

Pediatric Radiation Dose from 64 Slices-MDCT in Abdomen after Using the New Pediatric CT Scanning Protocol at Phramongkutklo Hospital

Suvicha Khampunnip, MD¹ ; Sutiporn Khampunnip, MD¹ ; Kaywalin Sutthipong, MD¹ ; Supakajee Saengruang-orn, PhD¹



Suvicha Khampunnip, MD

Abstract

OBJECTIVES: To study the radiation dose in pediatric patients after using a new pediatric computed tomography (CT) scanning protocol at Phramongkutklo Hospital as compared with the historical data and with reference level recommended by International Commission on Radiological Protection (ICRP).

MATERIALS AND METHODS: This study was a prospective and descriptive study. The study target population were all consecutive patients aged <15 year-old who had received a 64-slice computed tomography of the abdomen from January 2015- August 2016 using the new protocol. The control group was patients in the same age group performing CT scan of abdomen in the past before using the new protocol.

RESULTS: Total of 29 children were included in the analysis, 13 were male and 16 were female. The third quartile of the dose-length product (DLP) (75th percentile) was 125.0, 228.0, 305.6 and 381.0 mGy.cm for the patients < 1, 1 to < 5, 5 to < 10 and 10 to <15 year-old respectively. These DLP values were significantly lowered than previously reported in Thailand in almost patient age groups.

CONCLUSION: The radiation dose that our pediatric patients received from undergoing CT scan of abdomen was acceptable after using the new protocol. Data collection in future studies including a higher number of patients and longer follow-up time may be helpful.

Keywords: pediatric radiation dose, multidetector-computed tomography, MDCT, diagnostic reference level, DRL

¹ Department of Radiology, Phramongkutklo Hospital, Bangkok, Thailand.

* Address Correspondence to author:
Suvicha Khampunnip, MD
Department of Radiology,
Phramongkutklo Hospital,
315 Ratchawithi Rd.,
Bangkok 10400, Thailand
email: canjang@hotmail.com

The use of CT scanning in pediatric patients has been increasing since the introduction of multidetector-computed tomography (MDCT), resulting in high radiation dose to pediatric patients.^{1,2} As the cells in children have a more rapid growth than in adults and they have a longer living time left, the risk of cancer in long-term from radiation exposure should be more of a concern. Children who receive radiation in early life are at risk for cancer and this risk will last for a lifetime.³ Due to this concern, The International Commission on Radiological Protection (ICRP) defined the guidelines and recommendations about the diagnostic reference levels (DRLs) for pediatric patients in ICRP Publication 121. However, DRLs may vary upon the race or physical appearance of the population studied.⁴ Thus, the appropriate DRLs should be categorized by age and part of the body to scan (age-based DRL for pediatric CT) using the data from the national survey of United Kingdom in 2003 which was published in 2005 and the national survey of Switzerland in 2005 which was published in 2008.^{5,6}

There has been no published national survey of DRLs in Thailand, but there was a pilot study by Kritsaneepaiboon S, et al⁷ in 2001 which was published in 2012. It was a study by 3 medical schools that found the overall radiation dose in pediatric patients receiving CT scan of chest and abdomen was not as high as compared with those reported in United Kingdom and Switzerland. However, the dose was still varied among hospitals.⁷

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According to our institute information collection in 2013, there was data of radiation dose in pediatric patients aged <15 years who received CT scan of brain, chest and abdomen, and that the radiation dose was higher than the recommended DRLs of both the pilot study in Thailand and ICRP121.4 Then, we adjusted the protocol of CT scan using the recommended DRLs from ICRP121 since then in order to lower the radiation dose upon ALARA (as low as reasonably achievable) principle.⁸

Thus, this study was aimed to study the radiation dose in pediatric patients undergoing CT scan in our hospital after using this protocol in all CT scan abdomen studies.

Material and Methods

This study was a prospective and descriptive study. The research proposal has been approved by Institutional Review Board, Royal Thai Army Medical Department before performing the study. The study target population were all patients aged <15 year-old who had received a 64-slice computed tomography of abdomen from January 2015- August 2016 using the new protocol. The control group was patients in the same age group who had CT scan of abdomen in the past before using the protocol which was studied and recorded in the previous unpublished study. While the patients in the control group who underwent CT scan had a fixed radiation dose (old protocol), the patients in this study underwent CT scan with an adjusted radiation dose according to their age, height and parts of scanning (new protocol) as described in ICRP 121.⁴

Data collected was the dose-length product (DLP) for 32-cm phantom size which was shown on the monitor in dose information zone. After getting the DLP, it was multiplied by 2 to be an adjusted DLP in order to be able to compare with the other studies that usually reported DLP for 16-cm phantom size. All consecutive cases that had performed CT scan of abdomen during the study period were included. For all CT studies obtained in this study, the images were acquired using a 64 slice Toshiba Aquillion Prime scanner. The images were

acquired at 1 mm thick slices and reconstructed to both 3 mm thick slices in axial, sagittal, and coronal planes for viewing. CT scan of abdomen of pediatric patients was routinely performed in 1 phase. No sample size calculation was done.

