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# Diagnostic performance of magnetic resonance imaging for diagnosing acute appendicitis during pregnancy

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**Abstract. – OBJECTIVE: This retrospective study evaluated the diagnostic efficacy of magnetic resonance imaging (MRI) for identifying acute appendicitis during pregnancy.**

**PATIENTS AND METHODS: This retrospective study enrolled a total of 46 pregnant patients with clinically suspected acute appendicitis who underwent 1.5 T MRI and received a final pathological diagnosis. We evaluated the imaging characteristics associated with patients diagnosed with acute appendicitis, including the appendix diameter, the appendix wall thickness, intra-appendiceal fluid collection, and peri-appendiceal fat infiltration. A bright appendix on T1-weighted 3-dimensional imaging was identified as a negative sign for appendicitis.**

**RESULTS: Peri-appendiceal fat infiltration had the highest specificity of 97.1% for diagnosing acute appendicitis, whereas increasing appendiceal diameter had the highest sensitivity of 91.7%. The cut-off values for increasing appendiceal diameter and appendiceal wall thickness were 6.55 mm and 2.7 mm, respectively. Using these cut-off values, appendiceal diameter had a sensitivity (Se), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV) of 91.7%, 91.2%, 78.4%, and 96.9%, respectively, whereas these values for appendiceal wall thickness were 75.0%, 91.2%, 75.0%, and 91.2%. The combination of increasing appendiceal diameter and appendiceal wall thickness resulted in an area under the receiver operating characteristic curve value of 0.958 with Se, Sp, PPV, and NPV values of 75.0%, 100.0%, 100.0%, and 91.9%, respectively.**

**CONCLUSIONS: All five MRI signs examined in this study had significant diagnostic value for detecting acute appendicitis during pregnancy, with *p*-values <0.01. The combined use of increasing appendiceal diameter and appendiceal wall thickness displayed the excellent ability to diagnose acute appendicitis in pregnant women.**

*Key Words:*
Magnetic resonance imaging, Acute appendicitis, Pregnancy.

## Introduction

Acute appendicitis is the most frequent cause of non-obstetric abdominal pain among pregnant women, often requiring surgical emergency treatment. Acute appendicitis has a prevalence rate of 1/1,500 and occurs with equal frequency throughout the three pregnancy trimesters[1,2]. The diagnosis of acute appendicitis during pregnancy based on clinical signs and symptoms alone is challenging because acute appendicitis presents with nonspecific symptoms, and the appendix can be difficult to identify during pregnancy. Ultrasonography has been widely used as the first-line imaging modality for assessing the appendix because ultrasonography is readily available and economically feasible. However, ultrasound approaches are limited due to anatomic changes that occur to support fetal development in pregnancy, and the ability to assess the appendix using ultrasound in pregnant women greatly depends on physician technique[3,4]. The risks of premature birth, miscarriage, and fetal or maternal mortality dramatically increase with appendicitis severity. Therefore, the early diagnosis and treatment of acute appendicitis in pregnant women are tremendously important[5,6].

Due to technical advancements, magnetic resonance imaging (MRI) has been routinely utilized to assess the appendix during pregnancy, resulting in sensitivity (Se) values ranging

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from 50% to 97%, specificity (Sp) values ranging from 92% to 100%, and accuracy (ACC) values as high as 96%[7-11]. Furthermore, the advent of MRI not only reduces the radiation dose affecting on fetus compared to CT but also facilitates the sensitivity for detection of multiple obscuring findings on CT like bowel wall edema, distinguishing blood, and pus from other fluid contents. Several recent studies[7,8] have described the distinct imaging characteristics of acute appendicitis, including an increased appendiceal diameter, increased appendiceal wall thickness, the presence of intra-appendiceal fluid, and peri-appendiceal fat infiltration. A bright appendix on T1-weighted (T1W) 3-dimensional (3D) fat saturation (FS) sequences is also indicative of a normal appendix[12,13]. However, in the literature it was evaluated the overall performance of MRI for diagnosing acute appendicitis. To date, it has been independently analyzed the Se and Sp of the individual MRI variables used to diagnose acute appendicitis. In the present study, we independently assessed the diagnostic values of MRI parameters associated with the diagnosis of acute appendicitis in pregnant women to evaluate which parameters contribute to the accurate diagnosis.

## Patients and Methods

### Patients

The medical records and MRI results for 52 pregnant women suspected of acute appendicitis were collected, and 46 were enrolled in this retrospective study. All patients underwent an MRI examination in our radiology department and were treated at Viet Duc University Hospital during the 2-year period from June 2019 to June 2022. All patients with MRI-diagnosed acute appendicitis underwent surgical treatment. Patients with clinically nonspecific findings and MRI results suggestive of a normal appendix were followed for at least 2 weeks. The clinical symptoms and demographic information for all enrolled patients were recorded in our hospital's Medical Record Systems. The institutional review board approved our retrospective study protocol (Ref: 2674 /QĐ-ĐHYHN dated 13 July 2021). Informed consent was waived due to the retrospective nature of the study, including the analysis of anonymous clinical data. Our retrospective study was performed in compliance with the principles outlined in the Declaration of Helsinki (version 2013).

