

# Efficacy of magnetic resonance imaging among pregnant patients diagnosed with acute abdomen in the emergency department

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## ABSTRACT

**Aims:** Diagnostic procedures are very important for fetal safety during pregnancy. Magnetic resonance imaging (MRI) is characterized by a higher accuracy rate compared to medical follow-up and post-surgical diagnoses. However, it is very important to use it at the right time in order to maintain cost-effectiveness of the technique. In this study, we aimed to determine the efficacy of MRI in pregnant patients admitted to the emergency department with acute abdominal pain when the etiology has not been defined by other techniques.

**Methods:** The data of pregnant patients who admitted to the emergency department due to acute abdominal pain between January 2013 and February 2018 were retrospectively analyzed. All these patients evaluated with pelvic magnetic resonance screening, as they could not be diagnosed by physical examination findings, laboratory tests, or ultrasonography. Diagnostic performance of MRI, sensitivity, specificity, and negative and positive predictive values were assessed.

**Results:** The etiology of the pain was detected in 29 of 57 patients who applied to the emergency department with acute abdominal pain and evaluated with pelvic MRI. The most common cause of acute abdominal pain was acute appendicitis which all of them histopathologically confirmed (n=14). Pelvic abscess, severe hydronephrosis, giant ovarian cyst, pyelonephritis, ovarian torsion, and uterine fibroid torsion were among other causes.

**Conclusion:** MRI is a highly effective imaging method for diagnosing both acute appendicitis and other pelvic emergencies. Therefore, it would be beneficial for the diagnosis in pregnant patients with acute abdominal pain.

**Keywords:** Acute abdominal pain, appendicitis, pregnant, magnetic resonance imaging

## INTRODUCTION

There are many causes of acute abdomen during pregnancy. The incidence of acute abdominal pain range from 1 in 500 to 1 in 635 pregnant women. Acute abdominal pain may be categorized as obstetric, non-obstetric, or gynecological. In order to make a differential diagnosis, a detailed patient history needs to be gathered, and patients should be evaluated in conjunction with the findings obtained from physical examinations and laboratory tests.

Diagnostic procedures are very important for fetal safety during pregnancy. Ultrasonography (US) should be preferred due to its non-invasive nature for patients presenting with acute abdominal pain.<sup>1</sup> However, the compressive effect of a growing uterus and the resulting displacement of intra-abdominal organs may cause US

to be an inadequate diagnostic technique.<sup>2</sup> Therefore, a normal US does not necessarily exclude acute abdomen among pregnant patients.

The inability to use techniques such as radiography and computed tomography (CT) routinely during pregnancy due to the risk of radiation exposure makes it difficult to achieve an accurate differential diagnosis.<sup>2</sup> When these techniques are used in such cases, the patient should be made aware of the cost-benefit analysis, and the amount of radiation to be administered should be carefully considered.<sup>3</sup>

In pregnancy, magnetic resonance imaging (MRI) is characterized by a higher accuracy rate compared to medical follow-up and post-surgical diagnoses.<sup>4</sup> MRI provides a detailed information of biological structures,

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and, like US, is a non-invasive imaging technique<sup>4</sup> MRI has also been shown to be useful in reducing rates of negative laparotomy and perforated appendicitis in pregnant patients with acute abdomen.<sup>5</sup>

In this study, we aimed to determine the efficacy of MRI in pregnant patients admitted to the emergency department (ED) with acute abdominal pain when the etiology has not been defined by other techniques.

## METHODS

The study was carried out with the permission of Kırıkkale University Non-interventional Clinical Researches Ethics Committee (Date: 07/11/2018, Decision No:2018.11.1). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

### Patients

MR images and data of pregnant patients who admitted to the ED with acute abdominal pain between January 2013 and October 2018 were retrospectively analyzed. Pregnant patients with acute abdominal pain who could not be diagnosed by physical examination, laboratory tests and US and therefore additionally pelvic MRI performed were included in this study. Patients with incomplete medical records and follow-up data and who did not undergo an MRI scan for diagnosis were excluded from the study. All patients' physical examination carried out by a general surgeon and an obstetrician. MRI images were evaluated by a radiologist with eight years of experience in that field.

