



## MRI utilization in pediatric emergency department: An analysis over 5 years

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### Abstract

There are concerns on exposure to radiation especially in pediatric population, as magnetic resonance imaging (MRI) can be used in emergency departments and provides an imaging without radiation; its utilization has recently increased. This study aimed to evaluate MRI utilization trends in patients who underwent a MRI in a pediatric emergency department within a period of five years. Examination data of the patients admitted to pediatric emergency department between 2014 and 2018 were obtained from database of the hospital with the approval of Clinical Research Ethical Committee. Rate of MRI utilization in patients admitted to pediatric emergency department was 0.88%. There was a statistically significant increase in MRI utilization within five years ( $p<0.001$ ). The rate of male patients (1.24%) who underwent MRI was significantly higher than that of female patients (0.65%) ( $p<0.0001$ ). There was a statistically significant decrease in MRI utilization by age in all categories ( $p<0.0001$ ). Neuroradiology imaging was the most common. Complaints at presentation and pre-diagnoses were analyzed. The results of MRI were evaluated by radiologists and 53.9% of the results were normal. The highest rate (46.1%) of MRI utilization was between 4 pm and 12 am in a day. The highest rate of MRI utilization was on Friday and the lowest rate was on Sunday. While MRI utilization has increased in pediatric patients, neuroradiology imaging is the most common type. MRI utilization in pediatric emergency department is higher in male patients and in the early ages.

**Keywords:** pediatrics, pediatric emergency department, magnetic resonance imaging, clinical indication

### 1. Introduction

Emergency departments are dynamic areas where disorders and injuries of the patients are evaluated as acute or emergent and where the resuscitation, first care, diagnosis and treatment of these emergencies are performed. Pediatric emergency departments consist of 25% of all patients with an emergency (1, 2).

In addition to clinical evaluation, radiological imaging is also needed to diagnose several emergent cases. Although imaging is a guide for disorders, its potential damages should be considered as well (3-6). As there are concerns on exposure to radiation especially in pediatric population, there should be an effort to reduce the radiation dose in imaging for infant and pediatric patients in emergency departments (2, 7). As magnetic resonance imaging (MRI) can be used in emergency departments and provides an imaging without radiation, its utilization has recently increased (2, 8). Although it is hard to obtain an image in MRI for pediatric patients due to the noise, fear, and inability to remain indoors or inactive, it is possible to obtain quality images in some patients with sedation or general anesthesia.

This study aimed to evaluate the frequency of MRI utilization according to age, gender, indication and type of

examination in a pediatric emergency department in Turkey between 2014 and 2018.

### 2. Materials and Methods

This study was performed in a pediatric emergency department which was an 18-bed tertiary care center. Thirty-five thousand patients on average are admitted to this department every year. All age groups under 18 are admitted to the pediatric emergency department. Three MRI scanners are actively used in the Department of Radiology. While 2 MRI scanners were in use from January 2011 to January 2015, 3 MRI scanners have been used since 2015. Technical staffs work in shifts (8am-4pm, 4pm-12am and 12am-8am). This scheme operates 24 hours a day and 7 days a week. Scanners are active for imaging requested for the patients in emergency departments, wards, and outpatient clinics. Physicians who requested MRI examination for these patients are internal, external, or emergency physicians.

The patients who underwent MRI examination after admitted to the pediatric emergency department between January 2014 and January 2019 were accessed from the database of the hospital and included in the study. Data obtained in the study were transferred to IBM SPSS 23 for

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evaluation. For descriptive statistics, continuous data were given as mean and standard deviation while categorical data were given as counts and percentiles in the analysis of the data. Chi-Square test and T-test were used in the comparison of the data. The value of  $p < 0.05$  was accepted as statistically significant. This study was performed with the approval of the Clinical Research Ethical Committee of Ondokuz Mayıs University.

### 3. Results

The number of patients who were admitted to the emergency department between 2014 and 2019 was 175,331. While the number of patients admitted to pediatric emergency department was 24,411 in 2014, this number increased to 45,992 in 2018. Within this period of 5 years, 1,551 MRI examinations were performed for 1,233 patients (1.25 imaging per patient). While 1,198 (77.2%) of the patients were admitted to the emergency department, 353 (22.8%) had been followed up for a chronic disease. According to the years, the ratio of the number of MRI requested in pediatric emergency department to the number of patients was 0.86% in 2014 and 1.1% in 2018. There was a statistically significant increase in MRI utilization ( $p < 0.001$ ). The average rate of MRI utilization in patients admitted to pediatric emergency department over 5 years was 0.88%.

