, nord-tunisie. Données 2004–2006 [En ligne]. RCNT, 2012 [cité le 6/11/19]; [environ 80 écrans]. Disponible à l'URL: insp.rns.tn/doc/cancer17.pdf
2. Boussen H, Bouaouina N, Gamoudi A, Mokni N, Benna F, Boussen I, et al. Cancers du nasopharynx. Encycl Med Chir. (Elsevier Masson, Paris), Oto-rhino-laryngologie, 20-590-A-10, 2007, 23p.
3. Brennan B. Nasopharyngeal carcinoma. Orphanet J Rare Dis. 2006;1(1):23.
4. Boussen H, Ghorbal L, Naouel L, Bouaouina N, Gritli S, Benna F, et al. Nasopharyngeal cancer around the mediterranean area: standard of care. Crit Rev Oncol Hemato. 2012;84 Suppl1:S106-S109.
5. Toumi N, Benkridis W, Mnejja W, Bouzguenda R, Khanfir A. Docetaxel, carboplatin and fluorouracil induction chemotherapy followed by concurrent chemoradiotherapy for locally advanced nasopharyngeal carcinoma: Long term results of a tunisian series. Cancer Radiother. 2018;22(3):216-21.

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Contribution ID: 40 **Type: Poster**

Randomized Controlled Trial Comparing Virgin Coconut Oil and Salt and Soda Mouthwash Versus Salt and Soda Mouthwash Alone In Preventing Grade 2 and Above Radiation- Induced Mucositis In Patients With Nasopharyngeal Carcinoma (VCO-PRIM STUDY)

Misael Cruz (Cancer Institute, Sacred Heart Medical Center, Angeles City Philippines)
Enrico Tangco, Marigie Olvina, Thelma Sarmiento

Introduction:
Determine the efficacy and safety of combining Virgin Coconut Oil (VCO) with Salt and Soda Mouthwash (SSM) compared to SSM alone in preventing grade 2 and above radiation-induced mucositis(RIM) in Nasopharyngeal Carcinoma (NPC) patients.
Methodology:
From May 2009 to February 2013 all patients with NPC were invited to participate in the study. This is a randomized single-blind (assessor blinded) trial. Block randomization was done to achieve an equal number of participants. Allocation concealment was done by a third party using opaque sealed envelopes. Treatment group were instructed to use both VCO with SSM while control group use SSM alone. Outcome assessment was based on NCI-common toxicity criteria ver 2.0. Outcome measure includes incidence of RIM, time to develop, adverse events and serious adverse events. Intention to treat analysis (ITT) was done for all primary outcomes. Chi square test, Mann Whitney rank sum test, t-test and likelihood ratio test were used to compare groups. Relative risk (RR), absolute risk reduction (ARR) and relative risk reduction (RRR) were estimated at 95% confidence level. An informed consent was obtained and all study data were kept confidential. The study was conducted according to the ICH-GCP standards.
Results:
143 out of 168 enrolled patients were randomized. 72 to the VCO+SSM group and 71 randomized to the control group (Fig1). There were no withdrawals and losses to follow-up but 13 (18%) patients in VCO+SSM and in SSM did not strictly follow protocol. These patients were included in the ITT analysis. Baseline characteristics are comparable. Incidence of Grade 2 and above RIM is 4% less in the VCO group than the control [95% CI: -19, 12. p=0.64] (Table 1). Mucositis-related pain was less in VCO+SSM group compared with the SSM alone group [p=0.03] (Table 2). There was delay in the development of RIM in the VCO+SSM compared to SSM group [p =0.21]. Toxicity grading was less in the VCO+SSM group [p= 0.41]. All the seven serious adverse events are not related to interventions.
Conclusion:
Statistically, there is no definite evidence to show that using VCO as adjuvant with SSM in NPC patients can prevent the development of grade 2 and above RIM or decrease its incidence, delay the time of its development, and lower its toxicity grading. Clinically, there is a trend favoring benefit in using VCO+SSM at the start of the treatment for NPC patients. The 4% absolute reduction in risk and the delay in onset of having RIM maybe considered small but this minimal clinical important difference may change the concept of radiation oncologist in

their patient management. More importantly, VCO+SSM can decrease mucositis-related pain in patients with NPC undergoing radiation treatment with or without chemotherapy. This finding is both statistically significant and clinically relevant because it is the primary trigger for treatment delays, treatment interruptions, hospitalizations and possible treatment failure.

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Contribution ID: 39 **Type: Poster**

Treatment outcome comparison between 33 versus 35 fractions among nasopharyngeal carcinoma using helical approach: A retrospective study

Misael Cruz (Central Luzon Integrated Oncology Center, City of San Fernando Philippines)
Mary Ann Rose Agustin, Madonna Valenzuela

INTRODUCTION:
To compare the treatment outcome in terms of survival, treatment related side effects and treatment response of 33 fractions with simultaneous intensity modulated boost (SIMB) versus sequential 35 fractions using helical approach among nasopharyngeal carcinoma patients.
METHODOLOGY:
From September 2014 to September 2018, a total of 91 patients diagnosed with nasopharyngeal carcinoma were treated with either 33 fractions with SIMB (n=34) and sequential 35 fractions (n=57) using image guided intensity modulated radiotherapy (IG-IMRT)
helical approach concurrently with chemotherapy at the Central Luzon Integrated Oncology Center (CLIOC) and were followed up for four years. All were histopathologically confirmed undifferentiated and squamous cell type. Targets were defined as GTV=70Gy, CTV66 = 66Gy, CTV60=60Gy and PTV (target + 3mm) at 200 cGy per fraction. Daily megavoltage computed tomography was done and organ at risk were define with tolerance dose based on QUANTEC. Side effects were recorded based on common toxicity grading (CTC) ver 2.0. Patients were followed up using magnetic resonance imaging (MRI) every three months on the first year, every
six months on second year and every year on the third year onwards.
RESULTS:
There was no statistically significant difference in terms of clinical profile for patients treated with 33 fractions compared to 35 fractions. Patients who received 33 fractions showed no statistically significant difference in terms of survival time compared with 35 fractions (863 days
vs 903 days, p = 0.085). Four-year survival rate was higher in the 33 fractions compared to the 35 fractions group, 97.1% vs 89.5% respectively (Fig. 1) but not statistically significant. No statistically significant difference was noted in the proportion of patients who reported treatment related side effects such as xerostomia, ageusia, dysphagia, mucositis and skin desquamation among 33 and 35 fractions (Fisher's exact test p-values > 0.05)[Table 1]. although the mean time to event was shorter in the 33 fractions group. Treatment response showed 41.2% vs 35.1% improved, 8,8% vs 7% no improvement and 5.9% vs 1.8% re-treatment for 33 and 35 fractions respectively and found no significant difference (p value 0.511) [Table 2].
CONCLUSION:
The study presents 33 fractions with SIMB using IG-IMRT helical approach may be a practical option in treating nasopharyngeal carcinoma and it showed comparable results in terms of survival, treatment related side effect and response compared with the standard 35 fractionation.

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Contribution ID: 31 **Type: Poster**

The Immunomodulating Effects of Biobran (Rice Bran Arabinoxylan Compound) on Hematologic Profile, Nutritional Status and Quality of Life among Head and Neck Carcinoma Patients Undergoing Radiation Therapy: A Double Blind Randomized Control Trial

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JERICKSON ABBIE S. FLORES, MARY ANN REYNA

Introduction:
Radiation treatment delays in the management of head and neck malignancies secondary to anemia and poor nutritional status had greatly affected local control and survival. Immunostimulants in the form of soluble fibers have been explored to reduce the complications of radiation and chemotherapy to allow patients to tolerate treatment better in the hope of improving treatment outcomes and quality of life. This study aims to determine the immunomodulating effects of Biobran (RBAC) as a supplement among head and neck cancer patients in addressing radiation treatment complications such as anemia, leukopenia, weight loss and improvement of quality of life.

Methodology:
A total of 65 patients were enrolled in a double blind randomized study either to placebo or the Biobran (RBAC). Patients were given 3 grams of either placebo or Biobran (RBAC) per day, starting two weeks before the start of treatment, during radiation/chemoradiotherapy, and for two months after radiotherapy or radio-chemotherapy.
Complete Blood Count (CBC), Body Mass Index (BMI), percent weight loss and EORTC Quality of Life questionnaires for Head and Neck Cancer Patients QLQ H&N35 were used to assess the degree of anemia, weight loss and evaluate quality of life. These parameters were obtained weekly starting 2 weeks prior to start of treatment, weekly during the course of radiotherapy/radio-chemotherapy and; at 1 month and 2 months after treatment completion.

Results:
65 patients were enrolled in the study from November 2016 to February 2018. The median age were 52 years old, and majority were male. Most of the patients' malignancies were nasopharyngeal type with squamous cell carcinoma histology that are undifferentiated. Most of the patients had locally advanced stage and were given concurrent chemoradiotherapy. Majority of the total radiation dose prescribed was 70 Gy.
Based on overall complete blood count results, there were higher counts on all hematologic parameters in Biobran (RBAC) arm. Pre-treatment (2 weeks) CBC values showed higher hemoglobin, hematocrit, red blood cell (RBC), neutrophilic, lymphocytic, eosinophilic and basophilic counts in Biobran (RBAC) arm compared to placebo. During radiotherapy/chemoradiotherapy, patients given Biobran (RBAC) have favorable results in all CBC parameters except in WBC and neutrophilic counts. While on post-treatment hematologic assessment (2 months), Biobran (RBAC) patients have better results in all parameters except in eosinophilic and basophilic counts. These outcomes resulted to more blood transfusions, significant treatment delays and increased hospital admissions (secondary to blood transfusion and infections) in placebo compared to Biobran (RBAC).

On the nutritional status, recorded weight and BMI on follow-ups showed higher overall BMI for Biobran/RBAC (22.69) compared to placebo (21.52) and a lower percent weight loss on Biobran/RBAC (6.10%) versus placebo (6.91%).
Treatment related toxicity RTOG grading showed lower severity scores on all parameters in Biobran (RBAC) compared to placebo. Quality of Life (QOL) scores using EORTC H&N35 are worst in placebo compared to Biobran/RBAC. Deaths during the course of treatment were significantly higher in placebo (11) compared with Biobran (RBAC) with no recorded treatment related mortality.

Conclusion:

Results from this study showed better clinical outcomes based on hematologic parameters, nutritional status, treatment-related toxicities and quality of life in Biobran (RBAC) compared to placebo. These have led to fewer blood transfusions, less treatment delays and hospital admissions, avoidance of treatment mortalities and morbidities and improved quality of life among head and neck cancer patients undergoing radiotherapy/chemoradiotherapy given with Biobran (RBAC).

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Contribution ID: 36 **Type: Poster**

Induction Chemotherapy Followed By Concurrent Chemoradiotherapy in a 14 Year Old Patient With Poorly Differentiated Nasopharyngeal Carcinoma: A Case Report on the use of the ARAR0331 Protocol

Marc Vincent Barcelona (Jose R. Reyes Memorial Medical Center)
Jerickson Abbie Flores, Mario Go Jr., Jochyrs Estanislao

I. Introduction

A major consideration of radiotherapy in children is toxicity. Adults with nasopharyngeal carcinoma (NPCA) usually receive concurrent chemoradiotherapy with or without adjuvant chemotherapy as standard treatment; however, the rarity of pediatric NPCA patients makes the sequence and dosages of both modalities less clear-cut. Children are noted to be more sensitive to adverse effects of radiation, including the development of radiation-induced malignancies by a factor of 10-15. This provides a rationale for the possible role of dose de-escalation of radiation therapy to pediatric patients. Induction chemotherapy in pediatric NCPA patients has been used with good outcomes and its effect when combined with concurrent chemoradiotherapy has been evaluated in the ARAR0331 protocol published by the Children's Oncology Group. The results of which noted good 5 year overall survival at 88.2% and 5 year event-free survival at 85.5%.

II. Methodology

The objective was to discuss a case report of a 14 year old male patient with stage IV-A nasopharyngeal carcinoma in terms of tumor response, RTOG toxicity, and follow-up laboratories and ancillaries using the ARAR0331 Protocol.

The patient and his grandmother sought consulted at our institution with a chief complaint of a small, painful, palpable mass in his right neck, of one year duration, which was noted to have increased in size to around 5 x 5 cm around 5 months prior to consult. There was no associated fever or epistaxis. Endoscopy was done which revealed a polypoid nasopharyngeal mass extending into the right nasal cavity. Punch biopsy revealed squamous cell carcinoma, poorly differentiated. CT scan of the head and neck area revealed a lobulated mass at the right nasopharyngeal region, right masticator space, right pterygoid bone; same mass was extending to the right temporal lobe and sphenoid sinus; an enlarged level II lymph node on the right (2x3 cm) was noted.

At this time, a working diagnosis of squamous cell carcinoma, poorly differentiated, nasopharynx, Stage IVA (T4N1M0) was made. Initially, patient was advised referral for intensity modulated radiation therapy (IMRT) due to concerns of late toxicity which would be decreased by the use of more conformal forms of radiation therapy; however, the patient's grandmother was concerned with potential costs of treatment and both the grandmother and patient made the decision to be treated at our institution. Both were duly appraised and were instructed about the potential toxicities of 2D conventional radiation therapy. Consent to treatment at our institution was given. A multidisciplinary meeting was convened which discussed the feasibility of using what was then a recently published protocol presented at the American Society of Clinical Oncology 2016 meeting: the ARAR0331 Protocol which involved induction chemotherapy followed by dose-adapted chemoradiotherapy. This protocol is illustrated (please see attached file).

III. Results

As the patient was classified as Stratum B. Patient was planned to undergo 3 cycles of 5-fluorouracil 1 g/m2/day with cisplatin 80 mg/m2 for the first 5 days of each cycle every 3 weeks. Patient was re-assessed post-treatment. Endoscopy revealed disappearance of previously noted mass. A repeat CT scan of the head and neck was also done revealing the disappearance of the mass at the right nasopharynx; disappearance of the previous superior extension; and a complete regression of the right cervical level II lymph node. Patient was assessed to be a complete responder and underwent radiation therapy with a reduced dose of 61.2 Gy in 1.8 Gy per fraction for 34 fractions instead of the standard 70 Gy in 2.0 Gy per fraction for 35 fractions. Patient tolerated treatment for 7 weeks without complications. RTOG acute grade 1 toxicities to the skin, saliva, and mucous membranes were noted. On the third year of follow-up, patient only complained of slight dryness of mouth (RTOG Grade 1 late toxicity for salivary glands) Follow-up imaging up to 3 years post-treatment revealed absence of the mass and metastasis with most recent video nasopharyngoscopy showing no mass, lesion, or bulge at the nasopharyngeal area. Neurocognitive testing Mini-Mental Status Examination (MMSE) and Montreal Cognitive Assessement-Philippines (MOCA-P) revealed no cognitive impairment.

IV. Conclusions

The ARAR0331 protocol makes use of neoadjuvant chemotherapy using tri-weekly cisplatin and 5-FU followed by chemoradiotherapy with a response-adapted dose which, based on published results, gave excellent 5 year overall and event-free survival rates. This may help in potentially mitigating toxicities to pediatric patients both acute and late, including possibly reducing the risk of development of neurocognitive decline and secondary malignancies. The case reported has illustrated a complete response to induction chemotherapy with no note of locoregional recurrences, distant metastases, or severe late toxicities up to a 3 years of follow-up. To our knowledge, this was the first use of the ARAR0331 protocol for a case of pediatric NPCA in the country and this report helps illustrate the feasibility and effectiveness of said protocol in even the local, low-resource setting.

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Contribution ID: 96 **Type: Poster**

What is the optimal radiotherapy regimen for thoracic palliative radiotherapy in lung cancer?

Meriem Bohli (Radiotherapy Department, Abderrahman Mami Hospital)
Dorra Aissaoui, Raouia Ben Amor, Ghada Abdessatar

Introduction
Patients with lung cancer are often diagnosed with metastatic or locally advanced disease. Chemotherapy is the main treatment in this stage. Palliative thoracic radiotherapy (PTR) is effective for improving symptoms. Optimal schedules of PTR are not well defined. The aim of our study was to evaluate the impact of different PTR regimen on oncological outcomes.

Materials and methods
We retrospectively review a cohort of 50 patients with pathologically confirmed lung cancer treated in our center between 2018 and 2020. All patients were men. Mean age was 62.4 years (43-86). Fourteen patients (28%) had cardiac or pulmonary history. Performance status was 1 in 42% of cases (n=21), 2 in 48% (n=24) and 3 in 10% (n=5). The histological type was small cell lung cancer (n=6, 12%), adenocarcinoma (n=16, 32%), squamous cell carcinoma (n=19, 38%) and other non-small lung cancer (n=9, 18%). According to TNM 8 staging, tumors were classified stage IIIA (n=8, 16%), IIIB (n=11, 22%), IIIC (n=12, 24%) and IV (n=19, 38%). Forty-two patients had previous chemotherapy. Progressive and stable diseases were observed respectively in 16 and 14 patients. All patients had 3D conformal radiation therapy. PTR was indicated for dyspnea, chest pain, superior vena cava syndrome, and hemoptysis in respectively 56%, 50%, 22% and 4% respectively. Overall survival (OS) was calculated from the end of radiotherapy (RT) to date of latter news and estimated using the Kaplan–Meier method. Differences in outcomes were tested using the Log Rank method.

Results
The most commonly prescribed regimen was short course RT (84 %), either 20 Gy in 5 fractions (n=25), or 30 Gy in 10 fractions (n=17). Single fraction (8-6 Gy in one fraction) was delivered in 8 patients (16%). Clinical benefit was reported in 16 cases (34%). Median survival was 5 months. The 6 months and 12 months OS were 49% and 26%, respectively. Median survival was significantly correlated with tumor stage (56 weeks in stage III versus 39 in stage IV) (p=0.028) and fraction regimen (29 weeks in short course RT versus 3 in single fraction) (p<10-3). There was no difference between 20Gy in 5 fractions and 30Gy in 10 fractions, median survival was respectively 42 weeks and 54 weeks, p=0.9

Conclusion
We recommend 20Gy in 5 fractions in palliative thoracic radiotherapy since it is more convenient for this frail population without compromising their oncologic outcome and also to create capacity to treat additional patients in a context of shortage of RT facilities

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Contribution ID: 99 **Type: Poster**

Stereotactic Radiotherapy for Brain Metastases: Experience of Salah Azaiez Institute in Tunisia

ALIA MOUSLI (University Tunis El Manar)
Khalil Mahjoubi, Lotfi Ben Salem, Mounir Besbes

Introduction:
Stereotactic radiotherapy (SRT) is a highly precise form of RT initially developed to treat small brain tumors and functional abnormalities of the brain. Delivering the RT in a few sessions of high doses, can improve safety and allows the normal tissue tolerance. This study is to characterize the dosimetric properties and accuracy of a novel treatment platform in our institute for frameless, image-guided SRT for Brain metastasis (BM).
Methods:
We collected 9 patients treated for BM. A linear accelerator-based SRT systems Varian® with implemented Brain Lab® nominal Cones diameters from 7 to 40 mm were employed. Frameless brain lab® technique and iPlan Net Planning Treatment Systems (TPS) were used thanks to the donation of IAEA. Patients were treated with non-coplanar arcs in all cases.
Results:
The most common primary tumor was non-small lung cancer followed by breast cancer. We irradiated solitary BM in 6 cases. In 2 cases, patients were operated for symptomatic lesion before adjuvant SRT delivered in the located tumor bed. We used fractionated SRT for all patients three fractions of 9 Gy in the isodose 80 % in 3 patients, three fractions of 7.7 Gy in 3 patients and 5 fractions of 5.7 Gy in the isodose 70 % in three patients because of located near Critical organs such as brainstem (BS). The median conformity and heterogeneity index were respectively 1.8 (1.35-2.2) and 1.2 (1.18- 1.35). The dose constraint was respected. The maximal dose was respectively 1.65 Gy, 1.08 Gy for BS and optic nerves. The brain volume received 24 Gy was 4.9cc (0.7- 10 cc). SRT was well tolerated for all cases after immediate clinical evaluation. We have detected any case of radio necrosis after a median fellow up of 30 months.
Conclusion:
Our initiation of SRT is very encouraging thanks to the donations of the IAEA. We hope to enlarge our experience for other indications such as schwannomas and meningiomas in the future as well as radiosurgery.

