

Radiation Practices Regulation

9/3020/2015

25.5.2015

TRANSLATION. ORIGINAL TEXT IN FINNISH.

Safety licence holders for healthcare

**Reference levels for the patient's radiation exposure for paediatric CT scans**

The responsible party's (party running a radiation practice) duty to introduce reference levels for X-ray examinations is laid down in the Decree of the Ministry of Social Affairs and Health on the medical use of radiation (423/2000). The Decree also prescribes that the reference levels for the most common examinations shall be issued by the Radiation and Nuclear Safety Authority. The provisions concerning reference levels and putting them into practice are laid down in Sections 2, 16 and 17 of the Decree.

This decision provides the reference levels for the most common paediatric computed tomography (CT) scans: CT scans of a child's head, lungs, abdomen and body (lungs + abdomen).

Tables 1 and 2 present the reference levels for CT scans of a child's head as a computed tomography dose index ( $CTDI_{vol}$ ) and a dose-length product (DLP). Reference levels have been provided separately for two imaging indications: routine head CT scan and cerebral ventricle size examination. Figures 1–6 present the reference levels for CT scans of a child's lungs, abdomen and body (lungs + abdomen) as a computed tomography dose index ( $CTDI_{vol}$ ) and a dose-length product (DLP), both as a function of the patient's weight. Figures 1–6 also present the achievable dose levels; these describe the dose levels that can be achieved by means of modern CT equipment, such as those using iterative reconstruction. The equations for the curves presented in Figures 1–6 are provided in Table 3.

The reference levels presented in the table and in the figures (as well as the achievable levels) are based on a collection of patient doses. If the examination comprises multiple series of images, the provided reference levels denote the radiation exposure caused by a single series. Furthermore, the reference levels have been defined for examinations that only use one stack of images (e.g. whole body imaged with one stack, lungs and abdomen not imaged separately).

Responsible parties may introduce into practice the reference levels given in the table and figures or they may use stricter values of their own. When desired, responsible parties may determine reference levels for their own use for examinations, which have not been given reference levels.

This decision is valid as of 1 June 2015.

Director General                      Petteri Tiippana

Director                                      Eero Kettunen

Appendix      Instructions: Reference levels for the patient's radiation exposure for paediatric CT scans

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**Table 1.** Reference levels for the patient's radiation exposure for paediatric CT scans, when the imaging indication is a standard CT scan of the head.

Age group yrs	CTDI <sub>vol</sub> mGy	DLP mGy·cm
< 1	23	330
1-5	25	370
5-10	29	460
10-15	35	560

**Table 2.** Reference levels for the patient's radiation exposure for paediatric CT-scans, when the imaging indication is an examination of the cerebral ventricle size.

Age group yrs	CTDI <sub>vol</sub> mGy	DLP mGy·cm
<1-15	4	35

**Table 3.** Reference levels for the patient's radiation exposure and achievable levels for CT scans of a child's body; equations for the reference level curves presented in Figures 1-6.

CT scan	Quantity and unit	Equation for the reference level curve	Equation for the achievable level curve
Lung	CTDI <sub>vol</sub> , mGy	$y=0.726 e^{0.026x}$	$y=0.5773 e^{0.0273x}$
	DLP, mGy cm	$y=10.871 e^{0.0409x}$	$y=9.005 e^{0.04x}$
Abdomen	CTDI <sub>vol</sub> , mGy	$y=1.314 e^{0.0282x}$	$y=0.9648 e^{0.0283x}$
	DLP, mGy cm	$y=38.75 e^{0.0358x}$	$y=27.015 e^{0.0378x}$
Body (lung + abdomen)	CTDI <sub>vol</sub> , mGy	$y=1.8486 e^{0.0234x}$	$y=1.3108 e^{0.0267x}$
	DLP, mGy cm	$y=62.129 e^{0.0373x}$	$y=49.072 e^{0.0377x}$

