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Utilization and Anatomical Distribution of CT and MRI in a Pediatric Emergency Department

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Abstract:

Objective: To assess the anatomic distribution of magnetic resonance imaging (MRI) and computed tomography (CT) scans in pediatric emergency department patients and determine their frequency of use. We also aimed to assess whether there were any differences in imaging practices based on time of day or type of imaging performed.

Methods: This retrospective study was conducted in a single tertiary pediatric emergency department, staffed by pediatric emergency medicine specialists, pediatricians, pediatric residents, and general practitioners, with approximately 400,000 visits annually. MRI and CT scans performed on pediatric emergency department patients were categorized into three groups: neuroradiology, body and musculoskeletal.

Results: A total of 12,764 radiologic imaging procedures were performed in the pediatric emergency department, including 6,656 CT scans and 6,108 MRI scans. MRI was used in 1.62% of visits, and CT in 1.77%. The mean age of patients undergoing CT was 8.72 years (95% confidence interval [CI], 8.59-8.85), and the mean age of patients undergoing MRI was 9.06 years (95% CI, 8.93-9.20). CT was performed significantly more frequently in younger patients $P < 0.001$). Across all age groups, MRI was performed more frequently in the neuroradiology category, while CT was more common in body imaging. The number of scans performed was lowest between 04:00 and 08:00. The proportion of imaging requests among total patient admissions was highest in February and August, at 4.59% and 4.52%, respectively.

Conclusion: MRI and CT are used for diagnostic purposes in pediatric emergency departments. CT use remains common in young children. This may raise concerns about the potential long-term adverse effects of radiation. Identifying imaging trends within centers can help clinicians adjust their work schedules and ultimately improve patient outcomes.

Keywords: Pediatric Emergency, Radiology, Magnetic Resonance Imaging, Computed Tomography

The utilization of magnetic resonance imaging (MRI) in emergency departments (EDs) has increased in recent years, primarily due to its lack of ionizing radiation exposure.[1] Moreover, the availability of 24/7 MRI services allows imaging to be performed without the need to wait for standard working hours, potentially reducing the number of patients waiting in the ED. However, this increased

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accessibility may also contribute to the rising use of non-emergent MRI examinations. Currently, there is limited literature regarding the use of MRI in pediatric EDs.

In contrast, the use of computed tomography (CT) has increased significantly in recent years and has become an important component in the evaluation of critically ill patients within the ED.[2-6] Nevertheless, the growing reliance on CT imaging has been associated with increased radiation exposure and prolonged ED length of stay.[7]

To date, little is known about whether the intended use of advanced radiological imaging in the pediatric emergency department in our country is comprehensive or limited to specific imaging studies. Despite its limited availability and time-consuming nature, some studies have demonstrated an increase in MRI utilization within emergency departments.[7,8] However, the extent of this increase and its association with the type of imaging study performed have not been thoroughly investigated.

Recent studies have shown that rapid MRI scans may be a safer strategy than CT scans for patients presenting with neurological complaints.[9,10]

We hypothesized that MRI utilization would predominate in neuroradiologic indications, whereas CT would be more common in body imaging and younger age groups. This study aims to assess the anatomical distribution of MRI and CT imaging in pediatric emergency department patients, as well as to determine their frequency of utilization. Additionally, we aim to assess whether there is any variation in imaging practices based on the time of day or the type of imaging performed.

METHODS

Study Settings

This retrospective study was conducted in a single tertiary pediatric ED with approximately 400,000 annual visits, staffed by pediatric emergency medicine specialists, pediatricians, pediatric residents, and general practitioners. Ethical approval for the study was obtained from the Başakşehir Çam and Sakura City Hospital Clinical Research Ethics Committee (Date: November 8, 2023, No: 563). The pediatric ED is part of a tertiary-level children's hospital serving patients under 18 years of age and includes multiple pediatric subspecialty units. Children aged 1 month to 18 years who admitted to the pediatric ED and underwent MRI and/or CT scans were included. Patients presenting with trauma-related complaints were excluded from the study, as they are evaluated in a separate trauma center.

