Research Article

Using MRI in Emergency Departments; Expensive Choice, but sometimes The Optimal Means of Evaluation!

Betül Tiryaki Baştuğ[1]

[1]Department of Radiology, Eskişehir Osmangazi University Faculty of Medicine, Eskişehir, Turkey;betultryak@yahoo.com

* ***Correspondance: Betül Tiryaki Baştuğ, MD, Department of Radiology, Eskişehir Osmangazi University Faculty of Medicine, betultryak@yahoo.com,05354101542***

Abstract: Most pathologies in emergency departments(EDs) can be detected with using non-invasive, extremely safe magnetic resonance imaging (MRI). MRI is highly sensitive to abnormality, so when compared to Computed Tomography(CT), a negative MRI far exceeds the value of a negative CT. This was a retrospective cohort study comparing resource utilization between September 2016 and September 2017 in a university hospital ED. Descriptive statistics are presented with frequency, percentage, mean, standard deviation, minimum and maximum values. A chi-square analysis was conducted to examine the relationships. Analyses were conducted using the SPSS 22.0 package program. In the ED, MRI is available 24/7. MRI was performed on 954 (479 female, 475 male) patients. A total of 212 cranial, 604 diffusion, 57 lumbar, 40 cervical, 38 dorsal, two abdominal, and one orbital MRIs were performed. In most groups, the average age was over 40, and the age distribution was similar (p = 0.12). There was no significant sex difference except for lumbar MRI. Lumbar MRI and diffusion MRI groups were admitted to the hospital mostly in the day hours

(p = 0.03); in other groups, night and day admissions were almost the same. Neuroimaging takes the majority part of MRI examinations in our ED.

Keywords: Magnetic Resonance Imaging, Emergency Departments, Utility

1. Introduction

When diagnostic imaging is required, the ordinary approach in emergency departments (EDs) has been to perform computed tomography (CT) rather than magnetic resonance imaging (MRI). The main reason is timing, because CT is faster than MRI. Moreover, CT scans have been performed because of their availability. But if we can achieve maximum productivity with minimum wasted effort with MRI in EDs, then MRI would probably be preferred over CT in some cases. Since MRI could potentially produce more informative diagnostic images of spinal cord damage, disc protrusions, and stroke pre-cursors, it is a better test for identifying soft tissue abnormalities. Reduction of the total radiation dose received by ED patients is another crucial point. Reducing the number of CT scans for patients, especially those under 40 years of age, is also critical because of their long life expectancy and cancer risk, and this was a significant reason for bringing MRI into the ED. For all these reasons, we wondered how, how often, and in which regions of body we used MRI in our ED in the past one year.

2. Materials and Methods

This was a retrospective cohort study comparing resource utilization during the 12 months between September 2016 and September 2017 in a single ED in a university hospital. The study was approved by the institutional review board through expedited review. The study was performed at the Eskişehir Osmangazi University Medical Faculty Hospital which has an academic ED with an annual volume of approximately 70,000 visits. This is a large hospital which is a Level 3 trauma and

stroke center. Medical informations were obtained from the records in the ED. In this center MRI was an available imaging modality and open 24 hours a day, seven days a week. Imaging was done after approval and notification by a radiologist. The electronic medical records database was queried using an automated query. Outcome measures included ED and hospital resource utilization, demographics, and clinical characteristics. MRIs ordered during patients' ED stays (i.e., before ED discharge) were considered ED-based MRIs. Demographics (age, sex) and clinical characteristics (chief complaint) were collected. Rapid MRI examination protocols were developed. This has minimized the time taken to perform scans. Total scanning time has shortened to even less than 10 minutes in most exams. The ED physicians can request exams with radiologist advice depending on the situation from a set of available exam protocols to minimize the time necessary for the MRI scan. In the analysis of the data, descriptive statistics are presented with frequency, percentage, mean, standard deviation, and minimum and maximum values. A chi-square analysis was conducted with the aim of examining the relationship among age, sex, and the proportion of admission hours according to the groups. Analyses were performed using the SPSS 22.0 package program.

3. Results

In the past one year, MRI was performed on 954 patients hospitalized in the ED. These patients included 479 females and 475 males. Cranial MRI was performed on 212 patients, diffusion MRI on 604 patients, lumbar MRI on 57 patients, cervical MRI on 40 patients, dorsal MRI on 38 patients, abdominal MRI on two patients, and orbital MRI on one patient. In all of these groups, the average age, except for orbital and abdominal MRI, was over 40.