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Contribution ID: 123 **Type: Poster**

Effectiveness of single fraction radiotherapy (8Gy) in Metastatic spinal cord compression

Raouia Ben Amor (Radiation Oncology Departement , Abderrahmen Mami Hospita)
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Introduction:
Hypofractionated radiotherapy (RT) (30Gy/10 fraction or 20Gy/5 fraction) is widely used for Metastatic spinal cord compression (MSCC) with or without surgery. Randomized studies comparing multifraction RT (MFRT) and single fraction of RT (SFRT) found no difference in outcomes of motor response or overall survival. Despite these results, there is still some reluctance to use SFRT for MSCC.
The aim of our study was to evaluate the motor outcome of SFRT in patient with MSCC
Methods:
This is a descriptive retrospective study involving 51 patients who were treated with SFRT (8 Gy/1 fraction) in combination with high dose corticosteroidtherapy for MSCC between August 2017 and januar 2020 at radiotherapy department at the Abderrahman Mami Hospital in Ariana, Tunisia. No patient had surgery. Primary tumor and location of MSCC were analysed. Motor status was evaluated before and three weeks after RT.
Results:
Solid tumor was the commonest primary tumor in 92% of cases. Hematologic tumors (myeloma) represented 8% of cases(4 patients). Motor dysfunction was observed in 84% of cases. Diagnosis was done by MRI in 43% of cases and CT scan in 57% of cases. An epiduritis was noted in 49% of cases. Compression involved the dorsal segment in 41% of cases, lumbar in 21% of cases, cervical in 10% of cases, cervico-dorsal in 10%, sacral in 4%, dorso-lumbar in 8% of cases and lumbo-sacral in 6% of cases.
Nine patients (18%) were not evaluated. The 3-week assessment revealed motor response in 79 % of cases and stability in 21% of cases. All patients with hematologic neoplasm had a motor response.
No difference in motor response according to the location of MSCC.
Fourteen patients (27.5%) required a 2nd fraction of RT (4/6 or 8Gy / 1fraction).
Conclusions:
Our study showed an improvement of motor status in 79% of patient. This is particularly reassuring in that SFRT can be considered a convenient and viable option for patient and medical systems in a context of limited ressources in this patient group.

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Contribution ID: 7 **Type: Poster**

The distribution and treatment outcomes of paediatric cancer patients referred for radiotherapy in low and middle-income countries – The Uganda experience

Awusi Kavuma (Uganda Cancer Institute - Kampala Uganda)
Daniel Kanyike, Israel Luutu

Introduction

Cancer is one of the major causes of death for paediatrics patients worldwide and the recorded incidences tend to increase with time. Low and middle income countries have younger populations and therefore the proportion of children with cancer is significant. Most of these children die from the disease because of the numerous social economic factors including poverty, few diagnostic health facilities, limited access to education / information, scattered rural populations, scarcity of oncology experts, limited treatment facilities, etc. In this study we followed the American Academy of Paediatrics that recommends people under paediatric care to be up-to the age of 21 years; categorised into: Infancy (birth-2), Childhood (2–12) and Adolescence (12–21) years of age. Paediatric tumors include a wide range of tumors and the burden of these tumors in our resource-challenged center, is not well documented. The main objective of this study was to evaluate the distribution and treatment outcomes of paediatric tumors, and to propose strategies that could improve outcomes.

Methodology

To evaluate the distribution and treatment outcomes of Paediatric cancers referred for Radiotherapy, we retrospectively reviewed all the patient's records/files referred to our department, from January 2015 to December 2018. The study involved patients aged 21 years and below with confirmed histological diagnosis referred to the radiotherapy department. Information retrieved from patients records/files included age (categorised into infancy, childhood and adolescence), sex, histological diagnosis, stage, pre-treatment received, ECOG status, treatment intent, radiation dosages (fractionation/total-dose) and follow-up at discharge, 3-months, 6-months and 1-year.

Results

Between January 2015 and December 2018, a total of 4178 new cancer patients were referred for radiotherapy. Of these, 304 (7.3%) were paediatrics. The Male:Female ratios was 1.2:1.0. The percentage distributions into Infancy, Childhood and Adolescence were 9.2%, 53.6% and 37.2% respectively. The three most common tumours of Infancy where Wilms (53.6%), Retinoblastoma (17.9%) and Sarcomas (14.3%); Childhood tumours were Wilms (34.4%), Sarcomas (21.5%) and Lymphomas (18.4%), while Adolescents were Sarcomas (25.7%), NPC (23.9%) and Lymphomas (18.4%). Overall, the four most common cancers were Wilms (23.4%), Sarcomas (22.4%), Lymphomas (18.2%) and NPC (11.6%). Figure 1 show a summarised distribution pattern of the cancers referred for radiotherapy. Overall 65.8% of these patients presented in ECOG status 0–1 and 34.2% in ECOG 2-3. A precise staging was deficient in many files, but only 12% presented with stages I-II, the rest (88%) presented with stages III-IV diseases. Overall 61.3% were planned and treated with radical intention, the rest were treated palliatively. Wilms tumours which were dominant presented mainly with stage III disease, post-surgery/chemotherapy and treated radically with 1.8 Gy daily doses for 6 fractions. The prescribed radical doses ranged from 36.0 Gy for lymphomas to 70.0Gy in extremity soft-tissue sarcomas. In 65% of the palliative treatments, single doses of 6.0Gy,

8.0Gy and 10.0Gy were prescribed; other palliative prescriptions included 20.0Gy/5-fractions and 30 Gy/10-fractions. Because a large number presented relatively with advanced diseases and in poor ECOG status, 67.7% completed the prescribed doses. For those who completed their treatments, their conditions at discharge were 52.7% in ECOG 0-1, 25.8.7% in ECOG 2-3 and 21.5% in ECOG 4. After 6 months and one year of follow-ups, 47.7% and 56.8% respectively have been confirmed dead or lost to follow-up.

Discussion and Conclusion

Paediatric tumours comprised of a wide-range of cancers, accounting for ≈8% of all referrals. Paediatric tumours deserve more attention from policy makers. The results show that most of our patients (≈90%) present with locally advanced diseases and nearly 40% are treated palliatively which impedes on treatment outcomes. Precise diagnosis including pathology and imaging procedures to identify the stage - the foundation on which all subsequent management decisions are based is not readily available in most rural areas. One radiotherapy facility with long waiting times also resulted in some patients giving-up or failing to complete treatment. Logistical problems like transport/finances, cultural beliefs and alternative medicines, etc caused delayed referrals and presentations.

Possible strategies we propose that could result in improved outcomes include:
i) Increase public awareness on cancer presentations and symptoms – to improve on early detection, which is the most plausible drivers for better cancer outcomes.
ii) Better-trained health professionals in rural/regional referral hospitals to minimise delays in diagnosis and starting treatment
iii) Strengthened cancer services in regional/referral hospitals in collaboration with international organisations and other stake-holders.
iv) Need for comprehensive national paediatric cancer strategies to improve early diagnosis and treatment access to majority of children with cancer
v) Proper co-ordination of various treatments – to minimise delay in radiotherapy delivery
vi) Building dedicated regional research capacity / evidence-based cancer treatments
vii) Access to cancer treatments - essential requirements that need much bigger budget, staff and mandate to enhance the logistical complexities of acquiring and maintaining radiotherapy services.
viii) Paediatrics are more radio-sensitive than adults. Precautionary and quality measures are required when it comes to radiotherapy delivery.

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Session: Implementation of New Technologies

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Contribution ID: 83 **Type: Proffered Papers**

Optimization parameters in bladder and rectum for gynecologic cancer treatment with VMAT Technique through ProKnow platform

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Introduction

Gynecologic cancer represents 14% of new cancer cases in women in Argentina (Ministerio de Salud, 2018). The main treatment options to this disease are external radiotherapy, brachytherapy and chemotherapy. In the first two, the predominant concern are the dose levels administered to organs at risk (OARs), where bladder and rectum are considered critical organs due to their proximity to the treatment region.
Although the tolerance doses defined for these organs (in QUANTEC) are higher than the prescription dose recommended for pelvic irradiation, it represents good practice to optimize dose to healthy tissues to the minimum values achievable, according to ALARA principle. Volumetric Arc Therapy (VMAT) technique allows optimization of the dose delivered to these organs without compromising the dose to the target volume (PTV). That is the reason why sometimes this technique is chosen over Tridimensional Conformal Therapy (3D-CRT) technique, where dose optimization is limited.
In this work, Dose Volume Histograms (DVH) from gynecologic treatment plans using VMAT techniques are analyzed with Elekta's ProKnow platform, to collect statistical data from our population and identify average dose distributions in OARs, with the objective of establishing dose optimization parameters.

Methodology

Whole pelvic radiotherapy plans for gynecological malignancies, with a prescription dose of 46 Gy, in fractions of 2 Gy per day, planned in Elekta's TPS Monaco with VMAT technique and treated between June 2018 and June 2020 at Centro Oncologico Integral and Fundación Médica de Río Negro y Neuquén were identified. The selected plans were anonymized and uploaded to Elekta's platform Proknow, grouping these patients in a data collection destined to investigation. A scorecard was created in order to evaluate the dose delivered to organs at risk, as well as the PTV dose coverage.
In the development of the scorecard, evaluation metrics were defined: V10, V15, V20, V25, V30, V35, V40, V45, medium dose and maximum dose both in bladder and rectum and, homogeneity and conformality index, as well as D95 to evaluate the PTV. Lastly, the number of monitor units (MU) were included in the analysis as an indicator of the treatment plan's level of complexity. For statistical analysis, the median of each evaluated metric was selected. These values were used to define optimization parameters.
Next, the plans were replanned using the optimization values established. These plans were then uploaded to ProKnow platform and subjected once again to evaluation by scorecards to assess the results of optimization.

Results

A comparison of the DVH of the original and optimized plans shows a reduction in the evaluated metrics. With regards to the rectum, the median of low dose values (V10-V20) decreased by up to 18%. At medium dose levels (V20-V35), the reduction in the median had

greater impact, achieving a decrease of up to 23%; for the high dose range, (V35-V45), a decrease in the median of up to 11% was achieved. The median dose distribution in the rectum was reduced by 10%, from 30 Gy to 27 Gy.
In the bladder, the median of the low dose values (V10-V20) decreased by 19%; for medium doses (V20-V35), the median decreased by 21% and for high doses (V35-V45), the decrease in doses had a considerable result, reaching a decrease of 36% for V40 and 47% for V45. The median dose was reduced by 12%.
As for PTV and the complexity of the plan, no significant variations were observed.

Conclusion

Considering that the dose constraints for OARs involved in the irradiation of gynecological malignancies are higher than the dose levels administered in whole pelvic irradiation, all the plans analysed in the first instance comply with the reference values adopted.
With the implementation of ProKnow platform it was possible to quickly and effectively identify the dose distributions of our population, and determine optimization parameters for these treatment plans.
As expected, the dose distributions of our population were homogenized, showing less variability in values since all treatment plans were executed under the same optimization criteria. In most cases, a decrease in the dose values delivered to the risk organs was found without a considerable compromise to PTV coverage and plan complexity.
ProKnow proved to be a useful tool for statistical analysis of the population that allows continuous improvement in treatment planning and optimization of workflow, streamlining the evaluation and comparison of plans for clinical decision-making.

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Contribution ID: 47 **Type: Proffered Papers**

Evaluation of artificial intelligence based contouring tools in prostate cancer radiation therapy planning

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Background

Organs at risk (OAR) and target volume contouring is a labour intensive part of the radiation therapy (RT) treatment planning process. Recently, multiple vendors have introduced a segmentation tools based on artificial intelligence (AI) to reduce planning time through automation. In this study, the accuracy and efficiency gain for prostate cancer patient contouring was assessed for three vendors: Mirada Medical, Mvision AI OY and TheraPanacea *ART-Plan Annotate*.

Methods

CT scans of 5 prostate cancer patients that had not undergone prostatectomy and did not have hip replacements were selected for this study. Following structures were manually segmented on all of the CT scans by experienced radiation therapy technologists: body, bladder, rectum, prostate, seminal vesicles, femoral heads and penile bulb. Contouring time for each patient was measured. In order to estimate the time realistically, the contouring conditions were in line with the Centre's usual practice. Contours were created using Elekta MonacoSIM (5.11) TPS and its semi-automatic tools until the clinically acceptable results were achieved.

The same 5 CT scans, excluding the structure sets, were anonymized and sent to three different vendors to be segmented automatically. Segmentation accuracy was evaluated by comparing the automatically segmented structures to the ones created manually. Standard Imaging StructSure software was used to calculate the Dice similarity coefficient and to evaluate the differences in the volumes of the OARs.

To evaluate the efficiency gain of each AI algorithm, automatically created structures were manually edited to clinically acceptable results and time required for completing that task was measured. There were some discrepancies between the datasets received by the different vendors (e.g. body contour was added only by MVision algorithm), therefore, missing structures were contoured and time was added to the editing task. Average time per patient was calculated for manual contouring and for the editing task for each vendor.

The data used for training the first version of MVision algorithm, includes prostate cases from NEMC without the femoral heads. After receiving our feedback, the new model that included femoral heads data in the training set, was developed by MVision.

Results

Mirada Medical returned structure sets of 4 patients, MVision and TheraPanacea returned contours for all of the 5 patients. Table 1 shows both the accuracy of the different AI algorithms as well as the efficiency results. Bladder, rectum and prostate show highest accuracy results for all vendors (Dice 0.77-0.92). For prostate, MVision contouring tool systematically added extra contour on one CT slice above and below those outlined manually, which partly explains the larger volumes obtained. Largest differences in volume were observed amongst the femoral head contours. The accuracy of contouring femoral heads was significantly improved with the introduction of the updated MVision model. For penile bulb, accuracy results are expectedly

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low- due to its small volume, even a slight difference in contouring results in a large change in volume.
TheraPanacea had the highest segmentation accuracy results and editing of contours required 50.7% less time when compared to manual contouring. Manual contouring took on average 43.14 min per patient. The use of first version of MVision automatic segmentation algorithm reduced the contouring time by 20.5% and Mirada Medical reduced contouring time by 1.1%. After improving MVision´s algorithm, the editing task required 67.4% less time than manual contouring.

Table 1. Accuracy and efficiency results for different AI algorithms compared to manually segmented structures. Average manual contouring time per patient is 43.14 minutes.

	Mirada (n=4)		**MVision** (n=5)		**TheraPanacea** (n=5)		**MVision updated MODEL** (n=5)	
Average editing time (min)	42,68		34,29		21,26		14,05	
Efficiency gain	**-1,1%**		**-20,5%**		**-50,7%**		**-67,4%**	
	Volume difference	Dice	Volume difference	Dice	Volume difference	Dice	Volume difference	Dice
Bladder	-11,9%	0,90	-6,9%	0,88	-2,4%	0,92	-5,6%	0,89
Prostate	4,9%	0,83	52,5%	0,78	-3,4%	0,85	50,0%	0,79
Rectum	37,0%	0,77	5,7%	0,84	-10,9%	0,83	-0,3%	0,83
L femoral head	-4,5%	0,88	-30,0%	0,65	10,4%	0,89	11,8%	0,91
R femoral head	-5,5%	0,87	-31,6%	0,65	9,1%	0,89	10,7%	0,90
Seminal vesicles	-3,4%	0,66	-0,8%	0,69	-13,9%	0,73	11,0%	0,72
Penile bulb	255,8%	0,28	70,0%	0,35	148,7%	0,33	72,6%	0,32
Body	x	x	0,7%	1,00	x	x	0,6%	1,00

Conclusions

All AI based contouring tools were able to reduce the contouring time. Smaller gain in efficiency for Mirada Medical might imply that different contouring protocols were used by the clinics that contributed to the development of the algorithm compared to the protocols followed by NEMC Radiotherapy Centre. The structure definition in the training set is important and could be used for harmonization of the contouring practices among different clinics. While the manual editing is still needed, AI based contouring can reduce the OAR delineation time significantly.

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Contribution ID: 95 **Type: Proffered Papers**

Current opportunities and challenges in a period of 2D to 3D transition in Radiation therapy in Mongolia

M. Minjgee[1], E.Vanchinbazar[1], B. Luvsandorj[1], E. Nansalmaa[1]
[1]National Cancer Center of Mongolia

Background and Objective

The National Cancer Center of Mongolia (NCCM) takes main responsibility for implementation of national policies to control cancer and provides tertiary level diagnostic and specific treatment of most types of cancer.

Increasing number of cancer cases causes higher demand for services of NCCM. The most common cancers in Mongolia are liver, stomach, lung for men; and liver, cervix uteri and stomach for women. Cervical cancer occupy 38% of patients undergoing radiation therapy. Over 200 cervical cancer patients receive Brachytherapy and about 800 applications are performed each year.

Due to lack of equipment and technological obsolescence over the past years, only less than 15 percent of newly diagnosed cancer patients have undergone radiation therapy.

Many efforts have been made and step-by-step measures have been taken to improve radiotherapy facility at NCCM. 3D volume based treatment has become available in both external beam radiotherapy and brachytherapy in 2018-2019. An implementation of the project "Improving quality and access to cancer diagnostics and treatment" resulted in an introduction of Linear accelerators first time in June 2019 and 3D conformal radiation therapy has become available.

Methods

Commissioning of low and high energy linacs was done simultaneously from March to June 2019 under supervision of international experts. The experts were invited at different stages of commissioning.

- Acceptance test, radiation survey and beam data collection (8 Mar- 8 April, A. Cyelan, ACPSEM)
- Beam data modeling (S.H. Choi, KIRAMS 15-20 Apr),
- Validation and verification (Ritu Raj, IAEA (27-31 May)
- Train MPs and RTTs on Linac operation and planning (T. Lowe, RANZCR, 3-22 June)
- Conduct first treatment live-go (Soo Min, IAEA, T. Nakashima, HUH, 17-21 June)
- Electron commissioning and QA improvement (Alison Scott, AVI, 24 Aug - 8 Nov)

PDDs and profiles were measured for square fields sizes of 3-40 см^2 at SSD 100 cm. Beam quality factors were calculated from those values and were compared with BJR25. Profiles were compared Golden beam data. By first absolute dose measurement, it was 6.3% higher the factory calibrated value due to low atmosphere pressure of Mongolia. It was audited by IAEA Postal Dose Quality Audit. Standard deviation relative to IAEA mean dose was 2%. Output was measured at certain field size which was from 3×3 cm^2 to 40×40 cm^2, calculation defined by the ratio reading in 10x10 field. According to the chart, Output Factor is equal 1 in 10x10cm^2 and less than 1 in smallest field and more than 1 in largest fields. MLC transmission factor is 0.015

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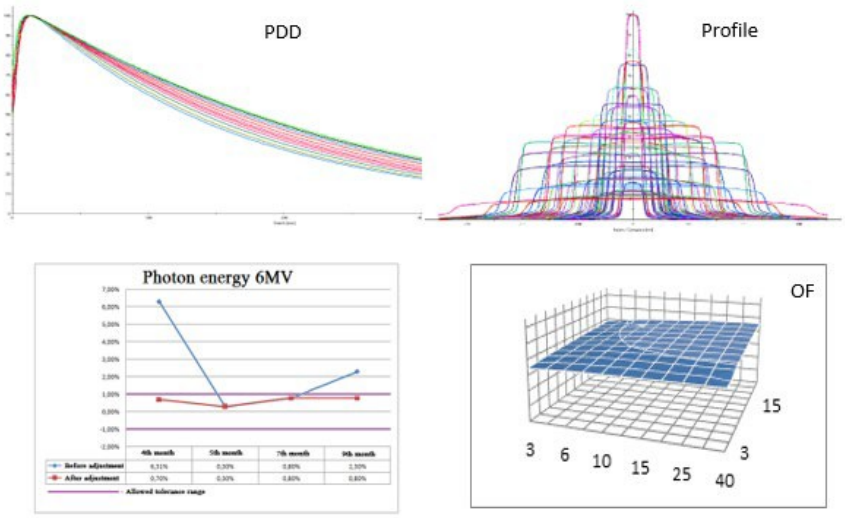

Figure 1. Beam data: 6MV, Low energy linac

Results and Discussion

The successful implementation of this project will contribute towards national efforts to respond to the growing demand for radiotherapy in the country. During the important step of transition of Cobalt-60 with linear accelerator with this phase I project, we have had a variety of new experiences with treating more than 1200 patients with Linac:

1. Delayed building of Premise of linacs that caused warranty period to expire only after 1 year. It has been built with insufficient air circulation system.
2. Commissioning: It was a first experience for medical physicists to commission our first linacs and it was a learning process at the same time. As a Member State of the IAEA since 1973, Mongolia has been closely involved with the Agency for decades, and it was one of many assistance that Mongolia has received in using nuclear applications to better the lives of its people.
3. Mongolia also suffered some significant exogenous shocks during the transition, including insufficient supply of some devices and applications of the linear accelerators
4. Maintenance of equipment: as a landlocked nation located within the interior of a vast continent, Mongolia faces challenges given by its topography. Sometimes it takes hours or days, even weeks to repair linear accelerators
5. Along with introduction of new technologies and equipment, we could improve radiation control and protection, and safety practices in accordance with international standards and guidelines with help of IAEA.

