# POTENTIAL FOR THE ESTABLISHMENT OF NATIONAL CT DIAGNOSTIC REFERENCE LEVELS IN THE RUSSIAN FEDERATION

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**Abstract**

Computed tomography (CT) is a widespread diagnostic modality that is commonly associated with relatively high patient doses. Hence, optimization of radiation protection of the patients from CT examinations is extremely important. An integrant part of radiation protection in medicine is a system of diagnostic reference levels (DRLs). The aim of the study was to evaluate the possibility of establishing DRLs for typical CT examinations on national level in the Russian Federation. The study is based on the dose surveys performed in different regions of Russia in 2009-2017. Data was collected on the most common native and multiphase CT examinations as well as whole body CT as a part of positron emission tomography combined with computed tomography (PET/CT) examinations. Establishment of DRLs on the region level in Russia is complicated due to the high number of regions and limited availability of dose data. Comparison between typical dose distributions indicated no significant regional differences, hence allowing establishing DRLs on the national level. The 75% percentiles of both DLP and effective dose distributions were proposed as the preliminary values of national DRLs. It was proposed to establish DRLs for whole native CT examinations or for one phase of multiphase CT examination.

## 1. INTRODUCTION

Computed tomography (CT) is a widespread diagnostic modality that is used either as an independent diagnostic method or as an addition in nuclear medicine. In Russia, the number of CT examinations is rapidly increasing (by a factor of 5 during the last decade, corresponding to 8 mln examinations in 2015). CT contributes up to 45% to the collective dose to the Russian population from medical exposure [1]. Moreover, CT examinations can be associated with high patient dose (up to 50-100 mSv per examination) [2]. That indicates the importance of focusing the radiation protection on this diagnostic modality.

Radiation protection of the patients from medical exposure in developed countries is based on the system of diagnostic reference levels (DRLs) [3]. DRLs are defined as a specific (usually 75%) percentile of a selected dose quantity distribution for a certain examination. A common approach to the establishment of CT DRLs is to use dose-length product (DLP, mGy·cm) or computer tomography dose index (CTDI, mGy). However, according to Russian legislation, each patient should be informed about the dose and the possible consequences (radiation detriment) from medical exposure [4]. The effective dose is used for rough risk assessment in Russia [5].

Establishing DRLs on a regional level allows considering the variations in local radiological practice. However, it is complicated due to the high number of regions in Russia (82 as on 2015). Not all CT examinations (i.e. whole-body CT-examinations) are widespread in each region. Hence, the aim of the study was to combine results from CT dose surveys in Russia and to evaluate the possibility of establishing DRLs for most common CT examinations on national level.

## 2. MATERIALS AND METHODS

Dose surveys were performed in two representative regions of Russia: St. Petersburg and Belgorod region [2] in 2014; previously collected data was complemented in 2015. Data was collected on typical native CT

examinations of head, chest, abdomen, pelvis and multiphase CT examinations with contrast injection (computed tomography angiography - CTA) of head, chest and abdomen. Additionally, data on whole body CT examinations as a part of whole body positron emission tomography combined with computed tomography (PET/CT) examinations was collected in 2012-2017. The following information was collected: patient data (sex, weight, age); protocol parameters (kV, total mAs, collimation, pitch, time per tube rotation), and patient dose parameters (CT dose index – CTDI and dose length product – DLP). Data was collected for at least 10 standard patients for each type of CT examinations for each CT unit. Typical patient doses were estimated as an average for the standard patient sample for each CT unit. Typical patient doses from current survey were combined with the published data on patient doses from CT examinations in Russia [7,8]. Overall data on the hospital/CT unit sample and the selected examinations is presented in Table 1.

