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

How we manage dose in paediatric CT at Graz/Austria

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

Patients were selected randomly from the HIS, but care was taken only to include single region investigations. In all data patients were classified in the following age groups:

Baby/Toddler: up to 3 years

Pre-School: 3 to <= 6 years

School Age: 6 to <=10 years

Youngster: 10 to <=14 years

Adolescent: more than 14 years (max age 18 years and additional 7 pediatric oncologic follow-up patients between 20 to 26 years)

Within some age groups there is no standard deviation (SDEV) listed, due to the limited number of patients and multi-organ scanning (e.g. chest CTA for sequestration) – those investigations were not included in dose analysis. Some CT machines always calculate CTDI and DLP for children based on a 16cm phantom, therefore these values were corrected in larger children (e.g. transversal diameter >= 24cm) by dividing CTDI and DLP by two.

Head:

		Indication		
Age Group		**Regular Head CT**	**Head CT for Shunt**	**Trauma Protocol**
Baby/Toddler	Mean - CTDI	16,80		22,32
	SDEV - CTDI	5,94		1,50
	Mean - DLP	238,08		472,75
	SDEV - DLP	89,15		78,34
Pre-School	Mean - CTDI	19,80		24,10
	SDEV - CTDI			
	Mean - DLP	252,80		562,50
	SDEV - DLP	35,36		44,03
School Age	Mean - CTDI	20,90		24,41
	SDEV - CTDI	1,81		1,81
	Mean - DLP	332,58		596,44
	SDEV - DLP	73,47		67,33
Youngster	Mean - CTDI	19,84	12,24	28,20
	SDEV - CTDI	0,36	0,11	0,77
	Mean - DLP	294,62	174,80	754,63
	SDEV - DLP	21,19	11,11	61,67
Adolescent	Mean - CTDI	24,00	9,00	28,34
	SDEV - CTDI	4,16	4,53	0,72
	Mean - DLP	392,65	126,05	727,17
	SDEV - DLP	110,52	63,00	39,24

Table 1: Age dependent dose values for head CT (Mean: mean value, SDEV: standard deviation, CTDI Computed Tomography Dose Index, DLP: dose length product)

Chest:

Age Group		**Regular Chest CT**
Baby/Toddler	Mean - CTDI	See Comment below
	SDEV - CTDI	See Comment below
	Mean - DLP	See Comment below
	SDEV - DLP	See Comment below
Pre-School	Mean - CTDI	3,40
	SDEV - CTDI	0,99
	Mean - DLP	101,60
	SDEV - DLP	45,45
School Age	Mean - CTDI	6,90
	SDEV - CTDI	
	Mean - DLP	255,40
	SDEV - DLP	
Youngster	Mean - CTDI	6,21
	SDEV - CTDI	3,52
	Mean - DLP	172,79
	SDEV - DLP	125,41
Adolescent	Mean - CTDI	4,37
	SDEV - CTDI	3,51
	Mean - DLP	128,98
	SDEV - DLP	93,89

Table 2 & Table1: Age dependent dose values for chest CT (Mean: mean value, SDEV: standard deviation, CTDI Computed Tomography Dose Index, DLP: dose length product)

There are no values for the Baby/Toddler because they usually undergo CTA Scanning. For that purpose we have developed the CTA Mircobolus Technique (Weissensteiner S et al;. Pediatric Radiology. 2013; 43 Suppl(3):S576-S576, http://www.auntminnieeurope.com/indexaspx?sec=edu_n&sub=cases&pag=case&UID=3J50QTAF)

Abdomen:

		Anatomic Region / Indication			
Age Group		**Abdomen**	**Appendix**	**Nephro / Ureterolithiasis**	**Trauma Abdomen**
Pre-School	Mean - CTDI	2,65	1,20		
	SDEV - CTDI	0,21			
	Mean - DLP	80,40	38,10		
	SDEV - DLP	4,24			
School Age	Mean - CTDI			4,30	3,60
	SDEV - CTDI				0,85
	Mean - DLP			164,60	138,15
	SDEV - DLP				32,31
Youngster	Mean - CTDI	9,10			5,20
	SDEV - CTDI	5,56			
	Mean - DLP	427,23			223,20
	SDEV - DLP	273,48			
Adolescent	Mean - CTDI	10,00		3,58	20,60
	SDEV - CTDI			1,73	9,19
	Mean - DLP	469,00		159,04	1150,00
	SDEV - DLP			73,05	639,22

Table 3: Age dependent dose values for abdominal CT (Mean: mean value, SDEV: standard deviation, CTDI Computed Tomography Dose Index, DLP: dose length product)