In order to further improve access to radiation therapy technological advancement in radiation therapy such as intensity modulated radiation therapy (IMRT), 4D gating, stereotactic body radiation therapy (SBRT) has to be introduced for reduced damage to normal tissue, enhanced quality of life for cancer patients. With the implementation of the proposed phase II project on equipment and human resources, Mongolia will be able to deal with the problems identified.

Conclusions

Any transition period in implementing higher technology needs solid experience of its previous adopted technology and successful cooperation with international organizations and institutes like IAEA, RANZCR, APSIG, KIRAMS with excellent experts would help us in safe introduction of new nuclear technology.

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Contribution ID: 75 **Type: Proffered Papers**

Implementing compensator IMRT using Low Cost Effective Solution - A Zambian Experience

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Cancer Diseases Hospital, Zambia

Purpose

IMRT is now the standard radiotherapy delivery mode. It was not available at the Cancer Diseases Hospital (CDH) of Zambia and many RT clinics in Low- and Middle-Income Countries. CDH has one Primus LINAC and two cobalt machines, all without MLC. There are two planning systems Oncentra External Beam and Brachytherapy and the Prowess planning system. CDH currently can deliver 3D EBRT and BT very well and has a mould room which is equipped to fabricate blocks and compensators and other immobilization devices. We report here our initial experience of implementing a recyclable compensator-IMRT solution. The solution is based on an in-house compensator-IMRT solution of the University of North Carolina that treated 1500 patients. We evaluated the feasibility of the IMRT solution from US in a LMIC clinic for clinical implementation.

Methods

The Government of the Republic of Zambia (MoH/CDH) and EmpowerRT signed a memorandum of understanding to bring the EmpowerRT solution to Zambia. The solution includes software (treatment planning software PLUNC and an eChart designed for manual operation clinics), hardware (milling machine and compensator fabrication materials), service (commissioning and local network setup), and training (software, QA, and procedures). The training consisted of weekly remote training and one onsite training to CDH physicists, radiation oncologists, and RTTs.

Results

EmpowerRT provided the 3D and IMRT commissioning of Primus Linac. The training included CDH staff teaching each other, a crucial step for us to make the solution our own. We found two PLUNC features particularly useful. Plan Comparison allows us to compare plans (i.e., a 3D and an IMRT) and make a clinical decision on which plan to use. Plan Motion-Effect shows the patient setup uncertainty on cumulative Dosimetry of a fraction treatment course. It allows us to use IMRT safely and sensibly as we do not have online imaging. We use standard immobilization devices. Estimated patient setup uncertainty is used to compute the cumulative dosimetry of an IMRT plan to determine if the IMRT plan safe to use. Our RTTs found EmpowerRT's color-coding system (each block and compensator pair labeled with a unique color dot) easy to use and the compensator fabrication and QA procedures are easy to follow to constantly produce high quality compensators. We have done initial testing of eChart, a new product of EmpowerRT for clinics that still use paper charts. In PLUNC users can export to the eChart treatment prescription, machine parameters of each field, DRRs of setup and treatment fields, isodose distribution, DVHs, plan goal sheet, and other information. The eChart is not linked to our analog treatment machines that we operate manually but it highlights the field and its machine parameters to be treated next, records the actual MU/time delivered provided by RTT, computes the delivered total dose so far, and highlights any deviations. Both

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the eChart and PLUNC run on a server and available to all connected CDH computers.

Conclusion

It is feasible to implement EmpowerRT's compensator-IMRT solution in Zambia using existing resources. The approach of training a trainer ensures local knowledge retention.

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Contribution ID: 10 **Type: Poster**

Prostate cancer: Simultaneous integrated boost with Radixact® System, about a series of 74 patients

MOHAMMED CHABANI (Central Hospital of The Army, Radiation Oncology, Algiers, Algeria)
IMAD ARAREM, SAMIA CHAMI, Mohamed Arezki AOUNI

Objective:
This retrospective study was done to assess the impact of helical Radixact® (HR) on frequency and severity of acute gastrointestinal (GI) and genitourinary (GU) toxicity in prostate cancer.
Methods and Materials:
Between May 13th,2019 and May 25th,2020, a total of 74 patients who were diagnosed with localized and locally advanced prostate cancer were the first to be treated with HR radiotherapy in our department. We treated these patients with Simultaneous integrated boost (SIB). Of 74 patients, 70 (94.5%) underwent either a short- or long-term androgen deprivation therapy (ADT): neoadjuvant, concomitant and more or less adjuvant hormone therapy. The therapeutic dose for these patients was 52.7 Gy (in four fractions of 1.7 Gy per day) to pelvic lymph node area, while seminal vesicles and prostate received a SIB to a dose of 62 Gy (in four fractions of 2 Gy per day) and 71.3 Gy (in four fractions of 2,3 Gy per day) respectively. A dose of 62 Gy was administrated to the involved lymph node regions. All patients were classified according to the national comprehensive cancer network classification (NCCN): 14 patients (18.93%) were classified as intermediate risk,50 patients (67,57%) either high or very high risk and 8 patients (10.8%) as regional risk. Acute toxicity scores were recorded and evaluated weekly and after 3 months of radiotherapy (RT) using the common terminology criteria of adverse events V 4.03 (CTCAE).
Results:
The mean age was 70.71 years old; the incidence of both acute grade 1 and 2 GI toxicity was (31.15%) and (13.5%). Acute Grade 1 and 2 GU effects were observed in (27%) and (31.15%) of patients respectively. No side effects of grade 3 or higher occurred due to strict dose constraints, dietary and water instructions given by our department.
Conclusion:
The main purpose of our department is to improve the management of patients by increasing the doses of radiotherapy in prostate cancer and reduce side effects to improve the quality of treatment.
The IAEA's contribution is undeniable in implementing IMRT in our department in terms of training medical physicists and radiotherapy manipulators.

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Contribution ID: 133 **Type: Poster**

Ideal Tumor Contouring for Radiotherapy in lung cancer - Enduring Myth

Jai Prakash Agarwal (Professor & Head, Department of Radiation Oncology Tata Memorial Hospital, Parel, Mumbai)
Anil Tibdewal, Mangesh Patil, Sabheen Bushra

Introduction:
Lung cancer is the leading cause of cancer related mortality worldwide. Approximately one third of patients presents at a curable stage of the disease. Radiotherapy plays a very important role in curative management of lung cancer. In stage I NSCLC, stereotactic body radiation therapy is the treatment of choice in medically inoperable patients and those who refused surgery. In stage III, concurrent chemoradiation is the standard treatment. Indications for radiation therapy to primary lung tumor has expanded with the recent evidence in oligometastatic non-small cell lung cancer. SBRT is also routinely employed for pulmonary metastases from other primary tumors.
Target delineation is a very critical step and is a common source of error in lung cancer radiotherapy. Tumor delineation is subjective, physician dependent and requires expertise. Intra and inter observer variability is a common feature in contouring of lung cancer. Positron emission tomography (PET) with computed tomography (CT) reduces interobserver variability but does not completely eliminate. Objective methods like PET-CT guided auto delineation of tumor depends on the segmentation method and threshold can be used for tumor volume generation.
Another significant challenge in target contouring is respiratory tumor motion. Motion encompassing techniques like four dimensional computed tomography (4DCT) is used to generate individual internal target volume (ITV). Post processing tools like maximum intensity projection (MIP)is the most common and time efficient technique for ITV generation. However, its utility is not proven in locally advanced lung cancer patients. Other techniques like tumor contouring in all 10 phases of respiration is laborious and time expensive technique. In this synopsis, we aimed to review 1) PET-CT based auto contouring using various thresholds and its comparison with pathological tumor size in early lung cancer and 2) ITV generation using MIP and contouring in all phases of respiration in locally advanced lung cancer.
Material and Methods:
In theseIRB approved studies, ideal contouring of tumor volume was assessed using two different methods in early and locally advanced lung cancer datasets. First,we assessed the PETCT based primary tumor delineation using various percentage thresholds of maximum standardized uptake value (SUVmax). From January 2013 to July 2014, 37 surgically resected early stage NSCLC who underwent PET CT at our institute were retrospectively enrolled. Here, we did auto delineation of primary tumor using various percentage threshold of SUVmax as objective criteria and compared the largest tumor diameter in any dimension with largest pathological tumor diameter. Optimal SUV threshold was obtained using linear regression analysis and Bland Altman plot. In second dataset, we compared primary tumorcontouring using MIP datasetand contouring in all 10 phases of respiration. From January 2014 till March 2017, 30 consecutive patients of locally advanced NSCLC who underwent 4DCT were retrospectively enrolled. Both the contoured volumes were compared using matching index

(MI). It is the ratio of the intersection of two volumes to the union of two volumes.

Results:

In early lung cancer, the mean optimal percentage threshold of SUVmax that correlated with pathological tumor size was 36% ± 18%. Using Bland-Altman plots, auto-contouring of primary tumor with 40% SUVmax was in greater agreement with thepathological tumor size. In the locally advanced lung cancer, tumorvolume delineation using MIP is significantly smaller than tumor delineation in all 10 phases of respiration. Themean MI was 0.75 (range 0.57-0.88). The mean tumor volume delineated using all 10 phases not covered by MIP based tumor delineation was 23.5%, compared to vice versa of 6%. Mean MI reduced to 0.73 for tumor adjacent to high density structures like mediastinum, chest wall and diaphragm. MI was not different between smaller and larger tumors. However, the average time required for ITV delineation was considerably less with MIP (9 vs 96 minutes).

Conclusion:

Precise and accurate tumor delineation in lung cancer is a complex process. Auto-contouring using percentage threshold of 40% SUVmax might be a good objective criteria for accurate tumor delineation and requires further validation in a larger cohort of all stage patients. MIP based primary tumor delineation is a simple time-efficient technique however, can miss the tumor edges. Continued use of MIP should proceed with caution especially in tumor adjacent to high density structures like mediastinum, chest wall and diaphragm. It is advisable to see for completeness of tumor contours on CT slice in various respiratory phases.

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Contribution ID: 26 **Type: Poster**

Geometrical Analysis of IMRT/VMAT on Head and Neck Case Using New and Reused Thermoplastic Mask in Dharmais Hospital National Cancer Center Indonesia

Kartika Erida Brohet (Radiotherapy department, Dharmais Hospital National Cancer Center (Indonesia National Cancer Center)
Syarifatul Ulya

Introduction

Based on The National Comprehensive Cancer Network (NCCN) Guideline, Intensity Modulated Radiation Therapy (IMRT) is the recommended radiotherapy technique for head and neck cancer cases. The reason is that IMRT is rapidly reaching its maturity in delivering very precise dose distributions with the ability to achieve a high dose in tumor while sparing normal tissue.[1] Thus, the efficacy of radiotherapy can be well maintained. However, its clinical success is limited by its requirement for motion management and reduction of an inter-fractional setup error. [2], [3] In cases where there are many critical organs at risk (OAR) that needs to be spared, such as head and neck cases, certain efforts must be made to ensure accurate positioning of the inter-fraction patient and obtain a repeatable dispensing of the dose, one of those efforts is the use of immobilization device such as a thermoplastic mask.[4], [5] The challenge for health practitioners, especially in low middle-income countries such as Indonesia is to maintain efficacy as much as possible with minimal operational costs. Currently, the mask device for most of the radiotherapy centers in Indonesia is still being reused, with consideration of high operational costs and the recommendation from the mask vendor that stated the mask may be reused. Therefore, this study was aimed to ensure the accuracy of thermoplastic masks and to determine of PTV margin, both new and reused.

Methodology

The experiments were conducted using Varian Trilogy Linear Accelerator with the IMRT and VMAT technique. In this study, we analyzed systematic and random error calculation in the setup verification of 27 patients with head and neck cases. Patients included in the study were head and neck cancer patients diagnosed as T1-4, N0-3 according to AJCC TNM Staging, 8th edition, and treated in the supine position. Moreover, the patients were randomized and divided into 3 groups: group A (Code A) using a new mask, group B (Code B) using first reused mask, group C (Code C) using a twice reused mask. The randomization and mask allocation was performed by the Radiotherapy Technician (RTT) in CT Simulator. The pre-treatment verification was performed on three directions: lateral (X-axis), vertical (Z-axis), and longitudinal (Y-axis) and the shift was recorded. The random error (σ) was defined as the average of a standard deviation of the shift per patient along with particular directions which can easily quantify systematic error (Σ) along with those directions. The systematic component of the displacement represents the patient movement at the time during the entire course of treatment.[6] The analysis of PTV margin was conducted using random and systematic error data, according to the formula founded by Strome et al. (2002) in their research.[7] Patient verification was performed using CBCT in the Linac machine before the first treatment and every five fractions of the IMRT and VMAT delivery. ICRU 62 reported that the PTV segment is divided into two distinct sub margins, the setup margin which accounts for uncertainties associated with patient setup, and the internal margin which accounts for target motion. [8]

Result

The systematic and random errors for new and reuse thermoplastic masks in each direction were listed in Table 1. It could be seen that the systematic error in the new mask (group A/code A) in the lateral, longitudinal, and vertical directions was 2,0 mm, 1,7 mm, and 2,6 mm, respectively. When all three translational coordinates in the mask device with code A were analyzed with random error, the results were 1.4 mm, 1,3 mm, and 1.6 mm. The systematic and random error in each mask treatment within each direction showed the only small difference. The PTV margin of head and neck cancer cases treated with the IMRT technique in all directions is shown in Figure 1. All of them were less than 3 mm. The CTV to PTV margin difference between Code A, B, and C of thermoplastic mask devices also only showed a small difference. This result may be used as a recommendation for head and neck radiotherapy treatment practice guidelines in our hospital.

Conclusion

The successful implementation of the IMRT/VMAT on the Head and Neck target requires accurate and reproducible treatment in delivering over 6-7 weeks of the treatment course. We studied the magnitude of daily patient positioning errors corrected by Cone Beam CT image registration. The composite geometric error of three Cartesian the CTV to PTV margin is less than 3 mm and the comparison between each mask (new, first reused, and twice reused masks) showed no mark difference. This research could be used to justify the use of new and reuse thermoplastic masks in head and neck cases treated with IMRT/VMAT technique in the developing country. To improve treatment efficacy, we encourage other radiotherapy centers to calculate the magnitude of the CTV to PTV margin in the new and reuse the thermoplastic mask.

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Contribution ID: 141 **Type: Poster**

How to better optimize radiotherapy workflow in developing countries

Mohamed Ait Erraisse (Department of Radiotherapy, University Hospital Hassan II)
Moulay Ali Youssoufi, Khalid Hassouni

Introduction:
Delay to access to radiation therapy in developing countries is challenging and compromising the cancer prognosis.
In our department we had one linear accelerator for a whole region in the country. We treated about 50 to 60 patient a day from 8 am to 8 pm and appointments were for more than 3 months. The medical and psychological impact on patients was important. Our objective was to shorten this delay while keeping a good quality treatment.

Methods:
To achive this goal, actions were taken on different levels :
The hospital executive decided to transform the oncology hospital to an emergency hospital with the possibility to work and treat 24/7, therefore, we could treat up to 100 patient a day or more.
we also treat on weekends especially palliative patients.
Concerning the patient workflow, patients were seen immediately when they arrive to the department, and if medical file is complete and ready to radiation, CT simulation was done within a week. Countouring, dosimetry and validation with safety checks were done within 3 days.
And finally, when possible, we chose hypo-fractionated regimens (Breast, rectum, single fraction for palliative, etc …).

Results:
By implementing the procedures above, we start observing significant improvement in the quality of radiotherapy management for our patients.
The new patients had access to medical consultation once arrived to the department. This was a big psychological relieve for the patient. He could have at least an idea about his disease, prognostics, management, radiotherapy and medication when necessary.
Shortening time between CT-simulation and treatment reduced errors at the first fraction set-up.
The appointment time started to drop from more than 3 months to almost 2 weeks after including all the patients in the waiting list.
Actually, the mean time between first arrival to the department and the first fraction is about 10 days.

Conclusion
In developing countries, access to radiotherapy is a real problem. The number of linear accelerators per capita is very low. Therefore delays are very long. This kind of approach, if sufficient human resources, could solve the problem while waiting for a second and maybe other machines.

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Contribution ID: 142 **Type: Poster**

HDR brachytherapy in low resource countries

Mohamed Ait Erraisse (Department of Radiotherapy, University Hospital Hassan II)
Moulay Ali Youssoufi, Khalid Hassouni

Introduction

HDR brachytherapy is still the best conformal radiotherapy technique. It is less expensive than any EBRT technique and could be used in developing countries as a curative intent or a salvage option and in some rare cases as palliative intent.
We report our experience in its use as a salvage treatment in pre irradiated sites not eligible for 3DCRT.

Material and Methods

This is a retrospective study of 9 patients : 8 with with nasopharyngeal cancer recurrence and 1 with oral tongue recurrence collected in the radiotherapy department of the University Hospital Hassan II in Fes between January 2014 and December 2019.
All patients with nasopharyngeal cancer received external radiation therapy at 70 Gy on macroscopic tumor volume (tumor and lymphadenopathy) during initial irradiation with or without chemotherapy. The patient with squamous cell carcinoma of the tongue had surgery (tumor excision with lymph node dissection) and adjuvant chemoradiotherapy at 60 Gy with concomitant cisplatin.
All recurrence were histologically proven.
For nasopharynx : Relapse was localized in 5 patients and associated with lymph node involvement in 3 patients. For the oral tongue: it was localized.
Concerning the technique of brachytherapy :
Intracavitary brachytherapy with Rotterdam applicator was used in nasopharyngeal recurrences : 2 patients received exclusive high-dose-rate brachytherapy at a dose of 30 Gy in 10 fractions and 6 received external radiation radiotherapy followed by brachytherapy (40 -50 Gy in EBRT followed by brachytherapy boost of 2-4 x 3 Gy.
Interstitial brachytherapy with flexible needles was used for the local recurrence of the oral tongue with trans-submandibular insertion at a dose of 12 x 4 Gy.