### MRI Technique

All patients underwent MRI using a Siemens 1.5 T Magnetom Essenza (Siemens Medical Systems, Erlangen, Germany). The examined region started under the liver and extended to the iliac wing. Patients were imaged while in a supine position using a body coil. The following protocols were applied: axial, coronal, sagittal T2-weighted (T2W) imaging using the half-Fourier acquisition single-shot turbo spin-echo (HASTE); axial T2W HASTE with FS; and axial T1W 3D gradient echo volumetric interpolated breath-hold examination (VIBE) FS.

The parameters used for each imaging sequence are detailed in Table I. The overall acquisition time was approximately 20 minutes, without the use of either oral or venous contrast-enhancing material.

### Image Analysis

We included 46 cases in which the appendix was detectable on MRI, including 13 pregnant patients diagnosed with acute appendicitis and underwent surgical treatment. Of these, 11 of them were pathologically diagnosed with acute appendicitis, whereas 2 had final intra-operative pathological diagnoses of ovarian torsion with a normal appendix. Among the 33 cases with non-appendiceal inflammation based on MRI outcomes, 2 cases underwent surgical treatment for ovarian

**Table I.** MRI protocols and imaging parameters applied for the diagnosis of suspected acute appendicitis in pregnant women.

| Sequences | Breath-hold | FOV (mm) | ST/Gap (mm/mm) | TR (ms) | TE (ms) | Matrix size |
|---|---|---|---|---|---|---|
| T2W HASTE | Yes | 360-440 | 4/1 | 800-1,000 | 60-80 | 256×192 |
| HASTE FS | Yes | 300-360 | 4/1 | 800-1,000 | 50-70 | 256×192 |
| T1W VIBE FS | Yes | 340 | 3/1 | 3.6-4.2 | 1.7-2.1 | 256×192 |

MRI, magnetic resonance imaging; FOV, field of view; ST, slide thickness; TR: repetition time; TE: echo time; T2W, T2-weighted; HASTE, half-Fourier acquisition single-shot turbo spin-echo; FS, fat saturation; T1W, T1-weighted; VIBE, volumetric interpolated breath-hold examination.

torsion, with intra-operative confirmation of a normal appendix (Figures 1 and 2). The remaining 31 cases were followed for at least 2 weeks. One case underwent surgical treatment 3 days after the MRI examination due to peritoneal inflammation secondary to inflammatory appendiceal rupture (Figure 3). A flow chart of the study procedures is presented in Figure 4.

Clinical information was collected from the medical records. Fever symptoms were measured by a temporal artery thermometer, with fever defined as 100.4°F (38°C) or higher. Image analysis was performed using the INFINITT PACS system (Infinitt Healthcare, Seoul, South Korea) by a gastrointestinal radiologist with more than 10 years of experience in this field who was blinded to the final diagnosis. The imaging characteristics that were assessed for associations with acute appendicitis included the largest appendiceal and the largest appendiceal wall thickness, which were measured using images from the T2W HASTE sequence (Figure 5). The largest appendiceal diameter was defined as the maximum distance between the two sides of the outer appendiceal layer. The appendiceal wall thickness was measured as the largest distance from the outer appendiceal layer to the inner appendiceal layer on one side of the appendiceal wall (Figure 5).

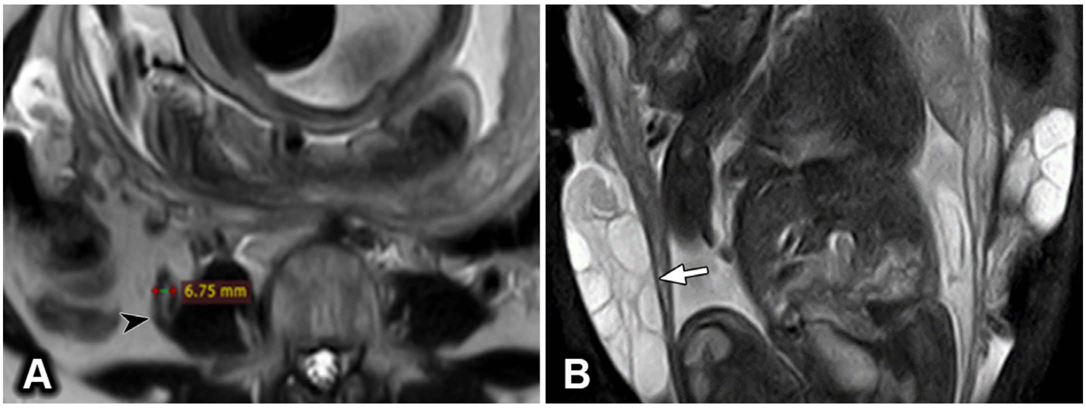


**Figure 1.** Misdiagnosis case 1: The patient was diagnosed with appendicitis on MRI but the surgical report confirmed normal appendix, the pain was identified due to right ovarian torsion. Figure (**A**) demonstrated a fluid-filled appendix and increasing diameter (black arrowhead) which dramatically led to a diagnostic error. A retrospective study revealed a failure to recognize the negative peri-appendiceal infiltration sign. Figure (**B**) illustrated bilateral symmetric ovaries with several ovarian cysts (white arrow). The ovarian torsion diagnosis was still skeptical in the retrospective studies.