All abdominal MRI group patients were between 19 and 40 years of age. In the brain MRI group, 2% of the patients were between 0 and 18 years old, 22% between 19 and 40 years old, 36% between 41

and 65 years old, and 40% over 65 years old. In the diffusion MRI group, 1% of the patients were between 0 and 18 years old, 14% between 19 and 40 years old, 37% between 41 and 65 years old, and 49% over 65 years old. In the orbital MRI group, patients were between 0 and 18 years old. In the cervical MRI group, 3% of the patients were between 0 and 18 years old, 26% between 19 and 40 years old, 40% between 41 and 65 years old, and 25% over 65 years old. In the dorsal MRI group, 3% of patients were between 0 and 18 years old, 24% between 19 and 40 years old, 42% between 41 and 65 years old, and 32% were over 65 years old. In the lumbar MRI group, 8.8% of patients were between 0 and 18 years old, 26.3% between 19 and 40 years old, 40.4% between 41 and 65 years old, and 24.6% over 65 years old (Table 1). The age groups were similar according to patient groups ($p = 0.12$).

Table 1: Groups and age distributions

Group	Age (years)	n	%
Abdominal MRI	19–40	2	100.0
Brain MRI	0–18	5	2.4
	19–40	47	22.2
	41–65	76	35.8
	65 and over	84	39.6
Diffusion MRI	0–18	4	0.7
	19–40	85	14.1
	41–65	221	36.6
	65 and over	294	48.7
Lumbar MRI	0–18	5	8.8
	19–40	15	26.3
	41–65	23	40.4
	65 and over	14	24.6
Orbital MRI	19–40	1	100.0
Cervical MRI	0–18	1	2.5

	19–40	16	40.0
	41–65	14	35.0
	65 and over	9	22.5
Dorsal MRI	0–18	1	2.6
	19–40	9	23.7
	41–65	16	42.1
	65 and over	12	31.6

All of the abdominal MRI and orbital MRI group patients (100%) were female. In the brain MRI group, 48% of the patients were male and 52% were female. In the diffusion MRI group, 49% of the patients were male and 51% were female. In the lumbar MRI group, 65% of the patients were male and 35% were female. In the cervical MRI group, 45% of the patients were male and 55% were female. In the dorsal MRI group, 45% of the patients were male and 55% were female (Table 2). Sex distribution was different according to groups, because the lumbar region group was composed of male patients with a higher incidence than in the other groups ($p = 0.04$).

Table 2: Groups and sex

Group	Sex	n	%
Abdominal	Female	2	100.0
Brain	Male	101	47.6
	Female	111	52.4
Diffusion	Male	298	49.3
	Female	306	50.7
Lumbar	Male	37	64.9
	Female	20	35.1
Orbital	Female	1	100.0
Cervical	Male	18	45.0
	Female	22	55.0

Dorsal	Male	21	55.3
	Female	17	44.7

The mean age of patients was 33.5 ± 2.12 in the abdominal MRI group, 65.07 ± 19.32 in the brain MRI group, 61.58 ± 17.30 in the diffusion MRI group, 22 in the orbital MRI group, 48.15 ± 18.61 in the cervical MRI group, 53.53 ± 18.08 in the dorsal MRI group, and 49.37 ± 18.22 in the lumbar MRI group (Table 3).

Table 3: Average age of patients

Group	n	Average	s.d.	Minimum	Maximum
Abdominal	2	33.50	2.12	32	35
Brain	212	56.07	19.32	18	95
Diffusion	604	61.58	17.30	18	95
Lumbar	57	49.37	18.22	18	82
Orbital	1	22.00		22	22
Cervical	40	48.15	18.61	18	82
Dorsal	38	53.53	18.08	18	81

Fifty percent of patients in the abdominal MRI group were admitted between 08:00–17:00 and 17:01–07:59. In the brain MRI group, 49% of the patients were admitted between 08:00 and 17:00 and 51% between 17:01 and 07:59. In the diffusion MRI group, 57% of the patients were admitted between 08:00 and 17:00 and 51% between 17:01 and 07:59. In the lumbar MRI group, 59% of patients were admitted between 08:00 and 17:00 and 50% between 17:01 and 07:59. Fifty percent of the cervical MRI group patients were admitted between 08:00–17:00 and 17:01–07:59. Forty-five percent of the patients in the dorsal MRI group were admitted between 08:00 and 17:00 and 55% between

17:01 and 07:59 (Table 4). When the abdominal MRI and orbital MRI groups were excluded, it was found that the lumbar MRI and diffusion MRI groups were admitted to the hospital mostly between 08:00 and 17:00 ($p = 0.03$).

