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Review Article

MRI performance in diagnosing acute appendicitis during pregnancy: a systematic review of contemporary evidence

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Abstract: Acute appendicitis in pregnancy is a common surgical emergency which presents diagnostic challenges because of the limitations of ultrasound and the potential risks of ionizing radiation with computed tomography (CT). Magnetic resonance imaging (MRI) has been shown to be a safe second-line imaging modality, but the heterogeneity in study design, protocols and diagnostic criteria across the literature remains unresolved. This systematic review aimed to synthesise recent evidence on the diagnostic accuracy of MRI for acute appendicitis in pregnancy and clarify the role of MRI following inconclusive ultrasound. A systematic search was performed on PubMed/MEDLINE, Embase, Web of Science, Cochrane Central, DOAJ and ScienceDirect for articles published from January 2020 to December 2025 with suspected appendicitis in pregnant patients undergoing MRI. Eligible studies reported measures of diagnostic accuracy, with surgical/histopathological confirmation or clinical follow-up as the reference standard. Two reviewers independently screened titles, abstracts and full texts, extracted study characteristics and performance data and assessed study quality using QUADAS-2. Twelve studies with a total of 1610 pregnant women were included. Most studies reported high sensitivity (usually 80-100%), high specificity (usually >90%) and negative predictive value of MRI with no study reporting a clearly negative MRI that was subsequently confirmed as missed appendicitis. The findings support an ultrasound-first, MRI-second diagnostic pathway, with MRI used when ultrasound findings are nondiagnostic or discordant with clinical suspicion; current evidence does not support MRI as a first-line modality. These findings require confirmation in large scale prospective multicenter studies with standardized protocols and gestational age stratified analyses to define the incremental value of diffusion-weighted and T1-weighted adjunct sequences.

Keywords: Appendicitis, magnetic resonance imaging, pregnancy

Introduction

Acute appendicitis is the most common non-obstetric surgical emergency during pregnancy, occurring in approximately 1 in 181 to 1700 pregnancies, with peak incidence in the second trimester [1, 2]. This condition accounts for two-thirds of all non-traumatic surgical emergencies encountered in pregnant women [3]. A timely and accurate diagnosis is critical, as delayed treatment substantially increases the risk of appendiceal perforation and maternal-fetal complications [4]. While uncomplicated appendicitis carries a fetal loss rate of less than 5%, this increases to 10-35% with complicated disease [5, 6]. Each day of delay to surgery has been shown to increase the odds of preterm delivery, preterm labor, or abortion by 23% [4].

Diagnosing acute appendicitis during pregnancy presents unique clinical challenges. Normal pregnancy-related physiological changes, including anatomical displacement of the appendix by the gravid uterus, physiological leukocytosis, and overlapping gastrointestinal symptoms, substantially complicate clinical assessment [3, 7]. The appendix migrates cephalad as gestation advances, rendering classical presentations with right lower quadrant pain less common in pregnant patients [8-11]. These diagnostic difficulties result in a higher negative appendectomy rate in pregnant women of approximately 21-25% compared to 5-9% in non-pregnant populations [3, 12]. Furthermore, pregnant patients experience significantly higher perforation rates (25% versus 3.3%) compared to non-pregnant women of reproductive age [12].

Diagnostic imaging plays an essential role in evaluating suspected acute appendicitis during pregnancy. Ultrasound (US) has traditionally been recommended as the first-line modality due to its safety profile and lack of ionizing radiation [13]. However, a systematic review and meta-analysis by Moghadam et al. [14] demonstrated that US has limited diagnostic performance in pregnant women, with a pooled sensitivity of 77.6% and a specificity of 75.3%, declining progressively across trimesters to

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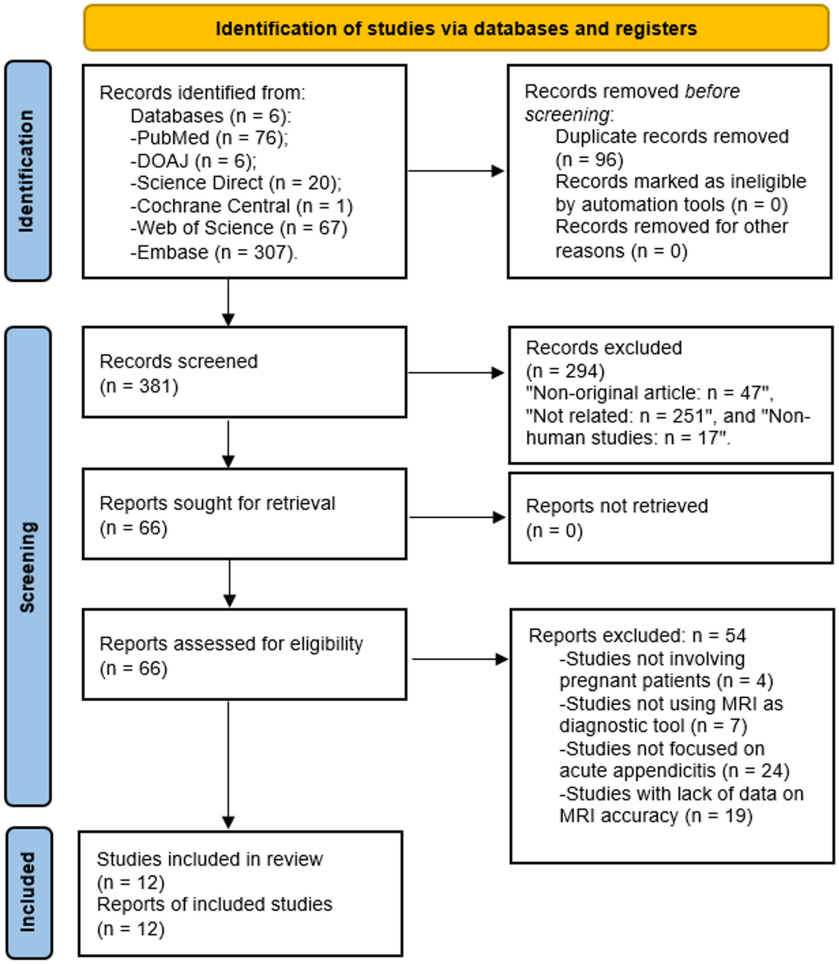


Figure 1. PRISMA flow diagram for enrollment of studies.

only 51% sensitivity in the third trimester. Computed tomography (CT) offers high diagnostic accuracy but is substantially limited during pregnancy due to concerns about ionizing radiation. The fetal radiation dose from abdominal CT can exceed 50 mGy, the threshold above which documented negative fetal effects may occur, including potential teratogenic effects and increased childhood malignancy risk [15].