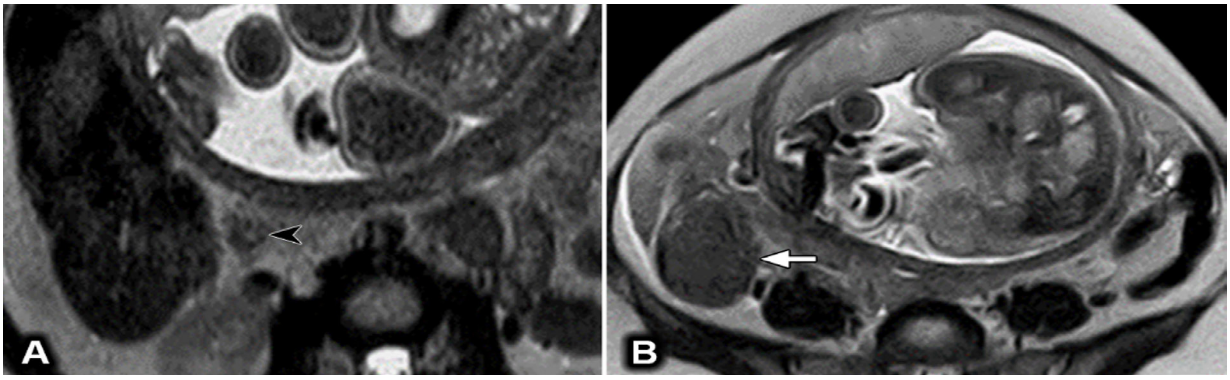


**Figure 2.** Misdiagnosis case 2: The patient was diagnosed with appendicitis on MRI, but the surgical report confirmed normal appendix, the pain was identified due to right ovarian torsion. Figure (**A**) demonstrated a tubular structure (black arrowhead) which was confused with an appendix due to wall thickening, irregular margin, right iliac fossa infiltration, and fluid collection. The right ovary was consistent with ovarian torsion including high displacement, increasing size compared to the contralateral ovary (white arrow), and hypo-signal on T2 (interstitial hemorrhage). The right iliac fossa infiltration and fluid collection canbe explained by this reason.

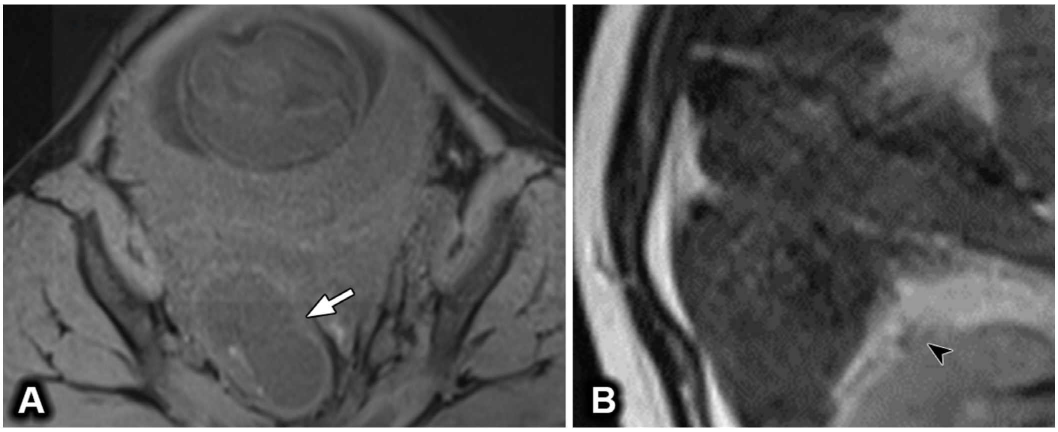


**Figure 3.** Misdiagnosis case 3: The patient was diagnosed normal appendix on MRI. On 3rd day of follow-up, the patient underwent an operation for peritonitis due to ruptured appendicitis. MRI imaging demonstrated bilateral cystic structures, regular wall, and heterogenous fluid with hyper-signal parts on T1W (white arrow) which most likely suggested hemorrhagic ovarian cysts. Figure (**B**), arrowhead indicates a normal appendix, the cause was still misunderstood.

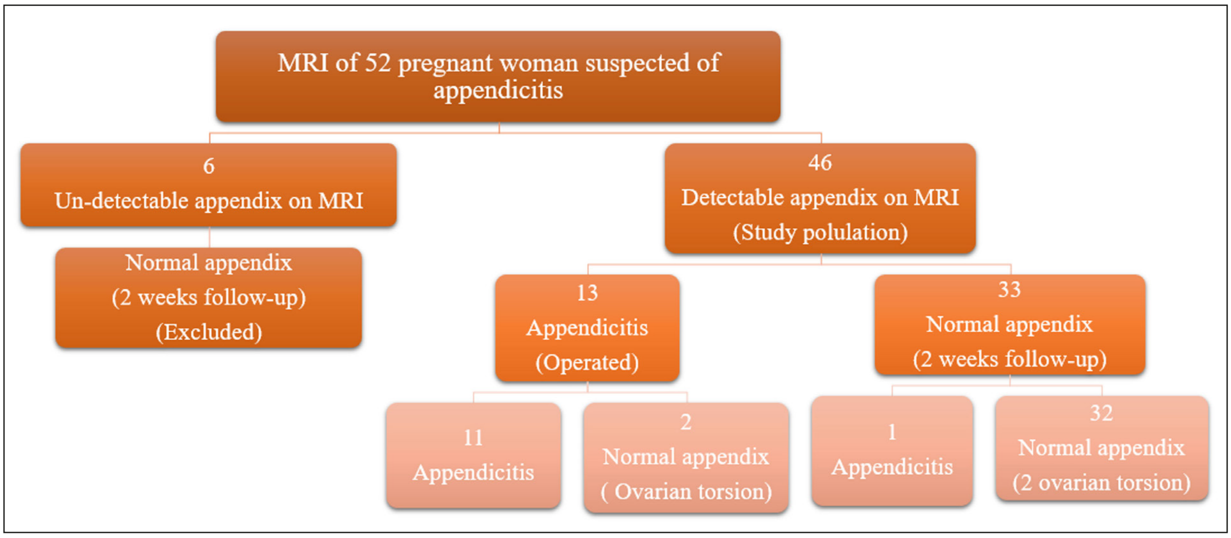


**Figure 4.** Flow chart depicting the procedures for applying MRI for the diagnosis of acute appendicitis in pregnant women.

