

Patient Doses in Chest CT Examinations: Comparison of Various CT Scanners

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Abstract: This paper presents results from study on patient exposure level in chest CT examinations. CT scanners used in this study were various Siemens and General Electric (GE) models. Data on patient doses were collected for adult and pediatric patients. Doses measured for adult patients were lower than those determined as Diagnostic Reference Levels (DRL) for Europe, while doses for pediatric patients were similar to those found in published data. As for the manufactures, slightly higher doses were measured on GE devices, both for adult and pediatric patients.

Keywords: Computed tomography, Patient doses.

1 Introduction

The introduction of computed tomography (CT) into clinical practice presented revolution in diagnostic radiology. CT examinations enabled visualizations of internal structures of human body and diagnosis of many diseases that was not possible before. These examinations shortened the time and lowered the cost of diagnosing which led to increase in number of examinations in the world. On the other hand, patient doses in CT are relatively high with increasing trend in both frequency of CT examinations and dose per examination. These facts contributed significantly to the increase of collective dose from medical examinations worldwide. Many studies, in past ten years, clearly showed high level of patient exposure in CT examination [1 – 3]. In 2001, special attention was raised by the study of Brenner et al., which showed that the risk for development of fatal cancer in children underwent CT examinations is 1 in 1000 [4]. From then on, the attention of scientific and professional community was directed towards optimization of imaging protocols [5 – 7] especially in pediatric radiology [8 – 10].

Contribution of CT examinations to the total population dose increases ever since the introduction of this technique, in the seventies of the last century.

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Based on UNSCEAR report from 2000, contribution from CT examinations to dose from medical exposures was 34% [11]. Studies from 2008 show that CT dose contribution is now 43%. Frequency of the examinations varies from country to country, and depends on the degree of development of health care system of that country. In developed countries, it is 7.9% of all medical examinations, while in developing countries it ranges from 2% to 14%.

Many researches show that number of pediatric CT examinations rapidly increases [3, 13, 14]. Pediatric CT examinations encompass from 2 to 5% of all CT examinations. It is also evident that in many institutions same exposure parameters are used for both adults and children, resulting in higher children dose [17, 18]. About 33% of all pediatric CT examinations are done in the first decade of child's life, and 17% on children younger than the age of five [19]. This fact requires particular attention owing the higher radio-sensitivity of children, especially newborns, and longer life expectancy that leads to higher probability for developing fatal cancer.

This paper presents level of radiation doses during pediatric CT examination, of chest, performed in patients in Serbia using different models of CT scanners. The obtained dose levels were compared with available literature data.

2 Method

Data on patient doses were collected on six CT scanners. Two of them are installed in dedicated pediatric hospitals and used for only of examinations of children. Four different models of CT units were included in study. All of them are from two different manufacturers (Siemens, Erlangen, Germany and General Electric, Fairfield, Connecticut, US). **Table 1** presents models of the scanner and their basic properties. Hospitals are internally labelled with letters A, B, C, D, E and F. Data was collected for four different age groups (< 1, 1–5, 5–10 and 10–15) and at least 10 patients per each age group. Patient doses were calculated as an average value for each age group.

As generally accepted quantities in CT dosimetry [1, 3] data on doses was collected in the form of CTDI_{vol} and DLP [20]. In addition, exposure parameters and patient information (age, weight and height) were noted. Annual examination frequency was taken from hospital archives.

3 Results

Tables 2 and **3** present the results of the study. Dose values for pediatric patients are given for four different age groups. Data on examination frequency for each scanner is given in the **Table 1**.

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Table 1

CT scanner properties and frequency of examinations per year.

Device Label	Manufacturer / Model	Number of detect.	Year of installation	Number of chest exam. per year	Total number of exam. per year	Remark
A	Siemens / Somatom Sensation	64	2006	374	6140	/
B	Siemens / Somatom Emotion 16	16	2007	371	6910	/
C	Siemens / Somatom Emotion 16	16	2008	51	1350	Pediatric
D	GE / Light Speed VCT	64	2006	4500	11570	/
E	GE / Bright Speed	16	2009	10000	47800	Emergency Dept.
F	GE / BrightSpeed	16	2008	84	1150	Pediatric

Table 2

Dose values in chest CT examinations for adult patients.

