ORIGINAL ARTICLE

Justification for Head Computed Tomography in Pediatric Patients in a Tertiary Hospital in Jeddah, Saudi Arabia

Mawya A. Khafaji[1], MSc, PhD, Ranim Y. Nasr[2], MBBS, Mashail E. Sabir[3], MBBS, Razan H. Alamoudi[4], MBBS, Abdalrashid F. Halawani[5], MBBS, Khalid G. Alsafi[1], MSc, PhD, Sarah K. Albahitia[1], MSc, PhD

[1]Associate Professor, Department of Radiology, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia

[2]Senior Resident, Department of Radiology, Faculty of Medicine, King Abdul-Aziz University, Jeddah, 21589, Saudi Arabia

[3]Senior Registrar, Department of Radiology, King Fahad General Hospital, Jeddah, Saudi Arabia

[4]Fellow, Department of Radiology, King Fahad Medical City, Riyadh, Saudi Arabia

[5]Junior Resident, Department of Orthopedic, King Faisal Hospital, Mecca, Saudi Arabia

Correspondence
Dr. Mawya A. Khafaji
Department of Radiology, Faculty of Medicine,
King Abdulaziz University
P.O. Box 8056, Jeddah 21589
Kingdom of Saudi Arabia
e.M: Mkhafaji@kau.edu.sa

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Abstract

Imaging justification considers the risk–benefit ratio to avoid unnecessary radiation exposure. The use of high-radiation-dose imaging modalities, including computed tomography, has increased. In Saudi Arabia, no clear guidelines exist for protecting pediatric patients from unnecessary exposure to ionizing radiation. We aimed to investigate the frequency of unjustified head computed tomography scans among pediatric patients at our hospital. In this study, we enrolled pediatric patients (0–14 years old) who underwent head computed tomography scans between September 2015 and September 2017, and evaluated the frequency of unjustified scans. Among the 1,109 scans, 40.6% (n = 450) had no findings; of these, 68.4% (n = 308) were justified and 31.6% (n = 142) were not. The majority of "no finding" cases were from the emergency department; (285 [63.3%]) and were from patients >5 years old (203 [45.1%]). Thirty percent of "no findings" cases from the emergency department were not justified and 19% were incompatible with the modality. Approximately 40% of cases from the outpatient departments were neither justified nor compatible with this modality. Our findings highlight the need for regular auditing to justify scan requests and a clinical decision system for medical imaging using ionizing radiation.

Keywords

A computed tomography; Diagnostic imaging; Head trauma; Pediatric; Radiation risk

Introduction

With respect to patient care, imaging justification in radiology involves considering the risk–benefit ratio, which is the responsibility of the radiologist. It aims to prevent unnecessary radiation exposure by ensuring that there is a valid clinical question to be answered, and the benefits must outweigh the radiation risks. Over the years, there has been a dramatic increase in the use of high-dose radiation imaging modalities, including computed tomography (CT). The use of CT in the emergency department (ED) has increased dramatically in the last decade, disproportionate to the increase in the number of ED patients[1–3], with no corresponding change in diagnostic yield.

The availability of CT might have created a supply induced demand with a concomitant increase in its use and variability in clinical practice, without a corresponding increase in the quality of care[4]. Most children with minor head trauma (MHT) present to the ED with minimal or no symptoms[5]. Several studies have reported variations in the ordering patterns of CT scans by emergency physicians and a substantial increase in CT use among pediatric patients[4]. Furthermore, anxious parents commonly pressure physicians to conduct further imaging investigations, including head CT scans[6]**.** As it allows the early identification of life-threatening intracranial injuries, there has been a rapid increase in the frequency of pediatric CT examinations[7]. It has been reported that 88–92% of patients with head trauma have mild traumatic head injury; however, the rate of positive CT scans in intracranial injuries is low[8]. Moreover, approximately 37% of referred pediatric head CT scans were of no use, and reasons for such requests require further investigation[9]. Despite its diagnostic accuracy, CT has several disadvantages. Compared to other radiographic and fluoroscopic studies, CT is considered the dominant contributor to the cumulative effective dose from radiographic examinations[10]. The radiation-attributable cancer mortality risk from exposure to cranial CT during childhood is as high as 1 in 1,400. Additionally, cranial CT performed within the first 22 years of life may increase the risk of leukemia or brain tumors[11]. Consequently, the National Cancer Institute and Food and Drug Administration have recommended a decrease in exposure in children, which involves strict justification criteria to avoid unnecessary CT scans[12]. This was complemented by the adjustment of technical parameters, allowing CT manufacturers to minimize pediatric radiation exposure while preserving image quality[13]. In Saudi Arabia, there are no clear guidelines protecting pediatric patients from the unnecessary use of ionizing radiation and potential radiation-related cancer risk[14]. The lack of clear protocols and diagnostic reference levels poses a significant concern for the wellbeing of children undergoing medical imaging. This study emphasizes the urgent need to establish comprehensive guidelines for minimizing radiation exposure in pediatric patients and ensure optimal patient care. Therefore, there is a crucial need to assess outcomes and reduce potential harm.