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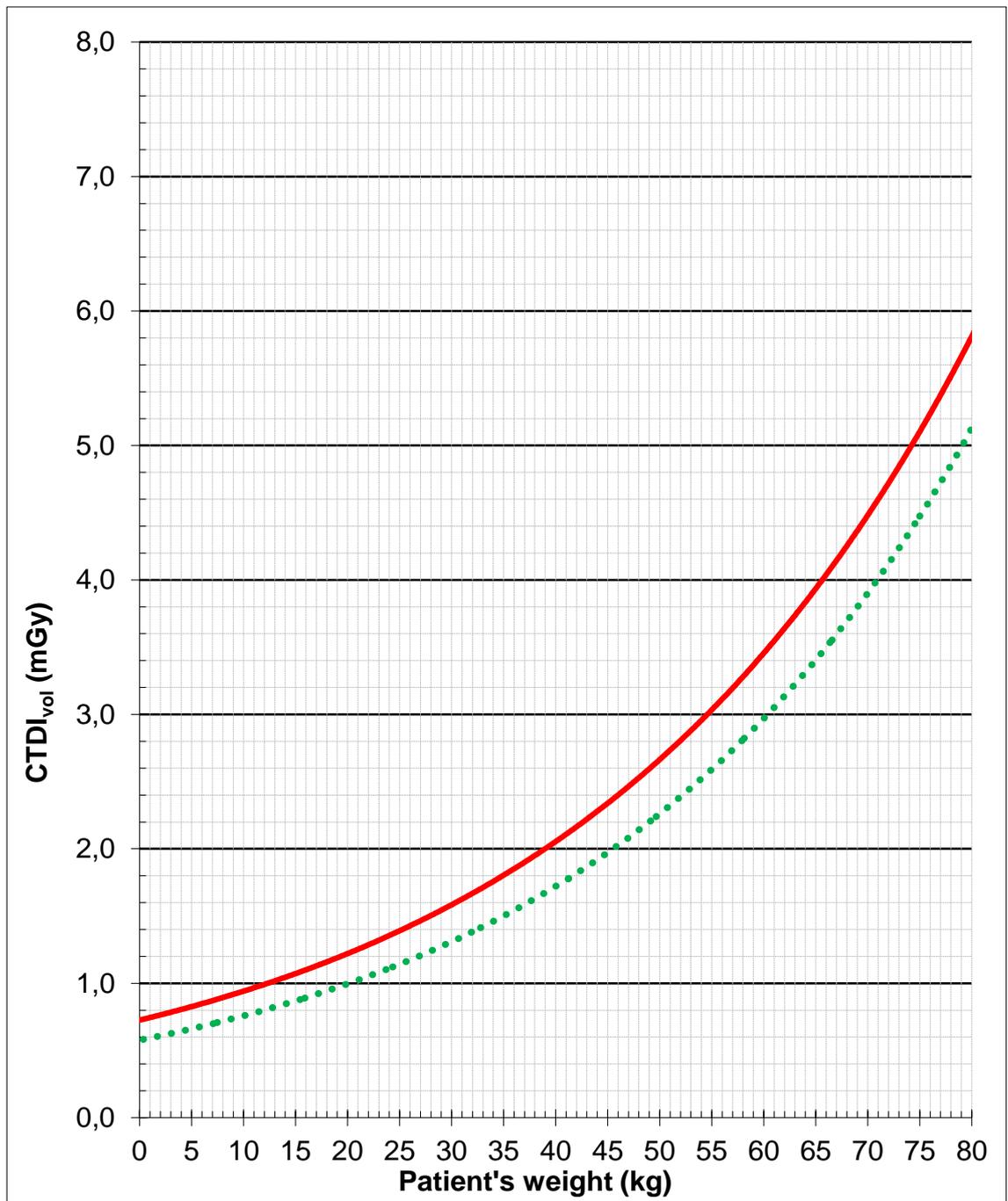


Figure 1. Lung CT-scans for children: CTDI<sub>vol</sub> as a function of the patient's weight. Solid red curve: reference level, dotted green curve: achievable level.