Imaging examinations were categorized according to the anatomical region recorded in the radiology information system. MRI studies performed on pediatric ED patients aged 0–18 years were categorized into three groups: neuroradiology (brain, head and neck, neuro-MR angiography, and spine), body (chest, abdomen, and pelvis), and musculoskeletal system. All CT scans performed in the pediatric ED were also classified into the same three categories.

MRI and CT imaging were performed using scanners located in a radiology unit adjacent to the emergency department and readily accessible to ED patients. CT scans were performed using a 128-detector CT scanner (Supria 128, Fujifilm Healthcare Corporation, Tokyo, Japan), and MRI examinations were conducted on a 1.5 T MRI scanner (Ingenia Omega HP, Philips Medical Systems, Best, Netherlands). CT radiation doses were adjusted for pediatric patients in accordance with the ALARA (As Low As Reasonably Achievable) principle to minimize exposure. Imaging was not part of a mandatory protocol but was ordered at the discretion of pediatric emergency physicians based on clinical indications.

Data Extraction

Data on all MRI and CT examinations performed in the pediatric ED between September 1, 2022, and August 31, 2023, were obtained from the hospital database. The decision for radiological imaging was guided by clinical indications, physical examination findings, and the patients' clinical conditions during follow-up.

Statistical Analysis

MRI and CT utilization were graphed by month and by hour of the day to identify the time periods with the highest and lowest imaging frequencies. MRI and

CT usage was tabulated according to patient age, and confidence intervals were calculated. Imaging studies were categorized, and the number of MRI and CT scans was graphed by age group for each category. Daily imaging request rates were also visualized in relation to the total number of ED visits.

The collected data were transferred to IBM SPSS version 29 for analysis. For descriptive statistics, continuous variables were presented as mean values with 95% confidence intervals, while categorical variables were expressed as frequencies and percentages. Continuous variables were assessed for normality using visual methods (histograms and Q–Q plots) and the Shapiro–Wilk test. Non-normally distributed continuous variables were presented as median (interquartile range) and compared using the Mann–Whitney U test. Categorical variables were summarized as frequencies and percentages and compared using the chi-square test or Fisher's exact test when appropriate and cross-tabulations were used for data comparisons. A P - value of <0.05 was considered statistically significant.

RESULTS

Over the one-year study period, a total of 12,764 radiological imaging procedures were performed in the pediatric ED, comprising 6,656 CT scans and 6,108 MRI scans. MRI was performed in 1.62% of pediatric ED visits, while CT was used in 1.77%. Among patients who underwent CT imaging, 54.9% were male, whereas 51.7% of those who underwent MRI were male. A statistically significant difference was observed in imaging modality by sex, CT scans were significantly more common in male patients compared to females ($P < 0.001$). A comparison of imaging findings by age category is also shown in Table 1.

The number of pediatric ED visits during the study period was approximately 400,000. The mean age of patients who underwent CT was 8.72 years (95% CI, 8.59–8.85), whereas the mean age for MRI patients was 9.06 years (95% CI, 8.93–9.20). CT was significantly more frequently performed in younger patients compared to MRI ($P < 0.001$) (Figure 1).

When imaging distribution was analyzed by age,

TABLE 1. Comparison of Radiological Imaging by Age and Sex in the Study Population

Characteristic	Total	CT use	MRI use	P-value
Total, n (%)	12764 (100)	6656 (100)	6108 (100)	–
Sex, n (%)				**<0.001**
Male	6813 (100)	3657 (54.9)	3156 (51.7)	
Neuro	4680 (68.7)	1688 (46.2)	2992 (94.8)	
Body	1713 (25.1)	1680 (45.9)	33 (1.0)	
Musculoskeletal	420 (6.2)	289 (7.9)	131 (4.2)	
Female	5951 (100)	2999 (45.1)	2952 (48.3)	
Neuro	4126 (69.3)	1376 (45.9)	2750 (93.2)	
Body	1453 (24.4)	1369 (45.6)	84 (2.8)	
Musculoskeletal	372 (6.3)	254 (8.5)	118 (4.0)	
Age, n (%)				**<0.001**
<1 year	857 (100)	441 (6.6)$_a$	416 (6.8)$_a$	
1–<3 years	1281 (100)	719 (10.8)$_a$	562 (9.2)$_b$	
3–<5 years	1159 (100)	625 (9.4)$_a$	534 (8.7)$_a$	
5–<12 years	4635 (100)	2467 (37.1)$_a$	2168 (35.5)$_a$	
12–<18 years	4832 (100)	2404 (36.1)$_a$	2428 (39.8)$_b$	

Data are shown as n (%). CT, computed tomography; MRI, magnetic resonance imaging.

