

# MAGNETIC RESONANCE IMAGING: A DIAGNOSTIC MODALITY FOR APPENDICITIS DURING PREGNANCY – AN APPRAISAL STUDY

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**Abstract:** Abdominal pain frequently represents a diagnostic challenge in an emergency clinical setting. Acute appendicitis tops the most common extra-uterine surgical emergency encountered during pregnancy. An accurate diagnosis of acute appendicitis is still uncertain due to the physical and physiological changes that occur during the course of pregnancy. Familiarity with reliable diagnostics may improve diagnostic accuracy and enable the quickest and most appropriate clinical management. When clinical examinations and ultrasound findings are inconclusive, Magnetic Resonance Imaging being highly sensitive and specific can be used as an alternate diagnostic entity for clinically suspected acute appendicitis in pregnant women. It is an excellent imaging technique with negative exposure of the fetus or the mother to ionizing radiation that pave a reliable option for pregnant patients with suspected acute appendicitis. A review appraisal on diagnostic techniques and accuracy of Magnetic Resonance Imaging for acute appendicitis during pregnancy is discussed in this article.

**Keywords:** Abdominal pain, Acute appendicitis, Pregnancy, Diagnostics, Magnetic Resonance Imaging.

## I. INTRODUCTION

Pregnancy is the period of life in which most of the pathologic symptoms may be supposed as physiologic changes. Hormonal changes cause nausea, vomiting, heartburn, gastro- esophageal reflux, and urethral dilatation in pregnancy [1]. Approach to patient with acute pain in right lower quadrant (RLQ) during pregnancy is a challenge as it has various causes including digestive, gynecological/obstetrical, and renal causes [2], [3].

Acute appendicitis (AA) is one of the most common non-obstetrical emergencies during pregnancy [4]. It is defined as an inflammation of the inner lining of the vermiform appendix that spreads to other parts which is caused by lymphoid hyperplasia of the appendiceal wall, foreign bodies, appendicolith, parasites, neoplasia and/or metastasis [5]. The classic clinical presentation of acute appendicitis including right lower quadrant pain, nausea, vomiting, fever, and leukocytosis, is confounded by normal changes in maternal physiology during pregnancy [6], [7]. On clinical examination, although moderate-to-severe tenderness in the right lower quadrant is a typical finding it is often not well defined. Diagnosis of AA becomes more apparent when inflammation has spread to the peritoneum, leading to diffuse abdominal tenderness together with guarding and rebound tenderness. Sudden onset of abdominal RLQ pain, changing location of the appendix from an enlarging uterus, nausea and vomiting from morning sickness or hyperemesis gravidarum, physiological fever and leukocytosis makes clinical diagnosis of appendicitis wandering in pregnancy. Acute appendicitis can occur at any time during pregnancy, most commonly during second trimester (45%) and 30% during first trimester and remaining 25% in third trimester [6], [8]. It can be summarized that the overall incidence of appendicitis being 0.15 to 2.10 per 1000 pregnancies. Appendicitis during pregnancy increases the morbidity and mortality rate of both the mother and fetus [5]. Anatomical shifting of the appendix by the enlarging uterus and physiologic changes of a woman during pregnancy makes the clinical and sonographic diagnosis difficult [9]. Early, accurate diagnosis followed by immediate treatment measures is essential to prevent perforation and thus minimize the risk of probable fetal and maternal death [9].

The systematic review and meta-analysis of all published studies since 2006 that evaluated the accuracy of Magnetic Resonance Imaging (MRI) as a diagnostic tool for acute appendicitis in pregnancy

concluded that MRI has a high sensitivity and specificity for the diagnosis of acute appendicitis, similar to that of previously reported Computed Tomography (CT) scan results. This appraisal study is established in order to consider MRI as a first line diagnostic tool for pregnant patients who presented with classic signs of acute appendicitis in the emergency department, for early identification and immediate treatment intervention to prevent further complications of the patient.

## II. DIAGNOSTIC IMAGING TECHNIQUES

Diagnosis of AA is clinically based on thorough history and physical examination. However, a rapid and reliable diagnosis of acute appendicitis during pregnancy impacts challenge because of the non-classical clinical presentation [3]. The complications of a perforated appendicitis carry a high risk rate of early delivery, miscarriage and maternal and/or fetal loss. As the gestational age increases, the accuracy of the diagnosis decreases and the likelihood of appendical perforation and other complications increase [2]. Without a classic clinical presentation of acute appendicitis, diagnosis is made very difficult and must be supported by imaging [8]. Ultrasound, CT, and MRI are the three main clinical imaging techniques commonly used in the diagnosis of acute abdominal pain [10].

