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RSSA CONFERENCE:RADIATION EXPOSURE FROM REPEATED CT SCANS IN CHILDREN: A QUANTITATIVE ANALYSIS

Sarah K. Albahiti[1,2]

[1]Department of Radiology, King Abdulaziz University Hospital, King Abdulaziz University, Jeddah, Saudi Arabia
[2]Department of Radiology, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT

Background: This study investigated the frequency of pediatric patients undergoing multiple CT examinations during the last five years that lead to high cumulative effective dose (CED) and determined their age distribution. Methods: This retrospectively reviewed data on pediatric CT exams performed from 2018 to 2023 using radiology archives of King Abdulaziz University Hospital Jeddah, Saudi Arabia. Results: A total of 2758 scans (representing 875 pediatric patients) performed in the past 5 years were included in this study. The mean and range of the DLP (mGy.cm) per procedure were 378(310-3986) for age group 0 to 5, 516 (129-4572) for age groups 6 to 10, and 572 (160-6474) for ages 11 to 15. The maximum number of repeats was 26 CT exams conducted from May 2020 to December 2022. Conclusions: Repeats were carried out frequently and pediatric doses varied up to 30 times for the same CT procedure. There is a crucial need for exposure reduction among pediatric patients and the use of dose-tracking software, with alert levels to reduce unnecessary repeats.

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Corresponding Author
Sarah K. Albahiti, Department of Radiology, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia. Mobile +96656-9186330, Email: shagi@kau.edu.sa

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1. INTRODUCTION

Over the past three decades in the United States, the average radiation exposure for Americans has doubled, with Computed Tomography (CT) scans being the primary cause of this rise [1]. Recent studies showed that a total of 33,407 (1.33%) patients received a cumulative effective dose (CED) of $\geq$ 100 mSv with an overall median CED of 130.3 mSv and a maximum of 1185 mSv [2]. In addition, approximately 1 million CT scans are conducted each year on children aged 5 and under [3].

The risk of developing cancer due to exposure to pediatric CT radiation is higher compared to adults [4]. Growing and developing tissues and organs are more susceptible to

radiation damage than to fully mature ones. Moreover, radiation's oncogenic impact may have a prolonged latent phase, and children's greater life expectancy highlights the potential oncogenic consequences of radiation in comparison to older adults. Nevertheless, the advantages of an indicated CT scan outweigh the potential risks associated with the exposure [4]. It is crucial to adopt appropriate measures to reduce the harmful health impacts of children's exposure to ionizing radiation and assess future exposure carefully.

According to Saudi Arabia's Ministry of Health (MoH), as recently as 2016, more than 9 million patients (out of a population of around 30 million at the time) were investigated using X-rays [5]. In Saudi Arabia, the focus of the regulators and the national governing bodies for several decades has been radiotherapy and nuclear medicine services where occupational doses and area monitoring regulations have been implemented. There is still room for improvement especially when it comes to monitoring patient radiation exposures in diagnostic imaging. Since 2017 the regulatory bodies including the Saudi Food & Drug Authority (SFDA), The Central Board for Accrediting Healthcare Institutions (CBAHI), and most recently the Nuclear and Radiological Regulatory Commission (NRRC) have taken interest in governing the diagnostic imaging practice to improve patient safety and ensure the highest standards of radiation protection is intact.

With reports that around 65% of the CT procedure performed "diagnosed as normal" [5], there is an urgent need to implement referral criteria, use automated dose management systems, and take better optimisation measures to ensure patient safety is not compromised.

There is no data about the frequency of repeated CT examinations in Saudi Arabian Hospitals and if justification practice is enforced as a standard safety measure. This study investigated the frequency of pediatric patients undergoing multiple CT exams during the last five years that led to high CED. The secondary aim of this study is to promote a radiation safety culture by indicating the need for improvement.

2. METHODS

This study retrospectively reviewed data on pediatric CT examinations performed from 2018 to 2023 using radiology archives of King Abdulaziz University Hospital Jeddah, Saudi Arabia. Dose management was performed automatically by a monitoring software solution, DoseWatch; General Electric Healthcare, Waukesha, WI, USA. The data extracted included CT Dose Index (CTDI) and Dose Length Product (DLP) of each CT study performed. The inclusion criteria consisted of all pediatric patients (ages ranging from 0 to $\leq$15 years) performed during the chosen period. The cumulative CT radiation exposure was estimated by summing typical CT effective doses per procedure.

3. RESULTS

A total of 2758 scans (representing 875 pediatric patients) performed in the past 5 years were included in this study. Out of those, 1432 repeated exams were for the age group 0 to 5 years old, 581 from the age group 6 to 10 years, and 744 repeated exams for the age group 11 to 15 years, Figure 1.