4. Discussion

Making the right choice of imaging is crucial for emergency physicians. MRI is a expensive choice, but sometimes the most appropriate means of evaluation. When compared with other methods, it is important to weigh the risks and benefits of MRI. In addition, in many hospitals, the MR can only be used during working hours, which makes it difficult to obtain emergency MRIs.

An ED doctor must decide if the patient can be admitted or discharged. With an appropriately planned MRI, an ED doctor can make this decision with more confidence. A range of protocols can be decided upon with a radiologist's advice to help ensure that referring physicians order the most appropriate MRI exam. The optimized MRI protocols also include 3D contrast-enhanced imaging, allowing neurosurgeons to comfortably use the isotropic data in the operating room while performing stereotaxic surgery. After the MRI scan, preliminary reports are made available in the emergency radiology unit, resulting in rapid patient turnaround.

MRI is highly sensitive to abnormality, so when compared to CT, a negative MRI far exceeds the value of a negative CT. A negative MRI can allow physicians to be more confident about making decisions.

Unenhanced CT of the spine is the regular examination of suspected vertebral fractures. Especially in Turkey, osteoporosis has become a socioeconomic challenge. For this reason, older people are examined for suspected osteoporotic compression fractures after trauma [1]. While CT scans are evaluated for osteoporotic fractures, the reduced mineral content of the bone often causes problems,

and the fracture is usually partly masked. In these cases, additional examination with MRI is helpful. Fat-suppressed T2-weighted MRI is the standard of reference for differentiating between acute and old fractures because it can depict vertebral hemorrhages and edema [2,3]. It is essential to establish the diagnosis quickly, especially in cases of planned vertebroplasty or dorsal stabilization [4].

Associated bone injuries are best evaluated with CT, but it does not assess the cord itself. Besides routine axial and sagittal T1 and T2 imaging, additional sequences of MRI depending on the clinical concern should be considered. T2* sequences (e.g., gradient echo, SWI) are more sensitive to hemorrhage, while STIR sequences are more sensitive to associated ligamentous injury [5].

Some conditions require rapid MR examination, since the outcomes can be cahanged with emergency. For example, if a doctor suspects spinal cord compression, an emergency MRI evaluation is necessary. Because the patient can lose the ability to walk and the chances of that patient walking again after therapy are small. Especially, cord compression because of a cancer results in the loss of ability to walk within hours. In this state MRI is essential to evaluate these patients on an emergency basis.

Emergency MRI evaluation may be required in many conditions. Most pathologies in patients can be detected with using non-invasive, extremely safe MRI. Emergency MRI is recommended in the assessment of suspected arterial dissections of brain blood vessels and even for alleged acute clotting of major veins that drain the brain. Moreover, MRI is used to detect some infections and non-infectious inflammatory processes of the brain like meningoencephalitis, lupus vasculitis, or SLE. Patient outcomes can be affected with timely diagnosis and subsequent initiation of appropriate therapy of these disorders .

Patients with a suspected stroke can be acutely evaluated with emergency MRI. MRI can determine which patients should be treated aggressively, as opposed to patients who do not need and might be harmed by aggressive therapy. Physicians now have a treatment that can change the course of a stroke if administered promptly.

Diffusion MRI plays a significant role in the following clinical situations: early identification of ischemic stroke, differentiation of acute from chronic stroke, differentiation of acute stroke from other stroke mimics, differentiation of epidermoid cyst from arachnoid cyst, differentiation of abscess from necrotic tumors, differentiation of herpes encephalitis from diffuse temporal gliomas, assessment of the extent of diffuse axonal injury, grading of gliomas and meningiomas, and evaluation of active demyelination [6,7].

Early diagnosis of an epidural abscess is vital to minimize patient morbidity and mortality. A study of 63 patients with spinal epidural abscess pointed out that 45% of diagnostic delays greater than 24 hours resulted in persistent motor weakness [8]. The American College of Radiology (ACR) has determined MRI as the most appropriate study to evaluate the spine for infectious processes. The emergency physician should stand on early MRI when there is clinical doubt of an epidural abscess to prevent poor neurologic outcomes [9].