Each subscript letter denotes a subset of imaging categories whose column proportions do not differ significantly from each other at the 0.05 level. Statistically significant P-values are shown in bold.

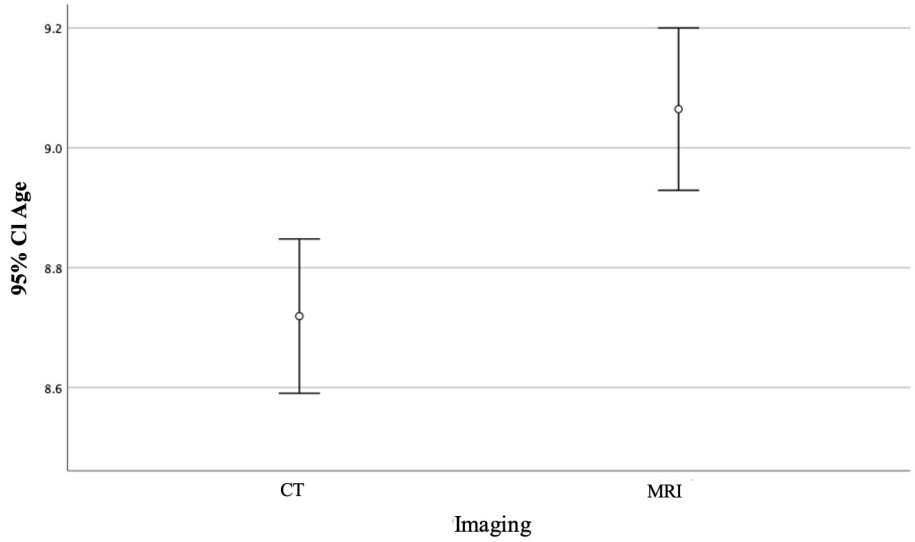

FIGURE 1. Distribution of radiological imaging modalities by age. CT, computed tomography; MRI, magnetic resonance imaging; CI, confidence interval.

CT was more frequently performed than MRI in most age groups. However, at ages 12, 15, and 16, MRI usage exceeded that of CT. A closer examination of these age groups revealed that the increased use of MRI was primarily due to neuroradiological indications.

When categorized by imaging type, 8,806 scans (68.99%) were classified as neuroradiological, 3,166 (24.80%) as body, and 792 (6.21%) as musculoskeletal. Across all age groups, MRI was more frequently performed than CT in the neuroradiology category, while CT was more prevalent in body imaging (Figures 2a and 2b).

Imaging frequency was also analyzed by time of day. The lowest number of scans occurred between 04:00 and 08:00. Although the number of CT and MRI requests followed a similar pattern across most hours, some time slots (18:00, 21:00, and 23:00) showed notable divergence between the two modalities (Figure 3).

Monthly trends in radiological imaging were also assessed. The fewest MRI scans were performed in