Statistical analysis

Data was described using descriptive statistics as mean, minimum value, maximum value and the 75th percentile of DLP. All data was categorized according to age group as <1 year-old, 1 to <5 year-old, 5 to <10 year-old and 10 to <15 year-old patients. The DLP radiation dose at 75th percentile collected from CT scan of abdomen before and after using protocol were compared using independent T-test. *P* value of ≤ 0.05 was considered significant.

Result

During the study period, a total of 29 children were included in analysis, 13 were male and 16 were female. Among these patients, the third quartile of DLP (75th percentile) was 125.0, 228.0, 305.6 and 381.0 mGy.cm for the patients <1, 1 to <5, 5 to <10 and 10 to <15 year-old respectively, as shown in Table1.

As compared with the historical control group in our hospital before using the protocol, the mean DLP was significantly decreased in the group of <1 year-old, 1 to <5 year-old and 10 to <15 year-old patients. The mean DLP of the patients in this study (New PMK) and the control group (Old PMK) are shown in Chart1.

In an attempt to compare the DLP of our study with the previously reported in Thailand and Switzerland, the distribution of dose at the 75th percentile for each age group is shown in Table 2 and Chart 2.

An example of CT scan image of pediatric patients before and after using the new protocol is shown in the Figure3.

Table 1: Distribution of patient number, gender, mean values, range and 75th percentile of abdominal CT- DLP in each patient group

Variables	Age group			
	<1 year	1 - <5 years	5 - <10 years	10 - <15 years
No. of patients	3	9	8	9
Male: Female	1:2	5:4	3:5	4:5
Age, mean	3.1 month	3 years	7.3 years	12.8 years.
Age, range	1.5-5.0 month	1.2-4.5 years	5.2-9.8 years	10.5-14.6 years
Mean DLP (mGy.cm)	119.1	203.4	281.2	376.2
Min-Max DLP (mGy.cm)	106.0 – 125.6	145.0 – 228.0	200.4 – 333.4	285.8 – 433.8
Third quartile DLP (mGy.cm)	125.6	228	305.6	381.0

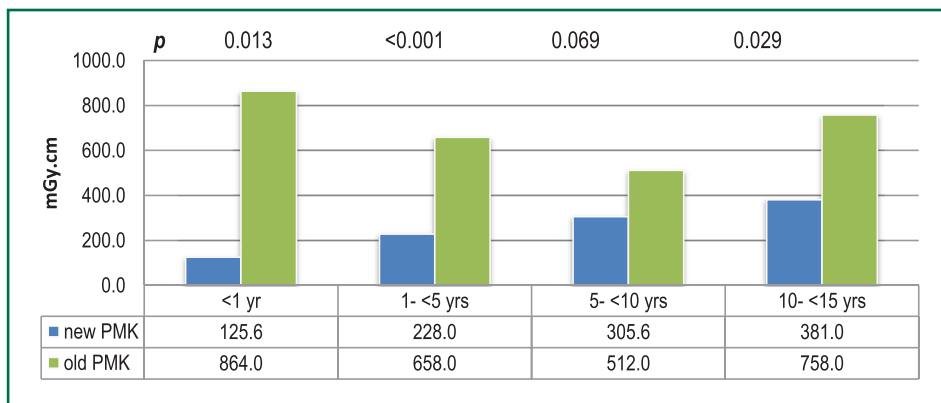


Figure 1: The DLP value at 75th percentile (third quartile) in mGy.cm for the patients in this study (New PMK) comparing to the historical control.

Table 2: The DLP value at the 75th percentile of our study as compared with the data previously reported.