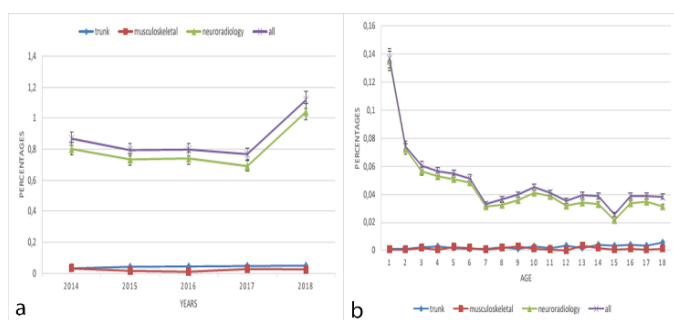
Out of 1551 patients, 859 (55.4%) were male and 692 (44.6%) were female. The rate of male patients ( $n=69,308$ ; 1.24% of the patients admitted to the emergency department) who underwent MRI examination was statistically significantly higher than that of female patients ( $n=106,023$ ; 0.65% of the patients admitted to the emergency department) ( $p < 0.0001$ ). While the number of neuroradiology and musculoskeletal imaging was significantly higher in male patients ( $p < 0.0001$ ), the number of body imaging was significantly higher in female patients ( $p < 0.0001$ ). The rate of male patients who underwent neuroradiology imaging among all MRI examinations was 52.1% ( $n=809$ ) and that of female patients was 40.1% ( $n=623$ ). The rate of female patients who underwent body imaging was 3.4% ( $n=54$ ) and that of male patients was 1.6% ( $n=25$ ). The rate of musculoskeletal imaging was 1.6% ( $n=25$ ) in male patients and 0.96% ( $n=15$ ) in female patients. The ratio of male to female patients in neuroradiology examination was 1.3:1, the ratio in musculoskeletal examinations was 1.6:1, and the ratio in body examinations was 1:2.1.

Among the categories of MRI, neuroradiology was the most requested imaging type with a rate of 92.3% (brain: 82.6%; spine: 3.4%; angiographic: 3.3%; orbit: 1.7%; pituitary: 1%; and MR spectroscopy: 1%). The rate of body imaging (chest, abdomen, and pelvis) was 4.9% and the rate of musculoskeletal imaging was 2%. When the categories of imaging were analysed, a statistically significant increase was found in neuroradiology imaging ( $p < 0.001$ ) (Fig. 1a). Complaints of the patients who underwent MRI examination

were given in Table 1. The most common complaint in neuroradiology imaging was seizure with a rate of 29.3%. The most common complaint was trauma in musculoskeletal imaging and abdominal pain in body imaging. The most common pre-diagnoses in MRI were cranial pathologies (vascular pathologies such as arteriovenous malformation, bleeding, thrombosis, and stroke, structural brain abnormalities, neurodevelopmental pathologies, etc.) with a rate of 54.9%, suspected infections (meningitis, encephalitis, etc.) with a rate of 18.5% and ventriculoperitoneal shunt dysfunction/infection with a rate of 12.3% for neuroradiology imaging. While the most common pre-diagnoses were acute abdomen (suspected appendicitis, ovarian torsion, etc.:  $n=28$ , 1.8%) and ovarian cyst rupture ( $n=23$ , 1.5%) in body imaging, they were arthritis/arthritis (n=23, 1.5%) and mass etiology ( $n=7$ , 0.5%) in musculoskeletal imaging. Eight hundred and thirty-six (53.9%) of MRI results were evaluated as normal by radiologists. There was a statistically significant decrease in MRI utilization by age in all categories ( $p < 0.0001$ ) (Fig. 1b). The rate of neuroradiology imaging was statistically higher in the age group of 0-6 than in other age groups ( $p < 0.0001$ ). And the rate of body imaging was statistically higher in the age groups of 7-12 and 13-18 ( $p < 0.0001$ ).

