DOSE REDUCTION TECHNIQUES IN PEDIATRIC CT

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Prudently and optimally used computed tomography (CT) may be the most valuable imaging tool. But CT is characterized by a significantly higher radiation exposure. Due to the increased biological impact of radiation exposure in patients, especially in young patients, pediatric CT examinations should follow a strict justification and optimization. Our review article has not covered all steps of the dose reduction techniques but the essential requirements and latest updates of CT dose optimization in pediatric patients are described. This article may be helpful for radiologists to keep in mind the "as low as reasonably achievable (ALARA)" principle and even more carefully use the principle when scanning children.

Keywords: radiation dose, pediatric CT, dose optimization techniques.

МЕТОДЫ СНИЖЕНИЯ ДОЗЫ В ПЕДИАТРИЧЕСКИХ КТ ИССЛЕДОВАНИЯХ

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Оптимально и разумно назначенное компьютерно-томографическое исследование может быть наиболее ценным методом диагностики. Но характерной особенностью КТ является высокая доза облучения. В связи с наличием биологического воздействия радиационного облучения на пациентов, особенно у лиц молодого возраста, исследования в педиатрии должны быть строго оправданы и оптимизированы. В нашей статье не охвачены все методы снижения дозы, но описаны основные требования и последние обновления по оптимизации дозы в КТ исследованиях.

Ключевые слова: доза облучения, КТ исследование детей, методы оптимизации дозы.

The use of computed tomography (CT) has increased about eightfold since 1980 and continues to increase in both the adult and pediatric populations [1], but in pediatric patients has grown dramatically[1,2]. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has stressed that there are approximately 93 million CT examinations performed annually all over the world at a rate of about 57 per 1,000 examinations. Approximately 7 million CT examinations were performed per year on children in the United States[3]. The radiation doses received by patients undergoing CT are generally in the order of 1–24 mSv per examination for adults and 2–6.5 mSv for children [3,26].

There are unique considerations in the patients under 15 years old because there is a difference in the risk for developing a radiation-related cancer in children compared with adults [4]. The rapidly dividing cells of children are normally two-three times more radiosensitive than adults to some types of radiation-related cancer including leukemia, thyroid, skin, breast and brain cancer [5,6]. Pediatric patients have a longer life ahead of them in which the oncogenic effect of radiation may become manifest. Pediatric patients also receive a high radiation dose than necessary when special CT protocols are not used [7]. We want to stress in our review article the importance of reducing the radiation dose from CT examinations in pediatric patients.

One has to start reducing the radiation dose and its associated risks in children by performing properly indicated CT examinations only. There were several publications suggesting that more than third of CT examinations of the patients under 15 years old were unnecessary or re-