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

Our Division of Pediatric Radiology does not run a webpage about our radiation protection strategy, but online resources from the division are available:
http://www.auntminnieeurope.com/index.aspx?sec=sup&sub=cto&pag=dis&ItemID=606029

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

Due the availability of CT and MRI at our division, MRI imaging is used whenever possible, e.g. for non-traumatic head injuries, inflammatory and neoplastic central nervous system diseases, hydrocephalus evaluation in ventriculo-peritoneal shunts, musculoskeletal diseases, cardiovascular assessment, abdominal/gastrointestinal questions, gynaecologic diseases, and oncologic follow-up, except chest, to name just a few.
CT scanning is used in trauma patients, complex cases and chest CT in oncologic follow-up. CT exposure settings are adapted to age, body constitution, as well as clinical question e.g. high-contrast examinations (inner ear, airways, chest, CTA) and low-contrast examinations (brain, abdomen). All types of protocol are saved on the CT console and documentation can be found on the division's intranet portal.

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

Due to the division meetings with clinical partners (e.g. daily interdisciplinary reporting at the ICU Units, regular weekly, interdisciplinary meetings) most patients are already discussed. The referral diagnosis for CT is checked by the attending paediatric radiologist and, in cooperation with radiographers, an appropriate protocol is selected or modified if necessary.
Those CT examinations with troublesome output (e.g. suboptimal enhancement after intravenous contrast injections, examinations with high noise content, unnecessary long scan range) are discussed in regular divisions meetings and a quality assurance programme exists.

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

Patients are carefully placed (e.g. head in centre) and all positioning tools and goodies are used. All steps in the 'imaging chain' (Fig.1) are optimised for children. Bismuth shielding (augmented by 2cm rubber foam between bismuth and skin in order to avoid artefacts) is combined with Z-modulation, which turned out to be the best option on our machine. Bismuth is used for the scan but not for the scout view. Tube down for scout view helps to reduce dose by 50% for thyroid and mammary gland. Scout view exposure settings are adapted to age. In babies, we use 80kV, between one and 14 years 100kV, and 120kV for all other ages. The mAs-settings are influenced by the above mentioned high/low-contrast situation, as well as by tube modulation. Care is taken in small children, as a paucity of fat means there is less contrast and more noise – this fact is compensated for in the protocols.
For image reconstruction statistical algorithms are used and the kernel selection has been optimised.

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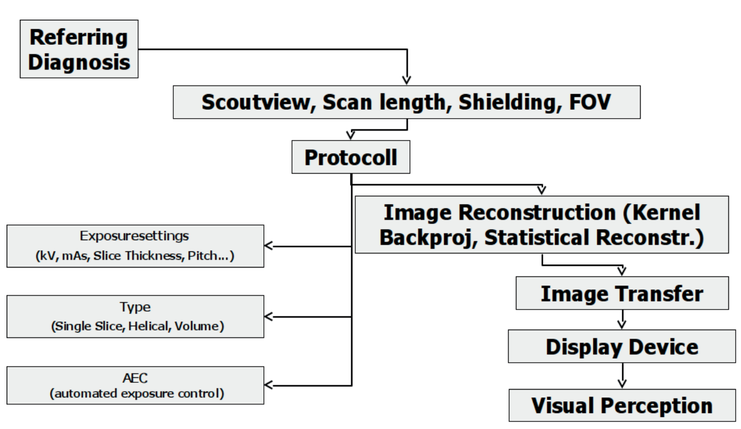

Fig. 1: Imaging Chain – all factors influencing dose in CT are listed and have to be optimised for children (modified after. E.Sorantin et al, Eur J Radiol. 2013; 82(7):1043-1049).

6. How we child size our CT imaging

For almost all indications there are age specific protocols on the CT machine and all investigations are planned and discussed in cooperation with radiologists and radiographers – both professions specialised in paediatric radiology. Due to the use of paediatric-adapted automated exposure control the machine keeps noise, according the chosen parameter, constant in slim and obese patients. For I.V. contrast injection an Excel sheet has been developed, which calculates the amount of contrast medium, as well as the delay for almost all frequent clinical questions. Since 2011 the 'Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations' (AAPM Report 204) has been implemented too.

7. Number of paediatric CT referrals that are reviewed by radiologists before giving appointments

As already explained above, paediatric radiologists visit daily intensive care units and there are several meetings with clinical colleagues. Moreover, since paediatric radiologists perform all types of imaging in children, with the exception of nuclear medicine studies and some interventional procedures, patient problems and clinical questions are usually known to division staff.

All CT referrals are reviewed by the attending paediatric radiologist, including patient history and previous imaging results. If ultrasound, or MRI, is the better modality to answer the clinical question then the patient is transferred to those modalities.