### 2.1 Ultrasound

Since there is no exposure to ionizing radiation ultrasound (US) has long been considered the preferred imaging modality for the evaluation of acute appendicitis in pregnant women [11].



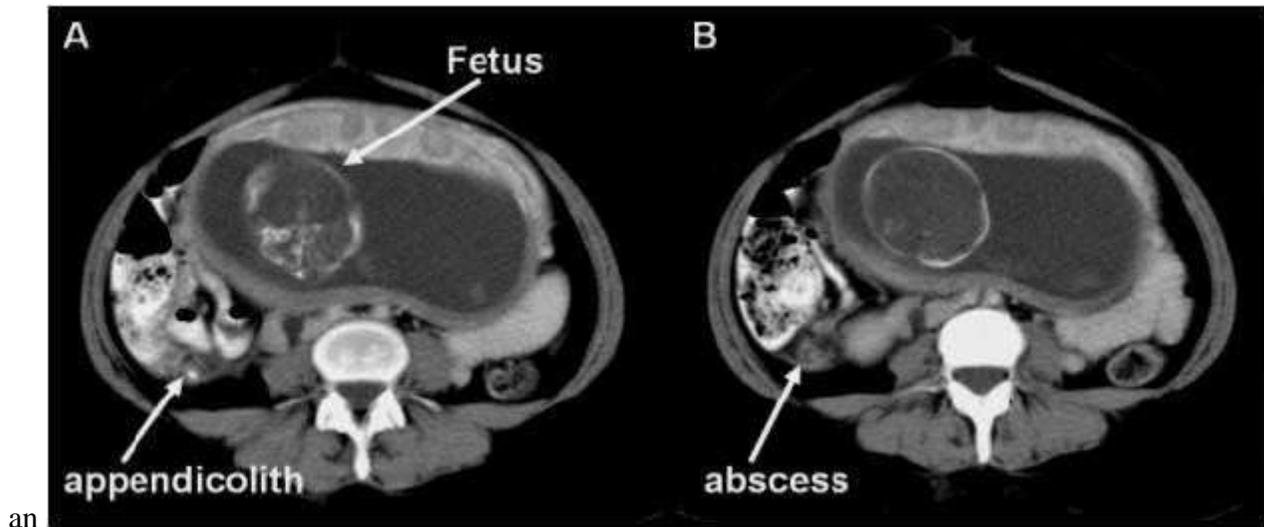
**Figure 1.** 24 years old women with 7 weeks age of gestation presents with nausea, vomiting and RLQ pain suggestive of acute appendicitis on ultrasound. (Available at <http://medicalechography.com/IMAGES/2N1/2N100006appendicitis-pregnancy-ultrasonography.jpg>. Webpage visited on 17/12/2020)

The main finding of appendicitis in US is the identification of a non-compressible, blind-ended tubular structure in the right lower quadrant, with a maximum diameter of lesion exceeding 6 mm [7] (fig. 1). Ultrasound is a rapid and inexpensive test that can be performed at the bedside and has no known safety-related contraindications [7]. However, ultrasonography is highly operator-dependent, its sensitivity and specificity is hindered by overweight, increased abdominal obesity or the presence of bowel gas.

### 2.2 COMPUTED TOMOGRAPHY (CT)

CT does not have the aforementioned limitations and has become the modality of choice for the workup of most patients with suspected acute appendicitis. It is widely available, rapid, and moderate in cost and operator independent. Inflammation of RLQ, a hollow elongated tubular structure and/or appendicolith/Fecalith marks the significant findings of appendicitis in CT scan [12] (fig. 2). CT is also highly effective for the evaluation of alternative diagnoses other than appendicitis [13]. However, CT scan expose the fetus to a considerable amount of ionizing radiation that may lead to risk of fetal teratogenicity

and a possible miscarriage or fetal loss especially in the first trimester which marks its limitation in its use.