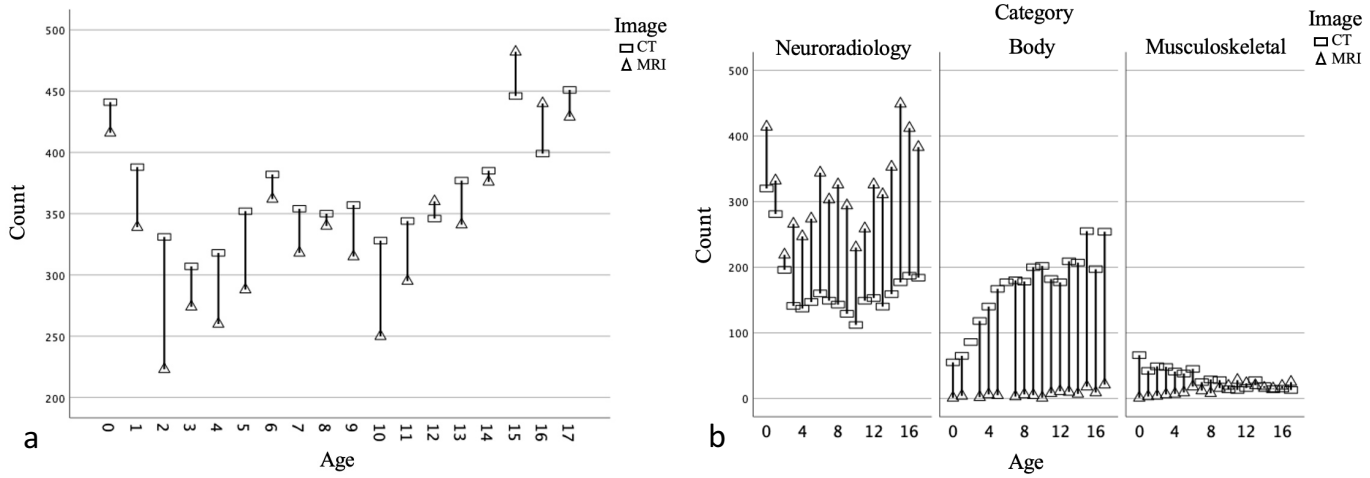

FIGURE 2. a) Age-stratified counts of radiological imaging modalities. b) Distribution of radiological imaging categories across age groups. CT, computed tomography; MRI, magnetic resonance imaging.

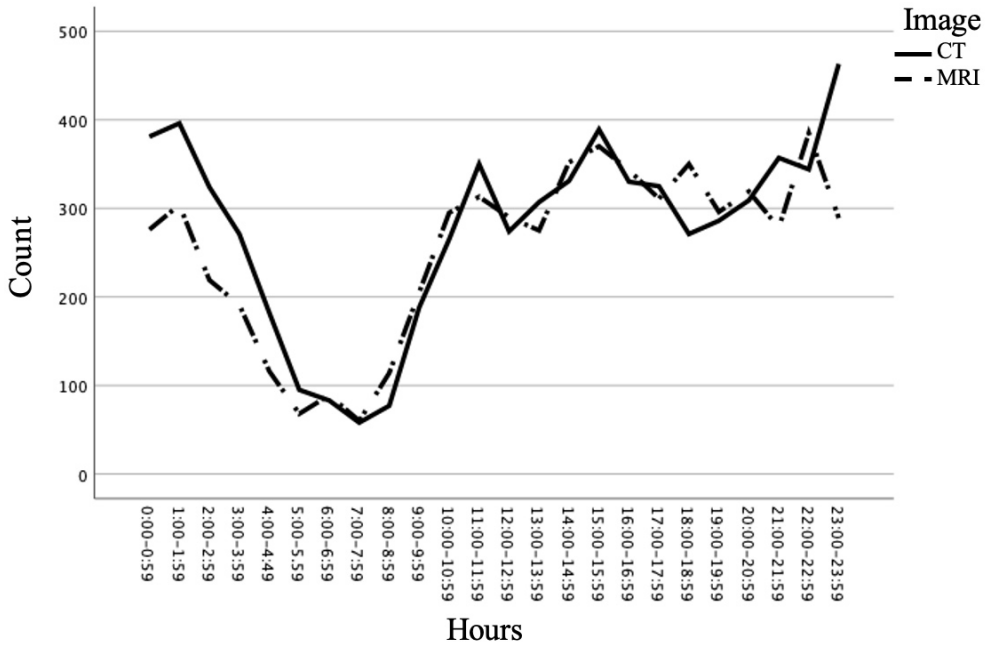

FIGURE 3. **Hourly distribution of radiological imaging modalities. CT, computed tomography; MRI, magnetic resonance imaging.**

October (378 scans, 6.2%), while the highest number occurred in January (710 scans, 11.6%). For CT, the lowest number of scans was observed in February (406 scans, 6.1%), and the highest in November (674 scans, 10.1%) (Figure 4).

The proportion of imaging requests relative to total pediatric ED visits was highest in February and August, at 4.59% and 4.52%, respectively.