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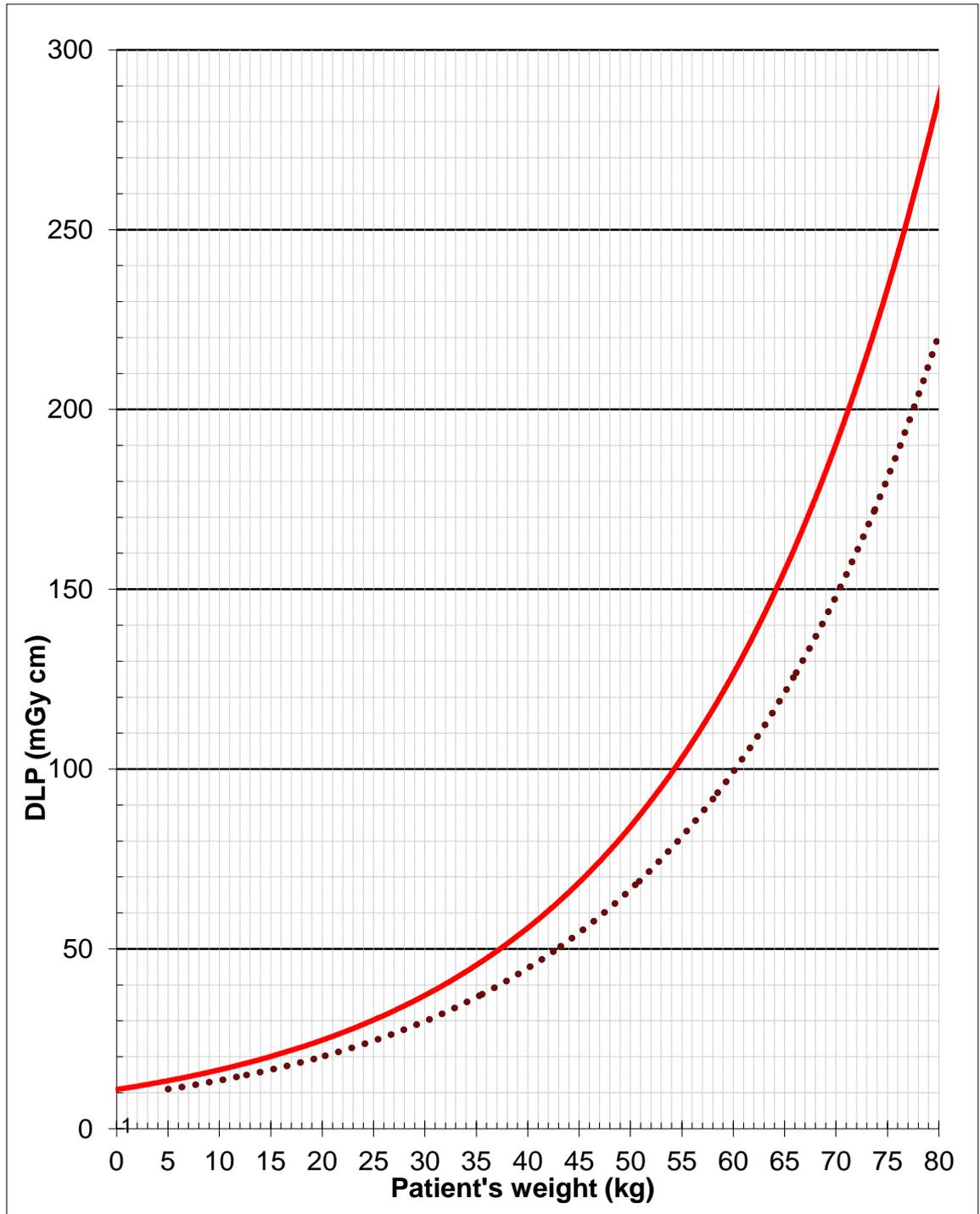


Figure 2. Lung CT-scans for children: DLP as a function of the patient's weight. Solid red curve: reference level, dotted green curve: achievable level.

