Paediatric CT Practice - How safe is imaging in different countries?

Paediatric CT practice in HUS

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Key messages:

- Paediatric CT protocols should be based on either the patient's weight (body) or age (head).
- The doses to paediatric patients in our hospital are remarkably low compared to the doses for adults.
- With the use of lower kVp values for smaller patients it is possible to reduce patient doses and, on the other hand, improve contrast-to-noise ratio in contrast-enhanced CT examinations.
- The use of modern CT scanners with new optimisation techniques, including iterative reconstruction and tube-current modulation, have reduced the patient doses significantly.
- Our CT optimisation practice follows the Finnish Guidelines for paediatric CT which includes practical advice for the optimisation of paediatric CT examinations.

1. List of the facility's CTDI and DLP for children from different age groups

Radiation doses, measured as CTDIvol and DLP, in head, chest and abdomen/pelvis CT in case of different patient groups are shown in Tables 1-3 and Figures 1-3. Data was collected between August 2012 and March 2013 from a single CT scanner (64-slice GE Lightspeed VCT XTe, GE HealthCare, Milwau-kee, Wisconsin, USA. CTDI and DLP values were normalised to respond to 32 cm CTDI-phantom.

Table 1: Head CT: $CTDI_{vol}$ and DLP values (mean ± std) in different patient groups.

Patient group	Number of patients	$CTDI_{vol}$ (mGy)	DLP (mGy*cm)
0<12 months	8	23.7 ± 6.5	359.2 ± 117.0
1-5 year-old	19	27.8 ± 3.2	415.2 ± 55.9
6-10 year-old	26	29.7 ± 1.7	457.0 ± 41.2
11-16 year-old	29	34.7 ± 3.1	543.2 ± 58.8
> 16 year-old	9	35.9 ± 2.1	542.2 ± 53.8
Adult	115	42.1 ± 4.3	641.8 ± 104.4

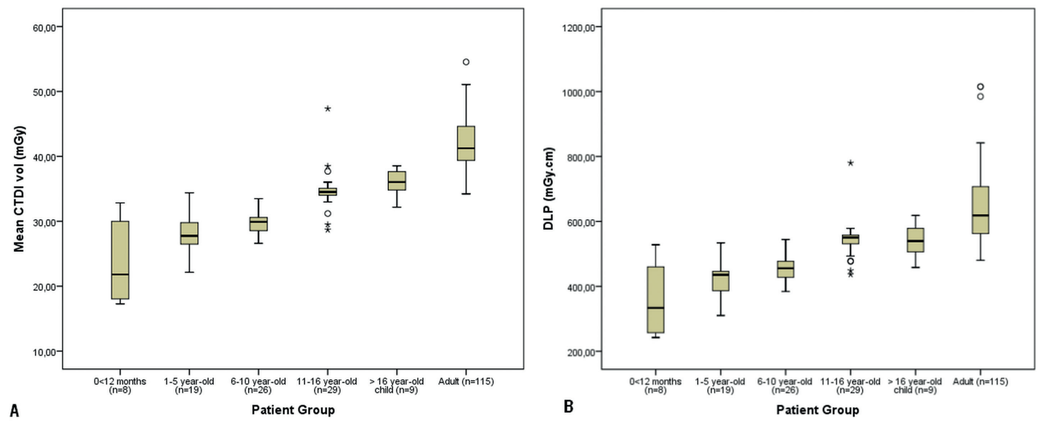

Figure 1: Mean $CTDI_{vol}$ (A) and DLP (B) values in different patient groups in head CT. The bottom and top of the boxes in the boxplots represent the first and third quartiles, and the band inside the boxes represents the median. The whiskers corresponds to the most extreme point within range of the first quartile - 1.5*(IQR = inter quartile range) and third quartile + 1.5*(IQR). The small circles and stars represent mild and extreme outliers that are either above or below the extreme points.

Table 2: Chest CT: $CTDI_{vol}$ and DLP values normalised to 32 cm diameter phantom (mean ± std) in different patient groups.