Magnetic resonance imaging (MRI) has emerged as a valuable diagnostic modality for suspected acute appendicitis in pregnancy, combining high diagnostic accuracy with the absence of ionizing radiation. MRI utilizes non-ionizing electromagnetic fields and radiofrequency pulses, with no conclusive evidence of fetal harm when performed at 1.5T without gadolinium contrast [16]. A comprehensive meta-analysis by Motavaselian et al. [17] evaluating 26 studies demonstrated that MRI achieves a pooled sensitivity of 92% and specificity of 98%, with an area under the receiver operating characteristic curve of 99%. Similarly, Duke et al. [18] reported in their meta-analysis that the sensitivity and specificity of MRI in pregnant patients were 94% and 97%, respectively (14).

Despite the growing body of evidence supporting the diagnostic utility of MRI for acute appendicitis in pregnancy, several questions remain inadequately addressed. Considerable heterogeneity exists across published studies regarding MRI techniques, diagnostic criteria, radiologist expertise, and methodological quality. Questions persist regarding optimal MRI timing, the impact of gestational age on diagnostic accuracy, and the clinical significance of appendix non-visualization [17, 19]. The availability of MRI resources varies considerably across healthcare settings, raising questions about the generalizability and practical implementation of MRI-based diagnostic algorithms.

Various studies on MRI for acute appendicitis in pregnancy have demonstrated variable diagnostic accuracy due to differences in radiologist training and experience, imaging quality, and technical parameters. Therefore, this systematic review aims to comprehensively synthesize evidence on MRI diagnostic performance for acute appendicitis in pregnancy.

Material and methods

Search strategy

To conduct this systematic review, we implemented an exhaustive search to identify pertinent studies that investigated the precision of MRI in the diagnosis of acute appendicitis during pregnancy. As illustrated in **Figure 1**, the research was conducted in accordance with the PRISMA standards, which stand for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. A comprehensive literature search was performed across multiple electronic databases, including PubMed/MEDLINE, Cochrane Central, Web of Science, Web of Science, EMBASE, DOAJ, and Science Direct, to identify all relevant studies published from January 2020 to December 2025. The Advanced Search Builder was used, and the keywords were searched in [Title OR Abstract]. Our search was without language restrictions, and the search strategy was developed in collaboration with a medical librarian. It included a combination of Medical Subject Headings (MeSH) terms and free-text keywords relevant to MRI, acute appendicitis, and pregnancy. The primary search terms utilized were: (appendicitis OR acute appendicitis) AND (magnetic resonance imaging OR MRI) AND (pregnancy OR pregnant OR gestation).

Table 1. Study characteristics of included studies

Study	Year	Country	Study Design	Total Sample (n)	Mean Age (years)	Mean/range of GA (weeks)	Confirmed AA (n)
Badr et al.	2021	Belgium	Prospective	85	29	19.9	6
Lukenaite et al.	2021	Lithuania	Retrospective	76	30.4	23.6	6
Le et al.	2023	Vietnam	Retrospective	46	28.4	26.2	12
Bufman et al.	2024	Israel	Retrospective	167	30	20	35
Wong et al.	2024	Taiwan	Prospective	80	32.0	20.6	29
Buckley et al.	2023	Ireland	Retrospective	45	28	20	10
Ahmed et al.	2022	USA	Retrospective	364	26	3-38	19
Kulali	2023	Turkey	Retrospective	72	29	24	10
Abgottspon et al.	2022	Switzerland	Retrospective	61	31	17	30
Bekhor et al.	2025	Israel	Retrospective	180	29	22	28
Kahana et al.	2024	Israel	Retrospective	255	28.6	9-38	29
Nguyen et al.	2023	Vietnam	Retrospective	179	29.7	22.6	62

GA, gestational age; AA, acute appendicitis.

Inclusion and exclusion criteria

This systematic review aimed to include original research that investigated the use of MRI to diagnose acute appendicitis in pregnant women. The studies that met the inclusion criteria were those that used MRI to diagnose acute appendicitis in pregnant patients, regardless of gestational age. Furthermore, the reference standard was either surgical or histological results for cases that underwent surgery, or an alternative diagnosis or unambiguous clinical follow-up for instances that did not undergo surgery, as determined independently from MRI results. Data on the accuracy of MRI diagnostics, including sensitivity, specificity, predictive values, and accuracy, or enough information to compute these metrics, also required studies. Exclusion criteria included the following: case reports, case series, editorials, letters, conference abstracts (in the absence of complete text or non-compliance with the requirements), research that failed to fulfill the criteria, and phantom or animal studies. Further exclusions from the final analysis included review papers, meta-analyses, and systematic reviews that lacked primary data. Twelve primary research articles met our inclusion criteria.

Data extraction

Titles, abstracts, and full texts of potentially eligible articles were reviewed by two authors (A.K. and F.K.). After applying the inclusion and exclusion criteria, data were extracted independently using a standardized form. For each study, we recorded design, clinical setting, country, sample size, maternal age, gestational age or range, MRI field strength, pulse sequences used, criteria for a positive MRI diagnosis, and the reference standard. Measures of diagnostic performance, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were recorded when directly reported. When these measures were not explicitly stated, they were calculated from the available data (e.g., 2×2 contingency tables) using standard diagnostic accuracy formulas [20].

Quality assessment

Two authors (A.K. and P.K.) assessed the quality of the published interventions. A third author (F.K.) ensured that any disagreements were resolved. To determine the possibility of bias in each of the included studies, the QUADAS-2 instrument was utilized to evaluate the population, technique, analysis, and reporting requirements of each study. The tool comprises four main categories: flow and timing, reference standards, index tests, and patient selection. For each specific study, every category was evaluated as either “low”, “high”, or “unclear” [21]. Then, the ratings for every domain were shown, along with a subjective judgment of the overall quality of the included studies.

Results

Search and selection process

The database search initially identified 381 records. After removal of 96 duplicates, 381 unique records were screened by title and abstract, and 294 were excluded as non-original articles, not related to MRI for appendicitis in pregnancy, or non-human studies. Sixty-six full-text articles were retrieved and assessed for eligibility. Of the 66 full-text articles assessed for eligibility, 54 were excluded (**Figure 1**). Thirteen studies met all inclusion criteria and were included in the review (**Table 1**).

Quality assessment

Figure 2 displays the QUADAS-2 risk of bias and applicability assessment for the twelve included MRI studies across the four domains of patient selection, index test, reference standard, and flow and timing. Most studies demonstrate low risk of bias in all domains, with uniformly low concerns regarding applicability. Abgottspon et al. [22] and Kahana et al. [23] show high risk of bias in the index test domain, while Bekhor et al. and Kulali et al.