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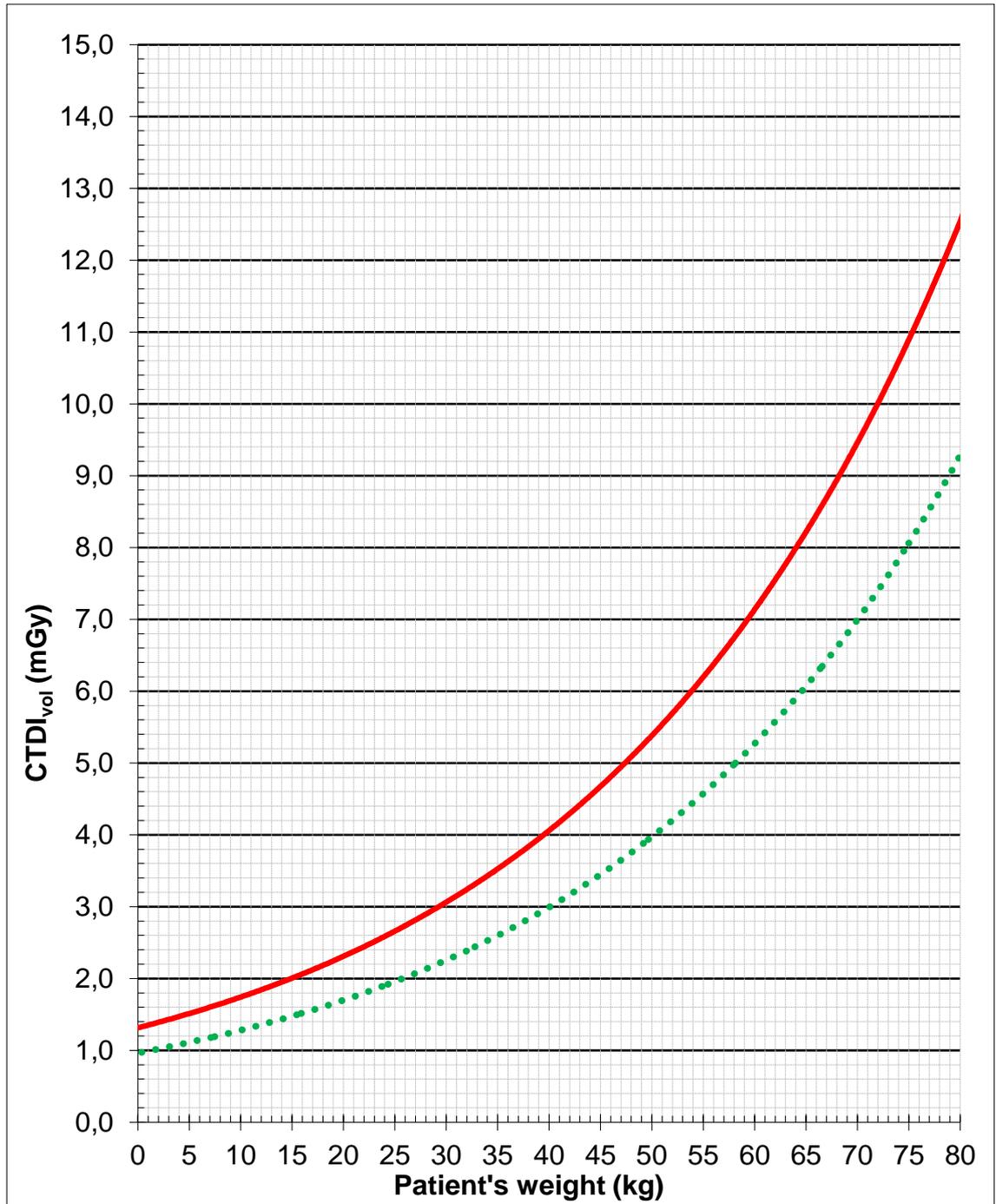


Figure 3. Abdomen CT scans for children: CTDI<sub>vol</sub> as a function of the patient's weight. Solid red curve: reference level, dotted green curve: achievable level.

