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Review Article

**REVIEWING THE ROLE OF MRI IN DIAGNOSIS OF  
APPENDICITIS DURING PREGNANCY**

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**Abstract:**

**Background:** Acute appendicitis is considered as one of the most common causes of abdominal emergencies. In pregnant women, appendicitis mostly occur in the second trimester. During pregnancy and as a result of uterus enlargement there will be alteration in maternal body habitus and organ displacement which makes the clinical evaluation of pregnant patient's challenging. Reviewing the recent publications regarding appendicitis diagnosis and evaluation in pregnant women is important in order to provide better outcomes for the patients.

**Objective:** In this study, we aimed at evaluating the role of MRI in diagnosis of appendicitis during pregnancy and provide a paper that summarize the recent publication.

**Methods:** PubMed database were used for articles selection. All relevant articles related to our review were chosen to cover the following topics: MRI, Evaluation of Appendicitis during Pregnancy, and Diagnosis. We excluded other articles, which are not related to our objectives.

**Conclusion:** Appendicitis is the most common indication for non-gynecologic surgery during pregnancy. Yet, the clinical diagnosis of appendicitis in pregnancy is often delayed. Imaging studies play a major role in diagnosing suspected appendicitis in the general population, as well as in pregnancy. Multiple studies demonstrated that MRI has high sensitivity and specificity for the diagnosis of acute appendicitis during pregnancy. MRI is suggested to be first-line modality in centers that provide 24-h MRI coverage because of its efficacy and its advantage over ultrasound performance in diagnosing acute appendicitis in pregnant women.

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**INTRODUCTION:**

Acute appendicitis is considered as the most common non- obstetric cause of abdominal pain and an emergency surgery indication in pregnant women, with a prevalence of 500- 2000 pregnancies (1). In pregnant women, as a result of uterus enlargement there will be alteration in maternal body habitus and organ displacement which makes the clinical evaluation of pregnant patient's challenging, given the wide range of differential diagnoses both obstetric and non- obstetric (2). Acute appendicitis in pregnant women mostly occur in the second trimester and as uterus enlarge due to fetus growth, the appendix has the tendency to migrate superiorly in an atypical location (2).

Acute appendicitis during physical examination classically present with right lower quadrant tenderness, rebound, and guarding. In pregnant women, these signs may not be present. Also, symptoms such as nausea and vomiting and white blood cells elevation might be normal during pregnancy and deceive the physician clinical assessment (3).

As a consequence of acute appendicitis diagnosis difficulty in pregnant women the chances of appendiceal perforation has increased in compare to non- pregnant female (14–43% vs. 4–19%) (3). Also, as a result of delay appendicitis diagnosis in pregnant women the risk of fetal loss increased 0.5% for non-perforated appendicitis to 35-55% for perforated appendicitis (4). This significant increase in the incidence of fetal loss led the surgeons to embrace a low threshold for surgical intervention, which led caused escalation in the number of negative appendectomy in compare to general population (3). However, negative appendectomy itself is also associated with increase in the risk of preterm birth and fetal loss (5).

In general, ultrasound is considered the first line modality of choice for evaluation of all patients suspected with appendicitis as it is widely available, inexpensive, and free of radiations. However, it is operator dependent and the results assessment can vary depends on the physician experience. In addition, we should take in consideration the change in position of pregnant women abdominal organs by

the enlarged uterus which makes the diagnosis very challenging even for experienced clinicians. Computed tomography (CT) scan may be used but it involve exposing the patients for a high rate of radiation, which is unfavorable for pregnant women (3). Magnetic resonance imaging (MRI) with contrast can be considered safe alternative, free of radiation, with excellent soft tissue multiple views for the diagnosis of acute appendicitis in pregnant women. In our review, we want to assess the role of MRI use in diagnosis of appendicitis, and compare its results with other modalities.

**METHODOLOGY:****Sample**

PubMed database was used for articles selection, and the following keys used in the mesh ((("Appendicitis/diagnosis"[Mesh] OR "Appendicitis/diagnostic imaging"[Mesh]) AND "Magnetic Resonance Imaging"[Mesh]) AND "Pregnancy"[Mesh]). A total of 69 articles were found, with further restriction by PubMed filters, and reviewing the articles titles and abstracts the final results were 11 articles. **Inclusion criteria**, the articles were selected based on the relevance to the project which should include one of the following topics, {Appendicitis, Diagnosis, Pregnancy, Magnetic Resonance Imaging}. **Exclusion criteria**, all other articles that did not have one of these topics as their primary end point, or repeated studies.