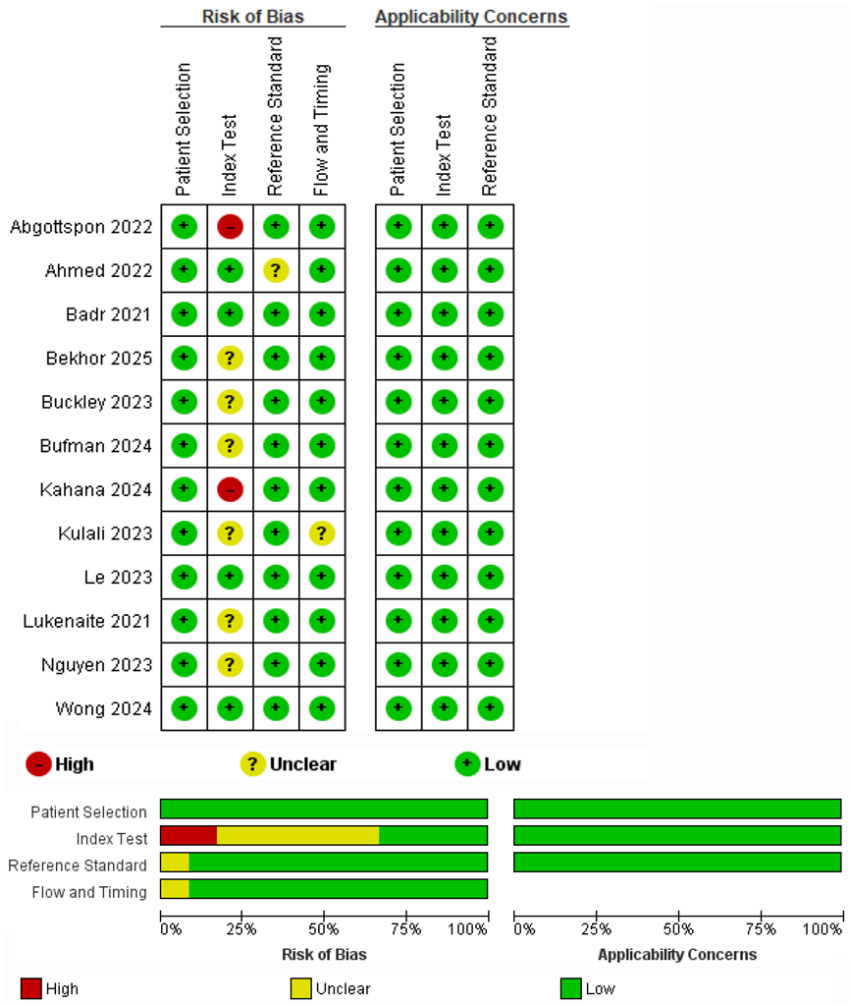


Figure 2. Quality assessment and bias risk assessment in the investigations included in this review.

have domains rated as unclear, predominantly for index test and reference standard. All other studies are rated as low risk across patient selection, reference standard, and flow and timing. The summary bar plots indicate particularly strong performance in patient selection, reference standards, and flow and timing, with more variability in the index test domain but no widespread serious applicability concerns.

Characteristics of included studies

The 12 included studies were published between 2020 and 2025 and conducted in Europe, Asia, North America, and the Middle East. The sample sizes ranged from 45 to 364 pregnant women with suspected acute appendicitis. Most studies evaluated MRI after inconclusive or nondiagnostic ultrasound, whereas a smaller number incorporated MRI more directly into the initial diagnostic pathway. All studies used non-contrast MRI of the abdomen or pelvis; where field strength was reported, 1.5T was the most common platform, although protocol details varied between cohorts. Multiplanar T2-weighted imaging was a consistent core component, usually with fat-suppressed T2-weighted sequences, and several studies also incorporated diffusion-weighted imaging (DWI) and T1-weighted sequences. Reference standards were based on surgical and histopathological confirmation in operated patients and clinical follow-up, symptom resolution, or alternative diagnosis in non-operated patients.

Overall diagnosis performance

Across the twelve contemporary cohorts, non-contrast MRI consistently demonstrated high diagnostic performance for suspected appendicitis in pregnancy (**Table 2**). Sensitivity values generally fell in the upper range, most commonly between 80% and 100%, while specificity was almost always above 90% and reached 100% in several series. NPVs were particularly strong and frequently approached or reached 100%, and no study reported a clearly negative MRI later being proven to represent missed appendicitis during available follow-up. PPVs showed more variability, reflecting the relatively low prevalence of appendicitis in many cohorts and the presence of false-positive interpretations in some series, but still exceeded 60% in most reports.

Despite differences in sample size, setting, and protocol details, this pattern was remarkably consistent. Larger studies, including those by Ahmed et al. [19], Bufman et al. [8], Kahana et al. [23], and Nguyen et al. [24], reported sensitivities at or near 100% with specificities in the mid-90% range or higher, translating into excellent rule-out performance in diverse practice environments. Smaller cohorts, including those by Badr et al. [25], Lukenaite et al. [26], Le et al. [27], Buckley et al. [28], Kulali [29], Wong et al. [30], Abgottspon et al. [22], and Bekhor et al. [31], showed some variability in point estimates, but none contradicted the overall impression that MRI is a highly reliable test for confirming or excluding appendicitis in pregnant women. Taken together, these data indicate that, when technically adequate non-contrast MRI is performed, the risk of missed appendicitis after a negative study is very low, while positive studies usually reflect true disease, even though thresholds and interpretive strategies differ somewhat between centers.

Direct comparison of ultrasound and MRI diagnostic performance

Several included studies reported the diagnostic performance of ultrasound, either alone or as part of a combined clinical pathway, allowing contextual comparison

Table 2. Diagnostic value of magnetic resonance imaging in the diagnosis of acute appendicitis during pregnancy

Study	MRI Scans (n)	TP**	TN**	FP**	FN**	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy
Badr et al.	85	6	78	1	0	100	98.7	85.7	100	98.8
Lukenaite et.	38	5	32	0	1	83.3	100	100	97.0	97.3
Le et al.	46	11	31	3	1	91.7	91.2	78.4	96.9	91.3
Bufman et al.	167	27	132	8	0	100	94.3	77.1	100	95.2
Wong et al.*	80	28	46	5	1	96.6	90.2	84.8	97.9	92.5
Buckley et al.	45	8	35	0	2	80	100	100	94.6	99.8
Ahmed et al.	141	9	127	5	0	100	96	64.2	100	96.4
Kulali*	72	6	62	0	4	60	100	100	93.9	94.4
Abgottspon et al.	15	11	2	0	2	84.6	100	100	50	86.7
Bekhor et al.	180	22	139	13	6	82.1	90.7	62.1	96	89.4
Nguyen et al.*	179	62	108	9	0	93.5	92.3	87.3	100	95
Kahana et al.	255	29	222	4	0	100	98.2	87.9	100	98.4