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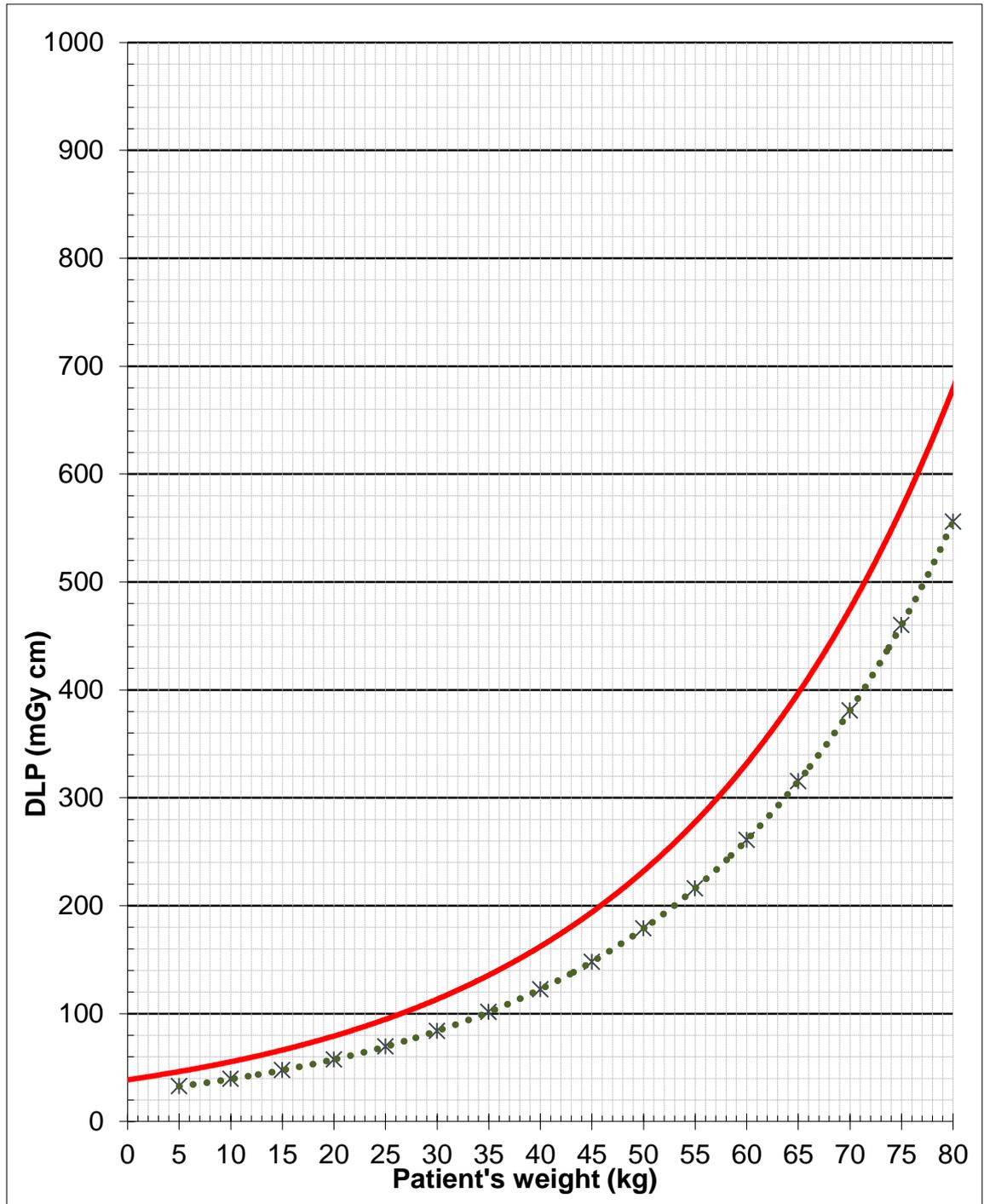


Figure 4. Abdomen CT scans for children: DLP as a function of the patient's weight. Solid red curve: reference level, dotted green curve: achievable level.