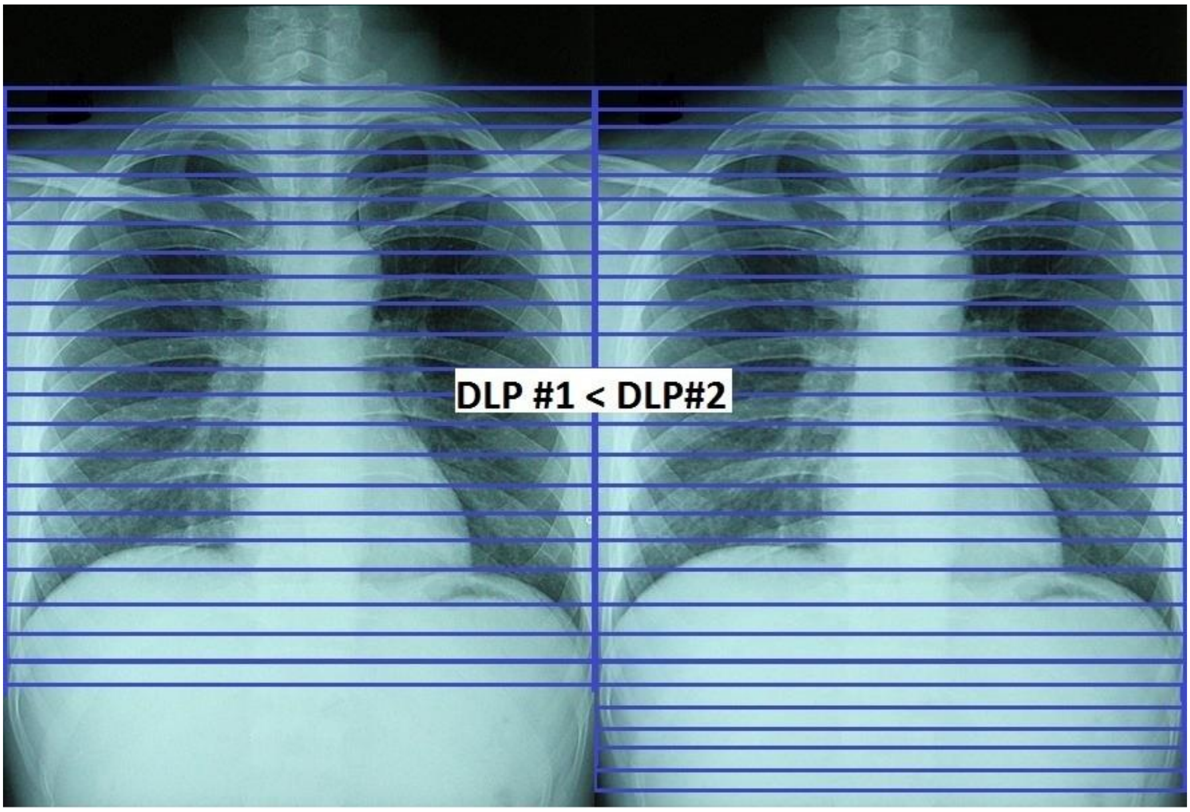

Fig. 1.

Fig. 1. Chest radiography, AP view.

Reducing the scan length will not significantly change CTDI, but reduces DLP proportionally to the scanned length. DLP #1 is less than DLP#2.

placeable by other imaging modalities with lower and no ionizing radiation [8]. The alternatives exist for children in most cases. They are good candidates for ultrasound imaging. Magnetic Resonance Imaging is also better alternative and has excellent accuracy in children [9]. The communication between radiologists and physicians is very important to avoid unjustified CT examinations [10,11]. To reduce the number of radiation related cancers patient's physician and radiologist should balance the risks and benefits for every patient.

Once the clinical indication of CT is deemed necessary for children, the appropriate CT technique must be used to optimize the image quality with the lowest possible radiation dose.

Scan length.

Scan length for all patients must be absolutely restricted to the zone of interest. This rule applies both for the scout view and the rotational scan. Reducing the scan length will not significantly change the CT dose index (CTDI), but reduces the Dose Length Product (DLP) proportionally to the scanned length (Figure 1). The referring physician and radiologist should find a compromise about the minimal body areas to be examined [12]. In routine scanning, it is not justified to extend the length beyond the minimum required.

Collimation.

Collimation is determined by the clinical question and size of the patient. A higher spatial resolution is needed in pediatric patients due to their small body size, which can be achieved by choosing a thin collimation. However, the important disadvantage of thinner collimation is a higher radiation dose [13]. Thicker collimation usually suffices for routine evaluation of the chest or abdomen for gross pathology processes. For evaluation of small vessels and focal lesions thinner collimation may be needed [14]. The choice of collimation should balance the necessary thin-section Multiplanar Reconstruction (MPR) images, 3D reformatting possibilities, noise level and low radiation dose level.

Pitch.

A high helical pitch and rapid gantry rotation time are desirable in pediatric CT examinations in order to reduce motion artifacts. Increase the pitch reduces the motion artifacts by increasing table speed and decreases the amount of radiation needed to cover the anatomical area of interest. Increasing the pitch from 1:1 to 1.5:1 decreased the radiation dose by 33 percent without loss of diagnostic information [15,16]. Most pediatric patients can be imaged at pitch of 1.3-1.5 in