TP, true positive; TN, true negative; FP, false positive; FN, false negative; PPV, positive predictive value; NPV, negative predictive value. *Several studies also acquired diffusion-weighted imaging (DWI) (Wong et al., Kulali, Nguyen et al.). The diagnostic metrics shown in this table refer to non-contrast MRI protocols based on T2-weighted (± fat-suppressed T2 and T1-weighted) sequences, not to DWI-only analyses. DWI-specific performance is summarized separately. **Values are shown as point estimates; 95% confidence intervals are provided where sufficient data were available to permit calculation.

with MRI. Ahmed et al. [19] evaluated 363 pregnant women who underwent ultrasound as first-line imaging and found that the appendix was visualized in only 1.65% of cases, yielding a very low overall sensitivity of 26.3% for acute appendicitis, whereas when the appendix was seen, interpretation was highly specific with a PPV of 100%. In the same cohort, MRI achieved a sensitivity and NPV of 100%, underscoring its superior reliability when ultrasound was non-diagnostic.

Although Badr et al. [25] focused on assessing MRI, they also provided information about the diagnostic accuracy of the combined assessment approach using clinical tests, laboratory tests, and ultrasound, which were found to have a sensitivity of 100%, specificity of 62%, PPV of 16.7%, and NPV of 100%. This pathway still requires MRI for clarification in many cases and highlights the limited specificity of an ultrasound-anchored strategy compared with MRI alone.

In a study involving 61 pregnant women suspected of having appendicitis, Abgottspon et al. [22] found that point-of-care ultrasound had a moderate sensitivity of 66.7% (95% CI 47.1-82.7) and an excellent specificity of 96.8% (95% CI 83.3-99.9). The researchers also found a positive likelihood ratio of 20.7 and a negative likelihood ratio of 0.3. The sensitivity of MRI in the same group of women (15 total) was greater (84.6% on the first reading, rising to 100% following expert evaluation), and the specificity was also 100%. MRI also properly diagnosed appendicitis in many women who had negative or non-visualized ultrasound results. In these contemporary studies, ultrasound has shown to be a very specific but inconsistently sensitive test, whereas MRI reliably gives a higher sensitivity and almost perfect negative predictive value, especially when administered following an inconclusive or negative ultrasound with ongoing clinical suspicion.

MRI protocol characteristics

The 12 studies used basically comparable non-contrast MRI methods for the abdomen and pelvis in pregnant individuals with suspected appendicitis. Protocols across cohorts are based on rapid multiplanar T2-weighted sequences, usually in single-shot or fast spin-echo sequence, often with fat-saturated T2 imaging to highlight periappendiceal edema and fluid. T1-weighted gradient-echo imaging routinely adds anatomical information, and diffusion-weighted imaging is included in numerous investigations, adding confidence for questionable structural findings. A few protocols add further refinements, bowel-opacifying agents, balanced steady state sequences or specialized 3D T1 techniques. Overall the protocols coalesce around fast, non-contrast, fat-saturated T2 imaging as the core strategy in the evaluation of the appendix and surrounding tissues in pregnancy, as summarized in **Table 3**.

Added diagnostic value of diffusion-weighted imaging

Three studies evaluated the performance of DWI in pregnant patients with suspected appendicitis, either as an additional sequence or in comparison with non-contrast anatomical MRI (**Table 4**). In Wong et al. [30], a T2-based MRI appendicitis score in 80 women showed high diagnostic values, with sensitivity above 95% and specificity above 90%, and a subset of 37 patients who also underwent DWI with apparent diffusion coefficient (ADC) demonstrated a DWI-augmented score that maintained sensitivity and specificity above 90% while slightly increasing the area under the receiver operating characteristic curve (AUC). Therefore, DWI was acquired in less than

Table 3. MRI protocols of the evaluated studies

Study	Condensed MRI protocol
Badr et al.	Non-contrast 1.5/3T abdominal-pelvic MRI with multiplanar T2-weighted (including fat saturation) and T1 GRE sequences.
Lukenaite et al.	Non-contrast 1.5T MRI of the abdomen/pelvis using axial/coronal T2 single shot and fat sat T2 plus T1 GRE.
Le et al.	Non-contrast 1.5T emergency MRI with multiplanar T2 single-shot FSE, fat saturation T2, and T1 GRE.
Bufman et al.	Non-contrast 1.5T MRI with oral mannitol using T2 SSFSE, fat saturation T2, BTFE, and 3D T1 (eTHRIVE).
Wong et al.	Non-contrast 1.5T MRI with T2 single-shot FSE (± fat saturation), T1 GRE, and DWI of the abdomen/pelvis.
Buckley et al.	Non-contrast 1.5T MRI, including multiplanar T2 and fat saturation T2 sequences, plus routine T1.
Ahmed et al.	Non-contrast 1.5T MRI using multiplanar T2 FSE/HASTE (including fat saturation) and optional TOF and in/out of phase T1 GRE.
Kulali	Non-contrast 1.5T appendix protocol MRI with T2 single shot, fat saturation T2, T1 GRE, and DWI.
Abgottspon et al.	Non-contrast 1.5T MRI with multiplanar T2 and fat saturation T2 plus routine T1 sequences.
Bekhor et al.	Non-contrast 1.5T MRI, including coronal/axial T2, fat saturation T2, and standard axial imaging.
Nguyen et al.	Non-contrast 1.5/3T MRI with T2 HASTE, T2 TIRM (fat saturation), T1 VIBE Dixon, and DWI.
Kahana et al.	Non-contrast 1.5T MRI with axial T1 VIBE Dixon, T2 HASTE (± fat saturation), and T2 TRUFI.

MRI, magnetic resonance imaging; T, tesla; FSE, fast spin echo; SSFSE, Single-shot fast spin echo; HASTE, Half-Fourier acquisition single-shot turbo spin echo; GRE, gradient-echo imaging; BTFE, balanced turbo field echo; TRUFI, true fast imaging with steady-state free precession; eTHRIVE, enhanced T1 high-resolution isotropic volume excitation; VIBE, volumetric interpolated breath-hold examination; DWI, diffusion-weighted imaging; TOF, Time of flight angiography.