Neoplasms may cause to the sudden onset of neurologic deficit. This event is another emergency that requires immediate imaging, neurosurgical consultation, and treatment with high-dose steroids [10].

An epidural hematoma is a rare case and myelopathy may be associated with this condition. It can be a result of recent spinal procedures or trauma. Anticoagulant therapy may be a risk. The symptoms may simulate an acute disc herniation [11].

Cauda equina syndrome (CES) can be suspected when there is severe lower back pain and radicular symptoms with saddle anesthesia and bowel/bladder/sexual dysfunction, especially at L5/S1. An emergency MRI should be planned for diagnosis and rapid surgical decompression [11].

In pregnant patients in 2011 ultrasound was assigned by the ACR as the first imaging work of choice to evaluate for acute appendicitis [12]. However, multiple studies have reported nonvisualization of the appendix to a range as high as 68–97%. Thus, while evaluating pregnant patients for appendicitis ultrasound may not be the most appropriate imaging study [13,15]. Ultrasound may be ineffective due to bowel gas, body habitus, and anatomic displacement of the appendix, as well as patient tolerance in the setting of an acute abdomen [14]. In a meta-analysis of six articles that consisted of 359 pregnant women with suspected appendicitis, MRI was reported to have 98% specificity and 99% negative predictive value if a normal appendix is visualized [16]. The ACR approves the use of MRI when the ultrasound cannot provide diagnostic information in pregnant patients. MRI can diagnose multiple pathologies like ovarian masses, ovarian torsion, uterine fibroid tumors, ectopic pregnancies, hernias, renal abscess, and appendicitis in pregnant patients with acute abdominal/pelvic pain [17,18].

A negative x-ray or CT is challenging for highly suspected hip fracture. The use of MRI in the ED can be useful. Despite the use of CT, there are still missed hip fractures with a range of 2–4% [19,20]. A delay to surgery > 48 hours is associated with higher mortality. A retrospective study of 6,638 patients with hip fractures indicated that surgery before 12 hours improved survival [21]. The results of this study suggest that patients can receive the appropriate treatment of a hip fracture as soon as possible with rapid diagnosis so complications can be avoided. There is 100% sensitivity and 99%

specificity in detecting hip fractures with MRI. This hip protocol MRI may also be used to identify avascular necrosis (AVN) with 97% sensitivity and 100% specificity [22].

In the past one year, we have used MRI for cranial, cervical, dorsal, lumbar, abdominal, and orbital regions. Two patients admitted to abdominal MRI were pregnant, and they were suspicious of appendicitis, which could not be verified by ultrasonography. The need for cervical, dorsal, and lumbar MRI arose after suspicious CT findings. Particularly in older patients, chronic vertebral osteopenic and osteodegenerative changes could be mixed easily with fractures. Also, in some younger patients, the clinical outcomes made us suspicious of a pathology, but tomographies were normal. The most common causes were falls, severe pain, and traffic accidents. Cranial and diffusion MRI was applied because of the clinical findings of a cerebrovascular accident after a normal tomography. One orbital MRI was performed to evaluate the optic disc in the past one year. In all groups in our study, there was no significant difference between the number of males and females, except for lumbar MRI. It was interesting that the number of lumbar MRIs in men was about twice that in women. Usually, osteopenia after menopause leads to lumbar fractures in women, but in our series of men, lumbar MRI rates were nearly two times higher than in women. This is because the men faced more hard work, trauma, and traffic accidents than women, which leads to higher MRI rates.

In our ED, the emergency doctor with a radiologist ordered targeted scans for a specific issue, so exams were performed in about 10 minutes or less. In particular, the doctors in the ED and physicians did not order extra scans, and they understood the means of shortened protocols that might extend the exam times.

However, there are some contraindications to MRI. Patients with a heart pacemaker and a metallic foreign body cannot have an MRI scan. Because the magnetic field may dislodge the metal. Patients with severe claustrophobia may not be able to tolerate an MRI scan. In these patients medical sedation is possible to make the test easier to tolerate .

Limitations are inherent to retrospective studies based on patient data automatically queried. Data were abstracted using an automated query, and, therefore, it is possible that there were a small number of patients inadvertently not included in the study sample.