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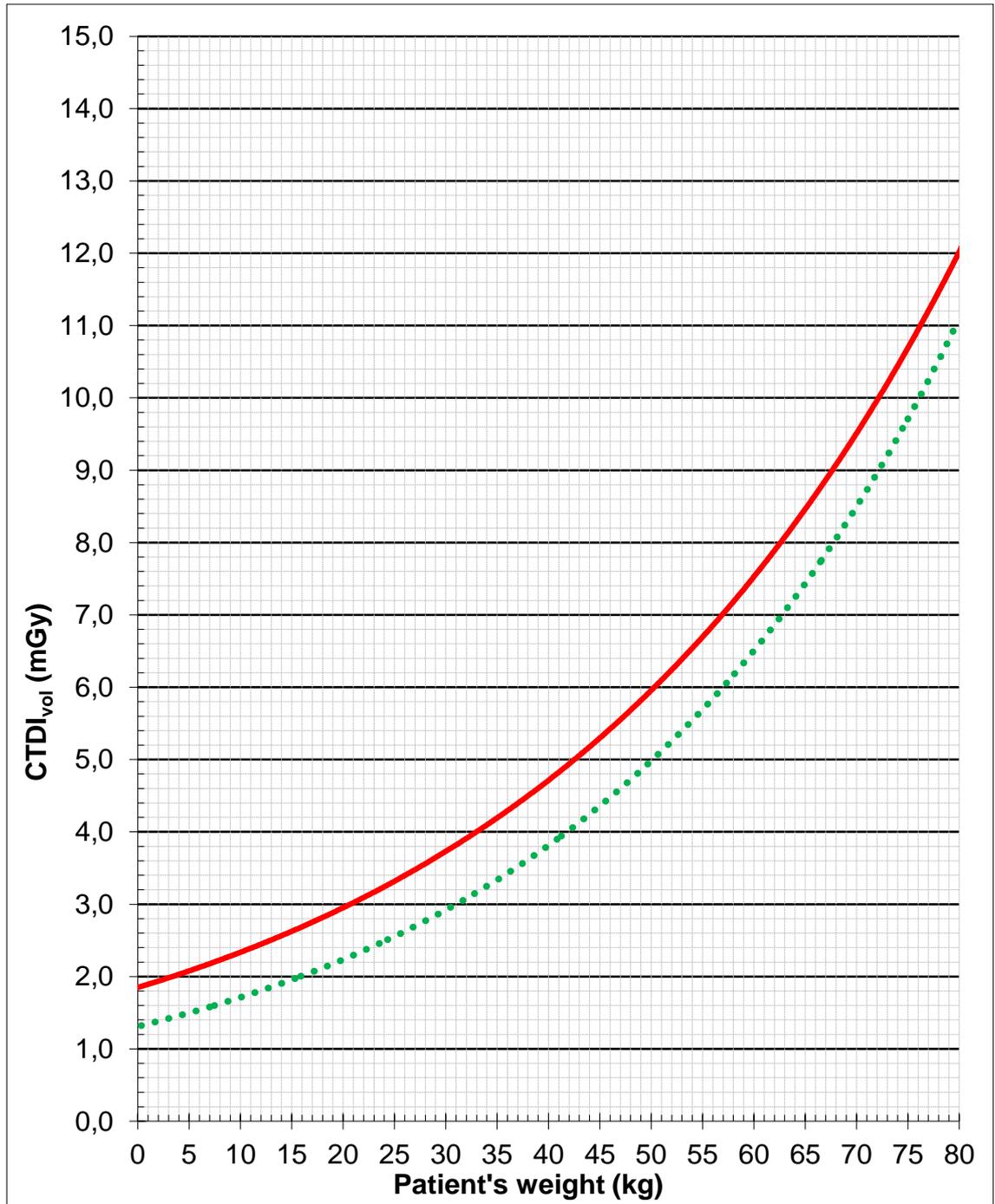


Figure 5. Body (lung + abdomen) CT-scans for children: CTDI<sub>vol</sub> as a function of the patient's weight. Solid red curve: reference level, dotted green curve: achievable level.