In this study, we aimed to assess the correlation between head CT findings and their justification in pediatric patients by referring physicians.

Methods

Study Design and Detting

This noninterventional retrospective cohort study was conducted between September 1, 2015, and September 30, 2017, at the King Abdulaziz University Hospital (KAUH), Jeddah, Kingdom of Saudi Arabia. Our objective was to evaluate the justification and optimization of the requested and performed CT head scans at our institutions. As specific guidelines for head CT scans in pediatric patients are lacking, we employed the National Institute for Health and Care Excellence (NICE) criteria as the framework for our assessment [15].

The NICE guidelines, specifically the "Head injury: assessment and early management" (CG176) guideline, served as the foundation for our evaluation. We applied these guidelines to emergency patients, inpatients, and outpatients to ensure the consistency of our approach.

The NICE criteria incorporate validated clinical decision rules, including those of the Pediatric Emergency Care Applied Research Network (PECARN) criteria. These rules consider important factors such as patient age, clinical presentation, and mechanism of injury to evaluate the risk of significant intracranial injuries. By utilizing the NICE criteria, we aimed to adhere to standardized and evidence-based practices for the use of CT scans for pediatric head injuries.

Inclusion Criteria

We enrolled pediatric patients who had undergone head CT with or without contrast medium at KAUH between September 2015 and September 2017.

The study was conducted between September 2015 and September 2017 and included all pediatric patients aged 0–14 years who underwent a head CT scan.

Exclusion Criteria

Patients aged >14 years and those who underwent CT scans of regions other than the head were excluded from the study.

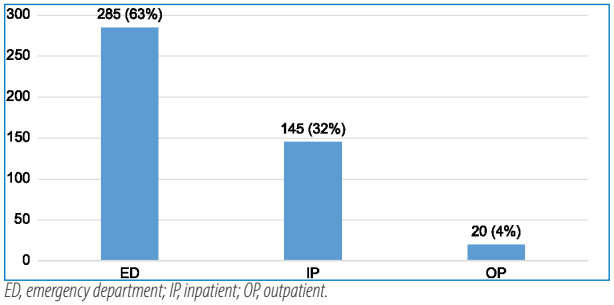
Sampling technique

We collected data from the electronic hospital records of all pediatric head CT scans conducted during the selected period. This duration was selected to resemble the full workload during 2 academic years. We used a data collection sheet to gather information from patients' medical records. The data collection sheet included basic information such as the date of birth, sex, and patient admission department, as well as details regarding the CT order, whether it was justified, symptoms during each request, and CT findings.

Table 1. Baseline data of all the patients (n = 1109)

Characteristics	N (%)
Sex	
Male	628 (57)
Female	481 (43)
Age	
Under 1 year old	148 (13)
From 1 to 5	445 (40)
Older than 5	516 (47)
Admission	
ED†	584 (53)
IP‡	454 (41)
OP§	71 (6)

†*Emergency department;* ‡*Inpatient department;* §*Outpatient department*



ED, emergency department; IP, inpatient; OP, outpatient.

Figure 1. Frequency of "no finding" cases across the departments (n = 450).

Justification Process

The requests for all pediatric CT scans were reviewed and audited by two radiologists with >10 years of experience using the National Institute for Health and Care Excellence head injury guidelines published in 2014; the updated version from 2019 was used to establish the justification algorithm in this research [16].

