Nordic pediatric CT project: Doses and level of optimization

A cooperation between the Nordic Radiation Protection Authorities

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Facts about CT and pediatric patients

- CT is generally associated as a high dose examination
- CT contributed to 60% of the collective dose to the population but only 12% of the performed radiological examinations (Norway, 2002)
- Pediatrics have a higher radiation sensitivity that adults
- Pediatrics are smaller then adults with great variation in size
- Adoption of scan protocols developed for adults on pediatric patients results in unnecessary high doses (~ factor 2-3)
- Limited dose data available for pediatric CT examinations

Need for dose surveys on pediatric CT examinations

Nordic pediatric CT project

Aims:

- Determine the doses to pediatric patients from CT examinations of the head, chest, abdomen and whole body
- Identify the level of optimization of pediatric scan protocols

Material and method: Data collection

Questionnaire

- Patient data
- Clinical indication
- Applied scan parameters
- Dose indicators provided by the CT scanner

Dose indicators provided by the CT scanner

- **$CTDI_{vol}$ – average dose in the irradiated slice [mGy]**
  - Reflects the applied scan parameters
- **DLP – integral dose of whole examination [mGycm]**
  - Reflects the scan length and number of subsequent scan sequences

Recommendation:

Irrespective of patient age and scan location, doses to all pediatric patients should be expressed in terms of absorbed dose to the standard head dosimetry phantom (16 cm in diameter).

Shrimpton PC, Wall BF, Radiat. Prot. Dosimetry 90, 249-252, 2000.

Most CT scanners:

- Pediatric trunk examinations: standard body dosimetry phantom (32 cm in diameter)
- Underestimate the absorbed dose by a factor of 2

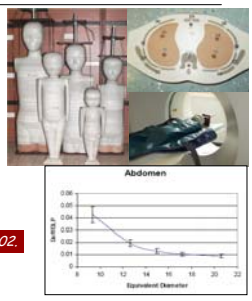
Material and method: Effective dose

$E = E_{DLP} \times DLP_{16cm}$

DLP to E conversion coefficient E_{DLP}

- Region-specific (head, chest, abdomen, pelvis)
- Function of patient size (equivalent diameter)
- Applicable to all patients and scanners for all scan areas

Chapple et al, Phys. Med. Biol. 47, 107-115, 2002.



DLP_{16cm} (head phantom)

- Obtained by different methods within the Nordic countries (see paper for details)

Results: Received questionnaires

- Totally 829 questionnaires were received from 19 hospitals
- 89 questionnaires were excluded from the survey
  - Incorrectly or insufficient filled out

Table 1: Total number of included questionnaires for examinations of the different scan areas from each Nordic country. The number of participating hospitals are given in brackets.

Country Scan area	Norway (n=5)	Sweden (n=5)	Finland (n=5)	Denmark[1] (n=3)	Iceland[1] (n=1)	Total (n=19)
Head	134	121	55	56	28	**394**
Chest	84	70	42	-	-	**196**
Abdomen	80	79	16	-	-	**175**
Whole body	15	29	20	-	-	**64**
Totally	**313**	**299**	**133**	**56**	**28**	**829**

[1] Denmark and Iceland received too few questionnaires for examinations of the pediatric trunk to be included in the survey.

Result: CT scanners and clinical indications

- All major CT vendors were represented
  - Totally 18 different scanner models
  - All but one were multi slice scanner (2, 4, 8, 10, 16 and 64)
- Common clinical indications
  - Trauma
  - Malignancy (including controls)
  - Infections
  - Different respiratory disorders

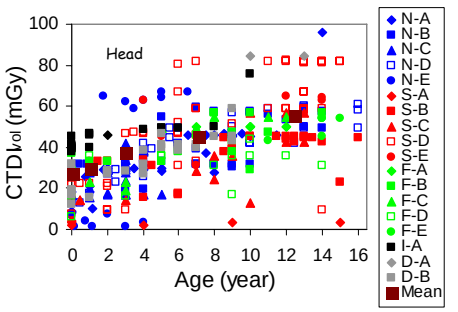
Results: $CTDI_{vol}$ and DLP

Table 2: Mean [min/max] values of $CTDI_{vol}$ [mGy] and DLP [mGycm] for examinations of the head, chest, abdomen and whole body from all the Nordic countries for different age groups.