### Imaging Technique

All patients evaluated by a 1.5 Tesla MRI device (Philips MRI Systems, Achieva Release 3.2 Level 2013-10-21, Philips Medical Systems Nederland B.V.) with a standardized protocol for pregnant patients. According to the protocol, sagittal, coronal, and axial turbo spin echo (TSE) T2, axial TSE T1, axial and coronal balanced fast field echo (BFFE), axial T1 and T2 SPIR, and axial diffusion-weighted imaging (DWI, b500-b1000) sequences were obtained.

The upper level of field of view (FOV) was set to the upper poles of the kidneys to include both kidneys. No oral contrast agent was administered during the examination. Intravenous contrast agent administered if the radiologist thought that it is going to significantly improve the diagnostic performance and also improve maternal and fetal outcome.

### Image Analysis

In MR images, an appendix calibration greater than 7 mm and the presence of T2 hyperintense fluid inside

the appendix lumen were considered signs of acute appendicitis. A thicker appendix wall - compared to those of other intestinal segments - and the presence of hyperintensities suggesting inflammation in both the appendix wall and adjacent mesentery, especially in the T2-weighted series were used as supporting criteria.

Increased ovarian volume with stromal inflammation was considered a sign of ovarian torsion.<sup>6</sup>

Hydronephrosis usually occurs as a result of the compression of ureter between the uterine and psoas muscle at the level of the sacral promontorium in pregnant. Ureteral stones were distinguished from hydronephrosis by observing the filling defects inside the ureter in the images obtained with the BFFE sequence.

Disorders like inflammatory bowel disease, diverticulitis, or obstruction recognized by observing hyperintensity in the bowel wall with a thickening in the fat-suppression T2-weighted series. Moreover, fistulae and abscesses as a result of complication of inflammation diagnosed by MRI.<sup>7</sup>

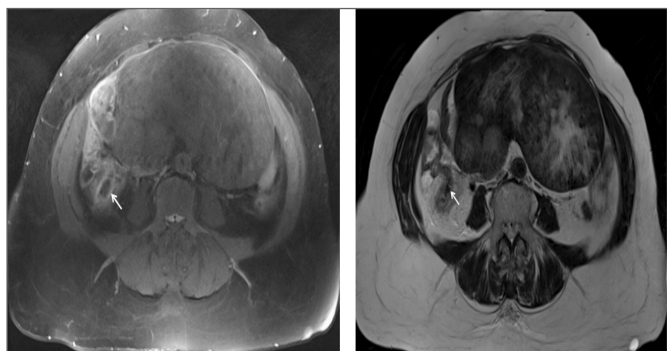
### Statistical Analysis

Descriptive statistic methods used for calculate positive and negative predictive values, categorical variables, and frequency calculations. The SPSS 20 (SPS Inc., Chicago, IL) software package was used for statistics of the study.

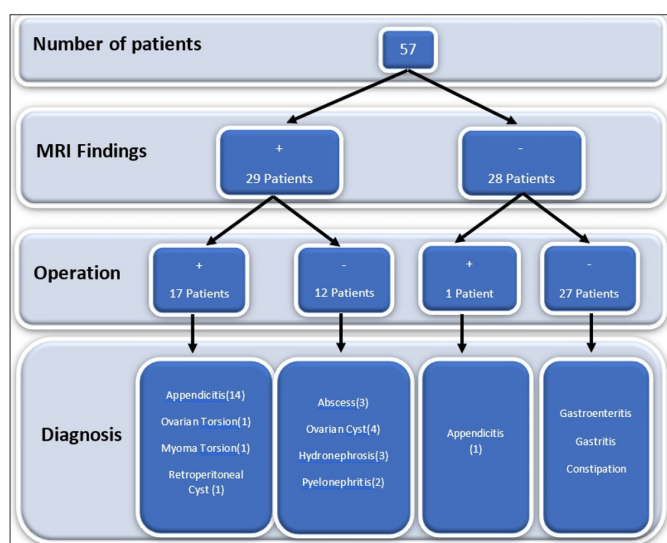
## RESULTS

Among the 65 pregnant patients who underwent pelvic MRI to define acute abdominal pain etiology, eight were excluded due to insufficient follow-up duration. The remaining 57 patients had a mean age of  $24.5 \pm 5.2$  (range 18-37) years. All patients evaluated with US before performing pelvic MRI. US revealed pericecal fat tissue edema in five patients and intra-abdominal free fluid in seven patients. The appendix could not be visualized by US in any patient.