Statistical Analysis

Frequencies and percentages are used for presenting the data in tables and figures. We used the Kruskal–Wallis H test to compare ages among departments. Additionally, we used Pearson's chi-square test to correlate between findings and justifications**.** The analyses were performed using the Statistical Package for Social Sciences (SPSS) version 23.0 (IBM, Armonk, NY, USA).

Results

We included 1,109 patients, of whom 628 (57%) were male patients. A total of 584 (53 %), 454 (41 %), and 71 (6.4 %) patients were admitted to the emergency department (ED), inpatient (IP) department, and outpatient (OP) department, respectively (Table 1). Overall, 659 (59%) and 450 (41%) patients showed positive and negative findings, respectively (Figure 1). Among the 450 cases with no findings, 308 (68%) and 142 (32%) CT scans were justified and unjustified, respectively (Figure 2); moreover, 344 (76%) and 106 (24%) were compatible and incompatible, respectively (Figure 3). The highest number of "no findings" cases was from ED (285 [63%]) and aged >5 years (203 [45%]). The majority of "no finding" cases were male patients (255 [57%]). Among the "no findings" cases in the ED, 30% were not justified and 19% were not compatible (Table 2). Among the "no finding" cases, the OP department had the highest number of unjustified (9 [45%]) and incompatible (8 [40%]) cases (Table 2). The mean ages of the patients in the ED, IP, and OP departments were 5.70 ± 4.14, 5.14 ± 3.88, and 5.85 ± 3.98 years, respectively. There were no significant intergroup differences in the mean age (p = 0.344). A higher proportion of positive findings were justified (94.4%) than those with no findings and justified results (68.4%) (Table 3). Additionally, the proportions of positive and unjustified findings were significantly

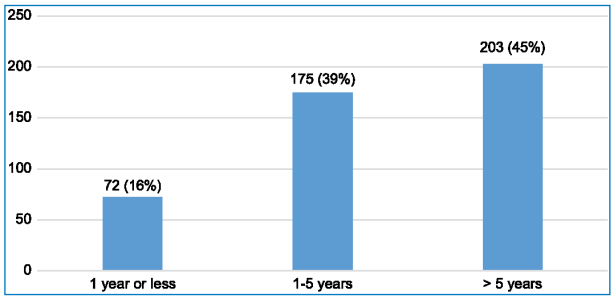


Figure 2. Frequency of "no finding" cases across the age groups (n = 450).

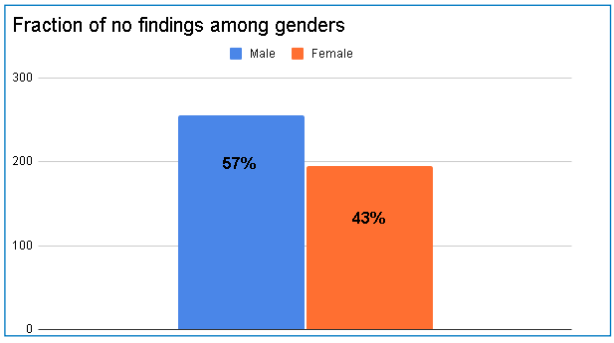


Figure 3. Comparison of the frequency of "no finding" cases between genders (n = 450).

Table 2. No finding per department, justification, and compatibility

Departments	No Findings N (%)	Justification N (%)	Compatibility N (%)
ED†	285 (63%)	200 (70%)	231 (81%)
IP‡	145 (32 %)	97 (67%)	101 (69%)
OP§	20 (4%)	11 (55%)	12 (60%)

†Emergency department; ‡Inpatient department; §Outpatient department

Table 3. Correlation between findings and justifications

Characteristics		Findings		p-value*
		No N=450	Yes N=659	
Justified	No	142 (31.6%)	1 (5.6%)	0.019
	Yes	308 (68.4%)	17 (94.4%)	
Missing		0	641	

*Pearson's Chi-squared test

lower than those with no findings or justifications (5.6% and 31.6%, respectively); this difference was statistically significant (p = 0.019).

Discussion

This study aimed to assess the correlation between head CT findings and its justification in pediatric patients referred by physicians.