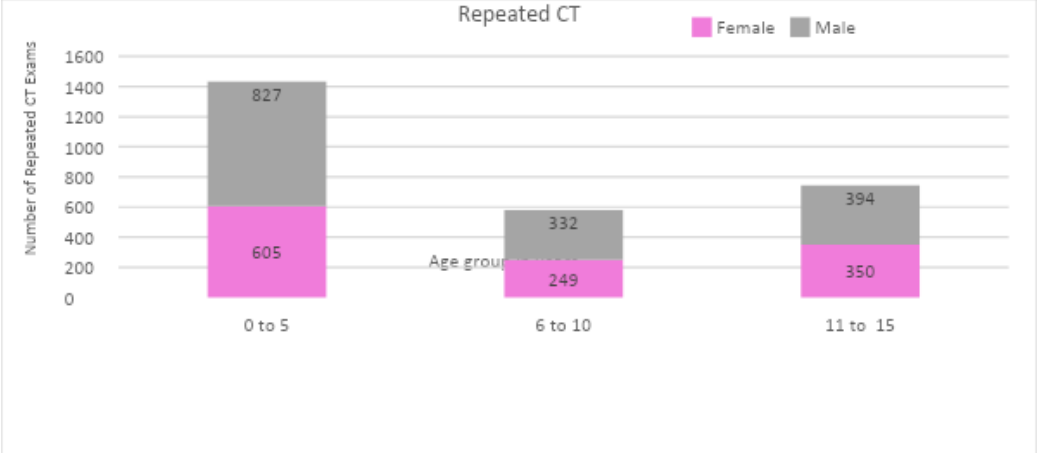

Figure 1 Repeated CT examination by gender among each age group.

The frequency of repeated CT examinations for the 875 pediatric patients in the past 5 years ranged from 2 to 26 for all age groups, Figure 2.

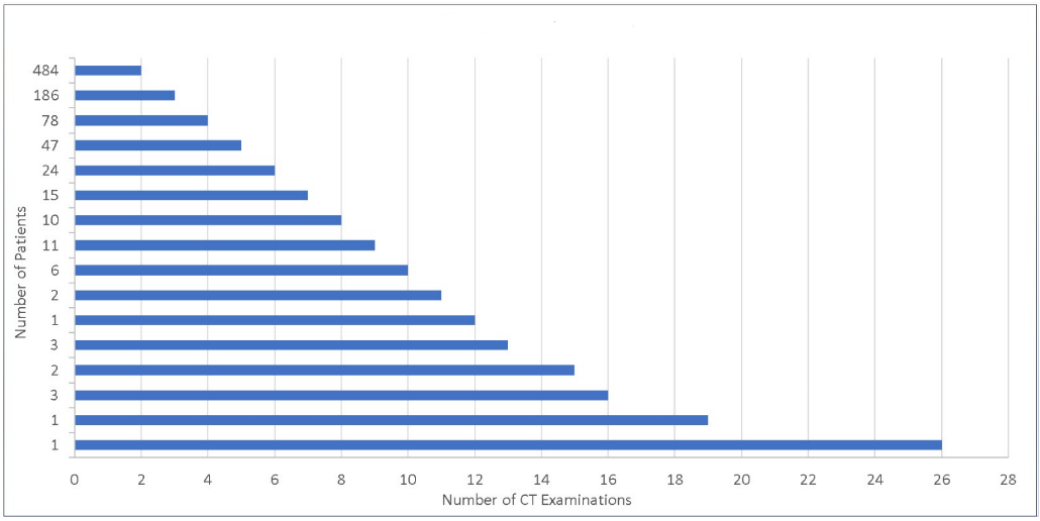

Figure 2 Frequency of repeated CT examinations for the study population.

The mean and range of the DLP (mGy.cm) per procedure were 378(310-3986) for age group 0 to 5, 516 (129-4572) for age groups 6 to 10, and 572 (160- 6474) for age 11 to 15.

Also, the cumulative effective dose ranged from 65 mSv to 260 mSv.

The maximum number of repeats was 26 CT examinations conducted from May 2020 to December 2022, table 1. The accumulated DLP for this patient was 13,160, and the effective dose was around 152 mSv.

Table 1 Highest number of repeated CT for one patient showing protocol and exposure DLP for each scan.