Results

The average age of our patients is 42 years old. There were 1 woman for 8 men. The mean time from symptoms to consultation was 6 months. Histology of nasopharyngeal carcinoma was WHO III and SCC for the oral tongue.
The average time to onset of relapse is 29 months.
With an average follow-up of 20 months, 37.5% of NPC patients and the patient with oral tongue recurrence are alive and in complete remission.

Conclusion

Brachytherapy alone or after EBRT could play an important role in reirradiation of locally recurrent Head and Neck cancers with acceptable toxicity.

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Contribution ID: 106 **Type: Poster**

Can accelerated hypofractionated radiotherapy (AHRT) be an acceptable treatment option in inoperable non-small cell lung cancer Myanmar patients?

Shoon Mya Aye (Radiotherapy department, Yangon General Hospital)
Lin Lin Kyi, Moe Hlaing, Aye Aye Myint, Khin Cho Win

Introduction

Lung cancer is one of the most common causes of cancer mortality worldwide. The prognosis is poor even if patients can undergo curative treatments such as radical surgery or standard radical radiotherapy treatment (60 Gy in 30 fractions over six weeks with or without concurrent chemotherapy). However, most lung cancer patients are diagnosed as advanced inoperable stage and majorities are old age, with comorbid diseases or with poor lung/ cardiac function. Therefore, for those patients, shorter course radiation regime such as accelerated or hypofractionated regime should be considered.
This study was conducted to assess the outcomes of accelerated hypofractionated radiotherapy (AHRT) (45 Gy in 15 fractions over three weeks by using 3D conformal planning) in inoperable non-small cell lung cancer (NSCLC) patients who were ineligible for surgery or standard concurrent chemo radiotherapy (CCRT).

Methodology

This was a hospital based prospective study (2018 January- 2019 June) which had been done in Radiotherapy Department, Yangon General Hospital, Myanmar. A total of 65 patients with unresectable or medically inoperable non-small cell lung cancer patients, who were unfit for chemotherapy due to some comorbidities (E.g., poor cardiac, liver or renal function, etc., or old age) were enrolled in the study. Patients with poor PS (ECOG PS >2), patients with distant metastasis or patients previously treated with thoracic radiotherapy or chemotherapy were excluded.
They were treated with the regime of 45 Gy in 15 fractions over 3 weeks by using 3D conformal RT technique. Locoregional response was assessed by chest CT before and six weeks after RT. Revised RECIST (Response Evaluation Criteria in Solid Tumours) guideline version 1.1 was used to detect locoregional response. Relief of symptoms such as cough, dyspnoea and chest pain was evaluated before RT, during RT and six weeks after RT. Treatment related acute toxicities such as dysphagia and radiation dermatitis were observed during and six weeks after RT. Common Terminology Criteria for Adverse Events (CTCAE) version 5.0 was used to study these symptoms and toxicities.

Results

65 patients with inoperable NSCLC (7 patients with stage II and 58 patients with stage III) were participated in this study. The most common age group was 71-80 years (36.92%) and most commonly found cell type was squamous cell carcinoma (73.9 %). The majorities were male (69.2%), smokers (67.7%), with PS1 (44.6%). Among them, two patients were lost to follow-up at 12 weeks after RT due to death. Assessment of locoregional response six weeks after RT showed that partial response (PR) was seen in 69.23% of patients and stable disease (SD) was seen in 30.77% while there was neither complete response (CR) nor progressive disease (PD). Associations between baseline characteristics and tumour response were also observed. Statistically significant associations were only found between pre-treatment tumour

size vs tumour response and performance status of the patients vs tumour response. Good relief of symptoms such as cough, dyspnoea and chest pain was found after RT, but no severe acute toxicities such as dysphagia and radiation dermatitis (more than grade 3) were resulted at the end of the study.

Conclusion

The locoregional response and symptomatic response of inoperable non-small cell lung cancer patients to this accelerated hypofractionated radiotherapy regime (with 45 Gy in 15 fractions over three weeks) were good. The treatment regime was well tolerated with acceptable toxicity results. As accelerated radiotherapy can decrease treatment time and treatment related costs, this may become an acceptable option for those patients who are unfit for prolonged intensive radical treatment in a resource limiting country like Myanmar.

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Contribution ID: 69 **Type: Poster**

Transitioning from 2-D to 3-D Image-Guided Brachytherapy (IGBT) in Gynecologic Malignancies in the Philippines: Looking Back and Moving Forward

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Introduction:
Brachytherapy is the standard treatment to achieve adequate tumor dose leading to better clinical outcomes. This paper aims to present the development, current status, clinical outcomes, as well as, obstacles in the use of brachytherapy specifically in the adaptation of IGBT in gynecologic malignancies in the Philippines.

Methods:
A survey was done regarding the status of IGBT in the Philippines.

Results:
In the Philippines, the 1st LDR manual-loading brachytherapy was launched at the Philippine General Hospital in 1962. Advancements included the 1s LDR remote afterloader (1985) and 1st HDR remote afterloader brachytherapy (1990's).
The concept of IGBT was introduced by Prof. Richard Potter through the 1st ESTRO-SEAROG-PROS teaching course (2009). 2 years after, the first IGBT was performed at JRRMMC. The Philippine adaptation of IGBT was strengthened by the RAS 6062 project of the IAEA in cooperation with PNRI, and reinforced by JRRMMC-IAEA National Training Course conducted by international experts.
International collaborations/trainings in IGBT were made possible through Forum for Nuclear Cooperation in Asia (FNCA) and Gunma University-Department of Radiation Oncology, Japan.
Since the introduction of IGBT in 2009, the number of radiotherapy (RT) facilities with IGBT capabilities has dramatically increased in the country. Currently there are 11 IGBT capable RT facilities across the country (NCR-7, Luzon-2, Visayas-1, and Mindanao-1) from the 18 centers with HDR brachytherapy units. Out of the 11 facilities, 8 of which started it's IGBT procedures namely: Jose R. Reyes Memorial Medical Center (2011), Makati Medical Center (2012), St. Luke's Medical Center –Global City (2012), University of the Philippines-Philippine General Hospital (2016), St. Paul's Hospital (2016), Asian Hospital and Medical Center (2016), St. Luke's Medical Center QC's (2017), and University of Santo Tomas-Benavides Cancer Institute (2017). As of April 2018, there are approximately 1644 procedures done using IGBT in the Philippines. The practice and art of which is significantly adapted by different centers in the country and the GEC-ESTRO guidelines were utilized for standardization of techniques, contouring, dose prescriptions and treatment planning by most centers tailored to their existing technical capabilities and preferences.The adaptation of IGBT in the country is still evolving as to clinical outcomes on local control, survival and treatment-related toxicities.

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Conclusion:

IGBT continues to evolve and many centers across the country have adapted this technology. Clinical outcomes in the use of IGBT in the Philippines are expected to be reported with the widespread use of this technology.

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Contribution ID: 112 **Type: Poster**

Treatment outcomes of stereotactic body radiotherapy for early stage non-small-cell lung cancer and lung metastasis

Thongtra Nanna (Ramathibodi Hospital, Mahidol University)
Keeratikarn Boonyawan, Putipun Puataweepong, Thitiporn Suwatanapongched

Introduction

Stereotactic body radiotherapy (SBRT) is a highly precise local treatment with high dose per fraction. Local control rate in lung tumors treated with SBRT is high, 85-95%. Several studies showed the predictor for local control of lung SBRT in patients with primary lung cancer and/or lung metastasis was the prescribed biological equivalent dose with $\alpha/\beta = 10$ (BED10) and common SBRT-related complications were radiation pneumonitis (RP), rib fracture, and cardiotoxicity. For central/ultracentral lung tumors, the fatal complications, such as pulmonary hemorrhage, were reported.
Despite increasing use of SBRT, there are still unclear predicting factors about its outcomes. Therefore, patients with lung tumors treated with SBRT in Ramathibodi Hospital were reviewed.

Materials and methods

A retrospective cohort study was performed in therapeutic and prognostic type and received ethics approval from the Institutional Review Board. Medical records and SBRT plans of all patients diagnosed early stage non-small cell lung cancer or lung metastases treated with SBRT from January 2009 to September 2018 in Ramathibodi Hospital were reviewed. Inclusion criteria were histologically confirmed early stage NSCLC (T1-2N0M0), lung metastasis with known primary malignancy and good performance status (ECOG ≤ 2). Exclusion criteria were missing data and reirradiation to in-field region.
We delineated additional interesting volumes such as a 3-cm shell outside the planning target volume (PTV), left atrium, superior vena cava, and ribs. Dose prescription was prescribed at isodose line covering PTV at PTV D95%. There was no clinical target volume (CTV) and gross target volume (GTV) was expanded 3- to 5-mm margin to be PTV. Radiation was delivered by three linear accelerators as follows, with ray tracing, Acuros and Analytical Anistropic Algorithm (AAA).
Imaging studies and SBRT plans were reviewed by either a thoracic radiation oncologist or a thoracic radiologist in order to identify local recurrence or post-radiation change.

Results

59 patients with 98 lung lesions were eligible which primary NSCLC and lung metastasis were 15.3% and 84.7%, respectively. Median follow-up time was 16.8 months (0.1-71.7 months). There were variations in patient demographics between two types of lung tumors. Primary NSCLC patients were older, more comorbidities and poorer performance status compared to the other. Majority of tumor origin and histopathology were primary lung cancer, 49% and adenocarcinoma, 82.7%. Median maximal diameter of the tumor was 2.3 cm (0.1-8 cm). Dose prescriptions were various from 25-60 Gy in 1-10 fractions.
As competing risk analysis, overall 1-year local control rate was 90.8%, 93.4% found in

primary lung cancer and 90.1% in lung metastasis. The most common pattern of failure was distant failure, 46.9%. The follows were local and regional failure patterns, 12.2% and 6.1% respectively. Of 9 (9.2%) lung tumors, pulmonary toxicities were observed which radiation pneumonitis grade ≥2 found in 8 (8.2%) lesions and one of four patients with ultracentral lesions experienced grade 5 pulmonary hemorrhage. The multivariate analysis of factors predicting local failure was mean BED of the PTV. Mean BED of the PTV <100 Gy had more 1-year local failure compared to the dose ≥100 Gy, 15.5% versus 3%, adjusted SHR 5.41 (95% CI 1.14-25.69), p-value = 0.034. The maximal diameter of the tumor >5 cm had higher grade ≥2 pneumonitis, 18% versus 3.3%, adjusted SHR 5.34 (95% CI 1.52-18.69), p=0.009. 1-year overall survival was 80% in primary NSCLC and 72% in lung metastasis. Median overall survival was 16.8 months (0.1-71.7 months).

Conclusion

Local control rate of lung SBRT was high with acceptable toxicity. BED PTV mean was the predictive factor for local tumor control. The tumor maximal diameter >5 cm might correlate with radiation pneumonitis grade ≥2.
Lung SBRT might not suitable for ultra-central lung tumor.

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Contribution ID: 74 **Type: Poster**

Adaptation of an Extended Five Field technique for the treatment of Head & Neck Cancer at Cancer Diseases Hospital

Kennedy Lishimpi (Cancer Diseases Hospital)
Barbara Chanda M'ule, Maurice Mwale, Catherine Mwaba

Background:
The definitive treatment of Head & Neck Squamous Cell Carcinoma (HNSCC) requires the delivery of high doses (66 – 70 Gy) to the planning target volume (PTV) which includes the gross tumor with associated microscopic disease, nodal levels I – VI depending on tumor site and a margin. In the absence of Intensity Modulated Radiotherapy (IMRT), this is safely delivered using a combination of two lateral opposed Head and Neck fields (photon) matched to an anterior neck field (photon) and electron beams for the treatment of the posterior neck area. The Cancer Diseases Hospital (CDH) is the only center offering radiotherapy in Zambia though in the recent past there has been frequent breakdowns and extended downtime on the only Linear Accelerator (LINAC) due to the wear and tear of the aging machine, and sometimes electrons are unavailable. With the existing challenges, the Head and Neck Unit at CDH searched for alternative treatment techniques for the treatment of HNSCC without the use of electrons. Fogliata et. al. (1999) described a 5-photon field technique covering the whole neck that avoided field matching and electron beams. This paper provided the basis of the feasibility and adaption of the 5-photon field plan without electrons on Cobalt-60 machine.

Methods and Materials:
Using the 5-field plan as described by Fogliata et. al. (1999), a HNSCC was selected and planned for radiotherapy on a cobalt-60 machine. The plan is mono-isocentric and the prescription to the PTV54 was 54 Gy. The PTV54 included Nasopharynx (NP), High Risk Lymph Nodes (HRLN) and Low Risk Lymph Nodes (LRLN). An additional 12 Gy boost was prescribed to a reduced Boost PTV66 which included NP and HLN to a total of 66 Gy. The plan was analysed using CBCHOP method (Dean, et. al., 2017). Presented here are the results for the case for a patient with nasopharyngeal cancer.

Results:
Using the 5-field plan the 95% PTV54 received 80.9% (43.7 Gy) of the prescribed dose. The maximum, minimum, median and mean doses were 115.1%, 66.6%, 98.2% and 96.9% respectively of the prescribed dose. The dose constraint to the spine was set at 79.6% (43 Gy) and what was achieved was a maximum dose to the spinal cord of 80.0% (43.2Gy).

Conclusions:
We therefore find it acceptable to treat patients with this technique in the absence of electrons. It is possible to plan patients for conformal HNSCC treatment on the cobalt machine. Further validation will be done through analysis of more plans for treatment on the cobalt machine.

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Session: Education, Health Economics and Health Systems Research

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Contribution ID: 87 **Type: Proffered Papers**

Revitalizing and strengthen the capacity of cancer management in Cambodia: Past-Present and future involvement of multi-stakeholders

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Not only after 2003 that the installation of a Cobalt machine with the efforts of Cambodian Government and the French NGOs (Physicien Médical san Frontière and Cancérologue Sans Frontière), an oncology department has reopened again at (Khmer-Soviet Friendship Hospital) to serve Cambodian population suffering from cancers. Alongside with the medical equipment and facilities, the need in term of the competent medical staffs are in a priority for helping policy. Due to the recent data estimated by Globocan 2012, there were at least 15,116 new cases of cancer patients in Cambodia. With a population of 16 million and the huge number of new cancer cases, at least 60% of cancer cases might need more radiation therapy facilities. Under support of health policy, National Strategic Plan 2008-2015 for Non-Communicable Disease and with the recommendation of imPACT mission report by the International Atomic Energy Agency in 2013 and Country Program Framework 2017-2023, has triggered stakeholders to get involved. A proposal made since 2013 and submitted to the World Bank via the Second Health Sector Support Project (HSSP2) of the Ministry of Health to support upgrading the radiotherapy unit at the department of oncology at Khmer Soviet Friendship Hospital, a non-profit healthcare institution affordable for poor people. The new radiotherapy machine using 6MV Linear Accelerator is now treating 40-45 patients per day and it replaced the old Cobalt 60 unit since March 2016. At the same time with efforts of the Cambodian government, Ministry of Health, and under the funding and technical support from the IAEA (Technical Cooperation), a new National Cancer Cancer was established since January 2018. For the perspectives to achieve sustainable success, the situation indicates that; the need for human resources (for better functioning of the cancer centers as well as to create a hub of local academic degrees for medical specialists, medical physics and radiation therapy technologies) with standard quality in the field of radiation therapy will play a crucial role in term of the current and future improvement of cancer management in Cambodia. So far, Stakeholders including National Hospitals, Medical universities and the TC program of the IAEA since 2012-2021, International partners (Such as PMSF, IPC, ICANS, CSF, APROSIG) play major roles in capacity building of medical professionals, enhancing cancer center facilities to the need of Cambodian people which follow the recommendation of United Nations' Millennium goals of sustainable development.

Abréviation: PMSF: Physicien Médical Sans Frontière, IPC : Institut Paoli Calmette, ICANS : Institut de Cancérologie de Strasbourg, CSF : Cancérologue Sans Frontière. APROSIG : Asia Pacific Radiation Oncology Special Interest Group.

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Contribution ID: 32 **Type: Proffered Papers**

The basic situation of radiotherapy in mainland China：A national survey in 2019

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Background and Objective

The radiation oncology developed rapidly in recently years in China, and our government also want to established and adjust the national development program. To provide data for making national radiation oncology development program based on the current situation and requirement.

CSTRO established in 1986. Provide proposal for government on how to develop and regulate the health policy is one of the tasks of CSTRO, In the past decades, 8 times national survey have done by CSTRO. In 2019, the 9th national survey was done.

Methods

The investigation method was adopted with the electronic questionnaire through internet platform.

Required information include: Staffs, devices, techniques, annual person-times of radiotherapy. The most common primary tumor treated by RT. RT units/million people and the proposal of WHO were calculated and compared, proposal for how to improve RT was submitted to the health authority.

Results and Discussion

The mainland China have RT centers: 1463, RT treated pts in 2019: 1,259,602 (<30% of newly diagnosed pts), the most common primary sites was: lung, followed by esophagus, breast, cervix, rectal, NPC. The RT human resource include RO 14,575, MP 4,172, RTT 8,940 and Engineers1,409. The RT equipment include: LA: 2021 uints, Cobalt-60 66 unit, brachytherapy 339 sets, photon or heavy ion 5 units, X-ray simulator 1453 units, CT simulators 355 units and MR simulator: 34 units. The RT development rapidly in the past decades.

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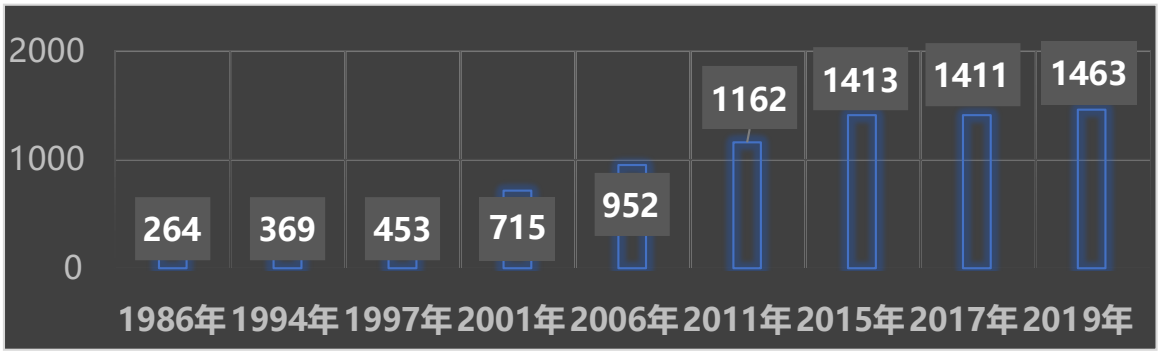

Figure 1 The developmemt of RT center in mainland China from 1986-2019

There were only 1.5 accelerate units /million people (LA+Cobolt) in mainland China, which is much lower than WHO recommendation. Only Beijing, Shanghai, Shandong provinces fulfill the recommendation of WHO which own 3.73/M, 2.54/M and 2.35/M respectively, the southern-western provinces such as Yunnan, Guizhou, Ningxia own lower than 1LA unit/M. Even the relative economically developed provinces such as Guangdong and Zhejiang only own 1.04/M and 1.07/M.respectively.

New RT technology was widely use in national level, 86.9% RT centers can provide 3DCRT, IMRT, SBRT, Tomotherapy etc. new RT technique. High technology RT equipment was rare in mainland China, only 2 proton and 1 heavy ion centers are running. But 16 proton centers will be built and put into operation in future 5 years.

Conclusions

Although huge progression have made in the past decades in RT in mainland China, there are still huge gap exist between the requirement and provided.

The most common primary tumor treated by RT was lung, followed by esophagus, breast, cervix, rectal, NPC etc.

Less than half of patients who need RT received RT national wide. High technology RT equipment is rare in China, but there is a plan that 16 proton centers will be built in the future 5 years

References

[1]. Gu XZ, Feng NY, Yu Y. Investigation report on the composition, equipment and technical level of radiation therapy team in China [J]. Radiat Oncol China, **3** (1989) 41.

