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Evaluation of Cumulative Effective Radiation Dose in Patients Under 12 Years of Age

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Abstract

Background: The most important complication of X-ray overdose is the increased risk of malignancies, especially cancers in children. The present study was, then, conducted to evaluate the effective dose of cumulative radiation among the under-12 patients referred to the CT-scan unit of Imam Khomeini Hospital in Ahvaz, Iran, during 2018.

Methods: This descriptive study was performed on 120 patients who were selected through census sampling method. A data collection form and the patient's medical records were implemented for collecting the required information. Data were analyzed by SPSS 22 software with a significance level of 0.05.

Results: The average absorbed dose per unit volume was 19.90±2.07 for the head, 3.45 ±1.22 for the neck, 2.07±1.58 for the chest, and for the abdomen and pelvis it was equal to 1.76±1.69. The mean absorption dose per unit volume was significantly different between the two organs while comparing the chest with neck (P=0.003), abdomen and pelvis with neck (P=0.0001) and abdomen and pelvis with chest (P=0.0001) (P<0.05). The mean absorption dose along the length was 278.20 ±71.75 for the head, 86.88 ±39.64 for the neck, 56.10±47.66 for the chest, and for the abdomen and pelvis it was 24.64 ±15.56. The mean absorption dose along the length was significantly different while comparing the abdomen and pelvis with neck (P=0.0001) and abdomen and pelvis with chest (P=0.0001) (P<0.05). The thickness was 4.8 mm in the head, 3 mm in the neck, 8 mm in the chest, and 5 mm in the abdomen and pelvis.

Conclusion: By calculating the dose indices in children, and comparing them with the internationally approved normal doses, we can minimize the harmful effects of radiation on children. The staff and radiologists should be trained about the protocols and principles of radiation protection, as well as the quality control of devices.

Key Words: CT scan section, Cumulative effective dose, Pediatric.

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1- INTRODUCTION

The widespread use of CT scans can possibly be considered as the most important advancement in diagnostic radiology. CT scans are like a descriptive section of the body in which all parts can be examined well. The CT scan uses X-rays to take pictures of the inside of the body. These images are more accurate than regular radiographs. However, compared to plain radiography, CT scan requires a much higher radiation dose, which leads to a significant increase in radiation. The main advantage of CT scan over conventional radiology is the elimination of interference of different structures and the presentation of high quality images, especially in soft tissues with low contrast (1).

Although CT scans are not the most common radiology tests, they have a large share of the cumulative dose in the community. In addition, the dose of CT scans is higher than other X-ray imaging methods. Chest imaging, for example, requires an approximate dose of 8 millisievert, which is about 400 times higher than the dose of a typical radiograph of the same area (2). Despite this fact, CT scan still has the largest share in medical imaging. It is recommended that the scan parameters be selected so that the patient's dose is minimal and the image quality is maximal, and that other imaging techniques be used as an alternative (3).

Currently, the effective dose is the best dose characterizer for determining the amount of random hazards in diagnostic radiology. The effective dose takes into account the relative sensitivity to radiation in all organs studied (4). The effective dose usually provides an accurate estimate of the damage resulting from radiographic examinations for adult patients, and the cumulative effective dose can be calculated by knowing the number of radiographs performed in a year in the community (5). With the increasing use of X-rays in medical diagnosis, it is necessary to know the dose received by patients and compare it with the world standard level (6).

The use of these rays necessitates more attention to the biological effects of the rays. These effects include a variety of cancers and genetic mutations. Genetic mutations may occur in the first generation or in subsequent generations (5). Many countries and legal institutions have introduced a diagnostic reference dose level for all ionizing radiation tests, which helps to ensure that patients' radiation levels at diagnostic centers are not ignored (7).

The findings show that the general requirements for superior quality imaging should not be limited to equipment inspection but also to the proper functioning of radiology staff. It has also been observed that the numerical value of DRL is tied to the clinical equipment of radiology departments (8).

Frequent breast augmentation of a woman with a dose of 10 mg before the age of 35 increases her risk of breast cancer by more than 13.6% compared to the usual rate of the disease in the community and a dose of 50 mg can increase it by 60% (9). According to Nishazaki, the effective dose for CT scan of the head is 0.99 mSv (10), and according to Caracappa, the effective dose for CT scan is 0.75 mSv (11); The International Commission on Radiological Protection (ICRP) reported the effective dose of head CT scan to be 1 mSv (12).

