

Original Investigation

## The Use of Magnetic Resonance Imaging in the Diagnosis of Suspected Appendicitis in Pregnancy Shortened Length of Stay Without Increase in Hospital Charges

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## Introduction

- Prevalence in pregnancy: 0.07% to 0.13%
- Most common **nonobstetric** indication for emergency surgery in pregnant patients
- Classic signs: right lower quadrant tenderness to palpation, guarding, and rebound may **not** be seen

- Increased loss of pregnancy
  - 1.5% for nonperforated appendicitis
  - 20% for perforated appendicitis
- Fetal loss rate: **1.88 times** higher in patients undergoing a negative appendectomy
- MR imaging may increase cost without improving outcomes

- Perform a comparative effectiveness evaluation comparing MR imaging with clinical evaluation
  - length of stay (LOS), maternal and fetal complications, and hospital charges

## Method

- A **retrospective** review
- From January 1, 2000 to July 31, 2011, at Yale–New Haven Hospital
- Magnetic resonance imaging was performed without gadolinium
- Diagnosis made by surgical impression in the operative report and pathology confirmation

## Result

- 96 pregnant patients with abdominal pain were evaluated
- 17 patients were excluded
  - traumatic injuries (n = 10)
  - cholecystitis that was diagnosed based on US (n = 7)

- 79 patients were suspected of having appendicitis
  - 34 patients (43%): pathology-confirmed
  - 45 patient (57%) did not
- 4 patients underwent CT (2 had appendicitis, while 2 did not) → excluded
- 31 patients underwent MRI.

Table 1. Clinical Features and Outcomes of Pregnant Patients With vs Without Appendicitis<sup>a</sup>

Variable	Appendicitis (n = 32)	No Appendicitis (n = 43)	P Value <sup>b</sup>
Pregnancy trimester, No. (%)			.97
1	15 (47)	19 (44)	...
2	11 (34)	16 (37)	...
3	6 (19)	8 (19)	...
Anorexia, No. (%)	20 (63)	14 (33)	.02
Nausea, No. (%)	30 (94)	33 (77)	.10
Vomiting, No. (%)	26 (81)	22 (51)	.01
Fever, No. (%)	4 (13)	1 (2)	.20
Abdominal pain, No. (%)	32 (100)	43 (100)	...
Duration of symptoms, mean (median), h	33.4 (24)	47.6 (24)	.13
Right lower quadrant tenderness, No. (%)	31 (97)	41 (95)	.80
Guarding, No. (%)	20 (63)	11 (26)	.002
Rebound, No. (%)	11 (34)	6 (14)	.07
Rovsing sign, No. (%)	11 (34)	4 (9)	.02
Generalized peritonitis, No.	0	0	...
Fetal distress, No.	0	0	...
White blood cell count, mean (SD), /μL	14 600 (3900)	11 300 (3500)	<.001
Attempted mechanism of diagnosis, No. (%)	...	...	<.001
Clinical diagnosis	8 (25)	22 (51)	...
US diagnosis	13 (41)	1 (2)	...
MR imaging diagnosis	11 (34)	20 (47)	...
Operative intervention, No. (%)	32 (100)	8 (19)	<.001
Adverse fetal outcome, No. (%)	2 (6)	7 (16)	.33

Abbreviations: ellipsis, not applicable; MR, magnetic resonance; US, ultrasonography. SI conversion factor: To convert white blood cell count to  $\times 10^3/L$ , multiply by 0.001. <sup>a</sup> The 79 total patients in the study include 4 patients evaluated by computed tomography. <sup>b</sup> t Test,  $\chi^2$  test, or Fisher exact test where appropriate.