**Figure 2.** CT scan finding of 28 weeks gestational women with acute appendicitis. (Available at: <https://images.app.goo.gl/EkAaLTPj1h8Zjgcs8>. Webpage visited on 17/12/2020)

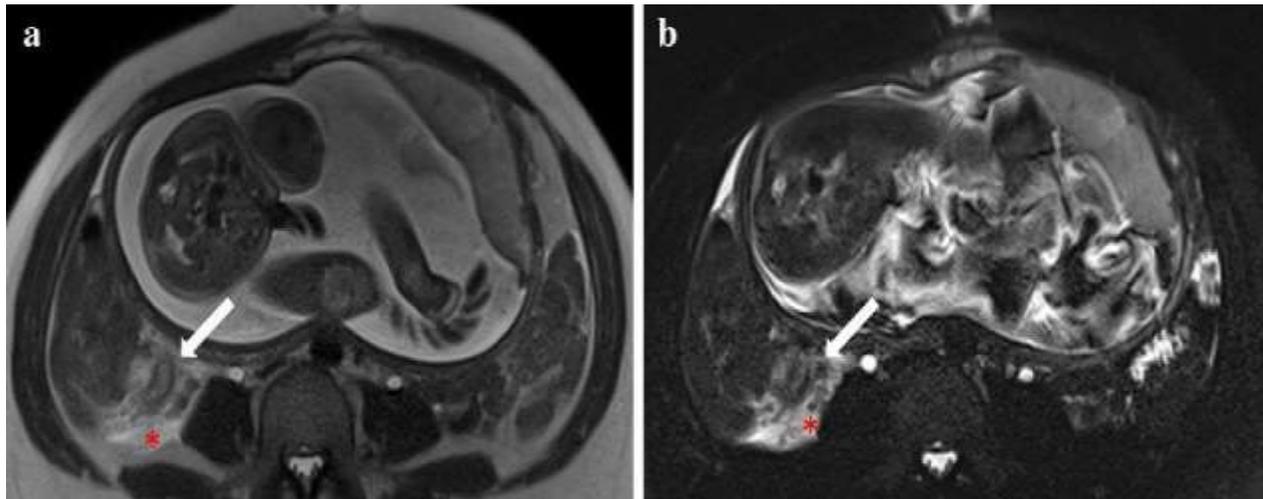
### 2.3 MAGNETIC RESONANCE IMAGING (MRI)

Abdominal MRI (fig. 3) appears to be alternate imaging modality [14]. MRI has recently become a relatively common investigation for acute abdominal pain in pregnancy.



**Figure 3.** MRI scan model (Available at: [https://www.google.com/url?sa=i&url=https%3A%2F%2Fgreaterwaterburyimagingcenter.org%2Fmri-safety-during.pregnancy%2F&psig=AOvVaw0FZqrBa\\_4pT30vTNSNY8Df&ust=1608391345474000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCMD Xib\\_r1-0CFQAAAAAdAAAAABAY](https://www.google.com/url?sa=i&url=https%3A%2F%2Fgreaterwaterburyimagingcenter.org%2Fmri-safety-during.pregnancy%2F&psig=AOvVaw0FZqrBa_4pT30vTNSNY8Df&ust=1608391345474000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCMD Xib_r1-0CFQAAAAAdAAAAABAY). Webpage visited on: 18/12/2020)

It offers the benefit of cross-sectional multiplanar images with excellent soft-tissue contrast resolution and without ionizing radiation or evidence of harmful effects to the fetus [15], [16]. MRI is often performed specifically for diagnosis of possible AA, which is the most common illness necessitating emergency surgery in pregnant women. Also, MRI aids its utility in identifying alternate pathologies causing patients' signs and symptoms [15]. MRI findings (Fig. 4) of appendicitis include an appendiceal diameter  $\geq 7$  mm, an appendiceal wall thickness  $\geq 2$  mm, hyperintense peri-appendicular fat stranding and fluid, high-signal-intensity luminal contents on T2-weighted images, and restricted diffusion in diffusion-weighted image [3], [5], [11], [13]. While its use is limited by higher cost, lower availability, longer acquisition time and technological advances in fast imaging sequences that made Magnetic Resonance (MR) imaging less accessible by patients.



**Figure 4.** A true-positive case for acute appendicitis in a 26-year-old patient with a 28-week gestation. (A) Axial T2 weighted image and corresponding, (B) axial fat-suppressed T2- weighted image. The appendix is thickened (arrow) and there is associated fat stranding and edema (asterisk) in the peri-appendiceal tissues. (Available at – <https://doi.org/10.1007/s00261-017-1078-7>. Webpage visited on 17/12/2020).

Table 1 shows the summary of advantages and disadvantages of commonly used imaging techniques in the diagnosis of acute appendicitis in pregnant population [3], [17].

