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Evaluation of Computed Tomography chest and abdomen Radiation Doses and Imaging Protocols for Pediatric Patients

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ABSTRACT

Background: The pediatric CT procedure, a frequent occurrence in the radiology department, is a crucial tool for diagnosing a range of clinical conditions. **Objectives:** This study, aimed at measuring patient dose and evaluating imaging protocols during brain and abdomen CT scans with 128 CT, is of utmost importance for your professional practice. **Materials and Methods:** A total of 30 patients were investigated, with 40% having undergone CT abdomen and 60% CT brain. The radiation dose parameters were presented in terms of CTDIvol and DLP. **Results:** The mean and range of the patient's age (years) ranged from 4.1(0.1-10.0). The mean dose per procedure was 230 and 670 mGy.cm for the abdomen and chest, respectively. The effective dose per abdomen and chest procedure were 3.9 and 11.2 mSv, respectively. **Conclusions:**This study revealed variations in doses, with the radiation dose in Brain CT being higher compared to the abdomen. The main contributor to this high dose was the adult protocol, underscoring the importance of using child-specific protocols in your professional practice.

1. INTRODUCTION

Since the introduction of the first computed tomography (CT) scanner was developed by Godfrey Hounsfield in 1971, who shared the Nobel Prize in Physiology or Medicine with Allan Cormack for their contributions to the development of CT in 1979 (Schulz et al., 2021). The CT technology evolved rapidly, leading to the development of multislice CT (MSCT), enabling new imaging techniques such as angiography and photon-counting detectors that enhance image quality while reducing radiation dose and resulting in improved spatial and temporal resolution due to advancements in computing technology (Jambi et al., 2024). Because children have a higher sensitivity to radiation due to their growing tissues and longer life expectancy. This makes them more susceptible to the long-term effects of radiation exposure, including the risk of developing cancer. Epidemiologic studies of Japanese atomic bomb survivors and children and newborns treated for benign disorders, including Tinea Capitis and hemangiomas, have revealed a different risk pattern for radiation-related cancers (Sulieman et al., 2015). This danger is highest for early radiation exposure and lasts decades. Adults who were irradiated for benign conditions as children had higher dose-related risks for thyroid, breast, brain, non-melanoma skin, and leukemia (ICRP 2017; Sulieman et al., 2011; ICRP, 2007). Radiological imaging is vital in pediatrics, but it presents several unique obstacles compared to adult imaging. It requires specific imaging methods to capture pictures and sedation or general anesthesia for prolonged treatments. Healthcare staff need particular training, and picture evaluation requires knowledge and competence, most significantly. If ionizing radiation is employed, radiation exposure must be considered. Finally, clinical care workers must win the child's confidence and cooperation before and throughout an examination, which can be challenging for sick or painful youngsters (ICRP 2007). To avoid repeat exams and get good photos, this is crucial. Even with a good exam, successful picture interpretation needs an understanding of complex anatomy and pediatric pathology. Thus, imaging pediatric patients in a specialized pediatric imaging department with pediatric CT technicians may improve protocol compliance and lower patient dosage (Sulieman &Almuwannis, 2023; Elshami et al., 2022; Alzimami., 2014; Sulieman et al., 2018). Follow the As Low As Reasonably Achievable (ALARA) approach to avoid ionizing radiation damage. This article highlights pediatric imaging issues and solutions. This project aims to create a sizeable global cohort of CT-scanned pediatric patients. (ii) describe CT use patterns over time and between countries, (iii) develop individual estimates of organ-specific doses from pediatric CT scans using improved dose estimation methods for pediatric patients, and (iv) evaluate the cohort's radiation-related cancer risk and pilot test biological markers of CT-irradiation effects.

2. MATERIALS AND METHODS

2.1 Data collection

The data used in this study were collected from King Khalid Hospital and Prince Sultan Center in Al-Kharj. Data on the technical parameters in the CT procedure was taken over six months. A 128-slice CT machine was used in this study. Experts from King Khalid Hospital And Prince Sultan Center In Al-Kharj carried out all quality control for the machines. All data were within acceptable ranges. Data were collected to investigate the effect of exposure-related parameters (gantry tilt, kilo voltage (kV), tube current (mA), exposure time, slice thickness, table increment, number of slices, and start and end positions of scans) on patient dose. The collection of the patient exposure parameters was done using patient dose survey forms prepared for the collection of patient exposure-related parameters

2.2 Imaging protocol

The data were collected for patients during the departments' routine CT imaging protocols, with no modifications made for dose optimization at this stage of the research. The imaging protocols were meticulously followed, based on a series of precise steps that ensured the accuracy and consistency of the data collection process.

i. The patient was placed in the supine position, head first into the gantry, with the head in the head-holder whenever possible.
ii. Center the table height so that the external auditory meatus (EAM) is at the center of the gantry.
iii. The scan angle was parallel to a line created by the supraorbital ridge and the inner table of the posterior margin of the foramen.
iv. This may be accomplished by tilting the patient's chin toward the chest or the

gantry to reduce or avoid ocular lens exposure.

