

OBSTETRICS

Utility of magnetic resonance imaging for suspected appendicitis in pregnant women

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OBJECTIVE: The purpose of this study was to estimate the rate and risk of appendix nonvisualization and alternative diagnoses made with magnetic resonance imaging (MRI) for suspected appendicitis in pregnant women.

STUDY DESIGN: We performed a retrospective cohort study of consecutive pregnant women who underwent MRI for suspected appendicitis at a single center from 2007-2012. Data on clinical presentation, imaging, and surgical pathologic evidence were extracted from electronic medical records. Odds ratios estimated risk factors for nondiagnosis. Radiologic diagnoses were identified, and rates of diagnoses were calculated. Subgroup analysis was performed among women who underwent initial imaging with ultrasound scanning.

RESULTS: Over the 5-year period, 171 pregnant women underwent MRI for suspected appendicitis. The rate of nonvisualization was 30.9% (n = 53). Of the remaining 118 women with a visualized

appendix, 18 women had imaging findings that were consistent with appendicitis and underwent appendectomy. Twelve cases of appendicitis were confirmed on pathologic evaluation (66.7%). Women with nonvisualization of the appendix on MRI were more likely to be beyond the first trimester (odds ratio, 2.1; 95% confidence interval, 1.0–4.5). Seventy-four women had disease diagnosed on MRI (43.3%). In the group of 43 women who had a nondiagnostic ultrasound scanning before the MRI, the rate of subsequent diagnostic MRI was 65% (n = 28).

CONCLUSION: MRI yields a high diagnostic rate and accuracy in pregnant women with suspected appendicitis and provides alternative diagnoses to guide further management. Given the high rate of appendix nonvisualization on ultrasound scanning that has been reported in the literature, we recommend MRI as the imaging modality of choice for this population in settings in which MRI is readily available.

Key words: appendicitis, imaging, MRI

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The clinical presentation of appendicitis in pregnant women is complicated by physiologic changes of pregnancy, such as anatomic displacement of the appendix by the gravid uterus, leukocytosis, and gastrointestinal symptoms such as nausea and vomiting. These confounding factors make it difficult to diagnose appendicitis based on clinical findings alone. Because of maternal and fetal morbidity and death that are associated with ruptured

appendicitis, early recognition and intervention are crucial.^{1,2}

Preoperative imaging has become an important component of the diagnostic work-up for suspected appendicitis in pregnant women, and there are data demonstrating a decrease in negative laparotomy rates for suspected appendicitis when imaging is used³; however, the optimal imaging modality remains controversial. The 2011 American College of Radiology Appropriateness

Criteria designated ultrasound scanning with graded compression as the initial imaging study of choice in this patient population; the criteria reserved magnetic resonance imaging (MRI) for cases of appendix nonvisualization on ultrasound scan,⁴ yet the rate of nonvisualization on ultrasound scanning ranges from 68–97% in the literature.⁵⁻⁷ A recent metaanalysis of 6 articles that evaluated MRI for suspected appendicitis in pregnant women included a total of 359 patients.⁸ This metaanalysis concluded that the diagnostic strengths of MRI included high specificity (98%) and negative predictive value (99%) and that a visualized normal appendix on MRI is highly accurate for excluding acute appendicitis; however, estimated rates of nonvisualization of the appendix ranged from 1–68% among these 6 articles, which is a difference that is attributed to the lack of standardized imaging protocols among the studies. Technical factors that preclude adequate

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visualization of the appendix on MRI in the pregnant woman include motion artifact from fetal movement and limited maternal breath holding, simulation of the appendix by dilated pelvic and retroperitoneal vessels, and inconsistency in the degree of anatomic displacement of the appendix among pregnant women.⁹

We performed a study of consecutive pregnant women who underwent MRI with a standardized protocol for suspected appendicitis to estimate the rate of and risk factors for nonvisualization of the appendix. Given the reported high rates of appendix nonvisualization on ultrasound scanning, we secondarily aimed to assess the ability of MRI to visualize the appendix in women with a nonvisualized appendix on ultrasound scanning. Because one of the potential advantages of MRI over ultrasound scanning in these cases is the ability to visualize many different types of intra-abdominal pathologic conditions, we also aimed to identify alternative diagnoses that are provided by MRI in this patient population.