CHEST		CTDI _{vol} [mGy]	DLP [mGy·cm]
		mean ± sd (min – max)	
Device Label	A	13 ± 6 (6 – 22)	350 ± 170 (63 – 894)
	B	11 ± 4 (5 – 16)	360 ± 140 (143 – 560)
	D	17 ± 9 (12 – 28)	670 ± 380 (404 – 1111)
	E	15 ± 6 (8 – 27)	517 ± 170 (267 – 820)

Table 3

Dose values in chest CT examinations for pediatric patients.

CHEST		CTDI [mGy]		DLP [mGy·cm]	
		mean ± sd (min – max)			
Device Label		C	F	C	F
Age group	0 – 1	3 ± 0 (3 – 3)	7 ± 3 (4 – 9)	90 ± 0 (90 – 90)	187 ± 70 (137 – 236)
	1 – 5	3 ± 0 (3 – 3)	8 ± 0 (8 – 8)	130 ± 50 (54 – 191)	305 ± 0 (305 – 305)
	5 – 10	4 ± 1 (3 – 5)	-	130 ± 50 (64 – 227)	-
	10 – 15	5 ± 2 (4 – 8)	5 ± 3 (1 – 7)	200 ± 100 (73 – 454)	470 ± 350 (30 – 995)

4 Discussion

Chest CT examination frequency ranges from 4% to 7%, except in two scanners with high workload, where it is 39% and 21%, respectively (devices D and E). Detailed national researches from Japan [21] show that in their country chest CT examination frequency is 14%, while in Germany it is 16% [22].

Results in **Table 2** revealed slightly higher values for $CTDI_{vol}$ on scanner from a particular vendor and even significantly higher DLP values. Average scan lengths, calculated dividing DLP and CTDI, were 27, 33, 39 and 34 cm respectively for models A, B, D and E. Considering $CTDI_{vol}$ value, DLP on model D increases due to both factors. Values for $CTDI_{vol}$ and DLP in this paper, for adult patients, are lower than the Europe DRL [23]. Based on the number of detectors in a row, the 64 slice models show slightly higher values than the 16 slice models by both manufacturers.

Values of dose quantities in pediatric patients increase with the increase of the age group (**Table 3**), which indicates the use of exposure parameters adequate with the age of children. DLP values were significantly higher on GE model, and are in accordance with $CTDI_{vol}$ values. Although there are many studies on the subject of pediatric doses in CT diagnostics and published values for DRL on national level [24 – 27], international DRL is not yet established. Data from this study are well in the range of the previously published data. It is important to highlight that this study included 2 out of 3 scanners that are used for pediatric procedures in Serbia, while the sample size in other researches was significantly larger. Both CT scanners included in this study offer in their protocols options to use adjusted parameters in pediatric procedures. Protocols are related to different parts of the body that are examined, although there are recent recommendations for use of weight-specific examination protocols [28]. Values for pediatric patients are significantly lower compared to those in adult patients, which were expected since both scanners are specialized for use in pediatric radiology.

5 Conclusion

Data from this study shows that patient doses in pediatric chest CT examinations, in Serbia are in the range of data published so far. However, as CT examinations can result in high patient doses, in particular in the case of repeated examination in the same patient, the use of this modality requires particular attention and precaution. Based on the region that is examined, number of examinations per patients and number of phases per examination, dose can be as high as 100 mSv [29 – 32], which are levels of doses related to induction of fatal cancer [4]. Also, range of values for $CTDI_{vol}$ and DLP in this study, for same age group and different models, indicated that there is an additional possibility for optimization of the examination protocols, which will

be a subject of further works of our group. The research should be oriented towards prevention of unnecessary radiation dose to pediatric patients, i.e. establishment of criteria for referring patients to CT examinations and further optimization of examination protocols.

6 References

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