Study date	Study Description	Device	Study Protocol Name	Age class	Gender	Total DLP (mGy.cm)
2020-05-05	BRAIN C-	Scanner 1	Head^HeadRout (Child)	[0-5]	MALE	465.27
2020-06-05	BRAIN C-	Scanner 1	Head^HeadRout (Child)			554.82
2020-07-05	BRAIN C-	Scanner 1	Head^01HeadRc (Child)			681.53
2020-07-14	BRAIN C-	Scanner 1	Head^HeadRout (Child)			438.89
2020-07-15	BRAIN C-	Scanner 1	Head^HeadRout (Child)			447.94
2020-07-19	BRAIN C-	Scanner 2	Head^HeadRout (Child)			649.41
2020-07-20	BRAIN C-/+	Scanner 2	Head^Brain_SA (Child)			402.70
2020-08-29	BRAIN C-/+	Scanner 2	Head^HeadRout (Child)			662.35
2020-08-30	BRAIN C-	Scanner 2	Head^AAPM_H (Child)			387.42
2020-09-01	BRAIN C-	Scanner 2	Head^HeadRout (Child)			1312.42
2020-09-02	ABDOM PELV C -/+	Scanner 2	Abdomen^Flash (Child)			119.25
2020-09-04	BRAIN C-	Scanner 1	Head^HeadRout (Child)			439.68
2020-09-07	BRAIN C-	Scanner 1	Head^HeadRout (Child)			465.95
2020-09-15	BRAIN C-	Scanner 1	Head^HeadRout (Child)			687.89
2020-09-25	BRAIN C-	Scanner 1	Head^01HeadRc (Child)			652.51
2020-10-03	BRAIN C-	Scanner 1	Head^HeadRout (Child)			472.45
2021-04-15	BRAIN C-	Scanner 1	Head^HeadRout (Child)			470.23

Continued on next page

Table 1 continued

2021-04-18	BRAIN C-	Scanner 1	Head^HeadRout (Child)	619.01
2021-04-21	BRAIN C-	Scanner 1	Head^Head_Rou (Child)	473.42
2021-05-26	BRAIN C-	Scanner 1	Head^HeadRout (Child)	496.31
2021-08-18	BRAIN C-	Scanner 1	Head^Head_Rou (Child)	439.19
2021-08-21	BRAIN C-	Scanner 1	Head^HeadRout (Child)	472.61
2022-02-20	CT- HEAD EMERGENCY	Scanner 1	Head^Head_Rou (Child)	497.15
2022-07-05	CT - BRAIN C-	Scanner 1	Head^Head_Rou (Child)	299.16
2022-11-12	CT - BRAIN C-	Scanner 1	Head^Head_Rou (Child)	271.95
2022-12-18	CT - BRAIN C-	Scanner 1	Head^Head_Rou (Child)	280.65

4. DISCUSSION

The amount of radiation associated with pediatric CT scans varies based on factors such as the protocols and equipment settings utilized for the examination, but mostly on the frequency of CT scans ordered for each child during their medical care. When evaluating the number of pediatric patients that underwent a repeated CT scan, 31% of the study population required a repeat in the 5 year period chosen. The frequency of repeated exams ranged from 2 to 26 times per patient. A study by Farach et al [6] in 2015 reported the number of scans repeated by the body area to be 20% for head, 10 % for pelvic, and 4% for chest CT exams, but they did not report how many repeats were performed for each patient.

The number of patients with repeated or multiple CT studies conducted in the Emergency Department was investigated in a study by Griffey et al [7] to quantify their cumulative doses and the life-long attributable risk of cancer. They reported that 130 patients have had 1,744 CT examinations in total, with a mean of 13.4 and a maximum of 70 scans.

Variances in practice may be justifiable, primarily due to variations in clinical indications. This discrepancy would increase if operators and practitioners lacked proper education in rapidly emerging technology. It is important to determine the lowest exposure threshold required to provide satisfactory image quality for each specific application, ideally based on clinical effectiveness.

5. CONCLUSION

When it comes to pediatric patients, the referring physicians need to consult the radiologist before performing a CT scan to form optimal imaging strategies and ensure that the CT scan is indeed necessary. This communication helps in optimizing the child's care [4, 8]. Radiologists have the responsibility to perform only appropriate examinations and to adjust scanning techniques based on the special considerations of pediatric patients. They also provide information on the CT protocols, techniques used, potential risks, and any additional techniques used in the practice. This consultation helps in making decisions that minimize radiation risk and ensure that any repeated examinations are truly necessary and justified [3].

This study shows that repeated CT examinations were carried out frequently and pediatric doses varied up to 30 times for the same CT procedure. There is a crucial need for exposure reduction among pediatric patients and the use of dose-tracking software with alert levels to reduce unnecessary repeats. It also concludes that imaging protocols need optimization, and the implementation of appropriateness criteria and the use of clinical decision support systems is vital.

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DISCLOSURE OF CONFLICT OF INTEREST

There is no conflict of interest to be disclosed.

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