DISCUSSION

In this study, we present a one-year profile of MRI and CT utilization in a pediatric ED. In our analysis, 68.99% of all imaging studies belonged to the neuroradiology category, which includes imaging of the brain, head, neck, and spine. In comparison, a study conducted in an adult emergency department

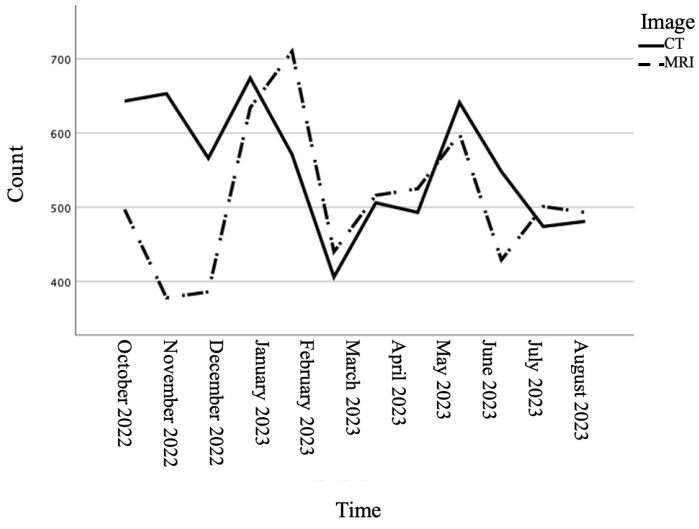

FIGURE 4. **Monthly distribution of radiological imaging modalities. CT, computed tomography; MRI, magnetic resonance imaging.**

reported a neuroradiology imaging rate of 98% [8]. Another pediatric ED study reported a rate of 90%, while an additional study in an adult ED setting found a rate of 92.2%.[11,12] Our findings confirm that neuroradiological imaging constitutes the majority of imaging in the pediatric ED, followed by body and musculoskeletal imaging. The body imaging rate aligns with previous pediatric studies; however, the musculoskeletal imaging rate was notably lower. The relatively low rate of musculoskeletal imaging in our study was expected, as musculoskeletal emergencies are less common, and trauma patients in our center are evaluated in a separate trauma unit outside the pediatric ED.

CT utilization was higher among male patients. CT is widely used in ED and plays a vital role in rapid diagnostic evaluation.[13] Among five studies examining sex differences in CT use, three reported that males were more likely to undergo CT imaging compared to females,[14-16] while one study found higher CT rates among females,[17] and another found no correlation between sex and CT usage.[18] The slight variation in the utilization of MRI among female patients is predominantly observed in the body region. In particular, for patients presenting with suspected ovarian torsion, when ultrasonography is insufficient, pelvic MRI evaluation becomes prominent. One possible explanation is the evaluation of gynecologic conditions, such as suspected ovarian torsion, in adolescent female patients; however, this remains speculative because imaging indications were not analyzed in the present study. This factor is believed to significantly influence imaging modality preferences in female patients.

The rates of CT and MRI requests among patients presenting to the pediatric ED were 1.77% and 1.62%, respectively. One pediatric ED study reported MRI utilization in 0.96% of emergency visits.[19] MRI offers a clear advantage in being radiation-free; however, it also presents challenges, such as higher cost, lower accessibility compared to CT, and limited tolerance among younger children—particularly those under 5 years of age.[20] Nevertheless, there has been an observed increase in MRI utilization driven by medicolegal concerns and the need to rule out specific diagnoses.[21,22] In children, unnecessary CT requests may also arise due to communication barriers associated with developmental age.[23] The higher imaging utilization rate in our study compared to the literature may be explained by the fact that our center is one of the most advanced referral hospitals in the region, which affects the characteristics of the patient population. It should be noted that our study did not assess the appropriateness of imaging based on etiologic necessity. Few studies have been published describing MRI utilization in pediatric EDs, and more evidence-based studies are needed to inform clinical practice.[11,12,19]

The time distribution of imaging procedures showed that the lowest number of scans occurred during the early morning hours. This finding is consistent with a five-year study conducted in a pediatric ED, which also reported minimal MRI use during early morning hours.[12] When imaging request and acquisition rates were analyzed according to the hours of the day, an increase in the use of CT was observed after 23:00. It is believed that the lack of ultrasonography availability, particularly between 23:00 and 09:00, leads to an increased indication for CT in patients presenting with acute abdominal conditions such as suspected acute appendicitis. The decrease in radiological imaging during the early morning hours is considered to be influenced by the overall reduction in patient admissions during this time period.