MATERIALS AND METHODS

We conducted a retrospective cohort study of consecutive pregnant women who underwent MRI for suspected appendicitis at Barnes-Jewish Hospital from 2007-2012. Study approval was obtained from the Washington University School of Medicine Human Research Protection Office. For suspected appendicitis in pregnant women, our institution uses a standardized MRI protocol that consists of noncontrast imaging with multiplane half-Fourier acquisition single-shot turbo spin-echo, true fast imaging with steady-state precession, and 2-dimensional Flash sequences performed at 1.5T on a Siemens Symphony or Siemens Espree (Siemens, Munich, Germany). Board-certified attending radiologists with experience reading abdominal and pelvic MRIs provided all final imaging interpretations and diagnoses. All consecutive pregnant women with suspected appendicitis who underwent standardized imaging according to this protocol comprised our cohort. Women were

included in the study if they had a positive urine pregnancy test and/or a visible pregnancy on ultrasound scanning at the time that they underwent MRI. Women were excluded if they were not pregnant or if they underwent an MRI for reasons other than suspected appendicitis.

Detailed data were extracted from electronic medical records on patient demographics, history (medical, surgical, social), pregnancy, symptoms, vital signs (temperature, heart rate, blood pressure, respiratory rate), abdominal examination findings (presence or absence of bowel sounds, tenderness, rebound, guarding), laboratory results (complete blood count, comprehensive metabolic panel, amylase, lipase), imaging reports (ultrasound scanning, MRI, computed tomography [CT]), intraoperative findings, and surgical pathologic findings. Data on pregnancy outcomes that included gestational age at delivery, mode of delivery, neonatal disposition, and postpartum complications were also collected. Women who did not deliver within our hospital system were contacted directly by telephone to obtain information on pregnancy outcomes.

Baseline characteristics were compared between women who had a visualized appendix on MRI and those who did not. Independent Student *t* test and Mann-Whitney *U* tests were used for continuous variables; χ^2 and Fisher exact tests were used for dichotomous variables as appropriate. Odds ratios (ORs) for nonvisualization of the appendix and 95% confidence intervals (CIs) were calculated for each of the variables of interest. Subgroup analysis was performed among women who underwent initial imaging with ultrasound scanning. Statistical analyses were performed with STATA software (version 10 special edition; StataCorp, College Station, TX).

RESULTS

Over the 5-year period, 178 patients underwent MRI with the institutional pregnant appendicitis protocol. Seven women were excluded: 1 woman who was not pregnant, 2 women who underwent MRI for Crohn's flare, 1 woman

who underwent MRI for further evaluation of a known psoas abscess of uncertain cause, 1 woman who underwent MRI for small bowel obstruction, 1 woman who underwent MRI for ruptured diverticulitis, and 1 woman who underwent MRI for hydronephrosis. The remaining 171 pregnant women who underwent MRI for suspected appendicitis were included in our study (Figure). The cohort was described and baseline characteristics were compared between women who had a visualized appendix on MRI and those who did not (Table 1).

The rate of appendix nonvisualization on MRI was 30.9% (*n* = 53 women). None of the women with a nonvisualized appendix subsequently underwent appendectomy. Twenty-four of these patients had a documented clinical diagnosis that may explain their complaint. These diagnoses included ruptured corpus luteum (*n* = 4), pyelonephritis (*n* = 4), round ligament pain (*n* = 3), degenerating fibroid tumors (*n* = 2), placental abruption (*n* = 2), gastroenteritis (*n* = 2), hyperemesis gravidarum (*n* = 2), ectopic pregnancy (*n* = 1), uterine rupture (*n* = 1), Crohn's flare (*n* = 1), urinary tract infection (*n* = 1), and incarcerated hernia (*n* = 1). Four of the 53 women with a nonvisualized appendix on MRI underwent surgery: 1 diagnostic laparoscopy for a ruptured corpus luteum, 1 right salpingectomy for a ruptured ectopic pregnancy, 1 total abdominal hysterectomy for uterine rupture, and 1 reduction and closure of an internal hernia. Women with nonvisualization of the appendix on MRI were more likely to be beyond the first trimester (OR, 2.1; 95% CI, 1.0–4.5). Obesity and previous cesarean delivery did not have significant effects on the risk of appendix nonvisualization (OR, 1.9; 95% CI, 0.3–4.4, and OR, 0.8; 95% CI, 0.8–1.3, respectively).

The remaining 118 women had successful visualization of the appendix on MRI to confirm or rule out acute appendicitis; 18 women with an abnormal appendix and 100 women with a normal appendix were identified. Of the 18 women with an abnormal appendix, all underwent appendectomy,

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