Patient group	Number of patients	CTDIvol (mGy)	DLP (mGy*cm)
< 10 kg	31	2.7 ± 0.4	34.9 ± 11.7
10-20 kg	48	0.8 ± 0.1	12.5 ± 4.8
21-30 kg	17	1.1 ± 0.2	26.3 ± 6.4
31-65 kg	54	1.5 ± 0.5	48.0 ± 17.7
> 65 kg child	7	5.2 ± 3.6	175.7 ± 102.1
Adult	35	5.1 ± 2.8	185.8 ± 111.2

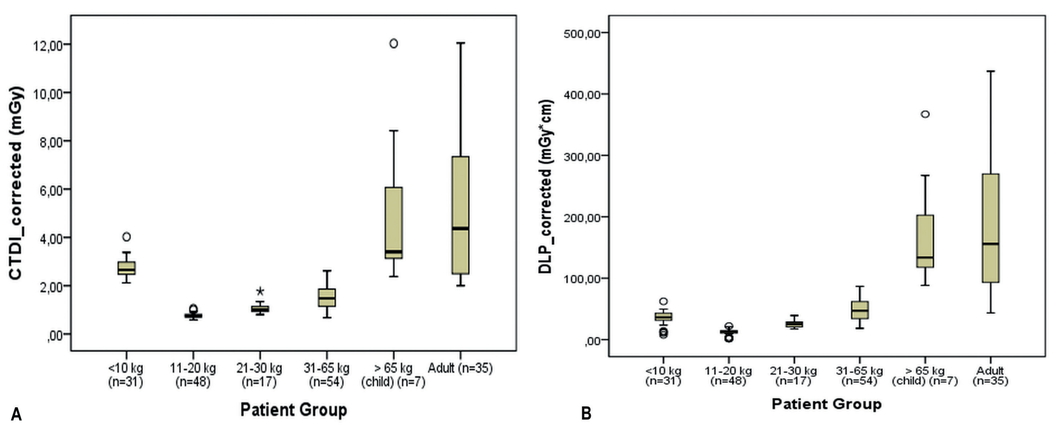

Figure 2: Normalised $CTDI_{vol}$ (A) and DLP (B) values in different patient groups in chest CT. The boxplot definition corresponds to the figure 1.

Table 3: Abdomen and pelvis CT: Normalised $CTDI_{vol}$ and DLP values (mean ± std) in different patient groups.

Patient group	Number of patients	$CTDI_{vol}$ (mGy)	DLP (mGy*cm)
< 10 kg	0	-	-
10-25 kg	5	6.3 ± 3.2	201.6 ± 154.6
26-40 kg	3	2.7 ± 0.1	105.0 ± 0.9
> 40 kg child	9	6.6 ± 3.5	299.1 ± 180.2
Adult	12	14.1 ± 6.5	717.0 ± 395.8

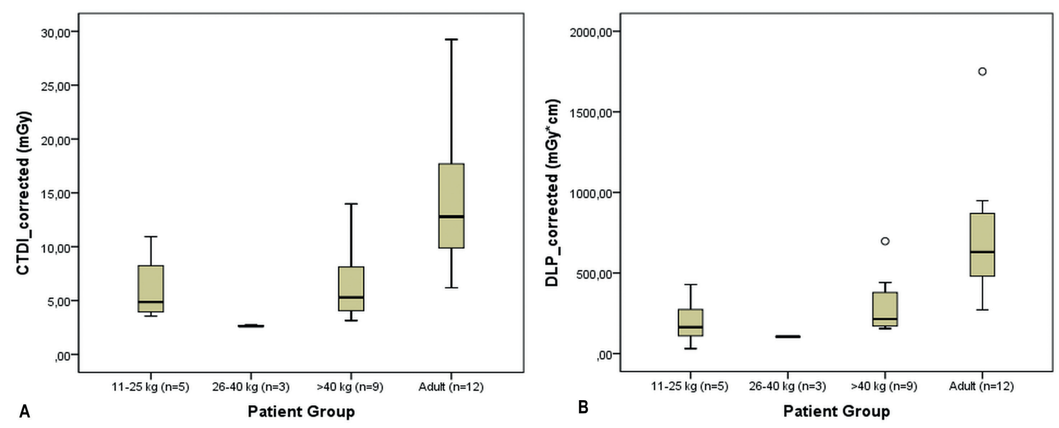

Figure 3: CTDI-phantom size corrected $CTDI_{vol}$ (A) and DLP (B) values in different patient groups in CT of abdomen and pelvis. The boxplot definition corresponds to the figure 1.