**Table 1.** Summary of imaging techniques

Imaging technique	Advantages	Disadvantages
Ultrasound	Cost and accessibility; safety profile	Limited assessment of alternative diagnoses; limited by body habitus; operator dependent; high rate of non-visualized appendix
CT scan	High sensitivity and specificity; accessibility	Exposure to ionizing radiation
MRI	High sensitivity and specificity; non-ionizing radiation exposure; no contrast needed; ability to identify alternative diagnoses	Cost and accessibility; robust imaging technique required for good results; relatively long examination times; technical

Table 2 shows the sensitivity (SE), specificity (SP), positive predictive value (PPV), negative predictive value (NPV) of MRI in various studies conducted by various authors from 2006-2018 as listed below;

**Table 2.** Summary of diagnostic performances of MR imaging

Authors	Year	Participants/ MRI performed	Mean Age	Confirmed Acute Appendicitis	Inconclusive	SE (%)	SP (%)	PPV (%)	NPV (%)
Pedrosa [18]	2006	148	28.3	4	3	100	93.6	61.4	100
Oto A [19]	2009	118	29.4	11	2	90	98.1	81.88	97.1
Vu L [20]	2009	19		5	-	50	100	100	94.4
Gary [7]	2010	33	31	4	1	50	100	100	66

Lodewijk [14]	2014	12	28	3	2	100	98.3	60	100
Konrad [21]	2015	114	28	91	-	100	98	88.3	100
Patel [22]	2017	42	26	6	20	60	91.9	50	94.4
Richard [23]	2017	233	28.4	14	-	92.9	96.3	61.9	99.5
Michelle [15]	2017	63	31	30	2	75	100	100	100
Kereshi [24]	2018	204	32	15	91	100	99.5	93.3	100
Vidyasagar [25]	2018	49	30.5	4	1	85	97.8	83.3	100
Donlon [17]	2019	29	29	2	1	100	96.3	66.7	100

Ultrasonography is the diagnostic modality of choice for acute appendicitis in pregnancy. However, in doubtful cases and for structures that cannot be examined with ultrasonography MRI can be considered as a modality for non-invasive evaluation contributing to 100% diagnostic accuracy. Given the effectiveness of ultrasound and MRI, CT scan should be used only in emergency cases or in situations where MRI is inaccessible or cannot be used because of its robust imaging technique.

### III. DISCUSSION

The diagnosis of (AA) is based on a thorough history and clinical examination of the patient. Clinical diagnosis of acute appendicitis should be strongly suspected in pregnant women with classic findings such as acute abdominal pain that migrates from the periumbilical area to the right lower quadrant [3], [4], [14]. Diagnosis of abdominal pain in pregnant women is confounded by several factors due to the physical, physiological and anatomical changes that occur at the time of gestation. The enlarged uterus can displace the appendix superiorly and elevate the anterior peritoneum, which hampers a proper physical examination; as a result, preterm labor and delivery can occur before or after the presentation of acute abdomen [1], [14].

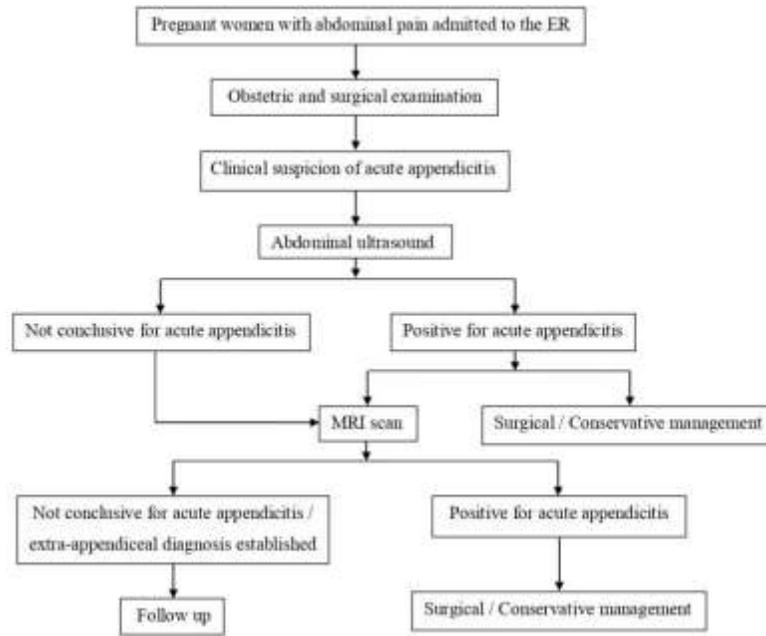
The symptoms of AA such as nausea, vomiting, anorexia, and abdominal discomfort are similar to those of morning sickness in pregnancy [8], [26]. Appendix is superiorly and laterally displaced by the enlarging uterus and thus, pushing it away from Mc Burney's point. Clinical studies previously conducted have shown that 84% of pregnant women presenting with appendicitis have pain at the right lower quadrant though it is reported that the appendix can also