[2].Yin WB, Chen B, Gu XZ. General survey of radiation oncology in China . Chin J Radiat Oncol **4** (1995) 271.

[3]. Yin WB, Tian FH, Gu XZ. Current status of radiation therapy personnel and equipment in China. Chin J Radial Oncol, **7** (1998) 131.

[4]. Yin WB, Tian FH. Survey report on national radiation therapy personnel and equipment in 2001. Chin J Radial Oncol **11** (2002) 145.

[5].Chinese Society of Radiation Oncology (Yin WB, Yu Y, Chen B, et al). Fifth nationwide survey on radiation oncology of China in 2006. Chin J Radial Oncol, **16** (2007) 1**.**

[6] Chinese Society of Radiation Oncology (Yin WB, Chen B, Zhang CL, et al). The sixth nationwide survey on radiation oncology of continent prefecture of China in 2011. Chin J Radiat Oncol, **20** (2011): 453.

[7]. Lang JY, Wang P, Wu DK, et al. An investigation of the basic situation of radiotherapy in mainland China in 2015. Chin J Radiat Oncol **25** (2016) 541.

[8].IAEA. Setting up a radiotherapy programme : clinical, medical physics, radiation protection and safety aspects. Wien : IAEA. 2008.

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Contribution ID: 8 **Type: Proffered Papers**

Competences of Medical Dosimetrists and Radiation Therapy Technologists working in a Costa Rican Radiotherapy Department: a benchmarking approach to the recommended ESTRO Core Curriculum using a Training/Competency Matrix

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Background and objective

The literature identifies various competences required for Medical Dosimetrists (CMD) and Radiation Therapy Technologists (RTT); however, these are varied and scattered among different publications [1]. The aim of this study was to identify the actual competences of CMD and RTT practicing on treatment planning (TP) with tri-dimensional conformal (3DC) or intensity modulated (IM) radiation therapy (RT) and linear accelerator (LINAC) respectively and their future training needs in Hospital San Juan de Dios Radiotherapy Department (RT-HSJD) according to a benchmarking approach over the recommended ESTRO Core Curriculum for RTTs [2], [3].

Methods

The recommended ESTRO Core Curriculum for RTTs [2], [3] was scrutinized for competences practiced by CMD and RTT. A systematic approach was performed by direct observation of the CMD and RTT daily practices to find relevant competences and training needs. A thematic analysis was performed to organize the competences according to themes [1], [4].

The themes analyzed were: 1) Non-technical competences (Quality and risk management, Decision making and critical analysis, Management and leadership, Team work and multidisciplinarity, Communication). 2) General technical competences in RT (Professionalism, Patient Care, Research, Education, Equipment quality assurance, File verification). 3) Technical competences in TP (Simulation, Contouring, 3DCRT-TP, IMRT-TP, Planning quality assurance). 4) Technical competences in LINAC (Positioning and immobilization, Delivery of treatment, Verification of patient setup, IGRT Image Verification). Then, a Training/Competency Matrix (T/C-M) was created to identify the relationship of the competences and the actual level achieved by each CMD and RTT in the RT department (Table 1). The competency level was set in the following qualifications: Great competency, autonomy and can teach others (4 points, purple color), Advanced competency and independent decision making (3 points, green color), Basic competency and dependent decision making (2 points, light blue color), In training (1 point, orange color) and Needs training (0 points, red color).

Results and discussion

The actual level, distribution and results achieved by each CMD and RTT in RT-HSJD can be observed in Table 1. A T/C-M is a tool used to document and compare the required competences for a position with the current skill level of the employees performing the role. It

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is used in a gap analysis to determine where an organization has critical training needs and as a tool for managing people development [5].

Table 1. Training/Competency Matrix for Medical Dosimetrists and Radiation Therapy Technologists in Hospital San Juan de Dios Radiotherapy Department.

	Caja Costarricense del Seguro Social Hospital San Juan de Dios Radiotherapy Department		1 Non-technical competencies					2 General technical competences in RT						3 Technical competences in TP					4 Technical competences in LINAC			
	Name	Role	Quality and risk management	Decision making and critical analysis	Management and leadership	Teamwork and multi-disciplinarity	Communication	Professionalism	Patient Care	Research	Education	Equipment quality assurance	File verification	Simulation	Contouring	3DCRT treatment planning	IMRT treatment planning	Planning quality assurance	Positioning and immobilization	Delivery of treatment	Verification of patient setup	IGRT Image verification
1	CMD1	Medical Dosimetrist																				
2	CMD2	Medical Dosimetrist																				
3	CMD3	Medical Dosimetrist																				
4	CMD4	Medical Dosimetrist																				
5	RTT1	Radiation Therapy Technologist																				
6	RTT2	Radiation Therapy Technologist																				
7	RTT3	Radiation Therapy Technologist																				
8	RTT4	Radiation Therapy Technologist																				
9	RTT5	Radiation Therapy Technologist																				
10	RTT6	Substitute RTT																				
11	CMD5	Substitute CMD																				
12	RTT7	Substitute RTT																				

Competency level	
Great competency, autonomy and can teach others	4
Advanced competency and independent decision making	3
Basic competency and dependent decision making	2
In trainning	1
Needs trainning	0

Source: Quality Management Committee RT-HSJD, 2020.

Conclusions

The T/C-M provides a comprehensive view of all the skills and behaviors needed in a RT department. It aids in managing the training budget because it identifies skill gaps across the organization rather than just one person at a time. It assists with planning by helping identify and target new skill areas that RT departments might need for the long term [5].

RT-HSJD has only two of nine fixed employees with professional training, and they summarize the highest competency levels. Both has a Licentiate degree in Diagnostic Imaging and Radiotherapeutics from the University of Costa Rica (LIC-IDT-UCR) with specific training in Radiation Oncology. The other team members are radiographers with empiric training in this specialized area.

Actual CMD and RTT across RT-HSJD must be formal trained to bridge the gap with professional standards or recommendations published such as the ESTRO Core Curriculum for RTTs and to ensure the best care possible is given to patients [6]. This study also promotes and emphasizes in the importance to incorporate professionals on CMD and RTT roles, as the ones with LIC-IDT-UCR.

References

[1] COUTO, JG. et al, Competencies of therapeutic radiographers working in the linear accelerator across Europe: A systematic search of the literature and thematic analysis, Radiography, (2019).

[2] EUROPEAN SOCIETY FOR RADIOTHERAPY & ONCOLOGY, Benchmarking document for Radiation TherapisTs, European Higher Education Area Level 6, (2014).

[3] COFFEY, M., LEECH, M., The European Society of Radiotherapy and Oncology (ESTRO), European Higher Education Area levels 7 and 8 postgraduate benchmarking document for Radiation TherapisTs (RTTs), Technical Innovations & Patient Support in Radiation Oncology, 8, 22–40, (2018).

← Back To Table of Contents

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, A Handbook for the Education of Radiation Therapists (RTTs), Training Course Series 58, Vienna, Austria (2014).
[5] KURUBA, M., Role Competency Matrix: A Step-By-Step Guide to an Objective Competency Management System, 1st edn, Springer Nature, Singapore, (2019).
[6] COFFEY, M., LEECH, M., POORTMANS, P., Benchmarking Radiation TherapisT (RTT) education for safe practice: The time is now, Radiotherapy and Oncology, 119(1), 12–13, (2016).

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Contribution ID: 53 **Type: Proffered Papers**

Closing the Radiotherapy Gap in Indonesia: Reflection on National Roadmap Program

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Background and objective

Cancer has been increasingly become a burden in the world, particularly in developing countries such as Indonesia. Based on GLOBOCAN 2018, Indonesia cancer cases is expected to rise from 348,809 to 575,814 in 2040 or a 65.1% increase. Moreover, cancer attributable deaths will also spike up 76.9% from 207,210 to 366,567 deaths in 2040. Out of those number, the five most prevalent cases are breast, cervix uteri, lung, colorectum and liver.[1] There are three mainstay treatments for cancer, including surgery, radiotherapy and chemotherapy. As one of the mainstay treatments, radiotherapy is an essential part of cancer management.[2] It is estimated that around 50% of cancer patients need this type of treatment. Looking into the number of cancer cases in 2018, around 174 thousand cancer patients need radiation therapy.[1,2] This number of cancer cases can be translated into 343 machines needed for the treatment of cancer using conventional fractionation. Using hypofractionation strategy, it is estimated that 268 teletherapy machines are needed. Talking about teletherapy machines needed per million population, Indonesia with over 270 million population, if 1 MV is needed for every 1 million population, 270 teletherapy machines are needed to ensure radiation treatment for every Indonesian citizen. Currently, radiotherapy (RT) machines available across the country only covered 29.82% of the country's needs (using hypofractionation strategy). This study aims to present the reflection on Indonesian Radiation Oncology Society (IROS) national roadmap program to close the gap of radiotherapy services in Indonesia.

Methods

Roadmap of Indonesia radiotherapy services were established in 2010 for the escalation of radiotherapy services. Moreover, this roadmap was updated every 5 year to calculate the accomplishment of the projected outcome. Further update is conducted in certain year whenever needed, especially if newest available data is needed for advocacies.

Results and discussion

These 5 yearly programs were divided into 9 different regions in Indonesia, each consisted of several provinces with different aims on the number of teletherapies needed. The rationalization on calculating the number needed are based on the number of populations, developing and archipelagic setting of the country, integration with national cancer control plan, cancer awareness among citizen, health promotion and continuing medical education for health professionals (especially oncologists). Multidisciplinary approach and guideline should also be obeyed by all oncologists to increase the utility of radiation therapy. Due to the circumstances that not all the criteria are able to be fulfilled, the society decided that this program aims to achieve 189 teletherapy machines by the end of 2035, or around 70% of 268 machines needed based on hypofractionation strategy calculation. Currently, this program has reached the second 5-yearly evaluation. By the end of 2020, it is known that 80 RT machines are currently available in Indonesia. From table 1, we can see that most teletherapies are available in region 3 (DKI Jakarta, West Java and Banten) and region 4 (Central Java and

Jogjakarta). However, despite being set up from 2010, there is one region (Maluku and Papua) which has no teletherapies at all. Looking at the data, it has fulfilled 100% of the target in 2020 (80 machines). Nevertheless, the fulfillment is not distributed equally across Indonesia as someplace even is yet to have a teletherapy machine.

Table 1. Roadmap of radiotherapy in Indonesia (2010-2035).

Roadmap Radiotherapy 2010-2035

5 yearly program to achieve 0.8 MV / 1 million population, from 2010-2035

No	Region	Population	Realization by the end of 2020	Step I 2010/2015	Step II 2015/2035				Total MV Needed*
				Program	Program	Program	Program	Program	
				I	II (2015/2020)	III (2020/2025)	IV (2025/2030)	V (2030/2035)	
1	Aceh, North Sumatera, West Sumatera, Riau	30.623.691	8	5	4	4	4	5	22
2	Jambi, South Sulawesi, Bengkulu, Lampung, Bangka Belitung, Riau Archipelago	25.009.775	4	4	3	3	4	4	18
3	DKI Jakarta, West Java, Banten	69.527.126	27	13	9	9	10	10	51
4	Central Java, Yogyakarta	39.386.738	21	7	5	5	5	6	28
5	East Java	41.192.606	9	7	5	5	6	6	29
6	Bali, West Nusa Tenggara, East Nusa Tenggara	14.363.547	4	3	2	2	2	2	11
7	Kalimantan Island	34.219.378	3	3	2	2	2	2	11
8	Sulawesi Island		4	3	2	2	2	3	12
9	Maluku,Papua	6.792.595	0	2	1	1	1	2	7
TOTAL		261.115.456	80	47	33	33	36	40	189

*Population data based on extrapolation from World Bank Population Projection 2018 and Indonesia National Population Census 2010

Conclusions

Cancer is an emerging problem in Indonesia. Radiation therapy plays a great role as one of the mainstay treatments for cancer, but the number of teletherapies is far from the needs. Nevertheless, the roadmap of RT services within the country is essential for every nation for guidance on how to close the gap of RT services in the respective country. There are several factors to be considered during the development of RT services, including distance in the archipelagic country with 17,000 islands, density of population, common cancer and public awareness. Using the respective guidance, IROS has set up the 5-yearly roadmap for radiotherapy from 2010 to 2035 to stepwisely guide, scale up and fulfill the demand of RT services. Despite of the challenges, Indonesia is currently on the track to close the gap of RT services, with 100% fulfillment in the second programs and being ready for the next 5-year program. There are still a lot of homework in the next decade to keep the sustainability of the track for closing the gap and achieve the goals of the roadmap. To fill up the disparities across countries, multiple cooperation from the society to national and local government, private sectors and military paths have been conducted. This roadmap of radiotherapy has been given to the stakeholders in the Ministry of Health and incorporated into the National Cancer Control Plan (2015-2019).[3] Further set up of the radiotherapy program has also been done with private hospitals or investors through public-private partnership framework (build operate transfer or joint cooperation). Additionally, to increase the utility of radiotherapy, setting up radiotherapy program should integrate multidiscipline and involve stakeholders.

Acknowledgments

We would like to acknowledge Indonesian Radiation Oncology Society (IROS) for providing the data as the basis of this publication.

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References

[1] International Agency for Research on Cancer-WHO. Global Cancer Observatory [Internet]. 2018 [cited 2020 May 20]. Available from: https://gco.iarc.fr/
[2] Atun R, Jaffray DA, Barton MB, Bray F, Baumann M, Vikram B, et al. Expanding global access to radiotherapy. Lancet Oncol. 2015;16(10):1153-86.
[3] National Cancer Control Committee-Ministry of Health Republic of Indonesia. Strategic plan National Cancer Control Committee (NCCC) 2015-2019. Jakarta: Ministry of Health Republic of Indonesia. 2014.

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Contribution ID: 14 **Type: Proffered Papers**

Weighted Goal Programming Approach for Solving Budgetary Radiation Therapy Treatment

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Background and objective

In today's fast paced and competitive era of healthcare service provision, optimal allocation of budgeted expenditure poses a critical concern among patients under radiation therapy treatment. In Levens et al [1] the authors explain how radiotherapy costs are often underestimated component of the economic assessment of new radiotherapy treatment and technologies. However, Jakovljevic et al [2] affirm how the budget impact on radiation oncology to large tertiary care clinics is likely to remain significant in the future. In Paravati etal[3] , the authors explained how factors unrelated to the individual patient can account for the majority of variation in the cost of radiation therapy treatment; suggesting potential inefficiency in healthcare expenditure. The objective of this study is to develop weighted goal programming model that allocates budgetary expenditure for radiation therapy of inpatients at a medical facility. The relevant components of budgetary expenditure considered included drugs/materials, labor and miscellaneous costs. In order to test the proposed model, data for budgetary expenditure was obtained on a monthly basis at Mulago Cancer Institute in Uganda. The study primarily examined cost requirements for two categories of patients. Category 1 patients showed symptoms of initial stages when cancer had just spread to nearby tissues of the body. Category 2 patients had the spread of cancer to several parts of the body.

Methods

A weighted goal programming model is developed and initially, the objective function is defined. The model seeks to minimize the deviation variables of the objective function.; subject to the goal values of budgetary expenditure allocated for treating category 1 and category 2 patients. The sum of weighted deviations is minimized so that actual expenditure on drugs/materials, labor and miscellaneous costs meets the projected expenditure. Resource leveling is achieved by using the simplex method for linear goal programming; that requires solving the standard minimization problem. A numerical example is presented for illustration; that determines the optimal allocation of expenditure on drugs/materials, labor and miscellaneous costs for inpatients under radiation therapy treatment.

Results and discussion

Results from the numerical example presented indicate that certain goals on drugs/materials, labor and miscellaneous costs can be fully or partially achieved. This however depends upon the priority levels and targets set for budgeted expenditure; in line with the two categories of patients under treatment. The application of this solution approach allows hospitals to identify satisfactory allocation of expenditure; based on the priority levels or goals set for meeting budgetary projected costs during radiation therapy treatment among patients.

Conclusions

The weighted goal programming approach for inpatient radiation therapy can be effective; where relevant cost categories can be priotized if necessary. This ensures cost-effective medical treatment in hospitals; a core ingredient of sustainable healthcare service provision.

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Acknowledgments

The authors would like to thank the staff and management of Mulago hospital (cancer treatment unit) whose data facilitated testing of the weighted goal programming model.

References

[1] LEVENS, Y. BORRAS, J.M. GRAU,C., ”Cost Calculation: a necessary step towards widespread adoption pf advanced radiotherapy technology ”Act Oncologica,54(2015)

[2] JAKOVLJEVIC, M. ZUGIC,,A. DAGOVIC,A ”Radiation therapy remains the key cost driver of oncology inpatient treatment ”J. Med Econ,18(1)(2015)

[3] PARAVATI, A. BOERO,,J. TRIPPLETT,D. HWANG,L.MATSUNO.R.XU,B. MELL,L. MURPHY,J. ”Variation in the cost of radiation therapy among medicate patients with cancer ”J. Oncol Pract,11(5)(2019)

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Contribution ID: 52 **Type: Poster**

Indonesia National Action Plan for Cancer Control 2020 – 2024

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Steven Octavianus, Putri Maharani, Tiara Bunga Mayang Permata

Introduction

Non-communicable diseases (NCDs) are responsible for 71% (41 million) of the 57 million deaths that occurred globally (2016). NCDs account for the most significant deaths from cardiovascular disease (17.9 million deaths, made up 44% of all NCD deaths and 31% of all global deaths) and cancer (9 million deaths, 22% of all NCD deaths and 16% of all global death).

Cancer will eventually become a major public health problem in Indonesia. The Basic Health Survey (RISKESDAS) revealed that cancer prevalence has increased by 28% from 1.4 per 1,000 (2013) to 1.8 per 1,000 (2018), equivalent to 477,000 increase for the last 5 years. The data also show more than 70% of cancer patients were diagnosed at late stage. Furthermore, GLOBOCAN (2018) indicates breast and cervical cancers are the most frequent cancers in Indonesia, amounting to 16.7% and 9.3% of all-cancer incidence, respectively.

In 2014 the Ministry of Health established the National Cancer Control Committee (NCCC). The NCCC was initially intended as a specific forum for managing cancer prevention and control across participants, sectors, and levels. However, the existence of the NCCC was ultimately only supported by sectoral policies at the ministerial level. The existence of "structural and functional" was under the auspices of the directorate, hence its lack of authority. It worsened by the lack of a State Budget allocation for working and supporting resources. Meanwhile, at the regional level, there is no certainty in coordinating and managing cancer work across parties, sectors, and levels. All of these factors have significantly weakened the performance of cancer programmes.

Reviewing from the IMPACT mission and challenges, and learning from past experiences, MoH intends to develop a focused and pragmatic National Action Plan for Cancer Control 2020 – 2024 (NAP). A comprehensive, evidence-based cancer control plan of action that emphasizes promotive and preventive efforts towards cancer risk factors through changes in community behavior and cancer discovery at an early stage through screening efforts and early detection at primary health facilities is a top priority. Firstly, the program may prioritize the three common cancers namely breast and cervical cancer in women and leukemia in children.

Method

With WHO technical support and guidance, the Ministry of Health through the Directorate for Prevention and Control of Non-communicable Diseases and the NCCC compiled a situation analysis and the NAP for Cancer Control 2020-2024: (1) through the review of the quantitative and qualitative data in the report, review, policy, journal undertaken by other parties such as cancer-related national and international institutions, WHO, MoH and other ministers; (2) in-depth interview and focus group discussion with representatives from the experts in medicine, public health, health financing, epidemiologist, medical and other health-allies associations, such as NGOs, patient/survivor groups, faith-based networks, and community-based organizations; (3) in-depth visits and interviews at health facilities.

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Results

The strategies and actions to prevent and control cancer along with noncommunicable diseases in Indonesia are inseparable from the local context as well as the regional and global commitments. Considering that, NAP for Cancer Control 2020 - 2024 was designed referring to these related principles: A. Outcome based provision of health program in the decentralized system; B. Equality and Universal Health Coverage; C. Community Empowerment; and D. Cross-sector Involvement and Stakeholders.