2. Information to indicate how radiation protection is promoted and practised

Our CT examinations follow the Finnish Guideline for paediatric CT, which was published in 2012 on the STUK website www.stuk.fi (translation into English 2013 http://www.stuk.fi/julkaisut_maaraykset/en_GB/stuk-opastaa/_files/89449395333694113/default/Advice-from-STUK-lasten-TT-2012.pdf) together with the Finnish paediatric radiologists and the Radiation and Nuclear Safety Authority, STUK.
It includes practical advice for the optimisation of paediatric CT, both technical parameters and clinical details, e.g. the use of contrast agent.

3. How radiation protection during paediatric CT is practised in the facility

Body CT protocols are based on patient weight-groups, and only head CT protocols are based on patient age. CT protocols have been optimised after the installation of the recent scanner in 2009. We are using automatic tube-current modulation in head CT, as well as in body CT protocols. Additionally, iterative reconstruction (ASiR) is used in each protocol. Furthermore, lower kVp values are utilised in the case of smaller patients and contrast-enhanced examinations. Adult protocols are never used for paediatric patients, most of whom are under 17 years of age.

4. Assessment of the number of paediatric CT examinations that lack appropriateness

Our facility is a dedicated children´s hospital. All referrals for CT are reviewed by a paediatric radiologist. If CT is not considered justified, the patient is referred to an alternative modality in cooperation with the referring doctor.
Self-assessment of the referrals has been performed twice, and both times the results were reviewed together with radiologists and clinicians [1]. The number of unjustified examinations decreased from 14% in 2009 to 8% in the follow-up study 1.5 years later.

5. Data on the percentage of dose reduction in CT of children

Figure 4 shows the decrease in DLP in routine chest CT when the previous CT scanner (Toshiba Aquilion 16-slice) was replaced by a new scanner in 2009 (GE Lightspeed VCT XTe 64-slice) [2]. The change was motivated by a growing awareness of dose issues and implemented with new technology, including the use of iterative reconstruction. Recently, further optimisation of the imaging parameters has become a continuous process with the emphasis on the use of iterative reconstruction and indication-specified protocols.

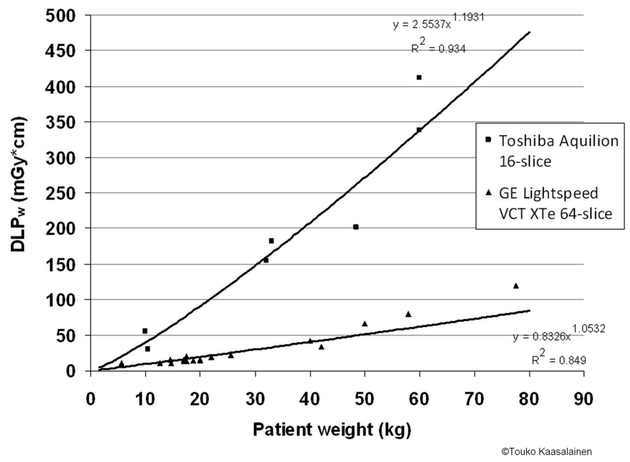

Figure 4: Decrease in DLP for routine chest CT for metastasis survey from 2008 with the older scanner and from 2010 with the new scanner. The remarkable decrease in dose was achieved by both the growing awareness of dose issues and the use of the new CT scanner's optimisation tools.

[1] Seuri R & Kalajoki-Helmiö T. Justification of paediatric CT, a self assessment in a paediatric hospital. Pediatr Radiol 2011; 41 (Suppl 1):S311–S428
[2] Järvinen H, Merimaa K, Seuri R, Tyrväinen E, Perhomaa M, Savikurki-Heikkilä P, Svedström E, Ziliukas J, Lintrop M. Patient doses in paediatric CT: feasibility of setting diagnostic reference levels. Radiat Prot Dosimetry 2011; 147:142-146. doi: 10.1093/rpd/ncr293. Epub 2011 Jul 21.