5. Conclusions

Making the right choice of imaging when dealing with emergency situations is crucial for emergency physicians. Magnetic resonance imaging is an expensive choice, but sometimes the optimal means of evaluation.

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References

1. Center JR, Nguyen TV, Schneider D, et al. Mortality after all major types of osteoporotic fracture in men and women: an observational study. Lancet 1999;353(9156):878–882.

2. Qaiyum M, Tyrrell PN, McCall IW, Cassar-Pullicino VN. MRI detection of unsuspected vertebral injury in acute spinal trauma: incidence and significance. Skeletal Radiol 2001;30(6):299–304.

3. Feller JF. MRI of bone marrow. Advances MRI-From Head To Toe, 2002; 1–3.

4. Mathis JM, Barr JD, Belkoff SM, Barr et al. Percutaneous vertebroplasty: a developing standard of care for vertebral compression fractures. AJNR Am J Neuroradiol 2001;22(2):373–381.

5. Parizel PM, van der Zijden T, Gaudino S, et al. Trauma of the spine and spinal cord: imaging strategies. Eur Spine J. 2010;19 Suppl 1 (S1):S8–17. doi:10.1007/s00586-009-1123-

6. Moritani T, Ekholm S, Westesson PL. Diffusion-Weighted MR Imaging of the Brain. Dordrecht ; New York :Springer; 2009. ISBN:3540787852.

7. UK. PP. Diffusion MRI: Theory, Methods, and Applications. Oxford University Press, Oxford, USA; 2010. ISBN:0199708703.

8. Davis DP, Wold RM, Patel RJ, et al. The clinical presentation and impact of diagnostic delays on emergency department patients with spinal epidural abscess. J Emerg Med. 2004;26(3):285–291.

9. Seidenwurm DJ, Wippold FJ, Cornelius RS, et al. ACR Appropriateness Criteria((R)) myelopathy. J Am Coll Radiol. 2012;9(5):315–324.

10. Arce D, Sass P, Abul-Khoudoud H. Recognizing spinal cord emergencies. Am Fam Physician. 2001;64(4):631–638.

11. Mukherjee S, Thakur B, Crocker M. Cauda equina syndrome: a clinical review for the frontline clinician. Br J Hosp Med (Lond). 2013;74(8):460–464.

12. Rosen MP, Ding A, Blake MA, et al. ACR Appropriateness Criteria(R) right lower quadrant pain–suspected appendicitis. J Am Coll Radiol. 2011;8(11):749–755.

13. Israel GM, Malguria N, McCarthy S, et al. MRI vs. ultrasound for suspected appendicitis during pregnancy. J Magn Reson Imaging. 2008;28(2):428–433.

14. Lehnert BE, Gross JA, Linnau KF, Moshiri M. Utility of ultrasound for evaluating the appendix during the second and third trimester of pregnancy. Emerg Radiol. 2012;19(4):293–299.

15. Vu L, Ambrose D, Vos P, et al. Evaluation of MRI for the diagnosis of appendicitis during pregnancy when ultrasound is inconclusive. J Surg Res. 2009;156(1):145–149.

16. Long SS, Long C, Lai H, Macura KJ. Imaging strategies for right lower quadrant pain in pregnancy. AJR Am J Roentgenol. 2011;196(1):4–12.

17. Furey EA, Bailey AA, Pedrosa I. Magnetic resonance imaging of acute abdominal and pelvic pain in pregnancy. Top Magn Reson Imaging. 2014;23(4):225–242.

18. Theilen LH, Mellnick VM, Longman RE, et al. Utility of magnetic resonance imaging for suspected appendicitis in pregnant women. Am J Obstet Gynecol. 2015;212(3):345 e341–346.

19. Hakkarinen DK, Banh KV, Hendey GW. Magnetic resonance imaging identifies acute hip fractures missed by 64-slice computed tomography. J Emerg Med. 2012;43(2):303–307.

20. Iwata T, Nozawa S, Dohjima T, et al. The value of T1-weighted coronal MRI scans in diagnosing occult fracture of the hip. J Bone Joint Surg Br. 2012;94(7):969–973.

21. Bretherton CP, Parker MJ. Early surgery for patients with a fracture of the hip decreases 30-day mortality. Bone Joint J. 2015;97-B(1):104–108.

22. Khurana B, Okanobo H, Ossiani M, et al. Abbreviated MRI for patients presenting to the emergency department with hip pain. AJR Am J Roentgenol. 2012;198(6):W581–588.