The NAP for Cancer Control 2020-2024 uses a strategic approach that takes into account various determinants which theoretically has the potential to produce synergistic interactions between approaches at the individual and population levels so that they can achieve common goals in these 5 years and for a long term in the next 15 years. These common goals are fewer Indonesians suffer from cancer, more Indonesians who suffer from cancer survive from it and Indonesians who suffer from cancer have a good quality of life.

Outcomes of National Action Plan 2020 -2024 (Figure 1)

1. Improvement of individuals with 9 healthy behaviors (no smoking; no alcohol consumption; low intake of salt, sugar and fat; increase physical activity; increase consumption fruits and vegetables; manage stress; participate in NHI; women to perform breast self-examination; recognize of signs and symptoms of cancer in children)
2. Fulfilment of Minimum Service Standards for early detection of breast and cervical cancers in accordance with Government Regulation No. 2 of 2018
3. Effective and evidence-based cancer control programme

Conclusion

The NAP was designed in an integrated manner covering two main pillars, namely (1) health promotion-primary prevention, and (2) health services. The basis of good governance and leadership will support the two main pillars. The NAP both at national and local levels will be implemented by the national, provincial and regency government in partnership with various stakeholders. The overall results and success of all plans depend on the commitment, cooperation, collaboration, and optimization of resources from many stakeholders across all levels of government.

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Contribution ID: 55 **Type: Poster**

Human Resources and Facilities for Radiotherapy Service Requirements in Indonesia: A Prediction Model over a Ten-year Period

Angela Giselvania (Faculty of Medicine, Universitas Indonesia – Department of Radiation Oncology, Dr. Cipto Mangunkusumo National General Hospital – Jakarta, Indonesia)
Melyda Melyda, Steven Octavianus, Soehartati A Gondhowiardjo

Introduction

Indonesia, while implementing the universal health coverage (UHC), is concurrently facing the growing burden of cancer. The Basic Health Research shows the increasing cancer prevalence up to 28% in the 5-year period from 2013 to 2018. Unfortunately, more than 70% cancer patients are diagnosed at latter stage, resulting in higher financial burden and low survival rates. Of all the total cancer patients, approximately 50% of them will need radiotherapy as part of the cancer management. A sufficient number of healthcare facilities and human resources for health (HRH) is needed to deliver a comprehensive radiotherapy service to achieve a successful UHC and to support cancer control planning in addressing these issues. However, the shortage of healthcare workforce and facilities for radiotherapy service still become a major threat in Indonesia. The available facilities and HRH still do not meet the population need and the international benchmark. Moreover, there is no formal guideline available to date regarding the forecasting of facilities and HRH-related oncology, especially in the radiotherapy field. We, therefore, modelled the healthcare facilities needed and translated it into year-by-year health workforce in requirements for radiotherapy service to ensure an effective cancer control planning in Indonesia.

Methodology

A Two-stage Markov state-transition model was developed. First, the model was used to estimate the number of healthcare facilities needed for radiotherapy service in Indonesia. Second, the projected healthcare facilities were translated into the radiotherapy workforce requirements using the national and international standard staffing. The one-year cycle length with a 10year-time horizon were used in the model. As the model was based on an annual planning cycle, which was a discrete-time process, the typical Markov model features such as discounting and half-cycles correction was not applied in this model. The base HRH requirements were further adjusted based on the ratio of HRH density. We also calculated the cost (salaries) implications of the projected radiotherapy staff requirements. Considering the uncertainty around the estimation result, sensitivity analysis was also conducted.

Results

The forecast is expected to show the need to expand the number and/or capacity of healthcare facilities to enable the comprehensive radiotherapy service for effective cancer control in Indonesia. The radiotherapy workforce shortage is predicted, resulting in a gap between the available and the requirement of healthcare workforce in radiotherapy field in Indonesia. This result will be a good comparison of the estimated model and calculation available from the IROS national roadmap.

Conclusion

Indonesia needs to expand the number of healthcare facilities and takes into account the serious shortage of radiotherapy workforce. Addressing these issues may require a substantial increase

in government spending on HRH. While long-term commitment to comprehensively address the HRH challenges is pursued, the immediate steps such as recruiting staff, improving HRH productivity and ensuring the equitable distribution of the existing HRH might need to be taken.

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Contribution ID: 54 **Type: Poster**

Leveling of Radiation Oncology Services in Indonesia

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Steven Octavianus, Handoko Handoko, Henry Kodrat

Introduction

Indonesia is the largest archipelago in the world, with the number of islands registered by the UN in 2017 totaling 16,056 islands. Administratively, the territory of Indonesia is divided into 34 provinces, 416 regencies and 98 cities, 7,201 districts, 8,479 subdistricts and 74,957 villages with an estimated population of 265,015,313 people in 2018. This condition has made health services becoming a great challenge especially the cancer management. Cancer management in Indonesia is usually only available in secondary and tertiary hospitals, therefore most of cancer patients will need to be referred sometimes multiple times to access cancer treatment.
Radiotherapy as one of the main modality of cancer management plays an essential role. The output of radiotherapy quality is very much dependent on the availability of equipment and human resources. In Indonesia, not all radiotherapy centers are equal. A lot of them still uses conventional technology with Coblat-60 machine. A mapping of technology availability is done by the Indonesian Radiation Oncology Society to enable a swift proses of referral whenever a more advanced technology is necessary to treat particular patients.
Apart from that, another essential element that need improvement is the availability of high quality human resources. Education and training for radiation oncology is an important aspect underpinning a good radiotherapy center. Radiation oncology education in Indonesia has to meet a standard of competency and at the same time it has to fulfill the immediate demand of human resources of various radiotherapy centers and capabilities nationwide. Until now, there is only one training and education center, which is situated in the capital, Jakarta under the Faculty of Medicine, Universitas Indonesia. The radiation oncology residency program in Indonesia is a 3.5 to 4 years program. Various knowledge and skills are imparted during the program. Here we presented in brief the mapping of various level radiotherapy centers capability for the purpose of patient referral and radiation oncologists allocation.

Method

The radiotherapy (RT) centers mapping was done by Indonesian Radiation Oncology Society annually. There are three main level of radiotherapy services that differ in its capability. Level 1A is RT facilities that provide RT with 2D technique and Level 1B is RT facilities that is able to provide up to 3D RT; Level II is RT facilities that is able to provide up to Intensity Modulated Radiotherapy (IMRT) or Stereotactic Radiosurgery / Radiotherapy (SRS / SRT); Level III is RT facilities that is able to provide all techniques from 2D, 3D, IMRT, SRS/SRT and Stereotactic Body Radiotherapy (SBRT).
The mapping was done based on the information gathered from all active radiation oncologists working in their own centers nationwide. This mapping became the guide to plan for RT center development, referral of patients, and radiation oncologists allocation. In center with level IA or IB capability, the society advocated and encourage to do technology upgrade. For center with Level III capability, a consultant will be allocated in that particular center.

Result

There are around 100 active radiation oncologists in Indonesia spread out across 44 centers in

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Indonesia with different level of capabilities. Most are concentrated in Java and Sumatera island. Some centers, especially in rural Indonesia, has only basic radiotherapy infrastructure, capable of only conventional radiotherapy with Cobalt-60 tele-therapy (Level 1). The levelling of radiation oncology services has resulted in better homogeneity in clinical practice, which then it was expected to translate into better patient care. The cancer patient with difficult cases or rare cases can be referred to a higher level of radiotherapy center for treatment whenever applicable. The consultant in level III radiotherapy center is expected to be able to provide a more specialized care as the availability of more advanced RT technology.

Conclusion

Radiation oncology profession in Indonesia is developing at a quick pace together with the increasing installation of radiotherapy equipment nationwide. An adapted and proper service leveling is required to be able to provide a better RT treatment for patients.

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Contribution ID: 49 **Type: Poster**

Breaking COVID-19 Transmission: Leveraging on Telemedicine for Cancer Management in Indonesia

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Endang Nuryadi, Soehartati A Gondhowiardjo

Introduction

The development of the application of technology in health services is experiencing rapid development. In Indonesia with a huge millennial generation, adoption of digital technology is progressing rapidly. The advancement is pushing the boundaries and making telemedicine low cost with high impact. Especially during this COVID-19 pandemic, utilization of technology to remove conventional face to face interaction is necessary. Specifically in cancer management telemedicine has been utilized for some time in Indonesia. Telemedicine has been used to connect different radiotherapy centres from various islands throughout Indonesia to discuss difficult cases, sharing of skills and knowledge, informing best practice, updating practice guidelines, and so on.
Recently during this COVID-19 pandemic, a new platform for communication between doctors and patients was developed. This was developed with aim to reduce unnecessary hospital visit by cancer patients thus reducing the COVID-19 transmission. This kind of teleconsultation platform is also meant to assist cancer patients who like to seek advice or do routine follow up after treatment with their oncologists without the need to be physically travel to the hospital. Various methods have been developed to find best solution to safely, securely, and conveniently connecting doctor and patient. The development of such technology is elaborated in brief below.

Method

The developed teleconsultation was in the form of two-way video communication which was thought to be an effective media. The system enables a doctor to provide services to his / her patients via video conference. The system allows patients to do appointment with a particular oncologist on their allocated designated time. The system will automatically mark the appointment and provide a consultation link in the doctor's digital calendar. The patient initial data was keyed in by the patient into the system to provide the doctor with some general information about the condition to be discussed. A reminder will be automatically sent both to the patients and doctors around 10 minutes before the consultation begins.
During the teleconsultation, the doctor is able to interact with the patient virtually, though physical examination is unable to be performed. The key summary of the findings can be noted by the doctor into the system, which will become the cloud consultation medical record. The doctor can also access the past consultation history through the cloud medical record. Whenever, a procedure is necessary, for instance biopsy, chemotherapy, surgery, or radiotherapy, then the doctor will consult the patients on how to safely access treatment in the hospital. The doctor note can be sent to the treating hospital after the consultation as the patient wish to enable a prompt procedure during the patients' visit.

Result

The development of telemedicine in the form of tele-consultations for cancer management is a relatively new model in Indonesia. This teleconsultation tool specifically developed to assist cancer management has shown some positive impact. This system is particularly very useful

to enable consultations of patients residing in rural areas with limited access of health services, particularly cancer services. This system provide great satisfaction because patients can access the oncologists early in the course of their disease, some even when there was just still a small lump. Furthermore, the cost of teleconsultation is exceedingly low compared to standard consultation in the clinic.

Those patients that were deemed necessary to undergo further clinical examination were then suggested to come to the clinics or hospitals. Some patients that were thought to have benign lesion can be consulted to delay their visit, but the alarming signs and symptoms of more severe condition is informed to the patients by the oncologist . Though, generally this system works well, nevertheless, some technical problems existed. The availability of hardware, network and connection are some of the technical problems. However, they seem able to be solved in most cases as Indonesia has 4G network in most of its archipelagos. Furthermore with digital transformation is happening now in Indonesia, with lots of daily activities have gone digital from market place, ride hailing, food order, and so on, the adoption of teleconsultation is soon become the norm too.

Conclusion

This result showed a high possibility that by applying telemedicine in cancer setting can have impact in continuation of cancer services in Indonesia, while preventing unnecessary hospital visit. This will be able to help slow down the COVID-19 transmission. However, some further adjustment is necessary to tweak the system and provide even better services for as many cancer patients as possible in Indonesia.

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Contribution ID: 114 **Type: Posters**

Current Status of Radiation Oncology Services in Paraguay

Julio Rojas Martinez (Instituto Nacional del Cancer)
Guisella Raquel Rivelli Zea

Introduction

The cancer problem is increasing worldwide, with most new cancer cases and related mortality occurring in low- and middle-income countries (LMICs). Paraguay is a LMIC of approximately 7 million inhabitants and does not have official estimates of future radiotherapy needs. According to GLOBOCAN 2018 database, it was estimated 11,244 new cases of cancer and 5,635 cancer deaths in the country. An estimated 50% of new cancer patients should receive radiation therapy and it is also considered that in developing countries 10% will need re-irradiation. It can be concluded that the total number of patients with indication of Radiotherapy in 2018 was 6184 patients. The aim of the study is to establish the current status of Radiation Oncology services in terms of access, human resources, infrastructure, equipment and types and quality of treatments.

Methodology

The country does not have a population-based cancer registry. Data collection has been carried out in two main centers with multidisciplinary cancer management in the country: the National Cancer Institute (INCAN) and the Social Welfare Institute (IPS).

Results

INCAN is the only government entity that has radiotherapy and brachytherapy facilities. The Paraguayan health system also includes the Social Welfare Institute (IPS), which provides health coverage to 21% of the population and has a fund to contract radiotherapy services to the private sector. The other 7.7% of the population is covered by other types of private insurance. Overall, 71.3% of the Paraguayan population is absorbed through the public health system.

Only 45% of the estimated radiotherapy demand in Paraguay for 2018 was covered leaving the rest without access.The main reasons are rurality, fragmentation of cancer care and the insufficient Radiotherapy machines. The INCAN has one linear accelerator (linac) and there are 5 linear accelerators in the private sector. Moreover, all radiotherapy services are centralized in the Greater Asuncion, the metropolitan area of the capital city of the country.Nationwide, the implementation of 3-dimensional conformal Radiotherapy as a standard treatment modality was in the year 2017. Few private insurances cover more advanced treatment modalities and most patients must pay out of their pockets. Regarding human resources, INCAN is training hospital with a residency program in Radiation Oncology and the majority of radiation oncologists were trained in this center. The are no clinical residecy programs for medical physicists in Radiotherapy.The IAEA-financed training courses have been of great importance for the development of Radiotherapy in the country. In the public sector, the number of medical physicists is limited and this prevents the expansion of Radiotherapy services. The lack of instruments for dosimetry and quality control also prevents the safe implementation of more advanced techniques.

Conclusion

There is a high demand for Radiotherapy treatments because the most frequent pathologies in

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the country are breast, cervical, prostate and lung cancer.Since the public sector absorbs approximately 71.3% of the country's cancer patients, the INCAN should increase to a minimum number of two more linacs in the short-term. The government has adquired one linac with IMRT and VMAT capabilities that should be installed by the end of 2020. The third one is being procured in coooperation with the IAEA under the project PAR6017.Subsequently, the decentralization of Radiotherapy services should be evaluated to improve access to the rest of the Paraguayan population. Regarding the implementation of more advanced techniques that accompanies with acquiring more radiotherapy machines, the following consideration should be taken into account. More technology available will allow the treatment of more patients after meeting a learning curve. Strengthening and increasing human resources remains the main challenge for the country. The importance of acquiring dosimetry equipment and implementating quality assurance programs should be considered a priority when incorporating more advanced treatment modalities.

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Contribution ID: 23 **Type: Poster**

Impact of Covid-19 in Radiation Oncology Practice in The Philippines: A Situational Analysis

Jerickson Abbie Flores (Jose R. Reyes Memorial Medical Center)
Misael Cruz, Gonzalo Banuelos, Thelma Sarmiento

Introduction

In March 11, 2020, the World Health Organization (WHO) announced the novel coronavirus 2019 (COVID-19) pandemic with the exponential increase of the number of cases across the globe. With the increasing number of local transmission, the entire region of Luzon was placed under an enhanced community quarantine (ECQ). COVID-19 imposes a challenge in any radiation facility on how to balance implementation of acceptable policies to reduce the transmission of COVID-19 while optimizing effective radiation treatment of cancer patients. It is crucial to evaluate how extensive the impact of this contagion in the operations of a radiation oncology facility of a developing country in order to plan and mitigate the risk considering there is limited resources. This study aims to present the overall operational impact and situational analysis of COVID-19 in radiation oncology facility in the Philippines.

Methodology

This is a cross sectional study conducted last April 13, 2020 using survey questionnaire participated by 19 radiotherapy facilities in the Philippines.

Results

A total of 19 radiotherapy facilities/cancer centers participated in the study. 47% are from the region of Luzon, followed by National Capital Region (NCR)(26%), Visayas(15%) and Mindanao(10%). There are 23 external beam radiotherapy machines (Linear Accelerators/Cobalt teletherapy), 18 computed tomography (CT) simulators and six High Dose Rate (HDR)- Brachytherapy machines from all participating centers.

Based on the survey questionnaire response, All of the domains of the 19 radiotherapy facilities were affected by COVID-19 . The highest impact was on manpower (doctors/professional staff) (100%), followed by clinical (referrals, treatment delays/interruptions) (95%), economic or financial (95%), patients census and triaging (89%), resources/supplies (personal protective equipment (PPE) and other equipment/maintenance(89%), and communication (check-ups/follow-ups)(58%), as the least area affected.

Clinical referrals were decreased due to the closure of the Out-patient departments/clinics of referring physicians. As an effect, there were decrease in number of patients undergoing radiotherapy to almost half the usual numbers, resulting to decrease net income of the facilities and creating a financial/economic impact. Approximately 1,059,000 USD was the profit loss due to the decrease in the number of patients undergoing radiotherapy with the highest financial impact in NCR based on the profit difference before and during COVID-19 pandemic and ECQ.

In order to address the impact of COVID-19, all 19 radiotherapy facilities in the Philippines created certain precautionary measures and policies to ensure safe and effective radiation treatment of cancer patients. These includes strict implementation of handwashing, disinfection of treatment areas before and after patient handling, daily disinfection of waiting areas, planning rooms and consultation areas, social and physical distancing (at least 1-meter apart), screening and triaging of patients. Surgical mask/N95 (surgical or N95 masks) and other personal protective equipment(PPE) were use in all facilities for both staff and patients.

Brachytherapy capable facilities are also operational with adapted COVID-19 precautionary measures in order to protect both the patients and staff without compromising the quality and benefit of treatment. Among radiotherapy facilities that are within cancer centers with chemotherapy units, all are still providing chemotherapy with similar COVID-19 precautionary measures.

Triaging and prioritization of patients were adapted by participating radiotherapy facilities in order to protect their patients, staff and the public from the possible transmission of COVID-19. Cases for radiotherapy classified as priority are emergency/urgent cases which includes brain metastasis, superior vena cava syndrome, spinal cord compression and bleeding tumors, as well as, head and neck and gynecologic malignancies. Usual cases delayed to avoid or lessen exposure/risk to COVID-19 and to avoid crowding of their facilities include low risk adjuvant cases, breast cancer, prostate cancer and medically managed and controlled bone metastasis.

Conclusion

The radiation oncology practice in the Philippines continues to evolve in order to ensure safe, effective and quality radiotherapy for all patients while minimizing the risk of exposure to COVID-19 for both the immunocompromised patients, hardworking professional staff and the general public. Despite the several impact of COVID-19 among radiotherapy facilities in the Philippines in all aspects (clinical, manpower, financial/economic, resources and communication), radiation oncology centers continue to address the threats of COVID-19 to their patients and staff through implementation of COVID-19 precautionary measures and policies in order to to prepare and to adapt to the new normal in radiation oncology practice.

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Contribution ID: 35 **Type: Poster**

Responding to the COVID-19 Pandemic: Perspectives from Two Radiation Oncology Departments in the Philippines

Thomas Vincent Vergara (St. Luke's Medical Center - Quezon City)
Miriam Joy Calaguas, Manuel Martin Lopez, Juan Martin Magsanoc

Introduction

On January 30, 2020, the Philippines reported its first case of severe acute respiratory syndrome coronavirus-2 (COVID-19). The number of cases and deaths have continued to increase since, drastically changing the landscape of healthcare delivery in the country. As of June 25, 2020, the country has reported over 34,000 cases and more than 1,200 deaths Radiation oncology departments worldwide have been forced to adopt certain changes in workflow and clinical practice in order to ensure continued delivery of care to cancer patients, while mitigating the risk of infection among patients and the workforce. Cancer patients are burdened with an increased risk of severe complications and mortality from the infection, while navigating the challenges of cancer diagnosis and treatment. In particular, those requiring radiotherapy may have an increased risk of acquiring the COVID-19 infection brought on by repeated facility visits during fractionated radiotherapy treatment. In this report, we describe our experience in St. Luke's Medical Center (SLMC) which operates two radiation oncology departments in Metro Manila. We describe the challenges faced, and propose institutional guidelines and policy recommendations for other radiation oncology centers during the COVID-19 pandemic.