Table 4. Diagnostic performance of diffusion-weighted imaging (DWI) and sequence combinations for acute appendicitis in pregnancy

Study	Imaging set (patients)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	AUC
Wong et al.	MRI appendicitis scale ≥ 2.5 (T2/FS T2; n = 80)	96.6	90.2	84.8	97.9	93.8	0.969
	DWI appendicitis scale (T2/FS T2 + DWI; n = 37)	92.9	91.3	86.7	95.5	91.9	0.991
Kulali	Non contrast MRI alone (T2/T1; n = 72)	60	100	100	93.94	94.44	N/A
	DWI only interpretation (appendix protocol; n = 72)	90	100	100	98.41	98.61	N/A
Nguyen et al.	T2 weighted imaging alone (n = 179)	93.5	92.3	87.3	100	95	N/A
	T2 + T1 + DWI combined sequences (n = 179)	96.8	94.9	90.9	98.2	95.5	N/A

MRI, magnetic resonance imaging; DWI, diffusion-weighted imaging; PPV, positive predictive value; NPV, negative predictive value; AUC, area under the receiver operating characteristic curve; N/A, not applicable.

half of the cohort and primarily affected performance within that subset.

Kulali [29] evaluated 72 pregnant patients using both non-contrast MRI and DWI. Non-contrast anatomical sequences alone had a sensitivity of 60% with perfect specificity and an accuracy in the mid-90% range, whereas DWI-only interpretation increased sensitivity to 90% and raised overall accuracy to approximately 99%, with an NPV approaching 98%. In this study, DWI produced a larger change in sensitivity and NPV than in specificity.

Nguyen et al. [24] studied 179 patients and reported that T2-weighted imaging alone achieved sensitivity and specificity in the low-to-mid-90% range with accuracy around 95%. When T2-weighted images were combined with T1-weighted and DWI sequences, sensitivity rose to just under 97% and specificity to just under 95%, with accuracy increasing slightly above 95%. In that larger cohort, sequence combinations produced measurable but moderate improvements in diagnostic metrics compared with T2-weighted imaging alone.

Clinical impact of MRI integration on patient management

Lukenaite et al. [26] demonstrated that the implementation of a systematic ultrasound-plus-MRI pathway reduced unnecessary surgery by 90% and diagnostic operations by 90% and shortened the median hospital stay by 81%. Ahmed et al. [19] reported that surgical exploration could have been avoided in 60-90% of cases with MRI-guided surgical decision-making. Bufman et al. [8] reported that MRI identified alternative pathologies in 18% of their cohort, including gynecologic, urologic, and gastrointestinal conditions. Bekhor et al. [31] demonstrated that 82% of their emergency department cohort was ultimately managed conservatively following MRI, with only a single delayed appendicitis diagnosis during a 90-day follow-up. Kahana et al. [23] showed that MRI findings of complicated appendicitis strongly influenced operative decisions, while MRI-positive but clinically equivocal

cases could be considered for nonoperative or delayed management.

Gestational age and MRI performance

Gestational age at the time of MRI spanned all three trimesters across the 12 included cohorts. Ahmed et al. [19] formally tested the association between gestational age and appendix visualization and found no significant relationship (P = 0.45), with MRI maintaining 100% sensitivity and NPV across the full gestational range. Badr et al. [25] reported a median gestational age at MRI of 19.9 weeks (32.9% first trimester, 67.1% second/third trimester) and concluded that gestational age and maternal BMI do not alter MRI appendix visualization rates. Buckley et al. [28] similarly demonstrated high MRI accuracy (sensitivity 80%, specificity 100%, overall accuracy ~99.8%) in patients distributed across all three trimesters. Taken together, these studies indicate that non-contrast 1.5T MRI maintains high diagnostic performance throughout pregnancy, with no evidence of a clinically relevant decline in accuracy as gestation advances.

Radiologist expertise and inter-reader agreement

Radiologist expertise varied among the 12 included studies, ranging from single experienced abdominal or gastrointestinal radiologists to larger mixed groups of general and subspecialty radiologists. Badr et al. [25] and Le et al. [27] reported high sensitivity and specificity in studies interpreted by dedicated subspecialty radiologists. According to Ahmed et al. [19], a diverse team of body radiologists with 2-28 years of experience was able to achieve 100% sensitivity and 96% specificity. There was a modest level of agreement for overall accuracy (κ = 0.56) and high inter-reader agreement for appendix visualization (κ = 0.70). Buckley and colleagues [28] evaluated MRI findings evaluated by 18 radiologists from different subspecialties. They found that the sensitivity was 80%, the specificity was 100%, and the NPV was 94.6%. Instead of discrepancies in interpretation, they found that inadequate imaging techniques were linked to false-negative results. Bufman et al. [8] reported almost perfect inter-reader agreement (Cohen's κ = 0.9). Bekhor et al. [31] showed that robust performance (sensitivity 82.1%, specificity 90.7%, NPV 96.0%) was maintained in an emergency-department setting with mixed-experience radiologists. Kahana et al. [23] demonstrated reliable identification of complicated appendicitis even when interpreted by trainees and attendings. Across studies, the most consistent determinant of diagnostic performance was protocol completeness rather than radiologist expertise.

Appendix visualization and non-visualization

Appendix visualization rates on MRI varied from approximately 60% to 100% across studies. Badr et al. [25] visualized the appendix in all patients with no false negatives. Ahmed et al. [19] reported visualization in approximately two-thirds of examinations but still found an NPV of 100% and no delayed diagnoses. Buckley et al. [28] noted non-visualization in approximately 42% of cases, yet specificity and NPV remained very high. Bufman et al. [8] visualized the appendix in 83.8% of patients. Nguyen et al. [24] achieved visualization in 81.8% of patients on T1-weighted images and 89.9% on T2-weighted images, increasing to 93.3% when combined. Bekhor et al. [31] found that only one patient in their negative-MRI control group developed appendicitis months later, implying that a non-visualized or normal appendix without secondary signs rarely represents missed disease.

Discussion

This contemporary systematic review of 12 studies suggests that non-contrast MRI often has high diagnostic accuracy for suspected acute appendicitis during pregnancy and may provide excellent performance in many settings. Across these cohorts, the sensitivity is generally in the 80-100% range, the specificity is usually above 90%, and the NPVs are near 95-100% in most series, although one small study reported a substantially lower NPV. This overall pattern appears broadly consistent with earlier meta-analyses [17, 18], and more recent studies provide additional details regarding protocol design, DWI, radiologist expertise, gestational age, appendix visualization, and downstream clinical outcomes.

A major practical finding of the present review is that MRI is especially valuable in cases with inconclusive ultrasound results. The clearest demonstration comes from Ahmed et al. [19], in which ultrasound visualized the appendix in only 1.65% of cases and had a sensitivity of 26.3%, whereas MRI in the same clinical setting achieved 100% sensitivity and very high specificity among diagnostic quality scans. Similar clinical pathways have been described by Lukenaite et al. [26] Bekhor et al. [31], Abgottspon et al. [22], and Bufman et al. [8], in which ultrasound functions mainly as an initial screening test, and MRI provides definitive clarification once sonographic findings are not visualized or are discordant with clinical suspicion. Taken together, these data support the view that a low threshold for proceeding to MRI when ultrasound is nondiagnostic may be appropriate and that a negative or non-visualized ultrasound alone may not reliably exclude appendicitis in pregnant patients.

