# 2nd Modification and Update of Diagnostic Reference Levels in Germany - Improvements and Consequences

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Background/Introduction

In July 2016, the 2nd update of diagnostic reference levels (DRL) in Germany was published by the Federal Office for Radiation Protection (BfS) [1]. The modifications made were based on different databases collected by either the "ärztliche Stellen" (a quality assurance board), the German society of interventional radiology (DeGIR), the AQUA institute, the reference centers mammography, and a nationwide survey on CT exposure conducted by the German Roentgen society in 2013-14 [2].
Description of activity and work performed

DRL for plain radiography

Compared to the previous DRL, established in 2010 [3], dose-relevant parameters could be decreased by 20%, on average (see Fig. 1 on page 6).

Relative changes of the DRL for conventional plain X-ray radiography showed a decrease by about 40% between 2003 and 2010. The main reason for this rather big difference is that at the time of introducing DRL in 2003 [4] only a small database of dose values in terms of dose area products (DAP) was available. This changed substantially for the 1st update, when the underlying database was much more comprehensive due to strong efforts in recording dose values in daily practice. Therefore the changes in the 2nd update were not as pronounced as in the first one and showed a mean decrease of about 15%. Two new exams have been introduced in 2016 namely shoulder (per view) and hip (per view).

Also the DRL for children were adapted and the classification scheme regarding age and weight according the ICRP publication [5] was used. As an example see the listed changes for the DRL of the MCU exam (micturating cysto-urethrogram) in Table 1 on page 8.

Consequences for mammographic screening in Germany

With the 2nd modification of the DRLs in 2016, the DRL for one examination of the breast was lowered from 2.5 mSv to 2.0 mSv. To estimate the impact of the 2nd modification of the DRLs for the mammography screening in Germany, more than 1.8 million exposures from 114 mammography system form 2016 (Jan to Aug) were analyzed. 113 DR-Systems and 1 CR-Systems. Fig. 2 on page 6 includes only the 20 systems with the highest mean average glandular Dose (AGD). The mean AGDs of 10 systems were above the new DRL.

Surprisingly the only CR-System (ID_11) was not under the first 10 systems. However, internal studies of the reference center Münster have shown [6], that the displayed AGD of CR-System deviates an average of 20% downwards. Therefore it must be assumed, that the real mean AGD of the CR-System is above 2 mSv. The manufactures and system types are listed in Table 2 on page 8.
DRL for CT

More CT exams appeared in the publications of DRL in 2016 according to the common changes in imaging techniques, especially the angiography exams of the carotis, the triggered coronal CTA and the CTA of pelvis and extremities (see Fig. 3 on page 7).

What is missing in the RDLs for CT procedures of adults is a value for CT perfusion of the brain. This limitation is caused by the very small number of reported dose values and the possible sources of errors due to a variety of different protocols, different tube voltages used and also different number of scans.

DRLs for CT examination of children (with the exception of the head values) are reported with respect to the 32 cm PMMA phantom (body phantom) for a better correlation with the displayed values at the operator console.

Differences for high contrast and low contrast imaging in CT

The updated DRL for CT present for several anatomical regions depending on the issue of the examination low- and high-contrast values. The low-dose protocols vary significantly in many parameters like kVp, slice thickness, kernel or windowing. The quite different ratios of the CTDIvol values (see Table 3 on page 9) show, that the potential of optimisation exists furthermore. A differentiation of the examinations in respect of the issue is of major importance.

DRL for fluoroscopy and interventional radiology

The adjusted values for fluoroscopy can be found in Fig. 4 on page 8. But with respect to the increasing imaging techniques in radiological interventions, there was the need for establishing DRLs for common interventional procedures. While in 2010 only PTA and PTCA were listed as interventional radiological exams, in 2016 DRLs for 13 procedures have been published, including PCI, TAVI, TACE EVAR and PTA.

Comparing DAP values for exams of adults in the abdominal region we can find always approximately a factor of 10 when switching from plain radiography (Abdomen AP: 230 cGy*cm²) to fluoroscopy (Colon Contrast Enema: 3.000 cGy*cm²) and to abdominal interventions (EVAR and TACE: 30.000 cGy*cm²).
Fig. 1: Relative changes in DRL for 1st and 2nd update of the DRL for plain radiography.

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Fig. 2: Overview of the 20 Systems with the highest mean AGD, sorted in descending order.

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Fig. 3: DRL for CT of adult published in 2003, 2010 and 2016.

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Fig. 4: DRL for fluoroscopy in adults published 2003, 2010 and 2016.

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Table 1: DRL for MCU exams of children in cGy*cm² (µGy*m²).

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Table 2: Overview of the different mammography systems with a mean AGD over 2 mSv.

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<th>Manufacturer</th>
<th>System types</th>
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<th>mean AGD Range (mSv)</th>
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<td>Hologic</td>
<td>Lorad Selenia</td>
<td>5</td>
<td>2.1 – 2.5</td>
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<tr>
<td>Hologic</td>
<td>Lorad Selenia Dimensions</td>
<td>3</td>
<td>2.0 – 2.3</td>
</tr>
<tr>
<td>GE Medical Systems</td>
<td>Senographe 2000D</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>IMS Giotto</td>
<td>Image 3DL</td>
<td>1</td>
<td>2.1</td>
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Table 3: CTDIvol ratios of low and high contrast examinations depending on anatomical regions.

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Conclusion and Recommendations

Future work and outlook for the 3\textsuperscript{rd} update

For the 3\textsuperscript{rd} update of RDLs it is planned to use not only values for the DAP but also introduce some values for the number of images and total imaging time.

Other countries have already successfully introduced RDLs for optimization. This will be also reported in an extended publication in Germany. Values of the 25 and 50 percentiles shall serve as resources for optimization processes as requested for example in the ICRP publication [5].
Personal/Organisational information

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