Thus, due to the existing controversies and the information gap about the total and effective dose received in the common CT scan of the CT scan department of Imam Khomeini Hospital in Ahvaz, this study was performed.

It is also important to note that unnecessary radiation equals irreversible risks, and this approach is pursued more seriously, especially in relation to radiation to children. Children are significantly more sensitive to ionizing radiation than adults; children have a longer life expectancy than adults, and as a result there is a longer opportunity to assess radiation damage in children. So radiation tests, especially CT scans, are justified to be performed in children (4).

This study, thus, aimed at determining the effective cumulative dose of radiation in patients under 12 years of age referred to the CT scan unit of Imam Khomeini Hospital in Ahvaz.

In addition, due to the economic and psychological costs that ectopic radiology requests impose on the community and hospitals, it is preferable to limit the costs by limiting such requests. However, with the right CT scan, the benefits a person can get clinically are incomparable to the risk of cancer. Therefore, in the first stage, treating physicians can refrain from unnecessary requests. In fact, putting ALARA (As Low as Reasonably Achievable) on the agenda means getting less exposure to X-rays.

2- MATERIALS AND METHODS

2-1. Design and sampling

This was a descriptive study performed, in 2018, on all records of patients under 12 years of age referred to the CT scan center of Imam Khomeini Hospital affiliated to Ahvaz Jundishapur University of Medical Sciences. After approval by the ethics committee of Ahvaz Jundishapur University of Medical Sciences, the researcher referred to the study site (CT scan center of Imam Khomeini Hospital in Ahvaz) and the samples were selected based on Census sampling method.

Using the Morgan table, the largest possible sample size for a limited population was obtained; moreover, taking into account the results of previous years, according to which approximately 1000 people needed a CT scan each year, and considering the following formula with a = 0.05 and d = 0.1s, a sample of 278 people were selected, among whom 120 people were included in the study.

$$n = \frac{\left(z_{1-\frac{\alpha}{2}}\right)^2 S^2}{d^2}$$

2-2. Inclusion and exclusion criteria

The inclusion criterion was the existence of a complete medical record in the hospital archive and the exclusion criterion was the existence of a defect in the patient's medical record so that the checklist information could not be completed.

2-3. Procedure

The data collection period was one year (2018). Quality control tests including the accuracy and reproducibility of the parameters of each CTscan applied to the device in clinical conditions, including center spacing of two consecutive sections, section thickness, milliamperes, maximum kV, number of sections, screw factor, scan area length and total scan time were performed. Then, by applying the obtained values to the device, the mean values of CTDivol and DLP were obtained.

CTDlvol was calculated based on the following formula: pitch*CTDlw=CTDivol/1 and Dlp based on the formula of DLP = CTnCTDI.T.A.t

In order to collect data, a checklist was used which included the patient's personal information (age, gender, height, weight) and the main variables of the study.

2-4. Data analysis

Data were collected in SPSS software version 22 and analyzed at a significance level of 0.05. In quantitative variables, mean and standard deviation were used to describe the data, and in qualitative variables, distribution and frequency were used. The normality of the data was checked using Kolmogorov-Smirnov test and t-test was used to analyze the quantitative data.

3- RESULTS

Table 1 examined the mean absorption dose per unit volume and the mean absorption dose along the length under CT scan for patients under 12 years of age.

Table-1: Average absorption dose per unit volume and average absorption dose along length

Absorption dose		Average	Standard deviation	Minimum	Maximum
Per unit volume	Head	19.90	2.07	8.65	30.35
	Neck	3.45	1.22	0.86	6.48
	Chest	2.07	1.58	0.28	5.76
	Abdominal and pelvis	1.76	1.69	0.27	8.96
Along the length	Head	278.20	71.75	29	440
	Neck	88.86	39.64	14	227
	Chest	56.10	47.66	2	196
	Abdominal and pelvis	56.15	64.24	3	474

Based on the results presented in Table 1, the average absorption dose per unit volume is 19.90± 2.07 for the head, 3.45±1.22 for the neck, and 2.07±1.58 for the chest; and for the abdomen and pelvis, it was equal to 1.76±1.69. The mean absorption dose per unit volume was significantly different while comparing the two limbs of the chest with neck (P = 0.003), abdomen and pelvis with neck (P = 0.0001) and abdomen and pelvis with chest (P = 0.0001) (P <0.05).