Another important contribution to the recent literature is a more detailed evaluation of MRI protocol composition. Multiplanar T2-weighted imaging remains the backbone of appendiceal MRI during pregnancy, and several studies have suggested that additional sequences may improve diagnostic confidence when T2-weighted images are inconclusive. In the study conducted by Wong et al. [30], it was reported that the addition of DWI to a structured MRI appendicitis score had a minor effect on sensitivity, specificity, and a significant improvement in the

AUC among patients undergoing DWI, despite the limited sample size of the analysis group who underwent DWI. In the study by Kulali [29] DWI interpretation was associated with greater sensitivity, NPV, and overall diagnostic accuracy than non-contrast anatomical imaging, despite high specificity in both techniques. Nguyen et al. [24] reported minimal differences in sensitivity and specificity when DWI and T1 sequences were added to T2 sequences. In general, these results suggest that DWI and T1 sequences may be useful in certain conditions, for example, in cases where visualizing appendiceal architecture is a challenge, or where minimal signs of inflammation are present. However, studies which directly assess their added efficacy in the context of pregnancy are limited, arousing doubts about the possibility of strong endorsement of the routine use of DWI in pregnancy-related MRI protocols.

The reviewed evidence also suggests that MRI may influence patient management beyond test accuracy alone. Lukenaite et al. [26] reported large reductions in unnecessary surgery, diagnostic operations, and hospital stay after the adoption of an ultrasound-plus-MRI pathway. Bufman et al. [8] and Bekhor et al. [31] described cohorts in which MRI frequently identified alternative diagnoses and was associated with conservative management in a significant number of patients with suspected appendicitis. Similarly, Abgottspon et al. [22] reported that MRI can be of help in clarifying a diagnosis after a negative or equivocal ultrasound, and that it appears to reduce the need for operative exploration for diagnosis only. The relevance of this broader clinical effect may be especially significant during pregnancy, when the reduction of unnecessary surgery and ionizing radiation are significant objectives.

The data on implementation were also encouraging. Despite the fact that some top-notch studies originate from subspecialty institutes, excellent outcomes are not limited to settings where only experts participate. With a strong protocol and appropriate evaluation of the appendix and periappendiceal region, the combined results of Ahmed et al. [19], Buckley et al. [28], Bekhor et al. [31], and Bufman et al. [8] suggest that radiologists of different levels of experience can continue to achieve high performance. Ahmed et al. [19] reported 100% sensitivity for the visualization of the appendix, high specificity, and good inter-reader agreement in a heterogeneous group of body radiologists with 2-28 years of experience. In a study by Buckley et al. [28], 18 radiologists with different subspecialties were able to sustain an accuracy rate of 99.8%, with instances of false negatives being due to inadequate imaging rather than misinterpretation. Additionally, Bufman et al. [8] and Bekhor et al. [31] exhibited excellent effectiveness in emergency care settings. The results suggest that the reputation of the center may be less essential than the structured interpretation, standardized acquisition, and sufficient anatomic coverage for the accuracy of diagnostic tests.

This review is illuminating when compared with previous meta-analyses. Motavaselian et al. [17] confirmed excellent aggregate MRI accuracy with pooled values of 92% and 98% in pregnant women, whereas Duke et al. [18] reported pooled sensitivity and specificity of 94% and 97%, respectively, in the subgroup of pregnant patients within a larger MRI appendicitis meta-analysis. Nevertheless, the main goal of those meta-analyses is to measure the overall diagnostic performance of the studies, whereas this review adds other insights at the study level that are not as apparent in pooled estimates. This review highlights the contemporary application of non-contrast MRI at 1.5T (with very limited use of 3 T) regarding modern methodologies, especially as a second line or problem-solving method following ultrasound in most reported pathways. The discussion includes evaluation of DWI, T1-weighted adjunctive sequences, visualization of the appendix, inter-reader agreement, gestational age-related effects, and downstream management consequences. This study therefore provides a broader insight on the role of MRI in the diagnostic pathway after unsuccessful ultrasound diagnosis, and the advantages of using MRI.

An important consideration when interpreting these findings is the substantial heterogeneity across the included studies in terms of design, MRI protocols, reference standards, radiologist expertise, gestational age distribution, and patient selection. Most cohorts were retrospective, single-center investigations, often from tertiary or referral settings, whereas a smaller number were prospective and more narrowly defined; these differences in setting and case mix may influence the sensitivity, specificity, and applicability of results to lower-risk obstetric populations. Prospective series, such as those of Badr et al. [25] and Wong et al. [30], enrolled smaller, more tightly selected groups and used standardized, often appendix-focused protocols, whereas larger retrospective cohorts, such as those of Ahmed et al. [19], Bufman et al. [8], Bekhor et al. [31], Kahana et al. [23], and Nguyen et al. [24], were drawn from broader emergency or inpatient populations with varying degrees of protocol completeness and clinical suspicion severity.

MRI protocols also varied in terms of field strength, sequence selection, fat-suppressed imaging, DWI/ADC use, anatomical coverage, and timing. These differences are likely to affect the visualization and detection of mild inflammatory changes. For example, Buckley et al. reported that most false-negative cases were due to incomplete imaging rather than misinterpretation, emphasizing the significance of image acquisition quality. Studies that routinely incorporated DWI or structured scoring systems often reported higher sensitivity or negative predictive values than those that used only anatomical sequences. However, DWI and T1-weighted adjuncts were not consistently used across all cohorts. All the included studies applied a consistent reference standard. Surgical histopathology for operated patients and clinical follow-up for those managed conservatively. The follow-up duration

for confirming negative cases varied modestly across studies (ranging from approximately 1 to 5 months), representing a minor methodological difference rather than a fundamental inconsistency in the verification approach. The reader's experience and modes of interpretation also varied from reader to reader. While some studies claimed that there was great accuracy that could be obtained regarding inter-reader agreement, the question remains as to the reproducibility of the results outside specialized settings or depending on the application of detailed protocols and structured reporting. Additionally, gestational age and patient selection should also be interpreted cautiously. Although several cohorts included women across all three trimesters, most studies were not specifically designed or powered to estimate trimester-specific diagnostic performance, and only a few reported accuracy stratified by gestaitional age. Later-gestation patients may also pose greater interpretive challenges because of cephalad appendix displacement and overlapping symptoms, and some cohorts were restricted to women with nondiagnostic ultrasound, which may not represent the full spectrum of presentations. On balance, the available data do not suggest a consistent decline in MRI accuracy with advancing gestation, but they are not yet sufficient to conclude that diagnostic performance is truly unaffected by trimester. These factors, especially the very small MRI sample in Abgottspon et al. [22], and differences in timing of MRI in the pathway, may help to explain the low NPV reported in the series, compared to the more reassuring negative results reported in most of the other cohorts. Overall, this heterogeneity means that the seemingly high accuracy of MRI in pregnancy is the aggregate experience of many different study designs and protocols, rather than a single, consistent performance that can be presumed to hold across all clinical settings.