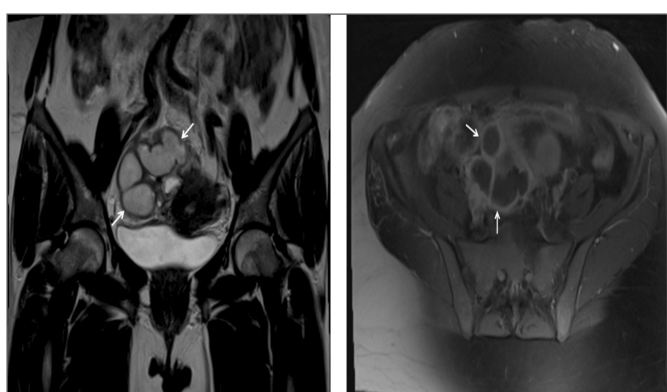
In 29 patients, MRI determined the cause of acute abdominal pain. Among these, the most common cause of acute abdominal pain was acute appendicitis (n=14) which all of them histopathologically confirmed (**Figure 1**). Two of the patients with acute appendicitis had perforated appendix and periappendicular abscess was observed in one of them. Three patients operated with the diagnosis of ovarian torsion, myoma torsion and retroperitoneal cyst (**Figure 2**). The remaining twelve patients whose abdominal pain etiology was determined by MRI, laboratory and physical examination had only medical treatment. Of these patients, 4 have giant ovarian cysts, 3 have marked hydronephrosis, 3 have PID and 2 have pyelonephritis (**Figure 3**).



**Figure 1.** Acute appendicitis. Axial, fat-suppressed contrast enhanced T1-weighted MR image shows an enlarged appendix with thickened and enhancing wall (A) (white arrow). Axial T2-weighted MR image shows a T2-hyperintense, enlarged appendix with an intraluminal T2 hypointense dot represents appendicolith (B) (white arrow).



**Figure 2.** The flow chart shows the distribution of patients according to their MRI findings, operation, and diagnosis.



**Figure 3.** Hydrosalpinx and tubo-ovarian abscess. Coronal T2-weighted MR image of the pelvis demonstrates a dilated, tortuous, right fallopian tube filled with T2 hyperintense content, representing hydrosalpinx (A) (white arrows). Axial coronal contrast-enhanced, fat-suppressed T1-weighted MR image of pelvis shows a peripheral rim enhancement after contrast administration (B) (white arrows).

In 28 patients, the cause of abdominal pain could not be determined by MRI. 27 patients were discharged after regression of clinical findings. One patient who remained undiagnosed by radiological studies and whose clinical findings did not improve underwent a diagnostic laparotomy. Laparoscopic appendectomy procedure was

performed to the patient and the diagnosis of appendicitis was confirmed histopathologically.

Mean appendix diameter measured on MRI sections was measured as  $9.7 \pm 2.9$  mm (range 7-15 mm) in patients with acute appendicitis, and  $5 \pm 0.3$  mm (range 5-6) in rest of the patients. In 64% of acute appendicitis cases, the patients were in the second trimester of pregnancy. Appendix diameters and trimester information measured on MR images of patients operated for acute abdomen are summarized in **Table 1**.

Table 1. Diagnoses, appendix diameters, and trimesters of operated patients			
Patients	Diagnoses	Appendix diameter (mm)	Trimester
1	Appendicitis	15	3
2	Appendicitis	12	2
3	Appendicitis	13	2
4	Appendicitis	8	2
5	Appendicitis	9	2
6	Appendicitis	10	2
7	Appendicitis	7	2
8	Appendicitis	9	1
9	Appendicitis	15	2
10	Appendicitis	7	1
11	Appendicitis	7.5	1
12	Appendicitis	8	2
13	Appendicitis	8	2
14	Appendicitis	8	3
15	Ovarian torsion	5	2
16	Myoma torsion	Not visualized	2
17	Retroperitoneal cyst	Not visualized	2

The negative predictive value of MRI for detecting acute appendicitis was 75% (95% CI 21-98) and positive predictive value was 100% (95% CI 73-100). Sensitivity and specificity were 93% (95% CI 66-99) and 100% (95% CI 30-100.0), respectively. The negative predictive value of MRI for detecting pelvic pathologies was 96% (95% CI 79-99) and positive predictive value was 100% (95% CI 85-100). Sensitivity and specificity were 96% (95% CI 80-99) and 100% (95% CI 84-100), respectively.

No complications, including allergic reactions, were observed in patients given contrast agent.