**Analysis**

No software was used to analyze the data. The data was extracted based on specific forms that contain (Title of the study, name of the author, Objective, Summary, Results, and Outcomes), these data were reviewed by the authors in order to evaluate the role of MRI for diagnosis of appendicitis during pregnancy.

**RESULTS:**

A total of 11 articles were enrolled in our review according to our inclusion and exclusion criteria. All of the enrolled studies were a retrospective cohort study. All of the study aimed for evaluation the role of MRI in diagnosis of appendicitis in pregnancy. The studies characteristics are shown in Table 1.

**Table 1: the 11 included studies.**

Study (year)	Study Design	Country	Participants (n)	Objective	Duration	Outcome and Conclusion
Burke et al. (2015)(6)	retrospective	USA & Canada	714	To determine the diagnostic performance of MRI in the diagnosis of acute appendicitis during pregnancy	5 years	MRI is useful and reproducible in the diagnosis of suspected acute appendicitis during pregnancy.
M. Burns et al. (2017)(7)	retrospective	Canada	71	To evaluate the performance of magnetic resonance imaging (MRI) for the diagnosis of appendicitis during pregnancy.	6 years	MRI is sensitive and highly specific for the diagnosis of appendicitis during pregnancy
D. Patel et al. (2017)(8)	Retrospective	Canada	42	To determine the diagnostic accuracy of MRI for detecting acute appendicitis in pregnancy	7 years	MRI is an excellent modality for excluding acute appendicitis in pregnant patients presenting with right lower quadrant pain.
Tsai et al. (2017)(9)	retrospective	USA	233	To determine the degree of interradiologist agreement between the MRI features of appendicitis during pregnancy, the outcomes associated with an indeterminate interpretation and the negative predictive value of non-visualization of the appendix.	13 years	The final impression by the two retrospectively reviewing radiologists of MR examinations performed for suspected appendicitis during pregnancy had near-perfect agreement. In patients where the appendix could not be visualized or in patients that were interpreted as indeterminate, no patients had acute appendicitis.

J. Konrad et al. (2015)(10)	retrospective	USA	140	To evaluate the sensitivity, specificity, and accuracy of ultrasound (US) as compared to MRI in pregnant patients with suspected appendicitis	2 years	Given the low likelihood of visualization of the appendix at US, the excellent accuracy of MRI and the ability of MRI to identify alternate diagnoses, we suggest that at certain institutions MRI may be considered a first-line imaging modality for pregnant patients of any GA with suspected appendicitis.
S. Al-Katib et al. (2016)(11)	retrospective	USA	58	To determine the clinical outcomes in cases of appendix nonvisualization with MRI in pregnant patients with suspected appendicitis and the implications of appendix nonvisualization for excluding appendicitis.	1 year	Despite only moderate level of interobserver agreement for appendix visualization, appendix nonvisualization on MRI in pregnant patients with suspected appendicitis confers a significant reduction in the risk of appendicitis compared to all comers.
Fonseca et al. (2014)(12)	retrospective	USA	79	To determine whether MRI in pregnant patients with suspected appendicitis improves outcomes, minimizes length of stay (LOS), and lowers hospital charges.	11 years	MRI in pregnant patients with suspected appendicitis does not affect clinical outcomes or hospital charges. It allows safe discharge from the emergency department and improves resource use.

Amitai et al. (2016)(13)	retrospective	Israel	49	To evaluate the contribution of abdominal MRI in the diagnosis of acute appendicitis among pregnant women.	6 years	Creation of an around-the-clock imaging service using abdominal MRI with the establishment of a workflow chart using a dedicated MR protocol is feasible. It provides a safe way to rule out appendicitis and to avoid futile surgery in pregnant women.
Theilen et al. (2014)(14)	retrospective	USA	171	To estimate the rate and risk of appendix nonvisualization and alternative diagnoses made with MRI for suspected appendicitis in pregnant women.	5 years	MRI yields a high diagnostic rate and accuracy in pregnant women with suspected appendicitis and provides alternative diagnoses to guide further management.
Shin et al. (a2017)(15)	retrospective	Republic of Korea	125	To evaluate the diagnostic value of the T1 bright appendix sign for the diagnosis of acute appendicitis in pregnant women.	7 years	The T1 bright appendix sign is a specific finding for the diagnosis of a normal appendix in pregnant women with suspected acute appendicitis.
Shin et al. (b2017)(16)	retrospective	Republic of Korea	155	To investigate the optimal MRI protocol in pregnant women suspected of having acute appendicitis.	7 years	Diagnostic performance of MR in pregnant patients with suspected appendicitis can be preserved with omission of sagittal or both coronal and sagittal SSH-T2WI.