The average absorbed dose along the length was 278.20±71.75 for the head, 86.88±39.64 for the neck, 56.10±47.47 for the chest, and 56/15±64/24 for the abdomen and pelvis. The mean absorption dose along the length was significantly different between the abdomen and pelvis with neck (P = 0.0001) and abdomen and pelvis with chest (P = 0.0001) (P <0.05).

Table 2 shows the average effective dose of radiation in CT scan for patients under 12 years of age.

Table-2: Mean effective radiation dose in CT scan

Absorption dose along the length	kvp	mAs	Pitch	Rotation Time (S)	Thickness (mm)
Head	110	120	1.3	0.6	4.8
Neck	110	80	1.3	0.6	3
Chest	110	70	1.5	0.6	8
Abdominal and pelvis	110	80	1.5	0.6	5

According to the results demonstrated in **Table 2**, the thickness was 4.8 mm in the head, 3 mm in the neck, 8 mm in the chest, and 5 mm in the abdomen and pelvis.

4- DISCUSSION

Sadra et al. (2014) in a study at Shahid Beheshti University of Medical Sciences, in Iran, stated that the absorbed dose of organs and the effective dose in some centers are higher than the international standard (13)

Yah et al. (2013) reported that the population-weighted effective dose increased by 30% mSv per capita in 2000 and by 0.74 mSv in 2013 and its annual growth rate was 7.2%, concluding that the growth trend indicates that the effective dose will increase in Taiwan (14).

Khalilpour et al. (2009) stated that the results of measuring organ dose and effective dose in two centers of affiliated hospitals with one type of device (Toshiba Xvision / EX) can confirm that the method of using the device and the amount of kvp, MAS are more important factors than the type of device; because both of the maximum dose and the minimum dose are reported based on one type of device but in two different centers (15).

Aldrich et al. (2006) in a study in Colombia stated that the average dose of patients was different in different hospitals. The highest range was related to abdominal CTs with an average of 101.1 mSv; the head had a mean of 9.3 mSv, the pelvic city an average of 9 mSv and the abdominal and pelvic CT an average of 16.3 mSv (16) which had a higher dose than what reported in the present study.

Ogbole (2010) investigating the risks and benefits of radiation dose in pediatric computed tomography stated that the frequency of pediatric CT examinations is increasing rapidly and estimates suggest that the risks of radiation, even at minimal levels, are considerable for children during their life. The effective absorption dose in children based on this study was 8 mSv for chest, 2 for head, 10 mSv for abdomen and 10 mSv for pelvis (17). In the present study, the mean absorption dose per unit volume for head was 19.90±2.07, for the neck was 3.45±1.22, for the chest was 2.07±1.58 and for the abdomen and pelvis, it was equal to 1.76±1.69. It should be noted that in the present study, the radiation dose for the head was higher and for the chest and abdomen, it was lower than those reported by Ogbole.

Kharbanda (2015), conducted a Radiation dose analysis on 478 pediatric patients. The mean age of the participants was 8.1 years; and 56.9% of them were boys. The mean effective dose for CT of the head was 2.68 mSv, which decreased with age. For abdominal CT, the mean effective dose was 5.06 to 6.03 mSv, which increased with age (3.67 to 11.12 mSv, p <0.001). For abdominal CT, 8% of children aged 5 to 10 years, 28% of those aged 10 to 15 years and 60% of patients over 15 years received effective doses above 10 milliseconds (18). These findings are not consistent with the results of the present study in regard to the effective doses of Head (19.90) and abdomen (1.76), since in the present study, the mean absorption dose of the head was much higher and the absorption dose of the abdomen was much lower.

In another study, Mazonakis (2004) stated that for radiography, depending on the age of the child, the effective dose ranges for head were 25.4-8.8, 27.2-8.2 and 22.7-8.4 microSv (19) Due to the lack of age determination in the present study, it was not possible to compare the radiation dose.

5- CONCLUSION

In general, by calculating the dose indices in children, and comparing them with the internationally approved normal doses, we can minimize the harmful effects of radiation on children. The staff and radiologists should be trained about the protocols and principles of radiation protection, as well as the quality control of devices.

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