Age group (years)	DLP value at the 75 th percentile (mGy.cm)		
	Present study	Thailand*	Switzerland**
< 1	125.6	220.0	130.0
1 - <5	228.0	275.0	300.0
5 - <10	305.6	560.0	380.0
10 - <15	381.0	765.0	500.0

* Preliminary for national dose survey in Thailand

**National survey dose in Switzerland, ICRP recommendation

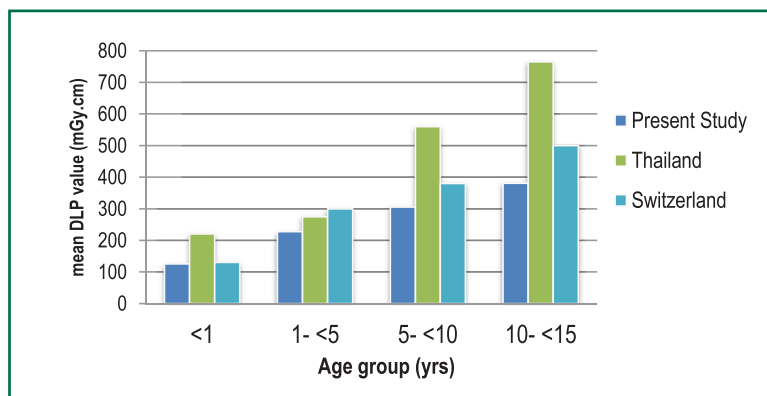


Figure 1: The DLP value at the 75th percentile

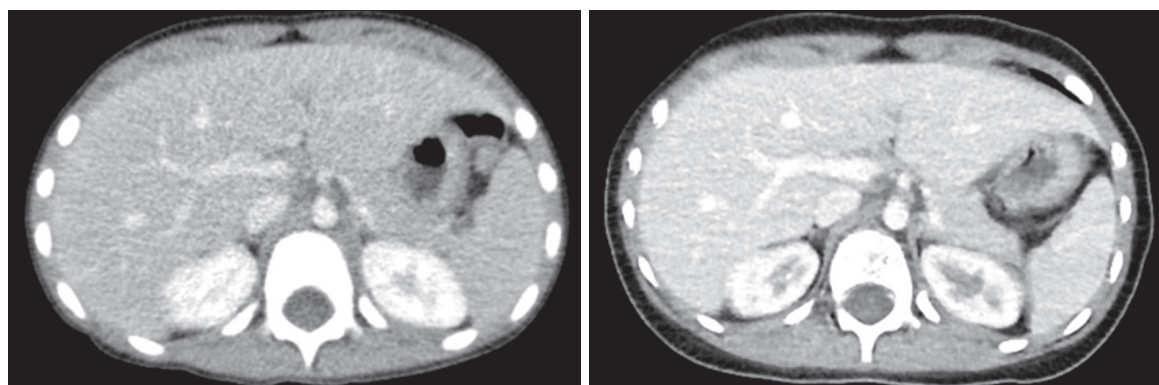


Figure 3: Images of the pediatric patients performed CT scan of abdomen before (3A) and after (3B) using the new protocol.

Discussion

In an attempt to reduce radiation dose to our pediatric patients, the new pediatric abdominal CT scanning protocol has been used in our hospital since 2016. In this new protocol, apart from the radiation dose reduction, indication of CT scan must be reviewed before making a schedule for CT. Moreover, CT scan was selected to be performed only in some phases, not routinely performed in all phases like a protocol for adult patients. Some parameters, for example, tube current (mA) and tube voltage (kVp) were also adjusted based on the patient's body weight and length of the scan. As shown above, the DLP values at the 75th percentile were significantly lowered in the patient < 1 year-old, 1 to <5 year-old and 10 to < 15 year-old patients ($p = 0.013$, < 0.001 and 0.029 respectively). For the patients in 5 to <10 year-old group, although it was not statistically significant ($p = 0.069$), there was a tendency to be lower as compared to the control group. This may be due to small number of patients included in each group.

However, there were some limitations in our study. First, a small number of patients was included and this may have resulted in a failure to detect the difference in some age groups. Second, the data about the quality of the image (both first and follow-up study) was not recorded. In an attempt to lower radiation dose delivered to the patients, the quality of the image is still important and needs to be evaluated too. Finally, the study period was short and the data about the clinical outcome was lacking. By including a higher number of patients and a longer follow-up time, it may be helpful for data collection in future studies.

Conclusion

The radiation dose that our pediatric patients received from undergoing CT scan of abdomen was acceptable after using the new protocol. However, more data collection in the future studies with more patients and longer period may lead to more helpful information. This may help answer whether lower doses of radiation are correlated with better clinical outcomes, such as lower incidence of malignancy from radiation.

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