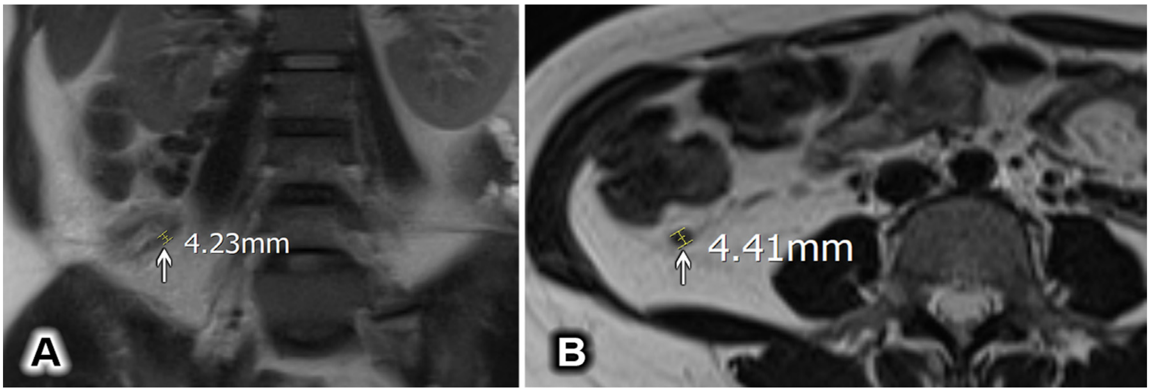


**Figure 5.** The thickness of the appendiceal wall (white arrow) was measured in the T2-weighted (T2W) coronal plane (**A**), and the largest appendiceal diameter (white arrow) was evaluated in the T2W axial plane (**B**).

The fluid-filled appendiceal sign (also referred to as intraluminal fluid collection sign) is best detectable on the T2W HASTE sequence, where it presents as a hyperintense signal (Figure 6).

Peri-appendiceal fat infiltration was examined using the T2W HASTE FS and T1W 3D FS sequences (Figure 7), which revealed hyperintense signals for peri-appendiceal fat. A bright appendix on T1W 3D FS was considered an indicator of a normal appendix (Figure 8).

### Statistical Analysis

Data were analyzed using SPSS 22.0 (Statistical Package for Social Sciences version 22.0, IBM Corp., Armonk, NY, USA). The non-appendicitis and appendicitis groups were compared across demographic, clinical, and imaging variables. The mean (± standard deviation) was compared between groups for maternal age, weeks of gestation/fetal age, largest appendiceal diameter, and largest appendiceal wall thickness, leukocyte count, in addition to the percentages of patients with fever (assessed according to the temporal artery temperature). Qualitative variable (fever) was compared using the Chi-square test or Fisher's exact test. The Shapiro-Wilk test was used to assess the normality of data distributions. Since the quantitative variables were non-normally distributed, they were compared using Mann-Whitney tests.

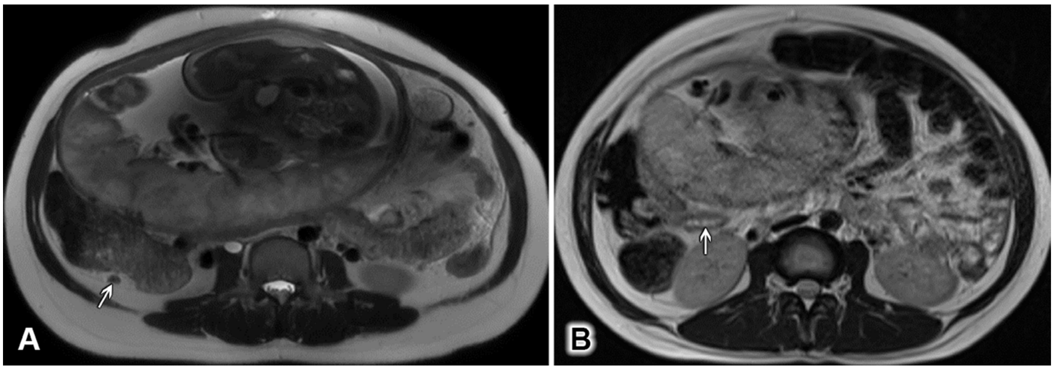


**Figure 6.** **A**, A 24-year-old pregnant woman at 24 weeks of gestation was admitted to our hospital for acute abdominal pain in the epigastric region. T2-weighted axial imaging revealed that the appendix (white arrow) appeared as a bowel structure with homogeneously low signal intensity and no fluid-filled appendiceal sign. This patient was pathologically confirmed as having a normal appendix. **B**, A 23-year-old pregnant woman at 28 weeks of gestation was hospitalized for acute abdominal pain in the right iliac fossa. The appendix was filled with fluid, which appeared as intra-appendiceal hyperintensity (white arrow). This patient underwent surgical treatment, resulting in the pathological and intra-surgical confirmation of acute appendicitis.