Figure 1. Diagnostic Modalities and Management of Pregnant Patients With Suspected Appendicitis

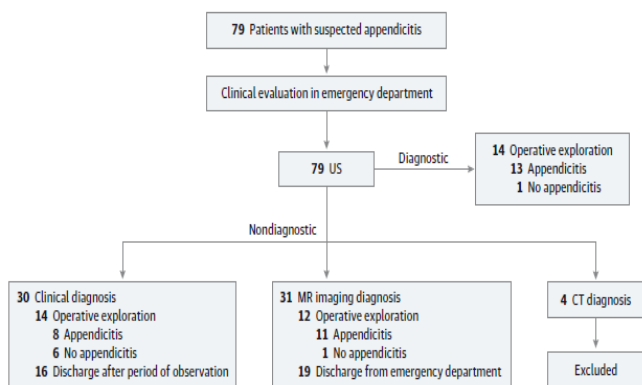


Figure 2. Sensitivity, Specificity, and Likelihood Ratios Associated With Various Diagnostic Modalities in the Management of Pregnant Patients With Suspected Appendicitis

<b>30 Suspected appendicitis</b> 4 Operative exploration 2 Appendicitis 2 No appendicitis 26 Admission and observation 10 Operative exploration 6 Appendicitis 4 No appendicitis 16 Discharge	<b>31 MR imaging</b> 11 Positive MR imaging 11 Appendicitis 20 Negative MR imaging 20 No appendicitis	<b>79 US</b> 14 Positive US 13 Appendicitis 1 No appendicitis 65 Nondiagnostic US 20 Appendicitis 45 No appendicitis
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	Clinical Diagnosis	US Diagnosis	MR Imaging Diagnosis
Sensitivity	25%	39%	100%
Specificity	91%	98%	100%
Positive likelihood ratio	11.00	18.07	20.00
Negative likelihood ratio	0.82	0.62	0.00

Table 3. Outcomes Associated With Undergoing MR Imaging

Variable	No MR Imaging (n = 44)	MR Imaging (n = 31)	P Value <sup>a</sup>	Odds Ratio (95% CI)
Time to operative exploration, mean (SD), h <sup>b</sup>	13.6 (9.6)	10.5 (6.0)	.23	...
Operative exploration, No. (%)	27 (61)	12 (39)	.07	0.45 (0.18-1.16)
Perforated appendicitis, No./total No. (%)	5/44 (11)	3/31 (10)	.82	1.20 (0.26-5.42)
Nontherapeutic exploration, No. (%)	7 (16)	1 (3)	.13	0.44 (0.08-2.32)
Admission for observation, No. (%)	22 (50)	8 (26)	.04	0.35 (0.13-0.94)
Adverse fetal outcome, No. (%)	4 (9)	5 (16)	.47	1.09 (0.90-1.31)
LOS, mean (SD), h <sup>b</sup>	64.8 (33.9)	33.7 (32.3)	<.001	...
LOS among nonoperated patients, mean (SD), h <sup>b</sup>	55.1 (35.7)	16.4 (11.8)	<.001	...

## Discussion

- The diagnosis of appendicitis is **not** straightforward in pregnant patients.
- The signs and symptoms of appendicitis are **nonspecific** and are shared with many other common conditions in pregnancy.
- Clinical diagnosis in our study was also specific (91%) but had a much lower sensitivity of 25%

- Ultrasonography was useful in detecting disease (specificity: 98%), but had a low sensitivity of 39%
- should be used as the **initial imaging** evaluation: inexpensive, readily available, no radiation

- In our study, MRI had a sensitivity of 100% and a specificity of 100%
- had lower incidences of operative exploration and nontherapeutic exploration
- in cases of negative or equivocal US likely will **minimize unnecessary operations**
- decrease in hospital admissions and LOS

- Although the use of MR imaging slightly increased the mean total hospital charges, the increase was minimal and differed by only about **10%**
- overnight admission approach the charges associated with MR imaging

## Limitations of study

- Selection bias
  - evaluated only patients in emergency department with abdominal pain
- The decision to perform MRI also was not randomized and may have been influenced by clinical presentation