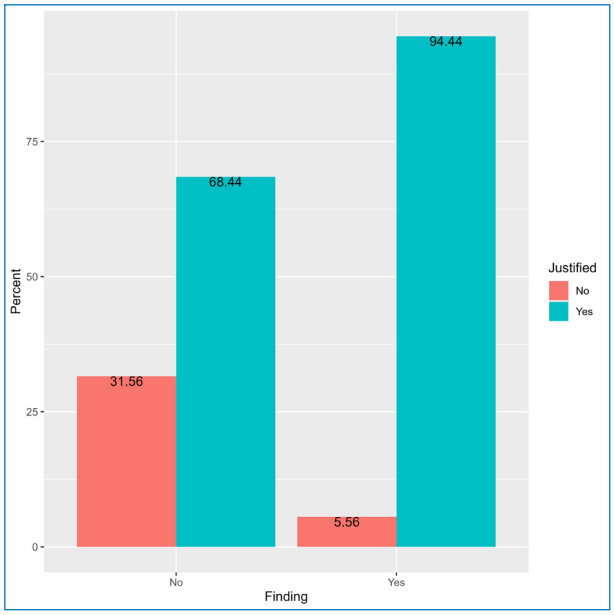


Figure 4. Correlation between findings and justifications.

The results of our study indicated that a higher proportion of positive findings were justified (94.4%) compared to cases in which no findings were observed or justified results provided (68.4%). Furthermore, the proportion of positive findings without justification was significantly lower than that of cases in which no findings were observed and no justification provided (5.6% and 31.6%, respectively) (Figure 4). These findings indicate that, in the context of our study, when a CT head scan in a pediatric patient yields positive results, there is a higher likelihood of a valid clinical reason for having ordered the scan. In other words, when positive findings were observed, there was a greater chance that the scan was justified based on the patient's clinical presentation and symptoms.

This suggests that healthcare providers are more likely to order a CT head scan for pediatric patients when there is a genuine medical need or suspicion of a specific condition or pathology. The presence of positive findings on the scan supports the appropriateness of the decision to order an imaging study, as it confirms the existence of an abnormality or justifies the need for further investigation. In contrast, cases in which no positive findings are observed on the CT head scan may raise questions about the clinical justification for ordering the scan. This indicates that alternative diagnostic approaches or further evaluations are warranted to determine the cause of the patient's symptoms.

Overall, these findings highlight the importance of ensuring that imaging studies, such as head CT scans in pediatric patients, are appropriately justified based on clinical indications. Valid justifications for ordering imaging tests help avoid unnecessary exposure to radiation and the associated risks while ensuring that valuable resources are utilized effectively in the diagnostic process. Relevant research in this field supports these findings; the research indicates that children with abnormal findings on their initial CT scans are more likely to present with justified clinical findings. Additionally, this study showed that patients with ventriculoperitoneal shunts were significantly more likely to have abnormal findings on head CT and required surgical intervention[17].

Although requesting physicians are ethically responsible for patient exposure to radiation, radiologists should ensure that the benefits of imaging procedures conducted in their department outweigh their risks. The benefits of CT, including time-sensitive diagnosis and detection of posttraumatic changes, have corresponding disadvantages. Therefore, unnecessary radiation exposure should be avoided, particularly in pediatric patients. This should be ensured by pediatricians when sending patients for imaging and by radiologists when determining the risk–benefit ratio. According to the American College of Radiology, pediatric patients have rapid mitotic rates and longer life expectancies than adults; concomitantly, the odds of developing cancers from X-ray exposure are significantly higher in pediatric patients than in adults[13]. Studies have reported that the probable risk of developing radiation-induced cancer, estimated at 5% per patient of all ages, significantly increases to 15% if the individual is exposed within the first decade of life[14,18].

Collectively, head trauma accounts for the most ED visits in children. The increased availability of CT scanners, along with the concern of missing clinically significant head injuries, has significantly contributed to an increase in the number of imaging scans[19]. Moreover, physicians have identified parental anxiety or requests as one of the most influential factors in ordering head CT scans for pediatric patients[20].

