Accuracy of Magnetic Resonance Imaging and Ultrasound for Appendicitis in Diagnostic and Nondiagnostic Studies

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Abstract

Objectives: Suggestive radiographic studies with nonvisualization of the appendix can present a challenge to clinicians in the evaluation of pediatric abdominal pain. The primary objective of this study was to quantify the accuracy of magnetic resonance imaging (MRI) and of ultrasound (US) in the setting of nonvisualization of the appendix. Secondary objectives reported include sensitivity of MRI and US overall and correlation between MRI and US for diagnosis of appendicitis.

Methods: Records of pediatric emergency department patients aged 3 to 21 years undergoing MRI and/or US for the evaluation of appendicitis were retrospectively reviewed. Radiographs were categorized as a normal appendix, neither demonstrating the appendix nor demonstrating abnormalities consistent with appendicitis; equivocal, not demonstrating the appendix but showing evidence of appendicitis; demonstrating an abnormal appendix consistent with appendicitis; or demonstrating an alternate pathology. The reading was compared with the final diagnosis for accuracy.

Results: Of the 589 patients included, 146 had appendicitis. Diagnostic accuracy for studies with a nonvisualized appendix without secondary signs of appendicitis was 100% for MRI and 91.4% (95% CI = 87.3% to 94.2%) for US. Diagnostic accuracy for studies with a nonvisualized appendix with secondary signs of appendicitis was 50% (95% CI = 2.5% to 97.5%) for MRI and 38.9% (95% CI = 18.2% to 64.5%) for US. Appendicitis was ultimately diagnosed in 8.6% of patients with an otherwise negative right lower quadrant (RLQ) US that failed to directly identify the appendix. There was a moderate correlation between US and MRI (ρ = 0.573, p = 0.0001) when all studies were considered.

Conclusions: Magnetic resonance imaging without secondary signs of appendicitis is effective in excluding appendicitis regardless of whether the appendix is directly visualized, while otherwise negative RLQ US that fail to identify the appendix are less useful. Secondary signs of appendicitis without visualization of the appendix were not helpful regardless of radiographic modality. Results of MRI and US correlated moderately well.

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Imaging for appendicitis may decrease the negative appendectomy rate and is frequently considered an integral part of the evaluation for appendicitis.¹ The need to balance this against the risk of radiation from abdominal computed tomography (CT) done for this purpose has led to the investigation of alternate radiographic modalities, particularly in pregnant women and children. Both ultrasound (US) and magnetic resonance
imaging (MRI) are alternatives to CT that spare the patient ionizing radiation.

Small studies of MRI in pregnant women demonstrate variable sensitivity with a substantial number of inconclusive studies.2,3 In children, small to moderately sized studies demonstrate a high sensitivity (96.2% to 97.6%) and specificity (96.2% to 97%) of MRI,3,5 which is comparable to the performance of CT.6 MRI seems to perform accurately regardless of duration of pain7 and is well-tolerated by most children.8 In the absence of direct visualization of the appendix, corroborative signs (free fluid, inflammatory fat changes) each have specificities ranging from 81% to 100%.9 In a small study of 41 cases, a superfast MRI protocol demonstrated a sensitivity of 91.7% and specificity of 100%.10

Algorithms using US, followed by MRI in inconclusive cases, have been shown equivalent to CT in terms of time to antibiotic administration, time to appendectomy, negative appendectomy rate, and length of stay.11 In one study, low-risk patients with inconclusive or negative right lower quadrant (RLQ) US had a 6% to 12% risk of appendicitis.12 The sensitivity and specificity of subsequent MRI, even in this US inconclusive group, approached 100%.13 Unfortunately, the total number of patients with appendicitis completing a full protocol of US and MRI in this study was small. Additionally, many studies consider US with findings suggestive of appendicitis nondiagnostic or equivocal if the appendix is not clearly visualized. Interpretation of suggestive but nondefinitive studies, both for MRI and for US remains a largely unanswered question.

The primary goal of this study was to determine the accuracy of probable findings of MRI and US in our population by evaluating studies where the appendix was not directly visualized but other findings pointed to or against appendicitis. The hypothesis was that probable findings would have reasonable accuracy for the diagnosis of appendicitis and it was anticipated that the sensitivity and specificity of the test would remain at or above 95% when probable findings without visualization of the appendix were included. Secondly, the test characteristics of MRI and US overall and correlation between US and MRI results are reported.

**METHODS**

**Study Design**

This was a retrospective chart review including radiology images. The protocol was reviewed and approved by the institutional review board.