The age of patients undergoing CT scans was significantly younger compared to those receiving MRI. CT imaging is characterized by short scan times and high image quality. Additionally, CT scanners are widely available in many centers and are relatively more cost-effective.[18] The higher frequency of CT use in younger patients can be attributed to several factors. Advances in technology have resulted in reduced scan times while maintaining high image quality [18], which is particularly beneficial in pediatric populations and often eliminates the need for sedation. Moreover, imaging in adolescent age groups tends to be predominantly MRI-based. Two previous studies have reported higher CT utilization rates in younger patients, with one plausible explanation being the difficulty of obtaining reliable physical examinations and medical histories in infants.[15,17]

The monthly rates of imaging requests relative to the total number of pediatric ED visits varied between CT and MRI. February was identified as the month with the lowest CT request rate, while October had the

lowest MRI request rate. Conversely, November and January had the highest request rates for CT and MRI, respectively. In a pediatric ED study by Akca et al.,[24] the highest MRI usage was reported in August, and the lowest in February. Similarly, a study conducted in an adult ED also observed monthly variations in MRI utilization. Consistent with these findings, our study demonstrated monthly fluctuations in the rates of radiological imaging throughout the year.

Strengths and Limitations

A major strength of this study is its large-scale dataset, which enables comprehensive comparative analyses based on demographics (age and gender), imaging modalities, anatomical regions, and temporal factors (time of day). However, certain limitations warrant consideration. Due to its retrospective, single-center design, the generalizability of the findings to the general population may be limited. Furthermore, the absence of an on-duty radiologist during specific periods potentially impacted imaging utilization rates. Other notable limitations encompass the lack of documented clinical indications, the inability to evaluate the appropriateness of the imaging procedures, the lack of data regarding clinical outcomes or diagnostic yield, and the exclusion of the trauma patient population.

CONCLUSION

Our findings underscore the critical importance of optimizing imaging selection in pediatric patients, although this study did not directly evaluate the clinical appropriateness of individual imaging decisions. Despite distinct variations in the utilization profiles of MRI and CT, overall imaging rates remain substantial. Notably, the continued prevalence of CT scans in younger children raises valid concerns regarding radiation exposure and its potential long-term adverse effects. Consequently, targeted strategies are warranted to minimize unnecessary CT utilization and radiation burden in this vulnerable population. Furthermore, identifying specific imaging trends within individual healthcare centers can guide clinicians in optimizing resource allocation and clinical workflows, ultimately enhancing patient outcomes.

Ethics Approval and Consent to Participate

This study was approved by the Başakşehir Çam Sakura City Hospital Clinical Research Ethics Committee (Decision No: 2023-563; Date: November 8, 2023). All procedures were conducted in accordance with the ethical standards of the institutional and national research committees and with the 1964 Helsinki Declaration and its later amendments. Informed consent was waived due to the retrospective nature of the study and the use of anonymous clinical data.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to ethical restrictions and patient confidentiality.

Authors' Contributions

Study Conception: RY, SG, NGA; Study Design: RY, SG, NGA; Supervision: RY, SG, NGA; Funding: None; Materials: N/A; Data Collection and/or Processing: RY, SG, NGA; Statistical Analysis and/or Data Interpretation: RY, SG; Literature Review: RY, SG; Manuscript Preparation: RY, SG, NGA; Critical Review: RY, SG, NGA.

Conflict of Interest Statement

All authors have completed the ICMJE uniform disclosure form and declare that no potential conflicts of interest, financial or otherwise, exist regarding the research, authorship, or publication of this manuscript.

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Generative Artificial Intelligence Statement

Artificial intelligence (OpenAI's ChatGPT, Model 4o) was used solely for English language editing to improve readability during the preparation of this manuscript. No other artificial intelligence-based tools or applications were utilized for content generation or data analysis. The authors review and edit all AI-

generated suggestions and take full responsibility for the final content of the study, which was produced in accordance with scientific research methods and academic ethical principles.

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