Methodology

In this report, we review institutional changes in clinical practice, policy, workflow, staff organization, and infection control measures implemented in two radiation oncology centers in Metro Manila, Philippines.

Results

We established a Pandemic Working Group (PWG) whose task was to oversee the implementation of department policies, evaluate all new cases referred for radiation therapy, provide clinical recommendations regarding patient prioritization, and assess the safety and feasibility of postponing radiation treatment for some patients, and promote the utilization of hypofractionated radiotherapy regimens when applicable. A three-tiered patient prioritization system was implemented in order to minimize the deleterious effects of unnecessary treatment delays for patients who need radiotherapy urgently, minimize the risk of exposure for patients whose treatment can be safely postponed without adversely affecting outcomes, while simultaneously reducing clinical load as the department faces a reduced workforce. We also describe changes in the staff organization, training, and support designed to prepare our workforce for the challenges of the pandemic. Infection control measures were put in place in coordination with the hospital infection control committee in order to minimize the risk of infection transmission within the department. Finally, the utilization of telemedicine and other online virtual platforms have been instrumental in maintaining open lines of communication between patients, radiation oncologists, and other members of the oncology team.

Conclusion

The current global pandemic has dramatically affected the practice of radiation oncology in our institution and the world at large, forcing us to rapidly adapt to a volatile situation. In this report, we have shown how our institution has adopted mechanisms in order to anticipate and

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prevent potential problems that could force our centers to severely restrict or halt operations, with ultimate the goal of continuing the delivery of life-saving and quality-of-life-improving radiotherapy services, while at the same time protecting our staff and patients. We hope that other institutions may benefit from a similar approach.

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Contribution ID: 121 **Type: Poster**

Is hypofractionated radiotherapy in breast cancer a cost effective approach?

Meriem Bohli (Radiation Oncology Departement , Abderrahmen Mami Hospital)
Raouia Ben Amor, Dorra Aissaoui, Lotfi Kochbati

Introduction:
Hypofractionated radiotherapy (HFRT) is becoming the standard treatement for breast cancer. Multiple studies have demonstrated similar efficacy and tolerability with moderate hypofractionation. In this study we aimed to assess the economic impact of HRT compared to normofractionated radiotherapy (NRT).
Methods:
We collected retrospectively all the patients treated for breast cancer between December 2017 and December 2019. All patients underwent radiotherapy at a dose of 40 Gy in 15 fractions (2.67Gy per fraction) +/- boost on the tumor bed (13.35 Gy in 5 fractions).
After 2 years, 249 patients underwent HFR, 151 patients after conservative surgery (3020 fractions per 2 years) and 143 patients after mastectomy (2145 fractions per 2 years). In NFR, it corresponds to 176 patients , 91 patients after breast conservative surgery (3020 fractions) and 85 patients after mastectomy (2145 fractions).
Cost estimation was based on the National Health Insurance and Social Security basis for the repayment (235 DT per fraction). The cost of HRT per 2-years was then estimated and compared to the cost of NRT.
Results:
After conservative surgery, The cost of HFR was 4 700 DT per patient and 709 700 DT per 2 years. With NFR, it is estimated at 7 755 DT per patient and 705 705 DT per 2 years.
After mastectomy, the cost of HFR was 3 525 DT per patient 504 075 DT per 2 years. With NFR, it estimated at 5 875 DT per patient and 499 375 DT per 2 years.
HRT, compared to NRT, permitted a gain of 3 995 DT (0,5%) after breast conservativ surgery and 4900 DT (1%) after mastectomy.
Conclusion:
Our study showed that HRT, compared to NRT allowed to treat more patients (more than 41%) with the same cost. In public and private sectors, HRT in breast cancer could be a cost effective procedure in addition to the carcinological equivalence and the best tolerance.

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Contribution ID: 86 **Type: Proffered Papers**

NTCP and estimation of secondary cancer risk in Modulated Arc Therapy for prostate carcinoma using in-house software.

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Background and objective

Prostate cancer ranks third in men's cancers after colorectal and pulmonary cancer in the word with 543000 new cases each year [1,2]. It reach 10 million in 2020 with 7 million death particularly for the developing countries. In Algeria, it was classified at the 4th position after stomach cancer.

The present study was performed on 12 patients treated for prostate cancer with high risk. To do this, we firstly evaluate the toxicities of the different Organ's at Risk surrounding tumor like rectum and bladder using our developed in-house software "Coupôle", and compare the results to those given by "Biosuite" software [3]. Secondly, a secondary cancer risk was estimated after radiotherapy. For this we choice to use of the one related to the United Nations Scientific Committee on the effect of Atomic Radiation UNSCEAR [4].

Methods

In this study, we are interested to investigate twelve clinical cases of patients treated with Volumetric Modulated Arc therapy [5] for high risk prostate carcinoma, the medium age of patients is 75 years old, and their stratifications vary from T2aN0M0 to T3bN0M0 with no metastasis. All patients were treated with 76 Gy using daily fraction of 2 Gy fractions. The 18 MV (ELEKTA) treatments were planned using MONACO TPS) [6].

Normal Tissue Complication Probability (Lyman-Kutcher-Burman) and secondary cancer probability (linear model rectum: $\alpha 1 = 0.017$, $\alpha 2 = 0.25$ and $(\alpha/\beta) = 4.5$; bladder: $\alpha 1 = 0.006$, $\alpha 2 = 0.25$ and $(\alpha/\beta) = 7.5$) were calculated for rectum and bladder using in-house software. The results of calculated NTCPs values were compared to those obtained with "Biosuite". Otherwise the formulae used to estimate the risk for secondary cancer is given by UNSCEAR (Eqt1):

$$EEEEEEEEEEEE = \left(\alpha_1 DD + \frac{\beta\beta_1^2 DD}{nn}\right) \exp\left[-\left(\alpha\alpha_2 DD + \frac{\beta\beta_2 DD^2}{nn}\right)\right] \quad \text{(Eqt1)}$$

Where: D: is the total dose given to the patient in n fractions; $\alpha\alpha_1$, $\alpha\alpha_2$: are linear factors of induction of DNA mutation and the cellular survival; $\beta\beta_1$, $\beta\beta_2$, are quadratic factors

Results and discussion

From this study, it could be confirm that all VMAT plans were acceptable clinically, dose volume histogram (HDV) were evaluated from the point of view of normal tissue complication probability and estimation risk to develop secondary cancer after radiotherapy.

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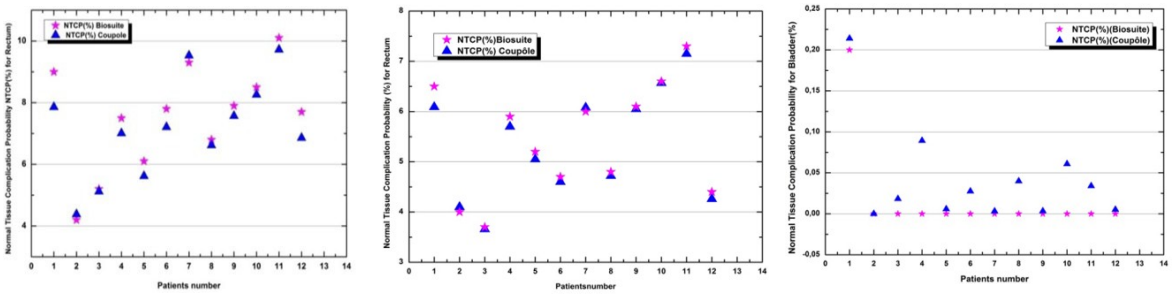
The mean normal tissue complication probability for rectal bleeding (grade>2) was 7.14% (range 4.38-9.72%) obtained with Coupôle versus 7.50% (range 4.2-10.1%) with "Biosuite" and for fecal incontinence we have obtained 5.43 % (range 3.7-7.3) versus 5.33% (range 3.66-7.15) respectively (figure1). The estimated risk for secondary cancer in the respective OAR is 0.066% for rectum and it was 0.0101% for bladder. Regarding the range of clinically observed risk for rectum (0.05-0.20%) and Bladder (0.15-0.32%) respectively [7]. Rectum was more subject to the risk for secondary malignancies due to some patient who has toxicity greater than 5% otherwise; there is no risk for bladder [8].



(a) **(b)** **(c)**

Figure1: Normal Tissue Complication Probability to induce Rectal Bleeding (a) , Fecal incontinence (b) in case of Rectum and Bladder contracture (c) in case of Bladder after radiotherapy.

Conclusion

Thanks to this study, our in house software "Coupôle" was validated against "Biosuite". The studied cohort of twelve prostate treatment plans was evaluated in terms of toxicity and second cancer risk estimate. Evaluation of NTCP and secondary cancer estimates can improve treatment quality, particularly when complex treatment modalities are involved.

Acknowledgments

One of the authors aims to express her grateful and thanks to Prof. M.Fellah, Prof. Alan Nahum and Dr Julian Uzan.

References:

[1]. Registre du Cancer, Setif, Algérie.
[2]. Place des Cancers Urologiques dans le Registre du Cancer de Setif.
[3]. J Uzan, A E Nahum. Radiobiologically guided optimization of the prescription dose and fractionation scheme in radiotherapy using Biosuite. BJR, 85(2012), 1279-1286.
[4]. UNSCEAR Sources and Effects of Ionising Radiation. Report to the General Assembly, with annexes. New York: United Nations: 1993.
[5]. Otto K. Volumetric modulated arc therapy: IMRT in a single gantry arc. Med Phys2007; 35:310-317.
[6]. Mac Clements, Nicholas Schupp, Megan Tattersall, Anthony Brown, Randy Larson. Monaco treatment planning system tools and optimization processes. Meddos.2018002.005. Doi.org/10.1016/j.meddos. 2018002.005.
[7]. Boice Jr.JD, Day NE, Andersen A, Brinton LA, Brown R, Choi NW, et al. Second cancers following radiation treatment for cervical cancer. An international collaboration among cancers registries. J Natl Cancer Inst 1985, 74:955-75.

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[8]. Liu YM.Shiau CY, Lee MI. et al. The rôle and strategy of IMRT in radiotherapy of pelvic tumors. dose escalation and critical organ sparing in prostate. Int JRadiat.Oncol BiolPhy 2007; 67:1113-23.

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Contribution ID: 85 **Type: Proffered Papers**

Neutron Capture Enhanced Particle Therapy (NCEPT): In vitro proof of concept

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Introduction

Neutron Capture Enhanced Particle Therapy (NCEPT) is a novel adjunct to proton and heavy ion therapy, which enhances the radiation dose delivered to a tumour relative to surrounding healthy tissue by capturing thermal neutrons produced during ion irradiation. NCEPT utilises ^{10}B and ^{157}Gd-enriched tumour-specific neutron capture agents presently approved or in development for neutron capture therapy. NCEPT improves tumour control by increasing the dose to the target volume, while reducing the normal tissue complication probability by reducing the primary radiation dose, hence reducing the radiation dose to normal tissue. Additionally, NCEPT can target nearby satellite lesions outside of the primary treatment volumes with a therapeutic dose. In this work, we report the outcome of three successful rounds of in vitro experiments, conducted at the National Institutes for Quantum and Radiological Science and Technology (NIRS, QST) Heavy Ion Beam research facility, which have provided the first experimental proof of concept for NCEPT.

Methodology

Experiments were conducted at the Heavy Ion Medical Accelerator in Chiba (HIMAC), Japan in July 2018, February 2019 and February 2020. T98G (human glioblastoma) cells were cultured in T25 flasks and inserted into a 300 mm cube of PMMA, such that the cell layer was positioned at the middle of the depth range of the spread-out Bragg peak and normal to the the beam. Two flasks were located within the planned target volume, with a further two flasks laterally offset such that they were just outside of the target volume (one on the left and one on the right). The cells were then irradiated with polyenergetic beams of either ^{4}He or ^{12}C (100 mm × 100 mm × 60 mm SOBPs).

Flasks placed in the two middle positions received a heavy ion dose of 0 to 10 Gy, with or without pre-irradiation treatment with the neutron capture agents (NCAs) ^{10}B-BPA and ^{157}Gd-TPP-DOTA. The two flasks outside of the primary target volume were used evaluate the effect of NCEPT on satellite lesions (since the neutron field extends well beyond the target volume). The effects of irradiation on cell proliferation and survival with and without the NCAs, both inside and outside the target volume, were quantified using the Resazurin Cell Viability Assay and clonogenic assay.

Additionally, the effect of NCA concentration on the efficacy of NCEPT in-beam (in the middle of the SOBP), both for ^{10}B-BPA and ^{157}Gd-TPP-DOTA was assessed for ^{4}He or ^{12}C ion beams, with a fixed radiation dose of 3 Gy.

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Results

Dose responses obtained via clonogenic assay for both NCAs and ion species are shown in Figure 1(a). A progressive reduction of cell viability in response to dose escalation (0 to 10 Gy) can be observed. A dramatic reduction in cell viability is observed at doses exceeding 2 Gy. The dose at which 50\% reduction in cell mass is achieved (IC50) was also estimated for carbon and helium ion therapy, with and without the presence of NCAs. To achieve a 50\% reduction in the mass of viable cells treated with carbon and helium ions alone, 3.1±0.1~Gy and 3.54±0.4 Gy are required, respectively. The addition of ^{10}B-BPA and ^{157}Gd-TPP-DOTA reduces the IC50 dose by 42\% and 68\%, respectively.

Concentration response results are shown in Figure 1(b). At a primary carbon and helium ion dose of 3 Gy, 100-250 uM concentrations of both NCAs are sufficient to obtain a reduction in viable cell mass comparable to 8 Gy of carbon and 10 Gy of helium ion irradiation in the absence of the NCA. Concentrations in excess of approximately 10 uM are sufficient to obtain a measurable decrease in viable cell mass.

Out-of-field dose responses are shown in Figure 1(c). A very strong (and approximately linear) response to escalating primary ion dose is observed out-of-field with both ion species and NCAs. Without the presence of the NCA, the impact on cell viability outside of the primary treatment volume is minimal (less than 20% reduction in viable cell mass at 10 Gy primary dose, compared to more than than 95% reduction in the presence of NCAs.

Conclusion

The effectiveness of NCEPT on cell cultures inside and adjacent to the target volume has been evaluated. NCEPT achieves substantial reductions in T98g cell viability with both boron and gadolinium-based neutron capture agents in the target volume compared to untreated control cell cultures subjected to an equivalent primary radiation dose. Although cells outside of the primary target volume receive little dose from the heavy ion beam, the addition of neutron capture agents to these cells also results in a substantial reduction in cancer cell viability. This is due to the extension of the thermal neutron field beyond the target volume. The next steps for NCEPT include (1) evaluating NCEPT in vitro with proton therapy and (2) in vivo evaluation of NCEPT for heavy ions and protons using both neutron capture agents.

While it was clear that TMPyP4 mounted a comprehensive anti-cancer effect, we also tested TMPyP4 with a low dose of 1 – 10 μM and chronic treatment up to 8 weeks by passaging cells regularly. Remarkably, TMPyP4 at these low doses shortened telomeres progressively and caused telomeric and chromosomal aberrations in the cancer cells.

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Contribution ID: 93 **Type: Proffered Papers**

Mechanism-Based Combination Therapy in Cancer: Studies on Cancer Cells

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Background and objective

Telomeres are DNA repeats at the ends of chromosomes that protect genome integrity along with specialized proteins that bind telomeres. Telomeres shorten with every cell division and a specialized enzyme telomerase can counteract it by adding telomeric repeats. In fact, telomerase activity, silenced in terminally differentiated somatic cells, is reactivated in cancers and there is a striking correlation between telomerase activity and cancer progression [1]. Because cancer cells have shorter telomeres than normal cells, exploring telomere-targeted therapeutics has the promise of treating not just one type but most types of cancer [2]. The objective of our study was to characterise a potential telomere-targeting drug, to identify combinatorial strategies that would sensitize cancer cells to the drug, and lastly, to uncover the underlying mechanism of action.

Methods

We used established human cancer cell lines as model of study, to rapidly test promise of the drug and to find effective combination treatments. The cell types were KNS60, A172 (glioblastoma multiforme) and ONS76 (medulloblastoma). The telomere-targeting drug in study was TMPyP4, a porphyrin, that recognises and binds G-quadruplex forming regions with high specificity. The combination strategy we used was γ-radiation (4 Gy). We assessed telomerase activity using the Telomeric Repeat Amplification Protocol; levels of telomerase and telomere-associated proteins using western blotting. We measured DNA damage by single cell gel electrophoresis (Comet assay) and chromosome and telomere aberrations using Peptide-Nucleic Acid FISH of metaphase chromosome spreads. We used MTT assay and Cell Titer Glo to assess cell viability.

Results and discussion

At an LC50 dose of 100 μM for 48 hours, TMPyP4 inhibited telomerase activity significantly in the cancer cells accompanied by a significant reduction in the levels of the catalytic protein constituting telomerase, hTERT. In addition, TMPyP4 also reduced the level of c-MYC, an important oncogene, and a master transcriptional regulator. C-MYC is known to have a G-quadruplex forming region in its promoter, so TMPyP4 could be binding there and blocking its transcription. TMPyP4 also caused significant DNA damage, read out by damaged DNA tails via electrophoresis, and activation of DNA repair sensors like ATM kinase.

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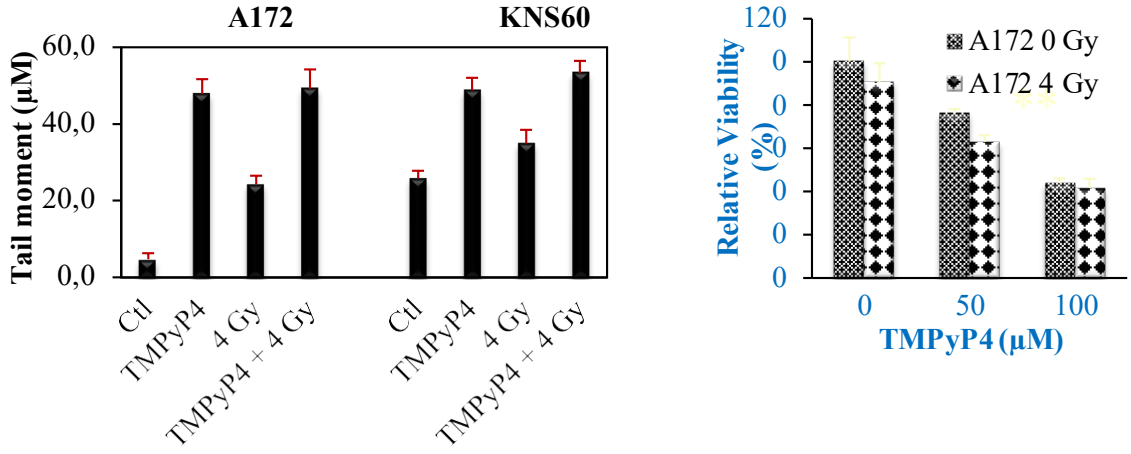

Figure 1 DNA damage induction (tail moment, left panel) measured by comet assay and relative cell viability (right panel) in cells treated with TMPy4 and γ-radiation.

Given the promise of TMPyP4 to disrupt telomere maintenance in cancer cells, we sought to identify how effective it would be in combination with gamma-radiation that induces DNA damage (measured as tail moment in Figure 1). Indeed, in combination with 4 Gy radiation, TMPyP4 was effective even at half its LC50 dose as evidenced by relative viability (Figure 1). The combination treatment induced much greater DNA damage than either one alone. Because TMPyP4 causes DNA damage – both directly and indirectly via disrupting telomere maintenance, we think that radiation acts as a great combination strategy.