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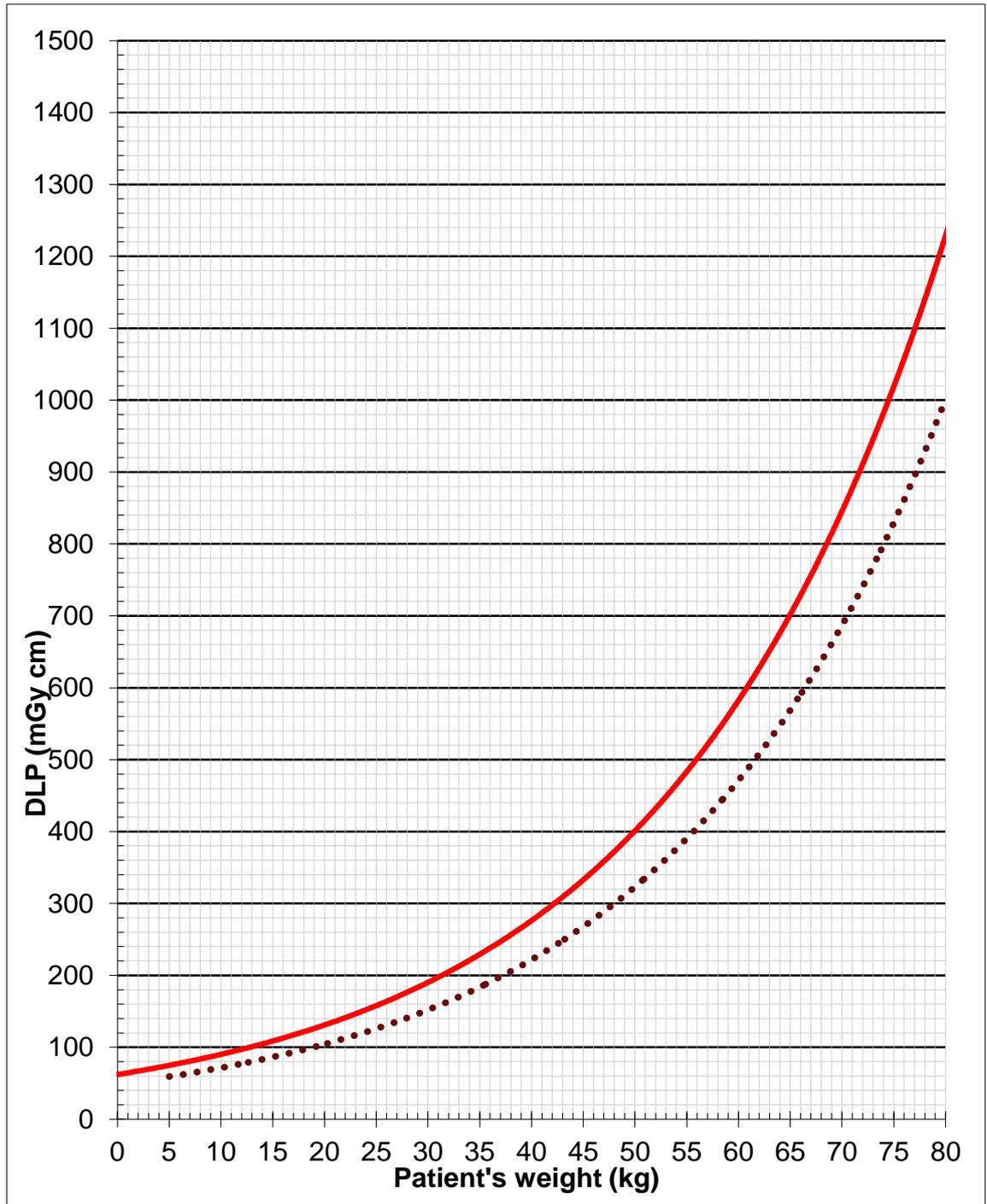


Figure 6. Body (lung + abdomen) CT-scans for children: DLP as a function of the patient's weight. Solid red curve: reference level, dotted green curve: achievable level.

