

## MRI a Diagnostic Tool in Acute Appendicitis with Pregnancy

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### Abstract

**Introduction:** Acute appendicitis with pregnancy is a crucial and critical issue requiring definite diagnostic tools to avoid unnecessary surgical interventions jeopardizing maternal and fetal clinical statuses. MRI in conjunction with other investigational tools could be implemented as a useful investigation in the management protocol in those categories of patients.

**Aim of the Work:** To access and evaluate MRI usage and implementation as an imaging diagnostic tool in conjunction with routine laboratory work up in diagnosing acute appendicitis with pregnancy.

**Methodology:** The current research study is a retrospective clinical trial that was performed on 26 pregnant cases with query appendicitis during the research study period from January 2012 to May 2017.

**Results:** MRI definite diagnosis of appendicitis was precise in predictability of surgical diagnosis of appendicitis (with a statistical sensitivity of 23.5%, a statistical specificity of 100%, an infinite positive likelihood ratio and a negative likelihood ratio of 0.77).

**Conclusions:** MRI is a highly valuable tool to avoid unnecessary laparotomy in acute appendicitis with pregnancy however future research should be multicentric in fashion with larger numbers of cases to implement future guidelines innovation to enhance clinical services to those categories of cases suffering query appendicitis issues with pregnancy.

### Introduction

Acute abdominal pain with pregnancy is a common challenging cases scenario in every day clinical practice particularly due to nonspecific signs and symptoms such as vomiting, colics, fever however in pregnancy anatomical changes associated add to the clinical and surgical challenges. The most common extrauterine illness associated with pregnancy that requires urgent surgical intervention is acute appendicitis with pregnancy.

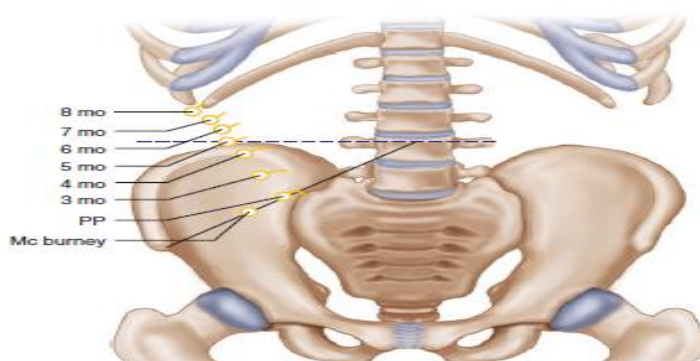
On the other hand, the zone of tenderness and rebound tenderness is altered due to anatomical changes and the clinical presentation is nonspecific, even investigational tools are usually in conclusive such as total leucocytic count due to physiological changes of pregnancy. Gastrointestinal anatomical changes are, due to physical displacement of intra-abdominal structures by the gravid uterus. Taking this anatomical fact in consideration operative intervention

for acute appendicitis requires a modified incision location [1-3].

Thorough knowledge of differential diagnosis and clinical algorithmic guidelines for management of those cases is crucial to minimize misdiagnosis and unrequired surgical intervention that increases the medical and surgical possibilities of complications jeopardizing the maternal and fetal wellbeing. However, once diagnosis of acute appendicitis is established the surgical intervention could be the cornerstone lifesaving interventional procedure to avoid perforation and generalized peritonitis issues. Imaging investigational tools are having a superiority and conjunctive play role to laboratory tools such as sonography and MRI due to absence of ionizing radiation and its possible teratogenic issues and sequelae therefore various practitioners prefer their performance over CT

scan that carries possible hazard in pregnant cases with acute appendicitis [4-6].

Interestingly the cases of acute appendicitis with pregnancy carry an elevated complication risk such as perforation therefore requires highly skilled and professional management and surgical intervention protocols and management to avoid unnecessary and hazardous diagnostic delay. MRI has gained popularity to accomplish the possible diagnosis of acute appendicitis with pregnancy and have to be implemented in harmony with other laboratory and clinical data available for the physician and those cases usually require multidisciplinary management to achieve optimal clinical outcomes from the general surgeon, obstetrician and radiologist to reach a proper diagnostic and management plan [7-9].