No protection shields were used to protect the sensitive organs such as thyroid or breast during the entire procedure.

2.3 Measuring CT radiation dose

In this study, the scanner software measured CTDIvol (mGy) and DLP (mGy.cm); using these parameters and conversion factors for the Brain, sinuses, and facial bone, the effective dose (mSv) was calculated.

2.4 Data analysis

Organ dose was estimated for all 30 examinations using CTDOSE software. The summary also consisted of scanning parameters used for each typical CT examination and nCTDI air. The data analysis was conducted with the utmost care and precision, ensuring that the conclusions drawn from the study are reliable and robust.

3. RESULTS:

The assessment of radiation dose in pediatric radiology necessitates an understanding of current dose values and reference levels applicable to all examinations. The data are beneficial for daily quality assessment; however, they are not fully established for certain radiographic examinations. This study aimed to assess routine CT scans of the abdomen and brain. Pediatric patients face an inherent risk from the radiation dose linked to CT examinations. These procedures are often essential and indispensable in the medical management of a patient. The probability of high doses necessitates consideration of potential deterministic and stochastic effects in certain instances of vascular interventional procedures. Pediatric patients exhibit greater susceptibility to the effects of ionizing radiation compared to adults, thereby underscoring the necessity of quantifying and minimizing patient doses. Patients experience partial exposure to radiation during radiographic procedures. Additionally, various dose descriptors were commonly employed in patient dose measurements. Consequently, patient dose should be reported as the effective dose, as this facilitates the comparison of dose burden across various imaging techniques and procedures. The effective dose is determined by the relative radiosensitivity of the exposed organs, which are assigned weighting values by the International Commission on Radiological Protection (Shripmton et al., 1998). The absorbed dose for each organ, as identified by the International Commission on Radiological Protection, is multiplied by the tissue-weighting factor. The resulting products are then aggregated across all organs to determine the effective dose. Direct measurement of organ doses during clinical procedures is virtually impossible; therefore, effective dose must be determined through indirect methods. Indirect estimates of effective dose can typically be obtained using computerized models, applying conversion factors to direct skin dose measurements, or through direct dose measurements with dosimeters placed in phantoms exposed in radiologic settings that simulate clinical procedures.

The results are presented in tables, indicating the mean ± standard deviation (sd) along with the range of readings in parentheses. The dose values in diagnostic radiology are minimal; thus, the doses are expressed in milli-Gray.cm and mGy for DLP and CTDIvol, respectively. The mean and standard deviation were computed using Excel and SPSS software. Patient-specific exposure parameters were documented for dose calculation, including tube voltage (kV), tube current, exposure time product (mAs), and pitch. The age of patients was reported by department. The doses administered to patients were measured in a radiology department for conventional pediatric radiography. The following CT routine examinations were analyzed: abdomen and brain. CT dose data were collected from three departments utilizing a 128-slice CT machine.

Table 1 pediatric patient age (years) per procedure (mean±sd(min –max)

Indications	No	Age (years)
CT brain	20	3.5±3.4 (0.1-10.0)
CT abdomen	10	4.6±3.6 (0.2-10.0)
Total	30	4.1±3.5 (0.1-10.0)

Table 2 : CT Patient dose values for pediatric CT abdomen and chest procedures

Parameter	Abdomen	Chest
Tube voltage (kVp)	116.6±7.7 (100-120)	120*
Tube current-time product (mAs)	74.5±20 (45-100)	242±50 (9#0-480)
Slice thickness(mm)	2*	1.8±1.4 (1-5)
Pitch	1.0*	0.4*
CTDIvol(mGy)	5.6±1.3 (3.4-7.0)	34±14 (14-70)
DLP (mGy.cm)	233.6±108 (70-412)	670±300 (370-1300)
Effective dose (mSv)	3.9±1.8 (1.2-7.0)	11.3±5.0 (6.0-22.0)
*Constant value		