**Table 1.** Complaints of the patients who underwent MRI

<b>Neurologic System</b>		
Seizure	454	29.3%
Fever / vomiting / seizure with ventriculoperitoneal shunt	195	12.6%
Headache	91	5.9%
Fever, headache, vomiting	83	5.4%
Fever, vomiting, somnolence	60	3.9%
Nausea, vomiting	57	3.7%
Visual impairment	45	2.9%
Somnolence	42	2.7%
Headache, vomiting	41	2.6%
Fever, seizure	40	2.6%
Ataxia	34	2.2%
Inability to walk	31	2%
Muscle weakness	28	1.8%
Fainting	23	1.5%
Neck stiffness	23	1.5%
Speech disorder	21	1.4%
Headache and visual impairment	19	1.2%
Facial paralysis	18	1.2%
Dizziness	13	0.8%
Bulging fontanel	12	0.8%
Numbness	10	0.6%
Other (Incontinence, Otorrhagia, Swollen eye)	13	0.8%
<b>Musculoskeletal System</b>		
Trauma	56	3.6%
Joint swelling	26	1.7%
Cervical swelling	7	0.5%
Soft tissue swelling	6	0.4%
Backache	3	0.2%
<b>General</b>		
Abdominal pain	59	3.8%
Abdominal mass	7	0.5%
Heart failure	4	0.1%
Cough	1	0.1%



**Fig. 1.** a. Magnetic resonance imaging (MRI) utilization by year, b. Magnetic resonance imaging (MRI) utilization by age

The rates of MRI utilization within a day were 35.9% between 8am and 4pm, 46.1% between 4pm and 12am and 18% between 12 am and 8 am. In the distribution of MRI utilization days, the highest rate was on Friday with a rate of 15.9% (n=246). The rates in other days were 15.7% (n=243) on Tuesday, 15% (n=232) on Thursday, 14.8% (n=229) on Wednesday, 14.1% (n=218) on Monday and 13.7% (n=213) on Saturday. The lowest rate of MRI utilization was on Sunday with a rate of 11% (n=170). The months when the rate of MRI utilization was the highest were August (n=171, 11%), December (n=162, 10.4%), September (n=151, 9.7%) and October (n=145, 9.3%). The months when the rate of MRI utilization was the lowest were February (n=92, 5.9%) and April (n=91, 5.9%).

#### 4. Discussion

MRI scanner is an imaging device used to evaluate a variety of diseases (9). Neuroradiology exams including brain, head, neck, and spine consisted of 92.3% of the total amount of imaging. MRI utilization especially for brain, head and neck has considerably increased and this increase was predicted in a study performed years ago (10). The rate of neuroradiology imaging was reported as 90% in a former study on a pediatric emergency department and 92.2% in another study on an emergency department in which adult patients were admitted. The rate of body imaging was consistent with those of other pediatric studies; however, the rate of musculoskeletal imaging was lower (11, 12).

Utilization of MRI was more in male patients than in female patients. While the number of male patients was significantly higher especially in neuroradiology and musculoskeletal imaging, the number of female patients was significantly higher in body imaging. Although MRI is not used as a primary care imaging in conditions on pelvic region such as ovarian torsion, it is helpful for the cases that are hard to be diagnosed (13). As in many studies conducted recently, the utilization of MRI with high sensitivity in the presence of free fluid and in intra-abdominal imaging has increased as an alternative of computed tomography (CT) in the diagnosis of appendicitis in conditions in which ultrasonography is insufficient (14, 15). MRI is a type of imaging that gives better results than CT does in the evaluation of appendicitis or adnexal pathologies in pregnant women (16, 17). As pregnant

women are admitted to the emergency department for adults even if they are under the age of 18, there were no pregnant women who underwent MRI examination in our study.

The most common complaint in neuroradiology was seizure. Seizures during infancy are different from those during childhood or adulthood and a variety of conditions such as eye misalignment, blinking or rapid eye blinking, sucking, smacking or other buccal movements and swimming or pedaling movements may occur. Moreover, there is generally no loss of consciousness (18). A variety of movements during childhood from simple but unnatural movements to complex motor movements like natural movements in inconvenient environments may be characterized with seizure (19). As several movements are evaluated as seizure by families, they present to the emergency department. The prevalence of lifelong seizure has increased by 4% with pediatric rates ranging from 0.4% to 1.0% (20). This is consistent with our study.