Therefore, Lorton et al. in 2016 validated PECARN for traumatic head injury prediction rule to identify children at low risk of clinically essential head injuries who probably do not require CT evaluation[18]. The definite indications for CT scanning after head trauma include a deteriorating clinical course, focal neurological deficit, abnormal mental status, evidence of skull fracture, and the presence of coagulopathy.

Moreover, until additional evidence becomes available, loss of consciousness and persistent vomiting (>3 episodes) should be considered.

There has been a substantial increase in the number of head CT scans, particularly in the ED [15,20].

Among the 450 "no findings" cases, 31% were unjustified and 23% were not compatible. The requests from the OP department yielded the highest number of unjustified requests (45%), whereas those from the IP department and ED were 31 and 30%, respectively. Among the "no findings" cases, the majority were male patients (57%) and aged >5 years (45%). This emphasizes that imaging requests did not follow strict guidelines, and that there is a need for referral guidelines or appropriate criteria in imaging facilities.

A prospective institution-based study was conducted in a teaching hospital in Ethiopia by Daniel et al. (2020); they found that only 47 (11%) of total 429 reviewed CT requests were not justified, and this helped protect against unnecessary radiation[21].

Furthermore, a retrospective study conducted at KAUH in 2012 by Elkhadir et al. in 2016 showed that among 417 children who underwent head CT scans, a significant majority (68.4%) did not confirm the clinical diagnosis[14]. Most participants were male (53%) and aged 1–5 years (33%).

An observational retrospective study was conducted by Tan et al. in a healthcare network in Singapore that consists of one tertiary pediatric hospital with pediatric IP, OP, and ED and three tertiary adult hospital with no pediatric services, involving 479 pediatric patients who underwent head CT (379 [79.1%] of them in pediatric ED and 100 [20.1%] in general ED); the study emphasized on the radiation doses by pediatric ED and general ED[22]. As expected, the doses were higher in the general ED, and they recommended providing more strategies to justify and optimize CT examinations to reduce radiation doses[22].

A national audit was conducted in Luxembourg in 2019 due to the high utilization of CT examinations per capita[23]. The study involved ten hospitals within four regions and was led by government auditing bodies.

Bouette et al. (2019) reported that 39% of CT requests were not justified, with A higher percentage among those referred by general practitioners. Surprisingly, their pediatric requests were more appropriate and compatible than those for adults. This may be due to the European Commission's efforts to implement the principle of justification in medical exposure and the impact of the European Society of Radiology, which adapted the Bonn Call for Action[24].

Taken together, there is a need for a hospital-approved protocol to be used by referring physicians and radiologists. A good example is the National Institute for Health and Care Excellence guidelines issued in January 2014, which provide detailed and comprehensive algorithms to justify CT examinations and prevent exposure of pediatric patients to unnecessary radiation[15]. Hospitals should implement aggressive systems for monitoring and auditing local referral practices. Referral guidelines are the primary tools used to improve the appropriateness and justification of medical imaging in large hospitals. To ensure the effective use of medical imaging examinations, international scientific communities have established several clinical decision support systems, including those used by the European Commission under the European Society of Radiology and the American College of Radiology to prevent unjustified and unnecessary patient exposure[25]. The limitations of our study include the small sample size and its retrospective nature, which means that any details missed by the physicians while referring to patients could have influenced our results.

Conclusion

Although CT helps physicians diagnose head injuries and trauma, our study highlights the need for a clinical decision support system for medical imaging involving ionizing radiation in addition to regular auditing of the justification of CT scan requests.

Conflict of Interest

The authors declared that there is no conflict of interest that is related to this study and this article.

Disclosure

The authors did not receive any form of commercial support, either in the form of compensation or financial assistance, for this case report. The authors have no financial interest in any of the products, devices, or drugs mentioned in this article.

Ethical Approval

The study was approved by the Ethics Committee of the KAUH in Jeddah, Kingdom of Saudi Arabia, also known as the Institutional Review Board of Hospitals under protocol number 41-18.

Data were collected from patients' medical records and electronic medical record systems; therefore, informed consent was not required. Full confidentiality, privacy, and patient anonymity were maintained by ensuring that only the research team had access to the files.

Informed Consent

No informed consent was required because the data were collected from the patients' medical records and electronic medical record systems.

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