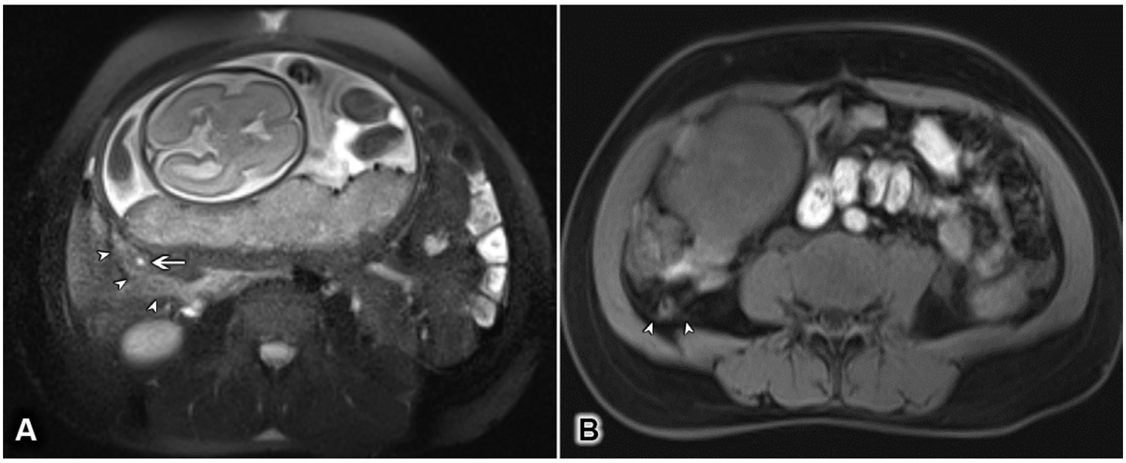


**Figure 7.** Representative images of appendicitis. **A**, A 22-year-old pregnant woman at 29 weeks of gestation. Axial T2-weighted fat saturation imaging shows a fluid-filled appendix (white arrow) and hyperintense peri-appendiceal fat (arrowhead) due to inflammation. **B**, A 23-year-old pregnant woman at 20 weeks of gestation. Axial T1-weighted 3-dimensional fat saturation imaging shows the infiltration of peri-appendiceal fat with hyperintense signal. These two cases had intra-operative and pathological evidence of acute appendicitis.

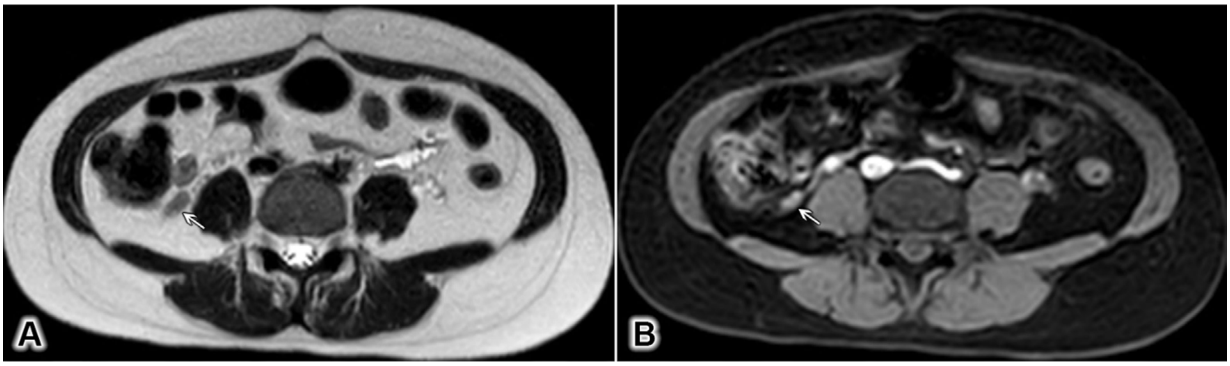


**Figure 8.** A 19-year-old pregnant woman at 14 weeks of gestation was referred to our hospital for nonspecific abdominal pain. **A**, Axial T2-weighted imaging shows an appendix in the right iliac fossa (white arrow). **B**, Axial T1-weighted 3-dimensional fat saturation sequence shows a hyperintense appendix (white arrow), indicating a normal appendix. This patient was then followed for 2 weeks without any clinical signs or symptoms of acute appendicitis.

The diagnostic value of each MRI parameter for distinguishing acute appendicitis from a normal appendix was assessed using receiver operating characteristic (ROC) curve analysis. Optimal cut-off values for each parameter were determined by maximizing the sum of the Se and Sp using the Youden Index. The Sp, Se, positive predictive value (PPV), negative predictive value (NPV), and ACC for each parameter at the optimal cut-off value were also assessed. The gold standards used for the accurate diagnosis of acute appendicitis or a normal appendix were the pathological results and follow-up outcomes. Associations between MRI variables and the final diagnosis were evaluated by calculating the odds ratio (OR) and 95% confidence interval (CI) for an accurate diagnosis. Significance was defined as *p*-values lower than 0.05, using a 95% CI.