**DISCUSSION:**

Abdominal pain due to obstetric or non-obstetric causes is a common presenting symptom of the pregnant population. Non-obstetric causes of abdominal pain range from self-limiting diseases, such as mild enteritis, to devastating conditions that need prompt surgical intervention, such as perforated appendicitis (17). Appendicitis is a significant health concern during pregnancy, and it is the most common indication for non-gynecologic surgery during pregnancy. Yet, the clinical diagnosis of appendicitis in pregnancy is often delayed. For the reason that acute appendicitis during pregnancy is known to have an unspecific clinical presentation, particularly close to term, due to a change in physiological and anatomical constitution. With this delay, it is not a surprise that the incidence of perforated appendicitis is higher in pregnant patients. The patient impact and medicolegal implications are tremendous as the risk of fetal loss in cases of ruptured appendicitis in pregnancy is up to 24% (1-2-10).

Imaging studies play a major role in diagnosing suspected appendicitis in the general population, as well as in pregnancy. According to the recent appropriateness criteria published by the American College of Radiology (ACR), Ultrasonography (US) is recommended as the first line imaging modality for the evaluation of acute appendicitis in pregnant patients because it is widely available, relatively inexpensive, and lacks ionizing radiation (18). However, due to difficulty identifying the appendix particularly during pregnancy, the diagnostic performance of US may be limited by a restricted sonic window, shifts in the locations of organs, and operator dependency. The use of computed tomography (CT), which is used to evaluate appendicitis in the general population, is also limited because of the risk of fetal exposure to ionizing radiation, which can result in increasing the possibility of genetic damage. The potential

biological effects of in utero radiation exposure of a developing fetus include prenatal death, intrauterine growth restriction, small head size, mental retardation, organ malformation, and childhood cancer (19).

The Included studies evaluated the role of abdominal MRI in the diagnosis of acute appendicitis among pregnant women. They demonstrated that MRI has high sensitivity and specificity for the diagnosis of acute appendicitis during pregnancy (1-2-3-4-5-6-7-8-9-10-11). In (Burke et al.) paper, the Sensitivity, specificity, accuracy, positive predictive value, and negative predictive values of MRI in diagnosing acute appendicitis among pregnant women were 96.8%, 99.2%, 99.0%, 92.4%, and 99.7%, respectively as it is shown in figure 1 (6). The data of the included studies supports the use of MRI in the diagnosis of acute appendicitis during pregnancy despite the presence of contradicting theories that suggest MRI is harmful during pregnancy. However, there is no definite evidence that MR is harmful to the human fetus. Furthermore, in some of the studies, MRI was accurate in diagnosing acute appendicitis without antecedent ultrasonography in most cases and was able to diagnose alternative diagnoses in many patients, which suggests that MRI is an effective first-line modality, because as mentioned earlier, multiple studies have shown that US has limited ability for excluding acute appendicitis during pregnancy (16). In many studies, the appendix was not visualized sonographically in any of the cases. One the other hand and in US defense, US is an excellent test for excluding a gynecologic explanation for right lower quadrant pain and has the advantage of being widely available, portable, and radiation free. However, in centers that provide 24-h MRI coverage, an argument could be made for omitting the US and obtaining a fast-tracked MRI given that MRI has superior diagnostic ability for excluding acute appendicitis (8).

**Figure 1: Performance data of MRI in diagnosing acute appendicitis in pregnancy in (Burke et al.) paper.**

<b>Statistical analysis of all included patients</b>		
<b>Magnetic resonance image</b>	<b>Clinical/pathologic outcome<sup>a</sup></b>	
	<b>Acute appendicitis</b>	<b>No appendicitis</b>
Acute appendicitis	61	5
No appendicitis	2	641

<sup>a</sup> Positive predictive value, 92.4% (range, 83.2–97.5%); Negative predictive value, 99.7% (range, 98.9–99.9%); Sensitivity, 96.8% (range, 89–99.6%); Specificity, 99.2% (range, 98.2–99.8%); Accuracy, 99.0% (range, 98.0–99.6%).

*Burke. MRI of acute appendicitis in pregnancy. Am J Obstet Gynecol 2015.*

(Shin et al.) published a paper that tried to optimize MRI protocol in diagnosing acute appendicitis during pregnancy (15). In 2016, they evaluated the diagnostic value of the T1 bright appendix sign for the diagnosis of acute appendicitis in pregnant women. They found that the T1 bright appendix sign is a specific finding for the diagnosis of a normal appendix.

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