Conclusions

TMPyP4 effectively had a profound effect on cancer cells both at the molecular level as well as at the cellular level. TMPyP4 was not only potent with an acute dose over a short term, but also over a therapeutically relevant long-term treatment window with chronic low doses in the cancer cell types. TMPyP4 induced telomere shortening and chromosome aberrations in those cancer cells over time thus disrupting telomere maintenance. While TMPyP4 inhibited telomere maintenance, the inhibition of either DNA-PKcs or ATM kinase led to an exacerbated effect on DNA damage, cell arrest and cell viability of the cancer cell types tested. The intricate crosstalk of telomere maintenance and DNA repair factors could underlie this effect. Exploring this combination in a context closer to in vivo cancer models will prove as a promising hunt towards new standard of care of clinically recalcitrant cancers.

References

[**1**] SHAY J.W., WRIGHT, W.E.. Mechanism-based combination telomerase inhibition therapy. Cancer Cell. 7 (2005), 1-2. [**2**] BARTHEL, F.P., WEI, W., TANG, M., et al. et al. Systematic analysis of telomere length and somatic alterations in 31 cancer types. Nat Genet. 49 (2017),349-357.

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Contribution ID: 3 **Type: Proffered Papers**

Concomitant boost in preoperative irradiation of rectal cancer

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National Military Medical Clinical Center "Main Military Clinical Hospital", Kyiv, Ukraine

Background and aim

The question of delivery of concomitant boost – additional small dose about 0.3 Gy locally to the tumor in the same fraction of external irradiation - is still under consideration. It was discussed in the literature from time to time. Especially it concerns the irradiation of rectal cancer. An obvious obstacle to this regime of irradiation is the additional time spent on an additional planning involving medical physicist and radiotherapist and additional load on the accelerator. Nevertheless, the analysis of the results in comparing of the treatment with and without concomitant boost could be of help in gaining deeper knowledge in radiobiology of tumor response to different regimes.
The aim of the work was to evaluate tumor regression after irradiation of the rectum cancer with and without additional dose 0.3 Gy locally in the same radiation session.

Methods

39 patients with confirmed colorectal cancer and the same clinical status have been involved into the study.
Colonoscopy has been performed followed by histological analysis.
In CT and MRI studies pathological lymph nodes in the iliac region have been diagnosed in 22 patients (N1-N2), in 17 patients the affected lymph nodes were absent at CT/MRI studies. In all patients, histological examination confirmed squamous cell carcinoma. No distant metastases were detected (M0).
Patients were divided into two randomized groups.
The first group before the operation received 2 Gy for the small pelvis by opposite fields up to 46 Gy. In the second group after delivery of 1.8 Gy to the small pelvis by opposite fields, rectum was irradiated locally by three fields technique up to 0.3 Gy.
The dose was administered over 23 fractions 5 times per week. Thus, in the second group, the pelvis received 41.4 Gy and the rectum – 52.9 Gy respectively.
Supportive care was the same in the first and the second groups. 5-FU with the aim of immunomodulation was prescribed in both groups according to protocol.

Results

The degree of tumor response was assessed by comparing CT/MRI scans before irradiation and two weeks after it. Surgical evaluation of treatment outcomes was also taken into account. From the side of critical organs, there was no difference in the number of reactions to irradiation in both groups. Vomiting, frequent urination, problems with bowel emptying in a percentage value was actually equal in both groups. About 75 % of patients in both groups experienced discomfort with the indicated symptoms during the treatment period. Nevertheless patients in the second group not reliably were in a better state during irradiation. In the first group where patients received standard fractionation, the degree of tumor regression amounted to 20 % of the initial volume in average (from 0 to 55 %). In the second group – up to 40 % on average (from 0 to 80%). In the independent assessment of surgeons it was indicated that the second regime with additional dose was preferable. It is interesting to note that we used concomitant boost in not-operable patients with brachytherapy followed external irradiation. It was based on more tumor regression in concomitant boost treatment. It

facilitates brachytherapy. In the case of the large tumors it is necessary to introduce needles into the pararectal zone for appropriate tumor irradiation. And in the case of sufficient tumor response, it is enough to indicate intracavitary brachytherapy with standard normalization 0.5 cm from the mucous.

Conclusion

Concomitant boost (0.3 Gy additionally to 1.8 – 2 Gy) in preoperative irradiation of rectal cancer results in more significant tumor regression compared with the standard fractionation. Patients tolerate this regime with the same degree of radiation reactions as in standard fractionation.

Concomitant boost can be used before brachytherapy giving the possibility to irradiate tumor intracavitary in the case of essential tumor regression.

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Contribution ID: 72 **Type: Poster**

Feasibility on use of gel electrophoresis-based quantification of DNA double strand break.

Jose Raj (Christian Medical College)
Rabi Singh, Timothy Santhosh

Introduction

The need for hospitals to be prepared for the act of clinical mistreatment, radiation accidents and radiological terrorism is of high priority. In order to quantify the amount of dose received during any radiation accidents, a well-developed and reliable method of dosimetry is required. At present, physical dosimeters are well established to quantify radiation doses. Whereas, on the other hand estimation of biological doses is also of key importance as these physical dosimeters do not correlate directly with the biological changes that conceivably happen after irradiation. At present, dicentric chromosomal assay (DCA) is considered to be the gold standard biodosimetric method due to its high robustness and reproducibility. Whereas, the major shortcoming of DCA is that the time taken for quantification of biological dose is 4 days and the cost for establishing a DCA lab is quite high.
This study reveals the use of gel electrophoresis based biodosimetric method for quantifying the double stranded break in DNA that happens upon irradiation of human lymphocytes for gamma rays. The time taken for completing the entire procedure to dose reporting takes 8 hours and the cost for establishing this biodosimeter is relatively low.

Methods and materials.

5 ml of blood from the 2 healthy individuals were collected by venipuncture and were stored in a heparin container in order to prevent clotting. The collected blood samples were irradiated in Equinox 80 (cobalt 60) machine for the doses of 0, 5, 10, 20, 25 Gy respectively. The irradiated blood samples were subjected to Ficoll solution followed by centrifugation at 3000 rpm for 30 minutes. The buffy coat of lymphocytes was aspirated into 1.5 ml centrifuge tube. Later the cells were subjected for 15 minutes of lysis using 20 µl of proteinase k at 550 Celsius. Soon after the lysis procedure the samples were subjected for gel electrophoresis. The samples were loaded into well of 1.2 % normal melting point agarose gel and were immersed in alkaline solution which consists of pH greater than 13 which was used as a running buffer. The lymphocyte samples were subjected for 3 hours of electrophoresis procedure and were mixed with 50 µl of ethidium bromide. Later the gel layer was gently removed and were exposed to UV transilluminator and the captured images were analysed using ImageJ software for measuring the sheared DNA length.

Results and discussion.

It is observed that up to 10 Gy there is an increase in response with the given dose. After 10Gy the dosimeter reaches to its saturation as shown in figure 1. This could be a result of complete DNA damage of lymphocytes in the given sample. From the above results it is evident that the gel electrophoresis method is a simple, rapid and cost-effective method for of quantifying DNA double strand break thereby serving as a suitable micro-biodosimeter.

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Contribution ID: 50 **Type: Poster**

Precision medicine in radiotherapy; discover a potential biomarker for treatment resistance

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Handoko Handoko, Takahiro Oike, Tiara Bunga Mayang Permata

Introduction

Radiotherapy is an important modality of therapy in cancer treatment. Despite of advances in technology and cancer genomics, treatment of cancer is still a big challenge, and the mutation signatures of radioresistant tumors have not yet been fully elucidated. Radiation therapy technique is evolving over time, as increasing of radiation conformity will increase therapeutic ratio, as well as the development of particle and heavy-ion therapy which provide hopes.
Precision cancer medicine is a treatment for cancer which uses the genetic information of individual tumors to guide the treatment, has become widespread in cancer treatment, especially in the field of clinical oncology. Advances in next-generation sequencing technologies provide the identification of genetic alterations that make tumor cells responsive to molecularly targeted drugs. This also showed the probability such genetic alterations may contribute to cancer cell radiosensitivity. However, genetic alterations profile in cancers associated with resistant to radiotherapy have not been fully elucidated.

Methods

We analyzed a unique set of clinical specimens from a uterine cervical cancer that repeatedly locally recurred after multiple rounds of radiotherapy. We performed next-generation sequencing with an Ion AmpliSeq Comprehensive Cancer Panel that covers 95.4% of the exons of the 409 cancer-related genes.

Results

Exon sequencing of 409 cancer-related genes in the treatment-naïve tumor and the tumors that recurred after initial and secondary radiotherapy identified (i) activating mutations in *PIK3CA* and *KRAS*, and putative inactivating mutations in *SMAD4*, as trunk mutation signatures that persisted over the clinical course; and (ii) mutations in *KMT2A* and *TET1* as acquired mutation signatures observed only in recurrent tumors after radiotherapy. Comprehensive mining of published in vitro genomics data pertaining to radiosensitivity revealed that simultaneous mutations in *KRAS* and *SMAD4*, which have not been described previously in uterine cervical cancer, are associated with cancer cell radioresistance.

Conclusion

The results of this study indicated that next-generation sequencing analysis of clinical specimens is a promising strategy to explore the mutation signatures that contribute to tumor radioresistance, which is worth pursuing with larger cohorts in the future.

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Contribution ID: 56 **Type: Poster**

In Vitro Study of Various Extracts and Bioactive Compounds Potential Role in Increasing Radiation Efficacy in Human Cancer Cell Lines

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Handoko Handoko, David Andi Wijaya, Soehartati A. Gondhowiardjo

Introduction

Despite technological advances in cancer treatment especially in radiotherapy, cancer cells radioresistance still leave a problem for radiation oncologist. In line with that, many efforts are being made in to increase therapeutic ratio, in order to reduce toxicity to surrounding healthy organ and increasing local/locoregional control in tumor. One among the most popular strategy to boost the radiation efficacy is using combination of chemotherapy and radiotherapy, known as chemoradiation. As a tropical country, Indonesia has a rich biodiversity. Many plants contain a great future potential as therapeutic agents, e.g. soursop (Annona muricata L.) and red algae (Eucheuma cottonii).
Numerous extract from plants component or bioactive compounds (e.g. piperine, and gallic acid) has been studied and found to have an anticancer effect in human cancer cell lines (in vitro) and in animal (in vivo). Unfortunately, there is still a lack of research that study the potential of this extracts/compounds to increase the radiation efficacy.
HCLL is a basic cancer cells model, which allows a research in a limited simplified controlled environment. We are also able to make a genetic engineering in HCLL. In vitro HCLL has several similarities with in vivo cancer cells, i.e. uncontrolled growth (oncogenic), unresponsiveness to anti-growth signal, cell cycle checkpoint avoidance, immortality, loss of negative feedback, and invasive characteristics. After a cell receives ionizing radiation, several changes involving plentiful of pathways and proteins known as cellular response happen. There are various pathways/proteins that could be used to increase the radiation potential.

Objectives

In the present in vitro study, we evaluate the possibility of several extracts and bioactive compounds in increasing radiation efficacy in human cancer cell lines (HCCL). Several extract and bioactive compounds have been collected. They are Annona muricata leaves extract, gallic acid, piperine, and Eucheuma cottonii extract. Many studies have reported their anticancer effect on numerous HCLL. Unfotunately, there is a lack of studies which reported their potential to increaes the radiation efficacy.

Materials and Methods

We will perform a cancer cells clonogenic assay, and give treatment of extracts/bioactive compounds. We will give radiation of several different doses to both groups (0, 2, 4, 6, and 8 Gy), making cell survival curve, and then compare the cell count of the cell line receiving extracts/compounds to the control group.

Expected Results

While all anticancer activity of these extracts/bioactive compounds has been well proven, we expect that there is synergy between radiation and agent administration, meaning that

combination of both of them will result in greater cancer cells killing effect than either of them when delivered alone.

Conclusion

Clonogenic cell assays is a valid method of pre-testing any potential treatment before clinical studies. We cannot make a final conclusion regarding the potential of aforementioned extracts/bioactive compounds, as the study is still ongoing, but postponed due to COVID-19 pandemic.

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Contribution ID: 33 **Type: Poster**

Localization Dose of Proton-irradiation Promotes DNA Damage Response

Tengku Ahbrizal Tengku Ahmad (Malaysian Nuclear Agency)
Teruaki Konishi

Introduction

The high-linear energy transfer (High-LET) radiation has shown to increase biological effects compared to Low-LET radiation. High-LET radiation deposits their energy locally and densely throughout their path, which allows more conformal dose delivery to the targeted cells. It is reported that biological damage from High-LET radiation is greater than the Low-LET radiation. Therefore, the purpose of this study is to prove that localized dose and its distribution can cause complex and clustered DNA damage, which is extremely difficult to repair. We observed differences in the localization doses per traversal, where DNA damage and repair are compared to the same dose in each nucleus with different number of target positions. In this study, fibrosarcoma cell lines (HT1080) cells were exposed to High-LET radiation using proton microbeam, which allow each nuclei of cell to receive the same doses of exposure. The HT1080 cells were exposed to 1 or 5 positions with the same amount of 100 or 500 protons. DNA damage induction and repair is based on γ-H2AX intensity in each cell's nuclei and cell progression in the cell cycle.

Methodology

The human fibrosarcoma cells (HT1080) were grown in specially designed microbeam dishes, with 6-µm thick polypropylene film at the bottom. Irradiation was performed using The Single Particle Irradiation System to Cell at the National Institute of Radiological Sciences (SPICE-NIRS), which delivers 3.4 MeV protons with a beam diameter of ~2 µm. Prior to radiation, cells were incubated with Hoechst 33342 for nuclei visualization and determination of the coordinates of each nucleus in irradiation region. The γH2AX immunofluorescence staining was performed to determine the DNA-DSB at 6 and 24h post-irradiation. Fluorescent images of cells were obtained using SPICE offline microscope system with two fluorescence channels, i.e. (1) cell nuclei stained with Hoechst 33342 and (2) γ-H2AX fluorescently stained with Alexa Fluor 555. Meanwhile, 1X Click-iT® EdU buffer additive Kits is used to determine cell location in S-phase of cell cycle at 6 and 24h post-irradiation.

Results

The gH2AX fluorescence intensity in nuclei is measured in relative fluorescence units (RFU). Results showed that γh2AX foci intensity decreased at 24h of post-irradiation, either HT1080 cells were exposed to 1 or 5 positions of 100 protons. Cells in both irradiation conditions were in G1-phase and the damage may still be repaired even at 24h of post-irradiation. Cells irradiated at 1 position of 500 protons showed an increase of γh2AX foci intensity, but the intensity decreased significantly at 24h post-irradiation when exposed to 5 positions of 500 protons. Regardless of whether the damaged is repaired or not, results have shown that cells were in S-phase at 24h post-irradiation. Based on these findings, the gH2AX intensity decreases at 5 positions of irradiation compared to 1 position in most post-irradiation times. This would suggest that with very high localized dose, DNA damage induced by multiple position irradiations was more effective to be repaired compared to single position irradiation. This is due to the 5 times more protons delivered and higher localized dose in the same nucleus

volume, resulting in more complexed and clustered DNA damage in the cells. However, no significant increase or decrease in EdU positive cells was observed when cells were exposed to 500 protons, which we assumed that cell cycle progression was delayed and under S-phase for DNA repair.

Conclusion

Differences in dose localization lead to different levels of DNA damage. High dose localization cause severe DNA damage and are difficult to repair. This proves that localization doses induce complex and clustered DNA damage. Further studies are needed to understand the mechanism of DNA damage repair, which will clarify the involvement of inter- and intra-signal in induction of DNA damage and repair in the cells.

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Contribution ID: 27 **Type: Poster**

Correlation Between the Levels of Salivary α-Amylase Activity and Xerostomia in Head and Neck Cancer Patients Undergoing Radiation Therapy

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Salivary α-amylase, an enzyme present in the oral cavity, is responsible for the breakdown of starch to smaller carbohydrate molecules. Xerostomia, or dry mouth, is a known effect on patients undergoing radiotherapy. Salivary α-amylase was used in this study to assess the severity of xerostomia on thirty (30) Head and Neck Squamous Cell Carcinoma (HNSCC) patients undergoing radiotherapy in Jose R. Reyes Memorial Medical Center. The main objective of this study was to correlate the severity of radiotherapy-induced xerostomia on HNSCC patients and the enzymatic activity of salivary α-amylase. Informed consent was obtained prior to saliva specimen collection. Unstimulated passive drool technique was employed and samples were collected into a polypropylene vial (Salimetrics®) and stored at -80ºC. Three separate collections were performed, prior to radiotherapy (Day 0), radiotherapy period (Day 21) and postradiotherapy period (Day 42) and Radiology Therapy Oncology Group (RTOG) scorings were also analyzed per collection. RTOG was used to evaluate the effects brought about by the toxicities of radiotherapy, and spectrophotometry was performed to assess the levels of salivary α-amylase activity through the principle of colorimetry.

Results of the experiment showed a mean salivary α-amylase activity of 183.10 IU/mL at Day 0, 31.36 IU/mL at day 21 and 72.93 IU/mL at day 42. Repeated measures of ANOVA showed that from Day 0 to Day 21 there was a 151.741 IU/mL ($p<0.001$) decrease in salivary a-amylase activity, a 41.564 IU/mL ($p<0.001$) increase from Day 21 to Day 42, and a 110.177 IU/mL ($p<0.001$) decrease from Day 0 to Day 42. Multinomial Logistics Regression showed that as the radiotherapy progresses the probability of having a RTOG Grade of 1 (850,000x) and 2 (100,000x) is greater than having a RTOG Grade of 0. Pearson correlation was utilized to determine if there is a significant correlation between the levels of salivary a-amylase and the mean parotid dose. There is a strong negative correlation (-0.966) suggesting that as the dose of radiation administered to the patients increases, the levels of salivary a-amylase decrease by 0.021 IU/mL.

In comparison to the baseline, there was a decrease in the levels of salivary α-amylase on the radiotherapy period. The salivary α-amylase levels during the postradiotherapy period were greater than that during the radiotherapy period but with high variations from each other. As the radiotherapy continues, the probability of having a RTOG Grade of 1 and 2 is greater than having a RTOG Grade of 0. The levels of salivary α-amylase and the mean parotid dose showed an inverse relationship that as the dose administered to the patients increases, the levels of salivary α-amylase decreases. Based on the study conducted and the established relationship between the variables, the quantitation of salivary α-amylase is an effective predictive marker for radiation induced salivary gland toxicity in HNSCC patients.

Other notes

The ICARO-3 Team would like to point out that due to uploading problems during the process of the abstract submission, in a few cases tables, graphics or images could not be extracted from the INDICO system and therefore do not appear in this book.

In some other cases, the formulas were submitted as part of the text but not as an attachment at the time of submission. For this reason, there can be some formulas missing and also some gaps in the texts.

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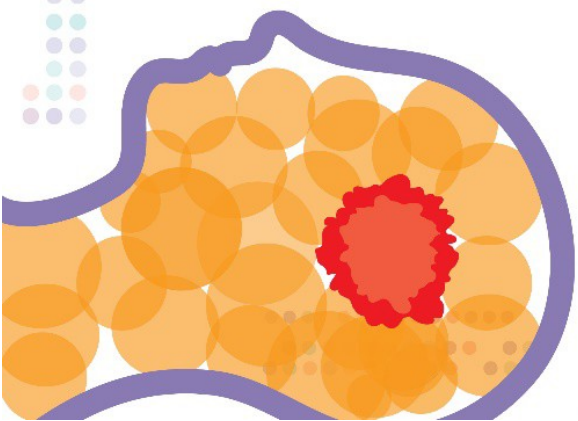

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