Furthermore, Magnetic MRI has become more popular in assessment and evaluation clinical management pathway of pregnant cases with acute abdominal pain cases scenarios. MRI supplies a multi-planar image with outstanding soft-tissue contrast resolution without the hazardous issue of fetal exposure to ionizing radiation, besides The American College of Radiology supports MRI usage for diagnostic issues in pregnant patients at any gestational trimester. As in cases of suspecting acute appendicitis in pregnant cases, MRI could be performed as a preliminary diagnostic tool or after performance of sonography in which the sonographic results are inconclusive [10-12].

To evaluate and assess the effectiveness and sensitivity levels of MRI investigational tools in acute appendicitis diagnosis.

## Methodology

This study was carried out in Saudi Arabia, in Jeddah at a private hospital (Bugshan Hospital) for a period starting from January 2012 to May 2017.

This study is a retrospective clinical trial that was performed on 26 pregnant cases with query appendicitis.

The following research data were obtained from the patient's records: the age, parity, gestational age, location of pain, TLC, CRP values and besides the diagnosis of appendicitis obtained by MRI, and surgical diagnosis of appendicitis. Data were obtained to analyze the diagnostic accuracy of laboratory and MRI as an imaging tools in diagnosis of acute appendicitis. All pregnant subjects who underwent non-enhanced appendix MRI in suspicion of acute appendicitis during the research study, were provided with an informed consent after receiving a full explanation of the nature and protocol of the study.

## Statistical analysis

Inferential analyses were done for quantitative variables using independent t-test in cases of two independent groups, ANOVA test for more than two independent groups with post hoc Tukey's test. In qualitative data, inferential analyses for independent variables were done using Chi square test for differences between proportions and Fisher's Exact test for variables with small expected numbers. Logistic regression was done for factors affecting clinical and completed first trimester pregnancy among the studied cases. The level of significance was taken at P value < 0.050 is significant, otherwise is non-significant.

## Results

A total of 26 pregnant women with suspected appendicitis were included in the current study.

Age (years)	
Range	22-34
Mean ± SD	28.81 ± 3.88
Parity	
Range	0-3
Median (IQR)	1 (0-2)
Gestational Age (weeks)	
Range	11.57-28.71
Mean ± SD	20.52 ± 4.80
Location of Pain	
Right Lower Quadrant	11 (42.3%)
Suprapubic	8 (30.8%)
Periumbilical	7 (26.9%)
SD standard deviation IQR interquartile range Data presented as range, mean ± SD; range, median (IQR); or frequency (percentage)	

**Table 1:** Initial Characteristics of Included Women.

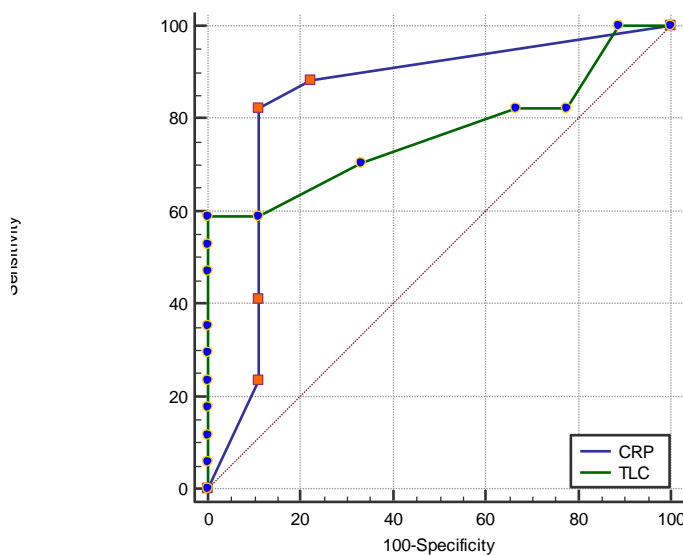
The mean age of included women was 28.81 ± 3.88 years (range: 22 – 34 years). The median parity was 1 (range: 0 – 3; IQR: 0-2). The mean gestational age was 20.52 ± 4.8 weeks (range: 11.57 ± 28.71 weeks). Of the included 26 women, 11 (42.3%) had the presenting pain located at the right lower quadrant of abdomen, 8 (30.8%) had it located in the suprapubic region, while 7 (26.9%) in the Periumbilical region (table-1).