This review may be particularly informative when considered alongside previous meta-analyses. Motavaselian et al. reported excellent aggregate MRI accuracy, and Duke et al. similarly found high pooled sensitivity and specificity; however, these analyses were primarily designed to quantify overall diagnostic performance. By focusing on contemporary protocols and reporting study-level details, the present review appears to complement those pooled estimates by describing how specific pulse sequences, appendix visualization, inter-reader performance, gestational age, and diagnostic pathways after inconclusive ultrasound have been implemented in recent practices. Within the limits of the available data, this review offers a more detailed, though still incomplete, picture of how non-contrast MRI is currently used in diagnosing appendicitis during pregnancy.

Clinical indications and diagnostic algorithm

Across the 12 contemporary cohorts, MRI was consistently integrated into diagnostic pathways for pregnant patients with suspected appendicitis, but almost always after initial clinical assessment and ultrasound rather than as an isolated primary test. Three recurring patterns were identified. In the most frequent pattern, MRI was obtained when ultrasound was technically limited, did not visualize the appendix, or yielded findings that did not adequately explain persistent clinical suspicion; this scenario is explicitly described by Lukenaite et al. [26], Bekhor et al. [31], Abgottspon et al. [22], and Bufman et al. [8], and can also be inferred in studies where patients were referred for MRI after a nondiagnostic ultrasound or gynecologic evaluation. In the second pattern, MRI was incorporated relatively early into the diagnostic pathway once available, but still typically after clinical assessment and ultrasound, with Ahmed et al. [19] and Badr et al. [25] emphasizing its high diagnostic accuracy and recommending a low threshold for MRI when ultrasound failed to resolve uncertainty. Another pattern concerns the interpretation of MRI after it has been conducted. Le et al. [27] focused on morphologic thresholds. Wong et al. [30], Kulali [29] and Nguyen et al. [24] considered the added value of DWI and structured scoring. Kahana et al. [23] discussed how MRI features help distinguish uncomplicated from complicated appendicitis and thus guide management decisions.

When the 12 studies were considered together, the indication most consistently supported by the evidence was persistent suspicion of appendicitis despite a nondiagnostic ultrasound. Ahmed et al. [19] illustrated this pathway clearly, ultrasound visualizes the appendix in only 1.65% of examinations and has a sensitivity of 26.3%, whereas MRI in the same cohort achieves 100% sensitivity and 96% specificity, with an NPV of 100%. Lukenaite et al. [26] showed that implementing a structured ultrasound-plus-MRI pathway reduced unnecessary operations by 90%, decreased purely diagnostic explorations by 90%, and shortened the median hospital stay. Bekhor et al. [31] reported that in an emergency department cohort where patients were referred for MRI after inconclusive ultrasound, MRI allowed conservative management in 82% of cases, with only one delayed appendicitis diagnosis during a 90-day follow-up. Abgottspon et al. [22] also showed that MRI clarified the diagnosis in women who had been chosen for additional imaging following negative or equivocal point-of-care ultrasounds, properly diagnosing appendicitis in patients with nondiagnostic ultrasound, and demonstrating that MRI can safely reassure in others. Consistent with guideline recommendations, ultrasound is favored as the initial test, with non-contrast MRI being the chosen next imaging step when ultrasound does not fully explain persisting clinical concerns.

Several studies have also highlighted that MRI is appropriate when the clinical picture remains discordant with ultrasound findings, not only when ultrasound is formally inconclusive. In Ahmed et al. [19], leukocytosis was significantly associated with appendicitis, whereas gestational age, maternal age, and temperature were not, suggesting that persistent clinical or laboratory concerns should prompt further imaging, even when ultrasound

results appear reassuring. Kahana et al. [23] described the low sensitivity of clinical scoring systems during pregnancy and highlighted the importance of imaging, especially MRI, in cases of persistent symptoms. This view was supplemented by the emergency department view, as described by Bufman et al. [8] and Bekhor et al. [31], in which MRI not only confirms or excludes appendicitis but also often detects alternative gynecologic, urologic, or gastrointestinal diagnoses, which changes the patient's care. Wong et al. [30] and Kulali [29] showed, with an emphasis on diffusion-weighted sequences, that DWI can boost diagnostic confidence in borderline or equivocal situations without contrast or ionizing radiation. Taken together, these data support a pathway-based principle: when ultrasound is negative or non-visualizing but clinical suspicion does not resolve, non-contrast MRI is the appropriate next investigation.

Therefore, a pragmatic diagnostic algorithm can be outlined rather than mandated. Initial evaluation centers on clinical assessment and basic laboratory tests, since none of the included studies suggest that imaging alone can replace clinical judgment. Ultrasound typically serves as the first imaging test, reflecting its wide availability, speed, and safety in pregnancy. When ultrasound clearly visualizes an inflamed appendix and the findings are concordant with the clinical picture, most pathways proceed directly to surgical consultation. However, contemporary cohorts indicate that failure to visualize the appendix, technically limited examinations, or ultrasound findings that do not convincingly explain persistent pain or inflammatory markers should be regarded as signals to consider MRI rather than reassurance that appendicitis has been excluded.

When MRI was performed, evaluated studies converged on fast, non-contrast protocols centered on multiplanar T2-weighted imaging, usually single-shot or fast spin-echo imaging, with routine inclusion of fat-suppressed T2-weighted sequences. Badr et al. [25] achieved 100% visualization of the appendix and 100% sensitivity using such a protocol, whereas Buckley et al. [28] showed that missed appendicitis cases are more often attributable to incomplete fat-saturated imaging than to interpretative errors. In centers where DWI is available, Wong et al. [30], Kulali [29], and Nguyen et al. [24] described the use of DWI and apparent diffusion coefficient maps to increase confidence in equivocal cases and refine structured MRI scoring systems, although only a limited number of studies have formally quantified its incremental effect on diagnostic performance. T1-weighted gradient-echo sequences typically reveal anatomical information and are employed in sequence-based frameworks, such as the one presented by Nguyen et al. [24], to resolve uncertainty after the assessment of T2 and DWI.