## Results

### Study Population

The assessed demographic characteristics included maternal age and weeks of gestation. Clinical variables included the percentage of patients with fever symptoms. MRI variables included the largest appendiceal diameter and the largest appendiceal wall thickness. The assessed characteristics according to group are summarized in Table II. No significant difference in mean maternal age or mean fetal age was observed between groups ($p$=0.894 and $p$=0.808, respectively). However, the percentage of patients with fever symptoms was significantly larger in the appendicitis group than in the non-appendicitis group ($p$=0.015). White blood cell counts were significantly higher in the appendicitis group than in the non-appendicitis group ($p=0.035$). The mean largest appendiceal diameter and the mean largest appendiceal wall thickness were significantly higher in the appendicitis group than in the non-appendicitis group ($p$<0.01 for both).

The epigastric pain was rarely found in pregnant women with appendicitis (8.33%). Table III illustrated the predominance of pain in the right iliac fossa and right-sided abdominal region (66.67%). The likelihood of abdominal pain was presented in any given case of pregnant appendicitis. However, the location was varied.

**Table II.** Demographic data, clinical characteristics, and MR imaging findings, according to group.

| | Appendicitis group (n=12) | Non-appendicitis group (n=34) | *p*-value |
|---|---|---|---|
| **Maternal age (years)** | 28.42±5.53 | 28.68±5.85 | 0.894 |
| **Weeks of gestation (weeks)** | 26.17±5.81 | 25.5±8.78 | 0.808 |
| **Largest appendiceal diameter (mm)** | 8.36±1.75 | 5.35±0.98 | **<0.01** |
| **Largest appendiceal wall thickness (mm)** | 2.86±0.51 | 2.04±0.42 | **<0.01** |
| **Fever (%)** | 75.0% | 29.4% | **0.015** |
| **Leukocyte count** | 12.71±2.83 | 10.28±3.68 | **0.035** |

**Table III.** The location of abdominal pain in 12 pregnant women with appendicitis.

| Location | Number | Percentage (%) |
|---|---|---|
| **Right iliac fossa and right-sided abdominal region** | 8 | 66.67 |
| **Epigastric region** | 1 | 8.33 |
| **Peri-umbilical region** | 3 | 25 |

**Table IV.** Predictive value of MRI findings for detecting acute appendicitis in pregnant women.

| | Se | Sp | PPV | NPV | ACC |
|---|---|---|---|---|---|
| **Intraluminal fluid collection** | 83.3% | 70.6% | 50% | 92.3% | 73.9% |
| **Peri-appendiceal soft-tissue stranding** | 75% | 97.1% | 90% | 91.7% | 91.3% |
| **Bright appendix on T1W 3D FS** | 73.5% | 91.7% | 96.2% | 55% | 78.3% |

MRI, magnetic resonance imaging; Se, sensitivity; Sp, specificity; PPV, positive predictive value; NPV, negative predictive value; ACC, accuracy; T1W, T1-weighted; 3D, 3-dimensional; FS, fat saturation.

### *Diagnostic Accuracy of MRI Findings*

The diagnostic values of quantitative MRI findings for identifying acute appendicitis in pregnant patients are illustrated in Table IV. The presence of peri-appendiceal soft-tissue stranding had the highest Sp (97%) and ACC values (91.3%) but a low Se value (75%). By contrast, the presence of intraluminal fluid collection had the highest Se value (83.3%) but an insufficient Sp value (70.6%). The detection of a bright appendix on T1W 3D FS had the highest PPV (76.2%) and Sp values (91.7%) for identifying a normal appendix but the lowest Sp and ACC values (73.5% and 78.3%, respectively).

ROC curve analysis was performed (Figure 9) for qualitative variables identified as significantly

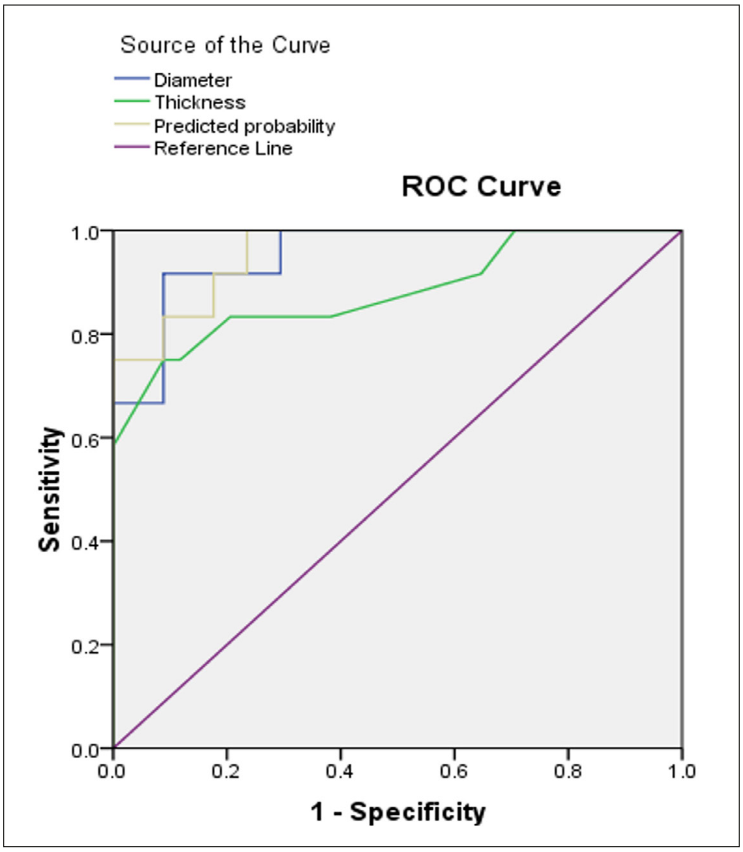


**Figure 9.** The receiver operating characteristic (ROC) curve analysis for the largest appendiceal diameter (blue line), appendiceal wall thickness (green line), and their combination (gray line). The reference line is shown in purple.

different between patients with a normal appendix and those with appendicitis, such as the largest appendiceal diameter and the largest appendiceal wall thickness.