TLC (x 1,000/cm <sup>3</sup> ) Range Mean ± SD	6.3-18.4 10.13 ± 2.97
CRP (mg/dl) Range Median (IQR)	0-24 12 (0-18)
MRI Diagnosis of Appendicitis Definite Diagnosis Probable Diagnosis No Diagnosis	4 (15.4%) 14 (53.8%) 8 (30.8%)
Surgical Diagnosis of Appendicitis Yes No	17 (65.4%) 9 (34.6%)
TLC total leucocytic count CRP c-reactive protein MRI magnetic resonance imaging SD standard deviation IQR interquartile range Data presented as range, mean ± SD; range, median (IQR); or frequency (percentage)	

**Table 2:** Diagnosis and Diagnostic Investigations of Appendicitis in Included Women.

The mean TLC in included women was 10.13 ± 2.97 (x1,000 per mm<sup>3</sup>) (range: 6.3 - 18.4). The median CRP was 12 mg/dl (range: 0 - 24; IQR: 0 - 18). Of the included 26 women, 4 (15.4%) had a definite MRI diagnosis of appendicitis, 14 (53.8%) had a probable MRI diagnosis of

appendicitis, while 8 (30.8%) had an MRI exclusion of the diagnosis of appendicitis. Of the included 26 women, 17 (65.4%) had a definite diagnosis of appendicitis on laparotomy/laparoscopy, while 9 (34.6%) had no appendicitis on laparotomy/laparoscopy (table-2).



**Figure 1:** ROC Curves for Predictive Value of TLC and CRP in Diagnosis of Appendicitis in Included Women.

TLC: AUC = 0.768, 95% CI (0.562 to 0.909), p=0.004  
 CRP: AUC = 0.840, 95% CI (0.644 to 0.953), p<0.001  
 AUC Difference = 0.072, 95% CI (-0.149 to 0.293), p=0.524  
 TLC total leucocytic count  
 CRP c-reactive protein  
 AUC area under the curve

Receiver operator characteristics (ROC) curves were constructed for estimating the value of TLC and CRP in prediction of definite surgical diagnosis of appendicitis. Both TLC and CRP showed significant predictability [AUC = 0.768, 95% CI (0.562 to 0.909), p=0.004; and 0.840, 95% CI

(0.644 to 0.953), p<0.001; respectively]. Although the AUC for CRP was larger than that for TLC; the difference was not statistically significant [AUC Difference = 0.072, 95% CI (-0.149 to 0.293), p=0.524] (figure-1).

	<b>Sensitivity</b>	<b>Specificity</b>	<b>LR+</b>	<b>LR-</b>
TLC ≥ 10.3 (x 1,000/mm <sup>3</sup> )	52.9% (27.8 to 77.0)	100% (66.4 to 100)	∞	0.47 (0.3 to 0.8)
CRP ≥ 6 mg/dl	82.4% (56.6 to 96.2)	88.9% (51.8 to 99.7)	7.41 (1.2 to 47.7)	0.66 (0.4 to 1.0)
MRI Diagnosis (Definite)	23.5% (6.8 to 49.9)	100% (66.4 to 100)	∞	0.77 (0.59 to 1.0)
MRI Diagnosis (Definite/Probable)	88.9% (65.3 to 98.6)	87.5% (47.4 to 99.7)	7.1 (1.1 to 44.9)	0.13 (0.03 to 0.5)
TLC ≥ 10.3 (x 1,000/mm <sup>3</sup> ) plus CRP ≥ 6 mg/dl plus MRI Diagnosis (Definite/Probable)	58.8% (32.9 to 81.6)	100% (66.4 to 100)	∞	0.41 (0.23 to 0.73)
TLC total leucocytic count CRP c-reactive protein MRI magnetic resonance imaging LR+ positive likelihood ratio LR- negative likelihood ratio ∞ positive infinity Data presented as value (its 95% confidence interval)				