TABLE 1. OVERALL DATA ON DOSE SURVEYS AND THE SELECTED EXAMINATIONS

| CT examination type | Native CT examinations | | | Computer tomography angiography (CTA) | Positron-emission tomography combined with CT (PET/CT) |
|---|---|---|---|---|---|
| Data source | Current survey | Bratilova et al. 2014 [7] | Matkevich et al. 2016 [8] | Current survey | Current survey |
| Typical examinations | Head, chest, abdomen, pelvis | Head, chest, abdomen, pelvis | Head, chest | Head, chest, abdomen | Whole body native and CTA |
| Surveyed regions | St-Petersburg/ Belgorod region | St-Petersburg/ Leningrad region | Moscow | St-Petersburg/ Belgorod region | 12*** |
| Total № of hospitals | 5/7* | 12/3** | 1 | 5/7 | 17 |
| Total № of CT units | 8/14* | 14/3** | 4 | 8/14 | 20 |
| Year of survey | 2014-2015 | 2009-2012 | 2012-2014 | 2014-2015 | 2012-2017 |

* St-Petersburg/Belgorod region
** St-Petersburg/Leningrad region
*** St-Petersburg, Moscow, Belgorod region, Kazan region, Primorsky krai, Bashkortostan, Tumen region, Tambov region, Kursk region, Lipetsk region, Orel region, Sverdlovsk region

The effective dose was calculated using CT-EXPO software [9] based on the tissue weighting coefficients from ICRP Publication 60 [10]. Median, 25-75%-percentiles of typical dose distributions were estimated for each examination for both DLP and effective dose. Due to specificity of radiation protection of medicine in Russia, two dose quantities were considered as a potential quantities for DRLs in Russia: DLP and effective dose. Preliminary national DRLs were estimated as 75%-percentiles of typical patient dose distributions for a pooled sample.

## 3.    RESULTS AND DISCUSSIONS

The typical patient dose distributions in DLP and effective dose for the pooled sample are presented on Fig. 1.
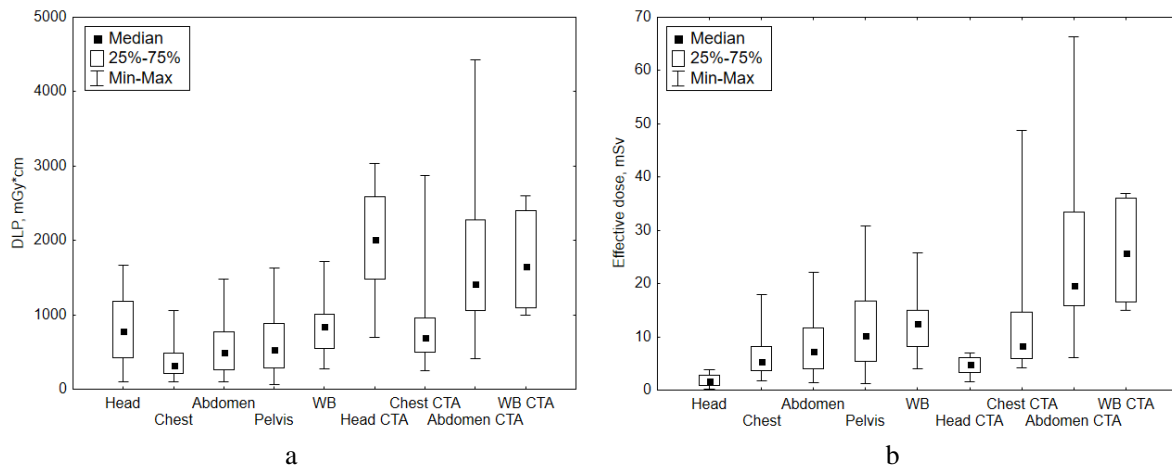
*FIG.1. Distribution of typical doses for different CT examinations for the pooled sample: a- for DLP (mGy·cm); b – for effective dose (mSv).*

Comparison between typical dose distributions indicated no significant regional differences, hence allowing establishing DRLs on the national level. Analysis of distributions indicated that variation in typical doses was smaller for standardized examinations (up to a factor of 10 for native CT examinations of head or chest). Variation in typical doses was significant (up to a factor of 25) for multiphase CT examinations or examinations where scan length was influenced by the physician preferences or the objective of the examination.