Area	Head		Chest[1]		Abdomen[1]		Whole body[1]	
Age	CTDI	DLP	CTDI	DLP[2]	CTDI	DLP[2]	CTDI	DLP[2]
0-1	27 [2]	394 [3.2]	2.7 [1.3]	36 [1.1]	7.7 [2.3]	284 [5.5]	-	-
1-2	30 [2]	472 [3.1]	4.8 [2.7]	66 [2.3]	4.2 [1.5]	131 [1.2]	-	-
2-5	37 [3]	558 [2.9]	2.9 [1.9]	50 [1.6]	3.9 [1.5]	137 [1.8]	8.7 [7.8]	327 [3.1]
5-10	46 [1.2]	614 [1.4]	4.0 [2.3]	80 [1.7]	5.8 [2.2]	246 [2.3]	11 [7.4]	538 [1.1]
10-16	56 [2]	580 [5.8]	5.6 [1.1]	158 [1.5]	7.4 [1.2]	340 [1.1]	11 [3.4]	520 [1.2]

[1] Examinations of the trunk: Data only from Norway, Sweden and Finland
[2] Data from Finland not included

Results: Variation between hospitals



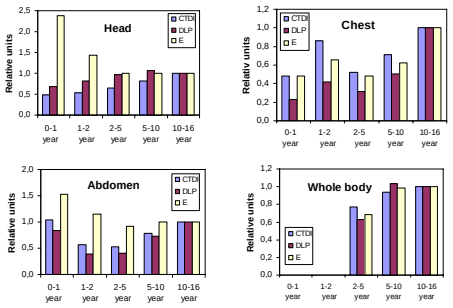
Results: Effective dose

Table 3: Mean [min/max] values of effective dose [mSv] for examinations of the head, chest, abdomen and whole body from all the Nordic countries, except Denmark. Effective dose are calculated from DLP_{16cm}.

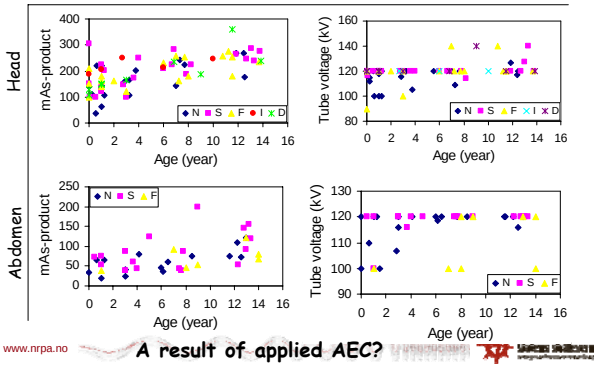
Scan area Age [year]	Head	Chest	Abdomen	Whole body
0-1	5.5 [2.8]	1.4 [1.6]	7.2 [1.9]	-
1-2	3.3 [2.2]	1.9 [1.6]	5.4 [1.4]	-
2-5	2.3 [1. 9]	1.4 [0.8]	4.3 [1.7]	4.1 [3.9]
5-10	2.3 [1.4]	1.8 [1.6]	4.7 [4.8]	5.9 [5.1]
10-15	2.3 [1.6]	2.9 [2.4]	4.7 [2.3]	6.0 [2.3]

Examinations of the trunk: Data only from Norway, Sweden and Finland

Results: Trends in doses versus age



Results: Level of optimization



A result of applied AEC?

Conclusion

- Large variation in local CT practice
- Low level of optimized size-specific scan protocols
- BIG POTENTIAL FOR OPTIMIZATION
- Nothing like a universal CT technique to be adapted
  - Physical differences between scanners from different vendors
- Important that the optimization process is a team work between radiologists, radiographers and medical physicists

http://rileychildrenshospital.com/images/CT_Scan_Child.jpg

Acknowledgment

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