**Table 3:** Diagnostic Accuracy of TLC and CRP in Diagnosis of Appendicitis.

According to these ROC curves, the best cutoff value for TLC to specifically diagnose appendicitis in included women was ≥ 10.3 x 1,000 per mm<sup>3</sup> (with a sensitivity of 52.9%, a specificity of 100%, an infinite LR+ and an LR- of 0.47); while the best cutoff value for CRP specifically diagnose appendicitis in included women was ≥ 6 mg/dl (with a sensitivity of 82.4%, a specificity of 88.9%, an LR+ of 7.41 and an LR- of 0.66) (table-3). An MRI definite diagnosis of appendicitis was accurate in prediction of surgical diagnosis of appendicitis (with a sensitivity of 23.5%, a specificity of 100%, an infinite LR+ and an LR- of 0.77) (table-3). An MRI definite/probable diagnosis of appendicitis was accurate in prediction of surgical diagnosis of appendicitis (with a sensitivity of 88.9%, a specificity of 87.5%, an LR+ of 7.1 and an LR- of 0.13). When TLC (≥ 10.3 x 1,000 per mm<sup>3</sup>) and CRP (≥ 6 mg/dl) were added to the definite/probable MRI diagnosis raised the specificity of 100% and the LR+ to infinity (table-3).

## Discussion

Pregnant cases are often a fear-inducing cases scenario for the general surgeon. This category of cases represents a unique and a complex challenge, in which surgical decisions have the impact in a direct manner on two lives. There are various crucial anatomic and physiologic changes in the pregnant case, and those changes affect every organ and

system. Those normal physiologic and anatomical changes should be put in consideration with emergency general surgical conditions such as acute appendicitis which is the most frequent surgical condition in pregnant cases representing around 25% of all non-obstetric surgical interventional procedures in pregnant cases, with an equal prevalence in the three gestational trimesters. However, this population does have a higher rate of perforated appendicitis, which correlates with an increased maternal and fetal morbidity and mortality [13,14].

Imaging investigations have become cornerstone tools than before in making specific diagnosis of acute abdominal pain in pregnant women. MRI is the most precise diagnosis tool to discriminate acute surgical conditions for pregnant cases complaining of acute abdominal pain [15].

In the current research study, the following findings were revealed the mean age of included women was 28.81 ± 3.88 years (range: 22 – 34 years). The median parity was 1 (range: 0 – 3; IQR: 0 – 2). The mean gestational age was 20.52 ± 4.8 weeks (range: 11.57 ± 28.71 weeks). Of the included 26 women, 11 (42.3%) had the presenting pain located at the right lower quadrant of abdomen, 8 (30.8%) had it located in the suprapubic region, while 7 (26.9%) in the Periumbilical region. The mean TLC in included women was 10.13 ± 2.97 (x1,000 per mm<sup>3</sup>) (range: 6.3 – 18.4). The

median CRP was 12 mg/dl (range: 0 – 24; IQR: 0 – 18). Of the included 26 women, 4 (15.4%) had a definite MRI diagnosis of appendicitis, 14 (53.8%) had a probable MRI diagnosis of appendicitis, while 8 (30.8%) had an MRI exclusion of the diagnosis of appendicitis. Of the included 26 women, 17 (65.4%) had a definite diagnosis of appendicitis on laparotomy/laparoscopy, while 9 (34.6%) had no appendicitis on laparotomy/laparoscopy.

Receiver operator characteristics (ROC) curves were constructed for estimating the value of TLC and CRP in prediction of definite surgical diagnosis of appendicitis. Both TLC and CRP showed significant predictability [AUC = 0.768, 95% CI (0.562 to 0.909),  $p=0.004$ ; and 0.840, 95% CI (0.644 to 0.953),  $p$  value  $<0.001$ ; consecutively]. Although the AUC for CRP was larger than that for TLC; the difference was not statistically significant [AUC Difference = 0.072, 95% CI (-0.149 to 0.293),  $p$  value=0.524].

Furthermore according to the current research study ROC curves, the best cutoff value for TLC to specifically diagnose appendicitis in recruited cases was  $\geq 10.3 \times 1,000$  per  $\text{mm}^3$  (with a statistical sensitivity of 52.9%, a statistical specificity of 100%, an infinite positive likelihood ratio and an negative likelihood ratio of 0.47); whereas the best cutoff value for CRP specifically diagnose appendicitis in recruited cases was  $\geq 6$  mg/dl (with a sensitivity of 82.4%, a specificity of 88.9%, an positive likelihood ratio of 7.41 and an negative likelihood ratio of 0.66). Interestingly an MRI definite diagnosis of appendicitis was precise in predictability of surgical diagnosis of appendicitis (with a statistical sensitivity of 23.5%, a statistical specificity of 100%, an infinite positive likelihood ratio and a negative likelihood ratio of 0.77).