These combined data can be used to construct interpretation strategies. Le et al. [27] supported the use of morphological criteria, such as appendiceal diameter, wall thickness, luminal signal, periappendiceal fat stranding, and fluid, as primary MRI signs of acute appendicitis. Ahmed et al. [19], Badr et al. [25], and Bekhor et al. [31] stressed the necessity of combining direct appendiceal observations with secondary inflammatory alterations and clinical contexts. Wong et al. [30] suggested an MRI appendicitis scale based on structural features and DWI signals, and Kulali [29] showed that diffusion metrics were significantly different between inflamed and normal appendices in their cohort. These results support the potential value of DWI as an adjunct in selected cases; however, further studies are needed to determine how consistently such findings translate into improved outcomes in broader pregnancy populations. Kahana et al. [23] proposed that MRI findings suspicious of complex appendicitis are of particular importance in operative decision-making and may influence the timing and type of surgical procedures. A common finding across cohorts is that technically sufficient MRI with the absence of periappendiceal inflammatory signals, even if the appendix is not directly visible, has a very high NPV and seldom leads to missed appendicitis on follow-up. This promotes conservative care with monitoring in such situations, as long as imaging quality is guaranteed and appropriate clinical follow-up is available.

The following is an evidence-based algorithm for suspected appendicitis in pregnancy, recognizing that local resources and practices may differ. Standard practice involves clinical evaluation of pregnant patients with suspected appendicitis and an initial ultrasound. If the ultrasound is unequivocally positive and correlates with the clinical presentation, management usually proceeds accordingly. If the ultrasound is nondiagnostic, fails to visualize the appendix, or is inconsistent with persistent suspicion, noncontrast MRI is often the next imaging modality of choice. MRI protocols emphasize multiplanar T2-weighted and fat-suppressed T2-weighted sequences, with DWI and, where helpful, T1-weighted imaging employed to resolve equivocal data. A clearly positive MRI generally supports surgical evaluation, particularly when signs of complicated appendicitis are present. A negative MRI - including studies in which the appendix is not seen but no secondary inflammatory changes are present - has consistently been associated with very high NPVs and often leads to conservative management with follow-up. Rather than prescribing a rigid universal pathway, the twelve studies and recent external literature collectively favor a flexible principle: ultrasound may initiate imaging, but MRI is usually the decisive modality whenever ultrasound does not adequately explain a pregnant patient's ongoing clinical suspicion of appendicitis. Also, the available data are not sufficient to draw firm conclusions about MRI-first strategies; any such use would be an extrapolation that requires further prospective evaluation.

Limitations

This systematic review has several limitations. Most of the cohorts analyzed were retrospective and single-cen-

ter-based, whereas a small proportion of the cohorts were prospective; the heterogeneity in inclusion criteria combined with this could limit the applicability of the findings to low-risk obstetric populations. The clinical setting was also inconsistently reported - some cohorts were emergency-department based, whereas others originated from referral centers or broader inpatient services - further limiting comparability of pretest probability across studies.

MRI protocols varied in field strength, sequence selection, DWI/T1-weighted use, anatomic coverage, and timing, and thresholds for a positive study and handling of nonvisualized or technically limited examinations were not standardized. However, different studies used the same standard reference: for operated patients, histopathology was used, and for the rest of the patients, clinical follow-up was utilized.

We did not conduct a meta-analysis review of diagnostic accuracy but rather proceeded with a systematic synthesis of individual study results. Despite the fact that some of the studies in the review reported results about their sensitivity and specificity, and some even provided 2×2 tables, attempts to pool these diagnostic accuracy measures have failed due to the major discrepancies in the patient selection, clinical settings used, and compositions of MRI protocols, as mentioned earlier, as well as the variations in the definitions of positive results and the fact that many studies involved small sample sizes or provided only partial data for 2×2 tables. Therefore, although pooled estimates of sensitivity and specificity may theoretically work statistically, they would not be clinically accurate, with the ability to hide essential variations between protocols and groups of patients. In this study, the diagnostic accuracy has been summarized descriptively at the study level and compared to the existing meta-analyses with aggregative data on the effectiveness of MRI applied in various or mixed groups of patients.

Most studies were not designed or powered to detect trimester-specific differences in diagnostic accuracy, and stratified reporting by gestational age was uncommon; larger studies with explicit subgroup analyses are needed to clarify this. Finally, evidence on the incremental value of DWI and T1-weighted adjuncts comes from a small number of studies, so conclusions about their added benefit should be considered hypothesis-generating rather than definitive.

Future directions

From a clinical perspective, current evidence supports integrating non-contrast MRI - particularly protocols that include fat-suppressed T2-weighted imaging and, where available, DWI - into diagnostic pathways for pregnant patients with suspected appendicitis after nondiagnostic ultrasound. This strategy appears to reduce unnecessary operations, avoid ionizing radiation, and maintain excellent diagnostic safety. However, these pathways have predominantly been evaluated in retrospective cohorts from tertiary centers with limited sample sizes. Consequently, their performance, feasibility, and cost effectiveness in community and resource-limited settings remain uncertain.

To address these gaps, future research should focus on prospective, multicenter studies that directly compare ultrasound-first, MRI-first, and ultrasound-plus-MRI strategies. Such studies should use standardized inclusion criteria and measure not only diagnostic accuracy but also time to diagnosis, negative appendectomy and perforation rates, maternal-fetal outcomes, and healthcare utilization [1, 2]. Parallel development and validation of consensus pregnancy-specific MRI protocols, including the role of DWI and structured MRI scoring systems, are needed to support consistent implementation across varying levels of radiologist expertise.

Longer-term registries and formal economic evaluations will be essential. They should determine whether the higher upfront costs and resource requirements of MRI are offset by reductions in unnecessary surgery, shorter hospital stays, and reduced radiation exposure. Additionally, they should clarify any subtle maternal or neonatal effects of different imaging strategies that are not captured in short-term studies [5, 6].

Conclusion

This systematic review of 12 contemporary studies indicates that non-contrast MRI generally shows high sensitivity, specificity, and particularly strong negative predictive value for suspected acute appendicitis in pregnancy, across varied centers and radiologist experience levels. MRI can be incorporated into diagnostic pathways specifically as a second-line modality after ultrasound is nondiagnostic, technically limited, or discordant with clinical suspicion.

The evidence does not support MRI as a first-line test: only a few studies directly evaluated pathways involving MRI after inconclusive ultrasound, and none provided an adequately powered comparison of MRI-first versus ultrasound-first strategies. Any first-line use of MRI falls outside current evidence.

These results reflect an overall trend, rather than a reproducible level of accuracy, since study protocols, radiologist experience, gestational age and patient selection were substantially heterogeneous. There is lack of evidence that performance is not influenced by gestational age. The added value of DWI and T1-weighted sequences is preliminary.

Within these limits, an ultrasound-first, MRI-second approach may reduce unnecessary surgery and radiation exposure. Confirmation of this and to fill the identified

gaps will require large prospective multicenter studies with standardized protocols and gestational age subgroup analyses.

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