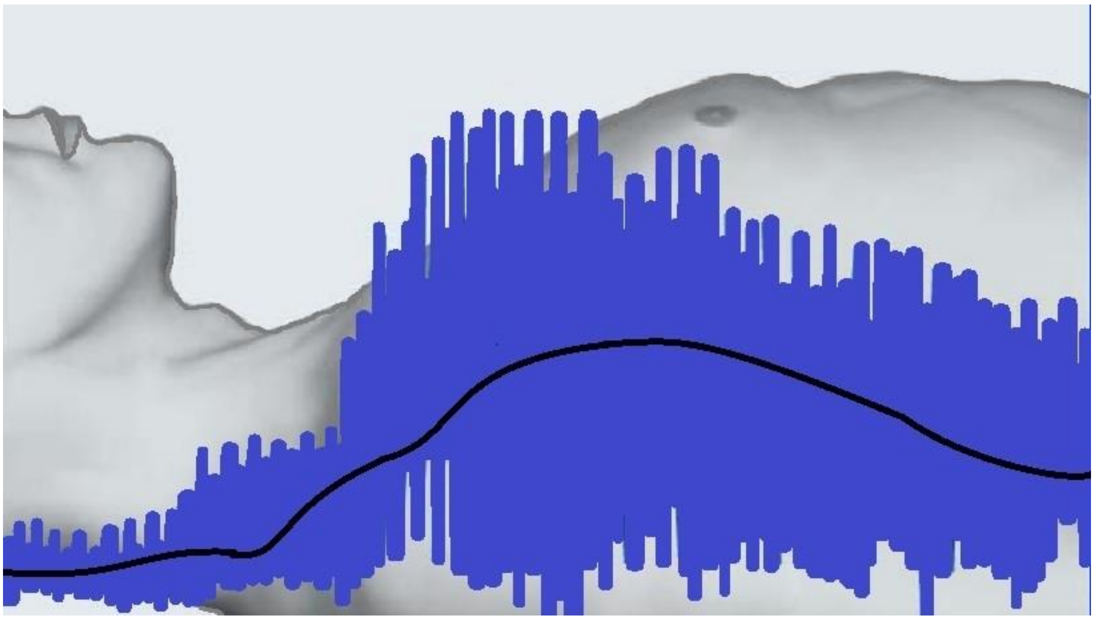

Fig. 2.

Fig. 2. Tube current is automatically modulated according to the patient size. Note the relatively higher tube currents through the shoulders and the lower tube currents through the midthorax and lower abdomen.

association with a fast rotation time except for some cardiac applications in which low pitch is needed. High non overlapping pitch up to 1.6:1 to 3.4:1 with a table speed up to 450mm/sec was used for the chest CT in pediatric patients [17,18]. Whenever possible the highest pitch should be used. However, because of the limitations of tube current inherent in CT scanners, the maximum achievable dose level may be limited, especially with the use of lower tube potential settings.

Tube current.

Tube current is the most commonly used scanning parameter for dose reduction in CT studies. Modulation of tube current significantly contributes to CT dose optimization by reducing dose according to body size, shape, and attenuation. By lowering the tube current a direct proportional decrease in the radiation dose is achieved. 50 percent reduction in tube current results in a 50 percent decrease in radiation dose [19,20]. Normally the tube current is automatically modulated according to the patient size (Figure 2). The disadvantage of a decrease in tube current is an increase in noise which reduces the radiologist's ability to make proper conclusion.

Most pediatric chest CT examinations are performed at tube current of 20 to 50mAs at 120kVp. For detecting renal stones tube current of 80mA are used for all children. For patients weighing less than 49kg one can reduce the tube current to 30mA [12,21,22].

Tube voltage.

Tube potential has a great influence on the radiation dose. In pediatric CT examinations lower kV settings must be used, depending on patient size and clinical indication. It helps reduce the radiation dose from CT examinations. The lower tube potential lowered diagnostic confidence by resulting higher image noise. But due to the smaller size of children it is usually possible to use the lower tube voltage [23]. Most children can be scanned at 80 kVp, especially in children with a body weight <45 kg. In 10 to 15 year-old children it is proper to use 100–110 kVp for CT of the chest, abdomen and pelvis. In the patients younger than 10 years 80–90 kVp is appropriate [24].

One must keep in mind that the higher tube potential is necessary for bigger children, which demands a weight-based technique chart. Use of a lower tube potential must be carefully evaluated for each type of examination to achieve an optimal tradeoff among contrast, noise, artifacts, and scanning speed [25].

In conclusion, we know that prudently and optimally used CT may be the most valuable imaging tool. But CT is characterized by a significantly higher radiation exposure. Due to the increased biological impact of radiation exposure in patients, especially in young patients, pediatric CT examinations should follow a strict justification and optimization. Our review article has not covered all steps of the dose reduction techniques but the essential requirements and latest updates of CT dose optimization in pediatric patients are described. This article may be helpful for radiologists to keep in mind the "as low as reasonably achievable (ALARA)" principle and even more carefully use the principle when scanning children.

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