Finally, in the current research study results an MRI definite/probable diagnosis of appendicitis was accurate in predictability of surgical diagnosis of appendicitis (with an estimated sensitivity of 88.9%, an estimated specificity of 87.5%, an LR+ of 7.1 and an LR- of 0.13). As total leucocyte count ( $\geq 10.3 \times 1,000$  per  $\text{mm}^3$ ) and CRP ( $\geq 6$  mg/dl) were added to the definite/probable MRI diagnosis raised the statistical specificity of 100% and the LR+ to infinity.

A prior research study like the current research in methodology and aim study results revealed and displayed that pregnant cases that have undergone MRI imaging investigation in cases susceptible to have acute appendicitis turned out to have both surgical and non-surgical conditions. The research team in addition revealed that acute appendicitis was the most frequent surgical disease followed by ovarian torsion. On the other hand, their research findings revealed that red degeneration of uterine fibroid was the most common non-surgical condition after that obstructive hydronephrosis of the right kidney MRI disadvantages are usually due to elevated costs in comparison to sonographic examination and requires

skilled and experienced radiologists and not possible for cases having claustrophobia [1,3,16].

Researchers in prior research studies didn't observe any harmful impact of MRI usage on the fetus, MRI deposits ahead form of energy in the cases. In prior experimental animal research studies, decreased fetal crown-rump length and raised risk of ophthalmic malformations were revealed and displayed after exposure to MRI consequently, it is unnecessary MRIs should be avoided during gestation, especially during the first gestational trimester [2,4,7,9].

Rate of negative appendectomy of pregnant cases is reported to be around 25%–36%, and this rate is statistically significantly higher in pregnant females in comparison to non-pregnant females (36% versus 14%;  $P$  value  $<0.05$ ). Negative appendectomy was revealed and displayed in 1 out of 13 cases (7.7%) in a prior research study. Therefore, MRI could decrease unnecessary laparotomies [5,8].

Prior research groups of investigators reported the MRI sensitivity for diagnosis of acute appendicitis to be 100%. Furthermore, other investigators as regards MRI in diagnosis of acute appendicitis revealed and displayed a statistically estimated sensitivity, specificity, Positive predictive value, and negative predictive value as 90%, 98.1%, 81.8%, and 99.1%, consecutively.

Another prior research study like the current study in approach and methodology revealed a statistical sensitivity, specificity, PPV, and NPV and accuracy of MRI for acute appendicitis diagnosis in the pregnant cases as 100%, 91.2%, 80%, 100% and 93.5%, consecutively. Additionally, MRI should be considered as a primary imaging tool in pregnancy particularly if sonographic data are inconclusive. Another research study was conducted on twenty-nine cases that have under gone appendix MRI imaging procedure after inconclusive sonographic findings the following results were revealed in which MRI studies delineated normal appendix in 18 cases (62.1%) with inconclusive or no visualization of the appendix on sonographic examination. Among the 29 pregnant cases that had inconclusive findings on sonographic examination, 22 cases (75.9%) could avoid unnecessary laparotomies [10,12,13].

Another group of investigators concluded that early utilization of MRI in conjunction with laparoscopic approach should be considered in pregnant cases with query appendicitis. Besides they revealed and displayed by their research study results that the best cutoff values to predict the acute surgical conditions were as follows: WBC  $\geq 11,000/\text{mm}^3$ , neutrophil  $\geq 79.9\%$ , CRP  $\geq 1.82$  and bilirubin  $\geq 0.66$  mg/dL [11,15].

## Conclusions and recommendations for future research

MRI is a valuable diagnostic tool in pregnant cases with acute appendicitis query diagnosis, however the anatomical changes that occur in the gastro intestinal system with racial and ethnic variabilities that could affect the imaging results, consequently future research clinical trials should consider racial and ethnic differences with variabilities in BMI categories by larger sample sizes and multicentric fashion in research .That would aid and enlighten future implementation of clinical guidelines about MRI investigational tool in cases with acute appendicitis with pregnancy aiding in reduction of unnecessary laparotomies due to misdiagnosis.

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