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ORIGINAL ARTICLE

Computed Tomography Dose Estimation using Dose Length Product Conversion Coefficients in Paediatric Patients from University of Malaya Medical Centre

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Abstract

The increasing use of computed tomography (CT) procedures provides a greater risk for paediatrics in developing radiation-induced cancer than adults. Therefore, a feasible method is required to quantify the received radiation dose. This study aims to estimate the effective dose (ED-estimated) received from CT Brain among paediatric patient of four age groups using published age-and-region specific dose length products (DLP) as ED conversion coefficients. A retrospective study was conducted over 2 months at the University of Malaya Medical Centre. Paediatric patients of four age groups: 0, 1, 5, and 10 years old who went through CT Brain scan was selected for this study. The DLP data that was obtained from the CT console was multiplied with age and region-specific conversion coefficient to estimate the ED. Over the 2 months of the study, there were numerous data of paediatric patients who went through CT Brain scan in the past 3 years from the date of 16 February 2020 that were kept by the hospital in their system. The estimated ED for the four age groups decreases as the age of paediatric patients increases. An inverse relationship will be observed between the age and effective dose of paediatric patients who went through CT Brain.

Keywords: CT brain dose, pediatric radiography, absorbed dose

Introduction

The use of CT has been proven to improve patient health care dramatically and provide great medical benefits such as improving cancer diagnosis and treatment,reducing the length of stay in hospital and guiding treatment of common conditions such as injury, cardiac disease and stroke. However, the fear of the possibility that the long-term risk might outweigh the diagnostic values of CT scan is arising among the public (Smith-Bindman et al., 2010). Particular attention is focused on paediatrics as they are more vulnerable to stochastic effects of radiation. In the context of radiation, the main stochastic effect is cancer.

Paediatric patients are at higher risk to develop radiation-induced cancer from CT examination when compared to adults (Kutanzi et al., 2016). It is said that radiosensitivity declines with age. This is what makes paediatrics to have increased radiosensitivity and to be

more susceptible to radiation risks than adults (Brady et al., 2012). Paediatric patients of different age groups were used to study the effective dose variation. At the same time, many programs are being carried out to increase the awareness of the potential increase in the risks of cancer in future with the increase in exposure. Programs such as proper counselling and educational speech can help parents to be more understanding about the potential risks of cancer.

ED is the parameter of choice in this study to assess and quantify the risk of cancer detriment from a CT procedure according to each organ's sensitivity (Dietze et al., 2005). CT dose information such as CT dose indices (CTDIvol, mGy) and dose length product (DLP, mGy.cm) for each scan can be obtained directly from the CT scanners. The Dose Length Product (DLP) associated with each CT Brain will be multiplied with the age and region-specific conversion coefficients to obtain the estimation of the effective dose of the paediatric population.

In this study, only paediatric CT Brain cases are chosen to be studied because CT Brain is one of the highly requested CT examinations in paediatrics. Therefore, this study aims to quantify the received radiation dose among paediatric patients of University of Malaya Medical Centre by estimating the effective dose (ED) received from CT Brain. This study will be conducted specifically at the University of Malaya Medical Centre.

Materials and Methods

A retrospective study of patient records at the University of Malaya Medical Centre (UMMC), Malaysia, for CT brain examination was retrieved directly from the Picture Archiving and Communication System. An ethical approval was obtained from this hospital Medical Research Ethics Committee to access these data. In clinical practice at the UMMC, the age of the patient is one of the recorded parameters for brain examinations. Thus, a total of 120 patient records were retrieved and grouped according to their age (Group: newborn to 3 months (0 year group), 4 months to 2 years 11 months (1 year group), 3 years to 7 years 11 months (5 years group) and 8 years to 14 years 11 months (10 years group). Only pediatric patients between 0 -15 years old and underwent CT Brain from 16-02-2017 to 16-02-2020 were included in the study.

All examinations were acquired by Siemens Somatom AS+ 128-slice CT scanner (Siemens, Erlangen, Germany). Typically, following the Ct scan examination, Dose Length Product (DLP) are displayed for each patient, based on the scan parameters used. This value was collected for selected patient for this study. To estimate the effective dose for CT Brain among paediatric patients, the retrieved DLP was multiplied with the age and region-specific conversion coefficients. The formula to estimate ED of paediatric patients is as following: ED = DLP x k where k is the age and region-specific conversion coefficients. The k-coefficients are derived from the ICRP Publication 103 tissue weighting factors for Head, Chest and Abdomen/Pelvis CT examination respectively (Haji-Momenian et al. 2018).

Results and Discussion

The number of patients involved is 120 people. Most of the pediatric patients received radiation dose of about 2.0 mSv to 4.0 mSv from the CT brain examination. The calculated ED that the paediatric patients had received for all age group was illustrated in the Fig. 1. ED from the CT Brain was the highest for the patient in age group 1 (8.56 mSv) while the lowest was from the patient in age group 10 (0.92 mSv).

ED for group 10 was significantly different with other groups except group 5 (p value: group 0 < 0.001, group 1 = 0.02, group 5 = 0.93). ED for group 0 significantly different with ED from all groups (p value: group 1 < 0.001; group 5 < 0.001 (Figure. 2). From the Pearson correlation test, there was no significant correlation between age and ED (r = -0.77 and p value =0.22).