**Study Setting and Population**

This study was performed at an academic hospital with a dedicated pediatric emergency department (ED). A list of patients aged 3 through 21 years of age undergoing imaging of the RLQ by US or MRI from 2010 to 2013 was retrospectively obtained by querying the electronic radiology system for 1) US labeled RLQ, pelvis, abdominal, or obstetric and 2) MRI labeled RLQ, abdomen, pelvis, or miscellaneous. Patients from this list with an US and/or MRI indication of consideration of appendicitis were included. During order entry, providers are asked for a history as well as specifically what pathology they are evaluating. Therefore “rule out appendicitis” would be a standard field when ordering these studies. Patients who left prior to completion of work-up or those who left against medical advice, as well as incarcerated patients, were excluded. Postsurgical patients undergoing evaluation for postsurgical abscesses were also excluded.

**Study Protocol**

Emergency department records, laboratory records, radiology records, inpatient medical records, surgical reports, and pathology records were obtained and reviewed on each included patient. Information recorded (when applicable) included age; sex; chief complaint; US outcome; MRI outcome; CT outcome; disposition location; ED diagnosis; final hospital diagnosis; whether surgical or medical management was performed for appendicitis; diagnosis per operative report; diagnosis per surgical pathology report; and times for triage, ED disposition, and each radiographic study. This information was gathered from four different computer systems: the ED electronic medical records (Wellsoft, Somerset, NJ), a system into which dictations are typed and laboratory and pathology reports recorded (Affinity, Al Nahla Solutions LLC, Oman), a system into which paper charts are scanned (Quantum, The Quan- tum Group, Lake Worth, FL), and the computerized workstation for viewing radiographs (Synapse, FujiFilm, Tokyo, Japan). This information was entered into SurveyGizmo (www.surveygizmo.com) as text for ED diagnosis and chief complaint, and categorical options for sex, surgical and pathologic diagnosis, disposition, and radiograph results, and then downloaded to a Microsoft Excel data sheet with unique study numbers, deidenti- fied but linked to patient-level information via a separate data sheet. For patients who were discharged from the ED or those who were transferred to another institution, up to three follow-up phone call attempts were made by one of three attending pediatric emergency physicians (EPs) and one medical student, following standardized scripts written by the primary investigator (PI). The electronic medical record was queried for updated and alternate phone numbers. These phone calls were made during 2014; therefore, the follow-up time period was between 1 and 4 years. For patients not reached by phone, hospital records subsequent to the index visits were reviewed for evidence of symptom improvement and documentation of other interventions. Patients who were not reached and had no follow-up data were eliminated for calculation of test characteristics, but maintained for correlation. All data collection was performed by one of eight pediatric EPs, pediatric or emergency medicine residents, or medical students not blinded to the study question. All received training instructions from one of the study coordinators. The study PI reviewed the data sheet to ensure that all appropriate fields were completed. Throughout the data collection phase, the PI would repeat data collection on five patients of each abstractor, as well as all that were labeled equivocal. If there were significant discrepancies, all abstractors were reeducated and all the data collected by that abstractor were repeated by the PI. Final attending radiologist readings of the MRIs and
RLQ US were used. Investigators categorized RLQ US and MRI reports as 0 = demonstrating a normal appendix; 1 = not demonstrating the appendix, but not demonstrating any abnormalities consistent with appendicitis (including free-fluid classified as either physiologic or small without other suggestive findings in adolescent girls); 2 = equivocal (more than physiologic free fluid); 3 = lymphadenopathy, inflammation of distal ileum; 4 = not demonstrating the appendix, but demonstrating evidence of appendicitis (abscess, periappendiceal inflammation); 5 = demonstrating an abnormal appendix consistent with appendicitis; or 6 = demonstrating an alternate pathology based on the radiology attending final read.

Definitions. Patients were categorized as having appendicitis if the diagnosis listed on the final surgical pathology report by the attending pathologist stated “appendicitis.” Both acute and chronic appendicitis were considered positive. If the surgical diagnosis was appendicitis, but the pathology demonstrated a normal appendix, this was considered not appendicitis. In the cases where surgery was not performed, the surgeons’ decision to provide medical therapy for appendicitis (either with antibiotics or with percutaneous drainage and antibiotics) was considered diagnostic of appendicitis. In cases that were transferred to outside institutions for surgery, diagnosis was based on confirmation with the family that surgery was performed and the child was diagnosed with appendicitis. Patients were considered negative for appendicitis if surgery was performed and the pathology was negative, if the child was hospitalized and a diagnosis of appendicitis was excluded clinically, if a child was discharged home and phone contact revealed that the child was not subsequently diagnosed with appendicitis within 30 days of the index visit, or if subsequent medical records from our hospital demonstrated resolution of symptoms without interventions for appendicitis. In dividing the radiographic studies into categories, 0, 1, and 5 were placed in the “appendicitis” group; 3 and 4 were considered “positive”; and the equivocal group (2) was excluded. However, the data were also run for comparison with the equivocals counted as positive and as negative.

Radiographic Studies. Right lower quadrant US was performed with a 14- or 9-MHz linear transducer with the use of Doppler. In August 2010, our center developed a protocol with radiology for dedicated imaging of the appendix by MRI, and all MRIs were performed with this protocol. MRIs are performed without contrast with a 1.5-Tesla magnet using 5-mm slices through the entire RLQ.