The largest appendiceal diameter and the largest appendiceal wall thickness were identified as parameters that contributed to the correct diagnosis of appendicitis (AUC values >0.8 for both; Figure 9). The cut-off value for the largest appendiceal diameter was 6.55 mm, which resulted in Se, Sp, PPV, and NPV values of 91.7%, 91.2%, 78.4%, and 96.9%, respectively, for diagnosing acute appendicitis. The cut-off value for the largest appendiceal wall thickness was 2.7 mm, which resulted in Se, Sp, PPV, and NPV values of 75.0%, 91.2%, 75.0%, and 91.2%, respectively, for diagnosing acute appendicitis. When using both signs in combination at their respective cut-off values, the AUC value was 0.958 (Figure 9), with Se, Sp, PPV, and NPV values of 75.0%, 100.0%, 100.0%, and 91.9%, respectively (Table V).

### *Association Between MRI Findings and Correct Diagnosis*

The association between MRI findings and correct diagnosis is depicted in Table VI. All MRI findings provided a $p$-value <0.01, illustrating the ability of MRI findings to distinguish between appendicitis and a normal appendix. The detection of peri-appendiceal soft-tissue stranding increases the diagnostic potential of MRI by 99-fold, making it the most valuable sign. The weakest diagnostic sign was intraluminal fluid collection, which increased the odds of a correct diagnosis by only 12-fold. The T1 bright appendix signs on T1W 3D FS increased the odds of diagnosing a normal appendix rather than appendicitis by 30-fold.

## Discussion

Acute appendicitis is the most common surgical emergency experienced among pregnant women[1]. Perinatal mortality occurs in 2%-17% of acute appendicitis cases during pregnancy in the absence of complications and increases to 19%-50% when peritonitis occurs[14]. The accurate and rapid diagnosis of acute appendicitis should be prioritized to achieve the best maternal and fetal outcomes. MRI is the modality of choice for assessing pregnant women with a clinical suspicion of acute appendicitis[7,15].

In this study, the mean maternal age in the appendicitis group was 28.42±5.53 years, which was not significantly different from the mean maternal age in the non-appendicitis group of 28.68±5.85 years. The mean fetal age was also similar between the two groups. Our findings align with those reported by Andersen and Niersen[1], which indicated that appendicitis occurrence was evenly distributed throughout pregnancy. A significant association between fever and the diagnosis of acute appendicitis in pregnancy was well estab-

**Table V.** The predictive values of appendiceal diameter and appendiceal wall thickness for diagnosing acute appendicitis in pregnant women, either alone or combined.

| Parameter | Cutoff (mm) | AUC | Se (%) | Sp (%) | PPV (%) | NPV (%) |
|---|---|---|---|---|---|---|
| **Appendiceal diameter** | 6.55 | 0.953 | 91.7 | 91.2 | 78.6 | 96.9 |
| **Appendiceal wall thickness** | 2.7 | 0.88 | 75 | 91.2 | 75 | 91.2 |
| **Both signs in combination** | | 0.958 | 75 | 100 | 100 | 91.9 |

AUC, area under the receiver operating characteristic curve; Se, sensitivity; Sp, specificity; PPV, positive predictive value; NPV, negative predictive value.

**Table VI.** Associations between MRI findings and appendicitis diagnosis.

| | *p*-value | OR | 95% CI |
|---|---|---|---|
| **Intraluminal fluid collection** | **<0.01** | 12 | 2.219-64.899 |
| **Peri-appendiceal soft-tissue stranding** | **<0.01** | 99.000 | 9.161-1,069.861 |
| **Bright appendix signs on T1W 3D FS** | **<0.01** | 30.556 | 3.439-271.469 |

MRI, magnetic resonance imaging; OR, odds ratio; 95% CI, 95% confidence interval; T1W, T1-weighted; 3D, 3-dimensional; FS, fat saturation.

lished in our study. Fever was detected in 9 of the 12 patients diagnosed with acute appendicitis. The lack of fever in the remaining three patients may be due to the immunosuppressing state and steroid hormone secretion associated with pregnancy. According to Cardall et al[16], a minimal statistical association exists between a temperature >99°F and the presence of acute appendicitis. In this study, white blood cell levels were significantly higher in patients in the appendicitis group than in the non-appendicitis group, consistent with Shin et al[12]. However, fever and high white blood cell levels may not be consistently encountered in acute appendicitis cases, which was the conclusion reached in the case series reported by Mourad et al[17] and Stone[18]. Therefore, clinicians should be cautious of using fever and high white blood cell levels as a sign of acute appendicitis[17].

The right iliac fossa pain was found in the majority of appendicitis in pregnancy according to our study. This work's results are in line with the publication of Mourad et al[17] with the percentage of pregnant appendicitis in the first trimester being 86%, the second trimester being 83%, and the third trimester being 78%.