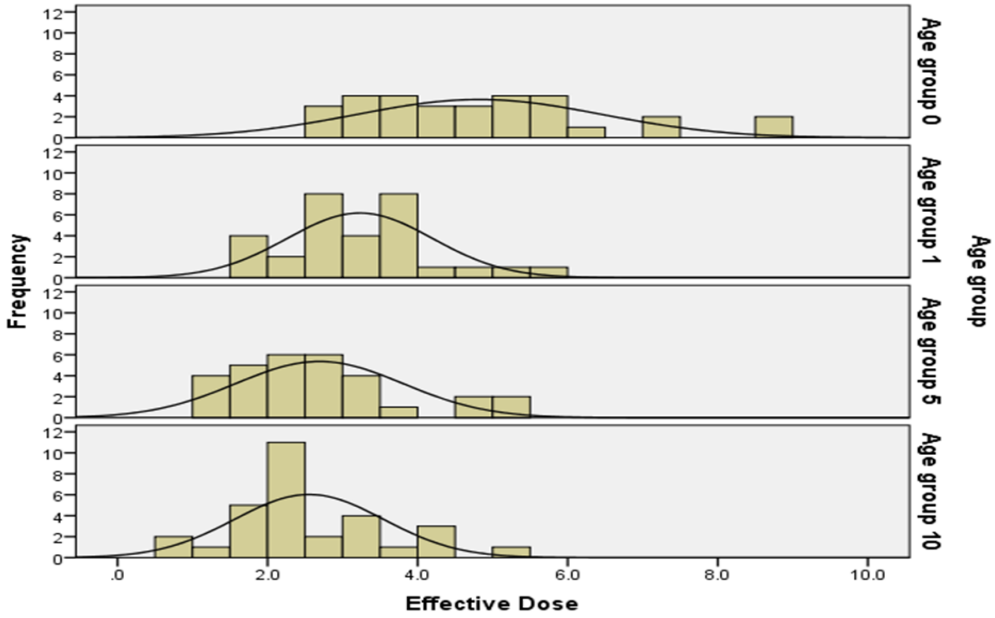
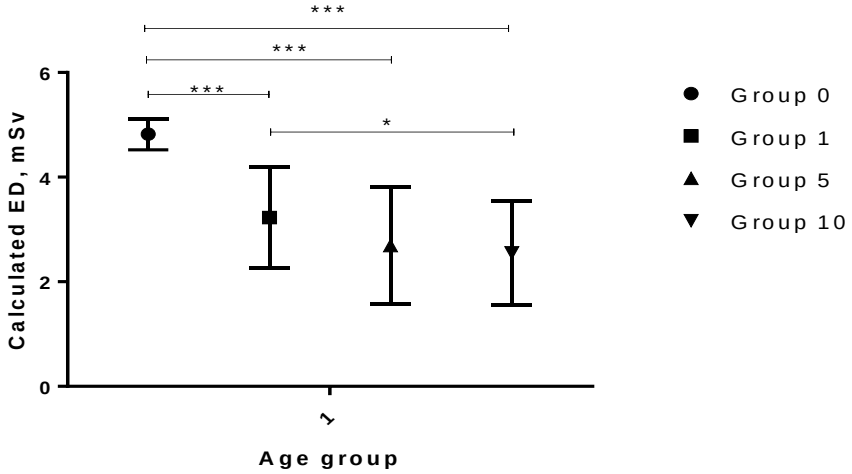


Figure 1. The effective dose of the paediatric patients of each age group separately and the frequency represents the number of patients.



* = significant.

Figure 2. Comparison between age group using One way ANOVA and Tukey test.

This study was conducted to investigate the effective dose received from the CT Brain scan by paediatric patients of 4 age groups. Based on the result, it was evident that there is a spread in DLP for CT Brain scan in paediatric patients of all 4 age groups. The observed spread in DLP was due to the application of different scanning techniques, scanner design and scan repetitions, which also produced a large spread of ED in paediatric radiation dose. Prior research conducted by Alzimami (2014) also reported variations in the effective dose received by paediatric patients of age 0 to 10 years ranging from 0.3 mSv to 8.2 mSv. Another similar study also reported variances in the effective dose associated with CT Brain scan which ranges from 2.0 mSv to 6.0 mSv among paediatric patients of two age groups 0–1 year and 1–5 years) (Bernier et al. 2012).

The calculated ED of paediatric patients was compared between the four age groups. Significant different between ED from group 0 and other group may indicates influence of the body size in absorbing radiation dose. When a smaller size object is radiated, there will be less attenuation and the mean section dose will rise (Huda 2002). The energy imparted to the

center of a younger and smaller paediatric body will be higher than the energy imparted to the center of an older and larger paediatric body for the same exposure. Therefore, when the organs of paediatric patients are much smaller, for a given amount of energy transmitted to the patients, the resulting doses will be considerably higher.

Conclusion

The method of using dose length product conversion coefficients has been proven to be an accessible and user-friendly method for Computed Tomography (CT) dose estimation. This research was able to provide an estimation of the effective dose (ED) of paediatric patients among four age groups who went through CT Brain scan in the University Malaya Medical Centre using the dose length product data and the age and region-specific conversion coefficients. The calculate ED was significantly different among the different age groups however there was no statistical correlation between age and calculated ED.

Acknowledgement

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