4. DISCUSSION

Diagnostic radiology is crucial to current patient evaluation and therapy. Depending on the infant's issues, several radiographs are needed. Radiographic evaluation of children, especially newborns, is of particular importance since longer life expectancies increase the risk of delayed radiogenic malignancies. In youngsters, radiation-induced leukemia is five times more often than in adults (ICRP, 2017, Suleiman et al., 2018, Alzimami et al., 2021). Because newborns are tiny, all organs are inside or near the usable beam, exposing them to more effective dose conversion factor per radiograph than adults. Thus, radiographic exams in pediatric departments must minimize radiation doses while retaining picture quality. In order to maximize patient safety, x-ray exams will help determine where to focus radiation dose reduction efforts. The UN scientific body UNSCEAR estimates that CT contributes over 70%, despite just 5–12% of these countries having CT exams. Since the last UNSCEAR report six years ago, the total dosage has increased by 2.5 times (UNSCEAR, 2022). CT's fast diagnosis and chronic illness monitoring have helped many people. This radiation exposure is raising concerns. Radiation is known to cause deterministic and stochastic damage. Deterministic effects such hair loss, skin burns, and cell death are dose-dependent but not below 150-200 mSv. Deterministic effects are rarely a problem because CT's usual estimated dosage is 2-10 mSv. Radiation causes cancer probabilistically. Higher radiation doses increase the risk of carcinogenesis, but even low levels can cause it, making it harder to determine a safe exposure level (Nievelstein et al., 2010)CT was traditionally considered a "high dose" method, however picture quality typically surpasses the threshold needed for reliable diagnosis and patient doses are greater than necessary (Shrimpton et al., 1998). Three CT departments with 128 Multislice CT machines evaluated 30 patients. Patients were separated into control and optimization groups. Patients were also categorized by examination type: brain or abdomen. Patients during brain scan averaged 3.5 years for abdominal group and 4.6 years for abdomen group. The minimum age was 0.05 and the maximum was 10. Different patient ages showed significant difference. Patient weight may rise with age, which may increase dosage measurement error and effective dose estimation (Table 2). Tables 2 showed all scan parameters. Generally, tube voltages, scan number, tube current, and repeated scans cause dosage changes. All hospitals used similar exposure, pitch, number of slices, and slice thickness. The pitch of CT brain was lower than CT abdomen. This study found CT brain dosages more effective than abdominal. The brain and abdomen are entirely different. Since the structural diversity is not as great as the other organs, the operator exposure procedure may be to blame. Suliman & Elshiekh, (2008) described CT brain dosage variation and provided numerous strategies to overcome it. Radiation exposure can be reduced by understanding variance and hazards. Consistent imaging methods and CT settings based on clinical indication and child size may limit medical imaging variance and radiation exposure. No link was detected between patient age and dosage, hence dose depends on exposure parameter and pathology The comparison of CT dosage and other imaging modalities to background radiation in Table 3 is crucial. The data shows that CT exposes patients 200 times more than other methods ((Alzimami et al, 2021; Obara, et al., 2017; Sulieman et al., 2011; Shripmton et al., 1998; ; Rushton & Majd, 1992)

Table 3 radiation dose compared to CT procedures ((Alzimami et al, 2021; Obara, et al., 2017; Sulieman et al., 2011; Shripmton et al., 1998; ; Rushton & Majd, 1992)

Source of exposure	Effective dose (mSv)
Average dose from natural background radiation per year	1.5
Extremities X-ray	0.005–0.05
Chest X-ray (2 views)	0.03–0.08
Head CT scan	1.5–2.5
Chest CT scan	1–3
Abdomen CT scan	4–10
Dental cone beam CT scan	0.1–0.2
Ultrasound	0
Magnetic resonance imaging (MRI)	0

Modern multidetector CT scanners provide dose reduction features to lessen radiation exposure. Lowering mAs reduces patient radiation (other parameters constant). Automatic tube current modulation reduces patient exposure in multidetector CT scanners by adjusting tube current based on anatomic thickness. Quality control monitoring may reduce equipment-related variances. Careful control of operator-dependent variables including scanning process, exposure parameters, and placement can help reduce dosage (Almujally et al., 2022’ Manssor et al., 2015).
When recommending for a CT scan, adults and adolescents must consider radiation exposure due to the increased cancer risk. This study found one additional cancer case per 1800 CT scans 10 years after exposure. (ARPANSA, 2025) believes a lifetime risk of one cancer per 1000 pediatric scans may be used to compare medical risks based on this study, other evidence, and worldwide practice. Risk depends on kid age, size, radiation dosage, and body region scanned. Clinically justified CT scans usually exceed the risk of damage (Sulieman et al., 2024).

. 5. CONCLUSIONS

The radiation dosage to pediatric CT brain and abdomen patients was examined. This research found dosage variation. The radiation dosage in brain CT is greater than abdomen. Adult protocol was the major cause of this excessive dosage, highlighting the need of child protocol. A CT scan's radiation danger is negligible compared to its advantages in precise diagnosis and treatment. Avoid unneeded radiation during medical procedures.

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