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Tips and tricks in paediatric computed tomography

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Computed Tomography (CT) is responsible for a large proportion of effective collective dose in the USA, UK, Germany and Portugal (66%, 47%, 60% and 67% respectively)[(1,2,3)] and the number of paediatric patients undergoing CT examinations has dramatically increased in the last decade [(4)].

Concern is particularly justified for paediatrics due to their higher sensitivity to radiation and longer expected life time [(5)], especially as some studies indicate that younger children are exposed to CT dose values similar to those for older children or adults [(4)].

To optimise paediatric CT examination the following procedures must be fulfilled:

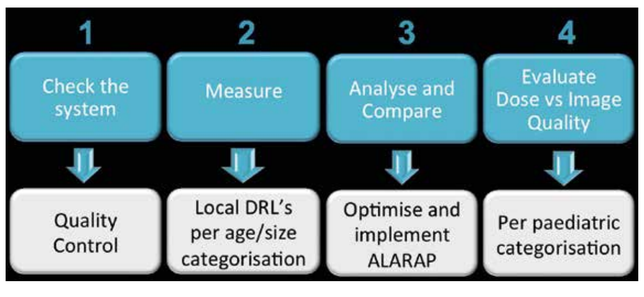

Fig. 1: Four steps to promote paediatric CT optimisation

The quality control of equipment must be verified, and the CT dose values must be analysed. The local DRLs must be established according to the paediatric categorisation they are particularly useful in areas where considerable individual or collective dose reduction may be realised [(4)].

Thus there appears to be a lack of standardisation with respect to age categorisation of paediatric patients for CT protocols across European countries, in the published work to date. These differences are presented but not discussed in detail within existing literature [(7,4,8)]. Some studies use the metric of weight to describe a cohort [(9)]. However, this information is, for most cases, unavailable. The patient diameter is also indicated as a possible method to categorise children for some body regions (chest and abdomen); nevertheless, the measurements must be performed on the topogram to enable protocol optimisation [(10)]. Despite the potential size difference within age categorisation metrics, this is the most practical and frequently employed method for paediatric categorisation.

The obtained local DRLs should be compared with the literature:

Tab. 1 - International paediatric head and chest CT DRLs published values described as CTDIvol and DLP values.

Body Region	Dose Descriptor	Age (years)	UK 2003 (11)	IE 2004 (12)	DE** 2006 (13)	CH*** 2008 (14)	FR 2012 (15)	DDM2 2012 (16)	PT 2011 (17)	PT 2013 (18)
Head	$CTDI_{vol}$ (mGy)	0	28	-	27	20	-	20	48	41
		5	43	-	40	30	40	35	50	43
		10	51	-	50	40	50	-	70	44
		15	-	-	-	60	-	-	72	55
	DLP (mGy.cm)	0	270	300	-	270	-	270	630	492
		5	435	600	-	420	600	470	770	542
		10	619	750	520	560	900	620	1100	824
		15	-	-	710	1000	-	900	1120	889
Chest	$CTDI_{vol}$ (mGy)	0	12	-	2	5	-	-	2.4	1.6
		5	13	-	5.5	8	4	-	5.6	3.0
		10	17	-	8.5	10	5	-	5.7	4.3
		15	-	-	-	12	-	-	7.1	6.4
	DLP (mGy.cm)	0	204	200	55	110	-	12	45	23
		5	228	400	110	200	65	55	140	70
		10	368	600	210	220	140	105	185	126
		15	-	-	-	460	-	200	195	232

UK (NRPB, 2005); IE-Ireland (Medical Council, 2004); DE-Germany (Galanski et al., 2006);
FR-France (Roch et al.,2012); DDDM2 (DDM2, 2012); CH-Switzerland (Verdun et al., 2008)
** Range of ages: <1 year, 1-5 years, 5-10 years and 10-15 years
***Range of ages: <1 year, 2 to 5 years, 6 to 10 years

The procedures must be adequate and it is also essential to:

- Know the CT equipment
- Regularly analyse CT dose values
- Preset protocols according to the paediatric age categorisation
- Adapt the protocol to the child's size
- Position the area of interest in CT gantry isocenter
- Use a lower tube voltage and tube current suitable for paediatric categorisation
- Use dedicated paediatric curves for tube current and voltage modulation
- Increase the pitch in order to avoid overlapping
- Use thin slices only when necessary
- Restrict scan range length to what is necessary
- Avoid multiphase scanning
- Use in-plane and out-of-plane shielding

In order to analyse the optimisation impact, image quality must be analysed in an objective and subjective mode. To perform objective analyses, image signal and noise must be compared pre and post-optimisation. Subjective analyses should follow the recommended imaging criteria and must be performed and discussed between radiographers and radiologists. A multidisciplinary discussion of the optimisation process is essential for paediatric CT dose reduction without impairing image quality.

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