The 75% percentiles of dose distribution of pooled samples were used as the preliminary values of national DRLs (table 2). Preliminary DRLs were determined for native CT examinations or for one phase of multiphase CT examination and compared with the DRLs from other countries (see Table 2). No significant differences with most common values of European DRLs were found.

TABLE 2. PROPOSED CT DRLs IN RUSSIAN FEDERATION IN COMPARISON WITH DRLs FROM OTHER CONTRIES

| Anatomical region | DLP, mGy·cm | |
| --- | --- | --- |
| | Russian Federation* | European DRLs [11] |
| Head | 1190 (3) | 1000 |
| Chest | 500 (8) | 400 |
| Abdomen | 780 (12) | 800 |
| Pelvis | 880 (17) | 550 |
| Whole body** | 1000 (15) | - |

*DLP, mGy·cm (effective dose, mSv)
** Dose from whole body CT scan of PET/CT examination

## 4. CONCLUSION

DRL establishment on a regional level for all regions of Russia is complicated due to the limited patient dose data available and the complexity of performing dedicated dose surveys. Hence, it is practicable to establish DRLs on a national level, providing all practitioners with initial values of DRLs for most common CT examinations. More data should be used to establish national DRLs; however, preliminary DRLs were proposed based on the available data. Preliminary national DRLs in DLP are comparable with the European DRLs.

# REFERENCES

[1]  V.S.REPIN V.S., BARYSHKOV N.K., BRATILOVA A.A., et al. Information bulletin: "Doses to the population of the Russian Federation in 2015", St. Petersburg, Russia (2016).

[2]  CHIPIGA L., BERNHARDSSON C. Patient doses in computed tomography examinations in two regions of the Russian Federation. Radiation protection dosimetry 169 (1-4) (2016) 240-4.

[3]  International Commission of Radiological Protection. Diagnostic Reference Levels in Medical Imaging. ICRP Publication 1XX Ann. ICRP 4X(X-X), (201x). Available from: http://www.icrp.org/docs/C3WPDRLDraftForPublicConsultation(011116).pdf.

[4]  VODOVATOV A.V., BALONOV M.I., GOLIKOV V.YU., et al. Proposals for the establishment of national diagnostic reference levels for radiography for adult patients based on regional dose surveys in Russian Federation. Radiation Protection Dosimetry 173 (1-3) (2017) 223-232.

[5]  BALONOV M., GOLIKOV V., KALNITSKY S., et al. Russian practical guidance on radiological support for justification of X-ray and nuclear medicine examinations. Radiation Protection Dosimetry 165 (2015) 39–42.

[6]  Patient doses in computed tomography examinations in two regions of the Russian federation. Available from: https://www.researchgate.net/publication/289553999_Patient_doses_in_computed_tomography_examinations_in_two_regions_of_the_Russian_federation [accessed Jul 2, 2017].

[7]  BRATILOVA A.A., GOLIKOV V.Y., KALNITSKIY S.A. Exposure levels of patients during computed tomography in medical organizations of Saint-Petersburg and Leningrad region. Radiatsionnaya Gygiena = Radiation Hygiene 7 (3) (2014) 33-38 (In Russ.).

[8]  MATKEVICH E.I., SINITSYN V.E., MERSHINA E.A. Comparative survey of radiation doses to patients in computed tomography in a federal hospital. Vestnik Rentgenologii i Radiologii = Journal of Roentgenology and Radiology, Russian journal 97 (1) (2016) 41–47 (in Russ.).

[9]  STAMM. G, NAGEL H. D. CT-Expoein – ein neuartiges Programm zur Dosisevaluierung in der CT. Fortschr Rontgenstr 174 (2002) 1570-1576.

[10] Recommendations of the International Commission on Radiological Protection. ICRP Publication 60. International Commission on Radiological Commission, Ann. ICRP 21 (1-3), 1991.

[11] European Comission. Diagnostic reference levels in thirty-six European countries. Radiation Protection 180 pt. 2. European Comission (2014).