be displaced into the right upper quadrant due to the globular uterus. Rebound tenderness and guarding of the abdominal wall are less commonly elicited during examination due to the laxity of the abdominal wall muscles during pregnancy; whereas a positive classical Obturator, Psoas and Rovsing signs are encountered in few patients [27]. Fever of upto 38.3°C, hypotension, tachycardia and blood tests, particularly the white blood cell count (WBC) is usually done to confirm or exclude the suspected appendicitis in patients with right lower quadrant pain [7], [18]. However, it may not be helpful and reliable in gestational women as leukocytosis (WBC count as high as 16000/ $\mu$ L) are normal physiological alterations during pregnancy [8]. The criteria for diagnosing appendicitis with imaging include a fluid filled appendix of > 6 mm to 7 mm in diameter and ancillary findings of inflammation [14].

Optimal clinical approach to the management of pregnant women suspected of having acute appendicitis is subject to debate. Perforation of appendix is most certain with increasing gestational age leading to preterm labor [11]. Rapid evaluation of appendicitis leads to successful life saving treatment of the patient as well as the developing fetus. Ultrasound, CT and MRI are frequently used imaging techniques for rapid diagnosis of suspected appendicitis in pregnant women.

The main finding is the identification of a non-compressible, blind-ended tubular structure in the lower right quadrant [8]. In such cases, ultrasounds can reveal the possible cause of the patient's symptoms. However, ultrasound is operator dependant, rates of non-visualization of the appendix remains alarmingly high with potential delay in diagnosis. Deterministic effects of radiation through CT scan results in damage

to a number of cells, with a dose threshold before damage occurs; such effects of radiation exposure include malformations, growth and/or mental retardation, and/or death [13].



**Figure 5.** Approach to patient with suspected acute appendicitis.

Visualization of the normal appendix by MRI virtually excludes the diagnosis of acute appendicitis and may help reduce negative laparotomy rate in patient population [13]. It is feasible to diagnose and differentiate acute appendicitis from other causes of abdominal or pelvic pain through MRI [3]. MRI accounts for a considerable discrepancy when assessing for appendiceal wall thickening within the spatial resolution. According to the safety committee of the Society for MRI, MRI is indicated for use in pregnant women when the result of nonionizing diagnostic imaging is inadequate for diagnosis [14], [15], [16]. According to the American College of Radiology, the preferred test after an inconclusive ultrasound in the evaluation of suspected appendicitis during pregnancy is MRI [28], [10], [29]. The sensitivity of MRI for diagnosing acute appendicitis has been reported from 80%–100% with a specificity of 91%–100% [11], [17], [18]. MRI has its own demerits, but benefits outweigh risks. In consideration, magnetic resonance imaging (MRI) can be considered as the best imaging modality for pregnant women suspected of having acute abdominal pain.

The accurate diagnosis of acute appendicitis in pregnancy is made with high clinical suspicion and skill when a pregnant woman complains of new abdominal pain other than labor pain. The combination of symptoms and clinical judgement is still vital in deciding which patient needs surgical treatment. It is likely that the gain for fetal outcome in the future lies in the diagnostic pathway rather than the type of surgery performed. As abrupt clinical diagnosis of AA can be difficult during pregnancy, imaging studies are highly recommended in order to reduce surgical delays due to diagnostic uncertainty and also to reduce the rate of negative appendectomies [20]. The risk of exposing the developing fetus to any diagnostic imaging technique that uses ionizing radiation (i.e., CT scan) is probably greater than the theoretical risk of MRI [30]. Hence, MRI is an attractive alternate to computerized tomography (CT) with no worry about the effect of potentially hazardous radiation exposure to the fetus.

#### IV. CONCLUSION

The current findings gathered from several published recommendations about the safety of MRI during pregnancy conclude that Magnetic resonance imaging (MRI) is not a contraindication to pregnancy and can be substantially performed at any stage of gestation with accurate diagnosis and good fetal outcome.

Without exposure to ionizing radiation, MRI is a valuable and safe technique that can also be used as first line agent for additional investigation to rule in/out acute appendicitis in pregnant women with high clinical suspicion and when the clinical examination and ultrasound are inconclusive. It is the responsibility of each primary care worker to identify the potential signs and symptoms of acute appendicitis in pregnant population making treatment more rapid and life saving for both mother and developing fetus.

## V. CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

## VI. ACKNOWLEDGEMENT

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