## Reference levels for the patient's radiation exposure for paediatric CT scans

### Definition of reference level

Reference level refers to a pre-determined radiation dose level that is not expected to be exceeded during an examination or procedure that is performed on a normal-size patient according to good treatment practice. For the purposes of children's X-ray examinations, a normal-size patient refers to a patient within a specific age or weight group.

### Using reference levels

Reference levels can be used to detect X-ray equipment and functions that cause higher than normal radiation exposure. The reference levels are not intended for use in limiting the radiation doses of individual patients; instead, they are used to compare the average radiation exposure of a group of patients selected in the manner described below to the exposure caused by good practice.

The fact that the dose levels are exceeded does not necessarily mean that the examination has been performed poorly. Using radiation exposure above the reference levels may be justified when a higher image quality is required, for example. On the other hand, the fact that the reference levels are not exceeded does not mean that the examination is optimised in terms of radiation safety. In this case, as well, it must be ensured that the radiation exposure is not unnecessarily high and that the image quality is sufficient for a reliable diagnosis.

### Determining radiation exposure

Radiation exposure is determined at least once every three years using the dose display on the CT. The accuracy of the dose display must be ensured by means of measurements performed in the CT standard phantom. For paediatric head CT-scans, the reading of the dose display must correspond to the dose received in a standard phantom with a diameter of 16 cm; for other paediatric CT scans, the dose must correspond to the dose received in a standard phantom with a diameter of 32 cm. The radiation exposure is determined for each age group (head CT scans) and for each reference curve (CT scans of the lungs, abdomen and body) for a group of at least ten patients. In case of the reference level curve, the patient doses should be determined as comprehensively as possible along the weight range depicted by the reference level curve (0–80 kg). The radiation exposure shall be determined and compared to the reference level again if any changes are made in the examination practices or equipment that may affect radiation exposure.

During the interim years, confirming that the radiation exposure has not changed and the image quality has not been reduced will be sufficient. The verification is performed for each CT device using at least one common examination type for which a reference level has been provided.

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### Paediatric head CT-scans

For paediatric head CT scans, the reference level is provided for different age groups. Radiation exposure is determined for a group of at least ten patients per each age group. The average radiation exposure is calculated for this group and is compared to the reference level for the age group.

### CT-scans of the lungs, abdomen and body

The reference level of paediatric CT-examinations of the lungs, abdomen and body (lungs + abdomen) has been provided as a diagram (reference level curve) where the reference level has been presented as a function of the patient's weight. Therefore, the weight of the patient must be known in addition to their radiation exposure. For example, the reference level curve can be used as a printed image; the radiation doses are marked in the image according to the patient's weight and compared to the reference level curve. If there are more dots above the reference level curve than below it, this indicates that the reference level has been exceeded and the deviations from the reference level curve must be examined in more detail.

The comparison to the reference level curve can also be performed by means of calculation (such as a spreadsheet) by comparing the curve fitted to the patient doses determined by the responsible party (exponential fit) to the reference level curve. If the fitted curve is above the reference level curve, the reference level can be seen to have been exceeded. STUK's website has a spreadsheet available for download that indicates the reference level as a function of the patient's weight. This can be utilised when using the reference level curve in calculations. See also STUK's decision concerning reference levels of the patient's radiation exposure for paediatric thoracic imaging (projection imaging), which otherwise employs the same principle but uses the patient's thickness instead of the patient's weight.

The comparison to the achievable level can be performed in the same manner as the comparison to the reference level. In the spreadsheet mentioned above, the achievable levels have also been provided as a function of the patient's weight, and comparisons to the achievable level as well as to the reference level can be made after the patient dose information has been entered.

### Results assessment and corrective actions

The radiation exposure information must be recorded and systematically compared to the reference levels. If the reference level is found to be exceeded, the cause must be determined and corrective actions must be taken if necessary in order to reduce the radiation exposure of the patients.

In this decision,  $CTDI_{vol}$  refers to a quantity that has been determined on the basis of the average imaging current used for the imaging. If the device defines the quantity in any other way, the reading of the device's dose display and the  $CTDI_{vol}$  value presented in the decision are not comparable.