### DISCUSSION

Gray scale US is the most commonly used imaging tool for pregnant admitted to the ED with abdominal pain.<sup>8</sup> Being non-invasive, safe, and easy to use make the US technique superior to other imaging methods. However, operator dependency and poor image quality due to obesity and abdominal gas are major limitations.<sup>1</sup> MRI allows cross-sectional imaging without exposing patients to the radiation, as well as diagnosing fetal and maternal disorders in pregnant patients.<sup>9</sup>



Acute appendicitis is the most common non-obstetric condition requiring surgery in pregnancy.<sup>8</sup> The effectiveness of the ultrasonography method in showing the appendix for the diagnosis of acute appendicitis has a wide range. In a study by Lim et al.<sup>10</sup> of 45 pregnant subjects with suspected appendicitis, US was 100% sensitive and 96% specific, with only three patients (7%) remaining undiagnosed by US. Zhang et al.<sup>11</sup> in a series of 65 cases, reported that US was able to make a diagnosis of appendicitis in 26 patients (40%). MRI is a good alternative to US when the latter is non-diagnostic in pregnant patients. It may not be easy to separate normal appendix from other intestinal segments. But the inflammation of appendix makes it more visible on MRI section which is very sensitive method to detect the hydrogen molecules. Pedrosa et al.<sup>12</sup> reported the rate of evaluation of the appendix separately from other intestinal segments on an MRI was 10%, while we reported as 42.1% in this study. Our study revealed a high specificity, sensitivity, and positive predictive value for appendicitis (100%, 93%, and 100%, respectively).

Acute appendicitis may occur in every trimester. Some studies have reported a higher prevalence in the third trimester.<sup>11,13</sup> Our study also demonstrated that it was most common in the second trimester, followed by the third and first trimesters.

The difficulty of diagnosing acute appendicitis results from a higher negative laparotomy rate in pregnant women than non-pregnant women. There is no difference between negative laparotomy and an appendectomy procedure performed early in pregnancy, with respect to the risk of preterm labor, and both impose minimal risk on the mother and the fetus. Therefore, a diagnosis must be made as quickly as possible.<sup>13</sup> In our study, no patient underwent a negative laparotomy procedure.

It is well understood that appendix perforation is more common in pregnant women than the normal population.<sup>14</sup> This may be due to the delayed hospital admission of pregnant women, attribution of their symptoms to pregnancy, and the absence of specific signs and symptoms associated with acute appendicitis. A delay of surgery for 24 hours increases the risk of perforation from 0% to 66%. While maternal mortality is 0.1% in unperforated cases, it rises to 4% when perforation occurs.<sup>13</sup> Perforation and abscess formation significantly increase the fetal mortality. The rate of fetal loss is 3-5% in acute appendicitis, and 26-30% in cases with complications.<sup>13</sup> In our study, two patients had perforation, one of whom also had an abscess. Maternal or fetal mortality did not occur in those patients.

MRI allows us to make a variety of diagnoses apart from appendicitis in patients with acute abdominal pain.

Some patients may have rare causes of acute abdomen.<sup>15</sup> In a study, the rate of making a clinical diagnosis of appendicitis or other causes of acute abdominal pain in pregnant patients with MRI was reported to be 43%.<sup>16-18</sup> In our study, apart from the 14 patients diagnosed with appendicitis, three patients had an abscess, four had severe hydronephrosis, four had a giant ovarian cyst, two had pyelonephritis, and two had torsion. Ovarian torsion is present in 2-3% of all gynecological emergencies.<sup>19,20</sup> Therefore, it is a great advantage that pathologies other than appendicitis which cause pelvic pain in pregnant patients with pre-diagnosis of acute appendicitis can be detected with MRI technique.

The retrospective design and limited number of patients were the main limitations of the study. There is a need for prospectively designed study with larger patient population.

## CONCLUSION

MRI is a valuable examination tool for making a diagnosis in pregnant patients presenting with acute abdomen. It is highly effective for diagnosing both acute appendicitis and non-appendicitis pelvic emergencies.

## ETHICAL DECLARATIONS

**Ethics Committee Approval:** The study was carried out with the permission of Kırıkkale University Non-interventional Clinical Researches Ethics Committee (Date: 07/11/2018, Decision No: 2018.11.1).

**Informed Consent:** Because the study was designed retrospectively, no written informed consent form was obtained from patients.

**Referee Evaluation Process:** Externally peer-reviewed.

**Conflict of Interest Statement:** The authors have no conflicts of interest to declare.

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**Author Contributions:** All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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