The most common pre-diagnoses established by the clinician working in an emergency department in which the most common complaint was seizure were intracranial pathologies. Pre-diagnoses of the patients who were admitted to the emergency department with seizures and who were considered to have suspected infections such as meningitis and encephalitis or ventriculoperitoneal shunt dysfunction varied according to their conditions. Almost half of the reported MRI results were compatible with the pre-diagnosis. Pre-diagnoses are of great importance in MRI reporting of the radiologist. It is important to establish a strong cooperation between emergency physicians and radiologists in deciding the correct examination according to the clinic of the patient. We could not find any study on pre-diagnoses and their results in literature.

The most common complaint in body imaging was abdominal pain and the most important reason to request abdominopelvic MRI for female patients was abdominal pain symptom of complex adnexal pathologies (13, 14). Although musculoskeletal imaging was generally low in number, the higher rate of male patients who underwent musculoskeletal imaging was associated with more active characters of boys and sports injuries (21). Moreover, the fact that the rate of septic arthritis and osteomyelitis and the prevalence of bone tumors are higher in boys is another factor for that (22, 23).

MRI utilization decreases by age. The rates of imaging increasing by age were reported in two different pediatric studies performed in Orlando and Bronx (11, 24). MRI is used more in younger age group because the young population, especially the population under the age of 5 is high and patients mostly present with seizures that are seen at very young ages. Although MRI utilization in emergency department differed according to the seasons, there was a slight increase during summer and autumn months. There was an increase in similar months in the study of adult emergency

department (8). There were also slight differences among weekdays. The day with the lowest rate of MRI utilization was Sunday and the shift with the lowest rate was 12am-8am. While MRI was not used during the shift of 12 am-8 am on Sundays due to the limited number of technicians two years ago, a single MRI scanner was used during the shift of 12 am-8 am on weekdays. MRI utilization is high during the shift of 4pm-12am. However, MRI utilization was higher in evenings and at nights in most of emergency departments (8, 11). While patients in outpatient clinics and patients admitted to emergency department share MRI scanners during the day, mainly patients admitted to emergency department use them at the evening hours. As our hospital is a tertiary care district hospital, the number of patient transfers from external centers increases at the evening hours and therefore, MRI utilization is more at these hours.

The number of CT examinations per 1000 people increased by 30% and the number of MRI examinations increased by 60% in Turkey between 2008 and 2010, which reveals the rapid increase in the number of demands. The number of MRI examinations per 1000 people was 79.5 by 2010 and nearly two times more than the average MRI examination (44.9) predicted by the Organization for Economic Cooperation and Development (OECD) in the same year (25). Although the date of our study was not similar, it revealed that the rate of MRI increased from 0.86% (2014) to 1.1% (2018) over 5 years. This increase was also seen in other countries such as the USA as well as our country (6, 26). The number of MRI utilization increased after 2014; however, increase in the number of patients was higher (4). Therefore, the increase in MRI utilization in our country was not as much as expected. In a study on pediatric MRI in the USA, this rate increased from 0.23% to 0.49% (11) and while the rate of increase was 113%, it was 27% in our study. The rate of increase in the study of emergency department for adults was 15% as the rate increased from 1.64% to 1.9% (8). In a study performed in Korea, the number of MRI per 1000 people increased from 8.1 to 74.6 within 10 years (12).

Increases in the number of MRI utilization are consistent with the effort of clinicians to establish a final diagnosis due to medical concerns (27). It is an undeniable fact that clinicians perform extra tests, procedures, or imaging in order to decrease their medical malpractice liability to protect themselves from legal actions (28). Moreover, diagnosis with MRI is a great advantage for patients especially with suspected ventriculoperitoneal shunt dysfunction as they are not exposed to ionized radiation on the contrary to computed tomography (29). Thanks to these advantages, MRI utilization is increasing. The cost of MRI is two times higher than that of computed tomography depending on the institution where MRI is used (30). Although its cost is high, this will not matter when a possible risk of cancer is considered in children (31, 32).

Our study had some limitations. The results are related to the approaches we used in our hospital. A broader study can be performed with MRI utilization trends of other centers. Although MRI has a great advantage in terms of exposure to radiation, its effects due to sedation were not considered in this study. Factors such as duration of hospital stays, or the cost of the examination can be analyzed in another study.

The rate of MRI utilization has increased within years. Neuroradiology imaging was used more. The rate of MRI utilization was higher in male patients than in female patients. While trends, approaches, examinations, and treatments change in medical world, more research is needed to understand the factors responsible for these changes and determine the effect of radiology utilization in emergency departments on patient results

### Conflict of interest

None to declare.

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None to declare.

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