Previous studies[7,10,11,19] have reported the Se, Sp, and ACC for general MRI applications ranging from 50%-90%, 92%-100%, and 96%, respectively, for the diagnosis of acute appendicitis, including Pedrosa et al[7], Vu et al[10], Duke et al[11], and Wi et al[19]. However, in the literature only few have evaluated the diagnostic value of individual symptoms for detecting acute appendicitis among pregnant women. In our study, soft-tissue stranding was unequivocally the most valuable finding for diagnosing acute appendicitis (ACC value: 91.3%). Tsai et al[20] found that peri-appendiceal soft-tissue stranding, appendiceal wall thickening, and increased appendiceal diameter had the highest inter-radiologist agreement values. Moreover, Pedrosa et al[7] and Spalluto et al[8] highly recommended using soft tissue stranding in cases in which a normal appendix could not be verified, but cecal wall thickening was observed. The appearance of a bright appendix on T1W 3D FS had the highest Se value for confirming a normal appendix (96.2%), which aligns with previously published results reported by Shin et al[12] (95.5%). The T1W 3D FS sequence allows for the determination of intraluminal hyperintense structures, including blood products and high-protein components, which can assist in evaluating other sources of abdominal pain during pregnancy, such as hemorrhagic ovarian cysts[21]. Fluid collection and peri-appendiceal abscesses are considered positive signs of perforation, and appendicolith is rarely detected on MRI[7]. Only one case with appendicolith was identified among our patients, and no cases of perforation were detected. Therefore, these signs were not included in our study.

The majority of previous research[7,8,22] has used cut-off values of 7 mm for the appendiceal diameter and 3 mm for the appendiceal wall thickness for the diagnosis of acute appendicitis. In this paper, we suggest the use of cut-off values of 6.55 mm and 2.7 mm, respectively, for appendiceal diameter and appendiceal wall thickness, which resulted in AUC values of 0.953 and 0.88, respectively. The Se and Sp of using 6.55 mm for the appendiceal diameter cut-off are 91.7% and 91.2%, respectively, and increased to 75% and 100% when combined with a cut-off value of 2.7 mm for the appendiceal wall thickness. Our results do not fully correspond with the previous report of Leeuwenburgh et al[23], which found that a cut-off value for the appendiceal diameter of 7 mm provided the highest OR of 355 (95% CI: 78-1.617) for the correct diagnosis. In our study, the combined use of appendiceal diameter and appendiceal wall thickness was associated with a PPV of 100%. This separation is due to the study of Leeuwenburgh et al[23] being conducted in multiple centers with large numerous patients and did not focus on pregnant women.

Several qualitative findings, including appendiceal intraluminal fluid, peri-appendiceal soft-tissue stranding, and the appearance of a bright appendix on T1W 3D FS, were significantly associated with a definitive diagnosis, resulting in respective OR values of 12 (95% CI: 2.219-64.899), 99 (95% CI: 9.161-1,069.86), and 30.556 (95% CI: 3.439-271.469). Increasingly, studies suggest that peri-appendiceal soft-tissue stranding is a valuable MRI finding for diagnosing acute appendicitis[7,20,23]. The PPV of peri-appendiceal soft-tissue stranding reported by Leeuwenburgh et al[23] was 93%, with an OR of 197 (95% CI: 66-589), which was higher than our results of 90% with an OR of 99 (95% CI: 9.161-1,069.861).

### Limitations

Our study had several limitations. First, this study enrolled a small population that may not represent all ethnic groups. Second, the appendiceal diameter and appendiceal wall thickness were only measured by one radiologist, and errors may have occurred because this study did not examine numerous essential findings, including the presence of appendiceal intraluminal gas or the restricted diffusion of the appendiceal wall on diffusion-weighted imaging and apparent diffusion coefficient, as these sequences were not included in this study. We believe that a significant quantitative measure able to define the presence of more symptoms and confirmed by at least two radiologists would result in better reproducibility.

## Conclusions

Our study has demonstrated that MRI findings, including increased appendiceal diameter, increased appendiceal wall thickness, intraluminal fluid collection, peri-appendiceal soft-tissue stranding, and the lack of bright appendix signs on T1W 3D FS, are principal signs suggestive of an acute appendicitis diagnosis in pregnant women. Increasing appendiceal diameter had the highest Sp, and the ACC of appendiceal diameter could be maximized when combined with peri-appendiceal soft-tissue stranding and increasing appendiceal wall thickness. These findings do not always present in acute appendicitis, and findings might also be present in cases of a normal appendix. Therefore, the presence of these findings should also be combined with clinical symptoms to determine a diagnosis of acute appendicitis.

### Ethics Approval

The institutional review board approved our retrospective research (Ref: 2674 /QĐ-ĐHYHN dated 13 July 2021).

### Informed Consent

Informed consent was waived due to the study's retrospective nature, and the analysis used anonymous clinical data.

### Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due to privacy concerns but are available from the corresponding author on reasonable request.

### Conflicts of Interest

The authors declare no conflict of interests.

### Funding

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### Authors' Contributions

D.-H. Nguyen and M.-D. Nguyen prepared, drafted, and revised the manuscript critically, for important intellectual content. T.-D. Le and D.-H. Nguyen contributed substantially to the acquisition, analysis, and interpretation of data. Each author gave final approval to the version of the manuscript submitted for publication and agreed to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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