Data Analysis. Descriptive statistics, sensitivity, and specificity with confidence intervals (CIs) were calculated. t-tests were used for comparison of ages between groups. p-values of <0.05 were considered significant. No adjustment was made for multiple comparisons. Tetrachoric correlation was used to estimate the relationship between US and MRI results to account for threshold differences as well, due to the fact that continuous variable of degrees of radiograph positivity and negativity were used, and then collapsed it into a more dichotomous variable of positive or negative. All statistics were performed on STATA (version 13).

RESULTS

The initial review of all patients with RLQ US or MRI of the appendix ordered yielded 632 patients. The final analysis included 589 studies. Reasons for elimination included postsurgical evaluation (n = 6), evaluation for another condition (n = 1), left against medical advice prior to completion of treatment (n = 4), incarceration (n = 4), and no medical records matching anticipated evaluation or duplicate medical records (n = 28). Of the 589 patients, follow-up was completed in 526 patients (89.3%). This includes nine patients who were transferred out, of whom four were reached in phone follow-up and one found in chart review. Mean (±SD) age was 14.4 (±5.6) years. Included patients and their outcomes are shown in Figure 1.

Of the 156 patients who received surgery, 11 (7.2%) had alternate pathology, four (2.6%) had negative laparoscopies, and 141 (90.4%) had appendicitis. Five patients with recognized appendicitis were medically managed; thus, the total number of patients with appendicitis was 146 (137 acute per surgical pathology, four chronic per surgical pathology, five medically managed). Of these, there were 38 (26%) with documented evidence of perforation. Patients with appendicitis had a mean age of 15 years (95% CI = 14.2 to 15.8 years) compared with 14.1 years (95% CI = 13.6 to 14.7 years) for the patients not diagnosed with appendicitis (p = 0.123).

A total of 583 patients underwent a RLQ US. The mean age of US patients was 14.5 years (95% CI = 14 to 14.9 years). There were only six patients in the study who did not receive an US, so the populations were not compared for difference. Follow-up was available on 521 of 583 patients (89.4%) who underwent a US. Table 1 shows the percentage of patients assigned to each category, as well as the number of patients with and without appendicitis in each group. Sensitivity for RLQ US was 81.5% (95% CI = 73.9% to 87.6%) and specificity was 93.8% (95% CI = 90.8% to 96.1%). The appendix was visualized by US in 23.6% of cases in which it was normal. Appendicitis was ultimately diagnosed in 8.6% of patients with nonvisualization of the appendix but no secondary signs of appendicitis by US. When the analysis was done with the equivocal patients treated as positive studies, sensitivity was 81.5% (95% CI = 74.2% to 87.4%) and specificity was 88.4% (95% CI = 94.8% to 91.5%). When done with the equivocal patients considered as negative studies, sensitivity was 76.4% (95% CI = 68.6% to 83.1%) and specificity was 94.2% (95% CI = 91.3% to 96.3%).

Magnetic resonance imaging was performed on 205 patients. The mean (±SD) age of MRI patients was 14.8 (±5.2) years versus 13.8 (±5.7) years for non-MRI patients. Follow-up was available on 192 of the 205 patients (93.7%) who underwent an MRI. Table 2 shows the percentage of patients assigned to each category, as well as the number of patients with and without appendicitis in each group. When equivocal studies were not included, the sensitivity was 95.2% (95% CI = 83.8%
to 99.4%) and specificity was 95.2% (95% CI = 89.8% to 98.2%). When done with the equivocal patients considered as positive studies, sensitivity was 95.8% (95% CI = 85.7% to 99.5%) and specificity was 82.6% (95% CI = 75.4% to 88.4%). When done with the equivocal patients considered as negative studies, sensitivity was 83.3% (95% CI = 69.8% to 92.5%) and specificity was 95.8% (95% CI = 91.2% to 98.5%).

Ultrasounds were followed by MRI in 158 cases for a number of different reasons, typically nonvisualization of the appendix (although many of these fell into the positive or negative group for this study) or concern that the US finding did not match the clinical examination. Further imaging was performed in some cases in which the US was clearly positive or clearly negative, at the request of the surgical consultant. There was a moderately positive correlation between RLQ US and MRI when studied using the groups defined above as positive and negative (p = 0.573, p = 0.0001). For the nonvisualized appendices by US in which there were no secondary findings of appendicitis, 44.8% were negative with visualized appendices on MRI, 20.1% had the same

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**Figure 1.** Flow chart of patient inclusion and outcome.

**Table 1**

<table>
<thead>
<tr>
<th>Category</th>
<th>% Total US (n = 521)</th>
<th>Positive for Appendicitis (n = 144)</th>
<th>Negative for Appendicitis (n = 377)</th>
<th>% Accuracy</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (appendix normal), n = 87</td>
<td>17</td>
<td>1</td>
<td>86</td>
<td>98.9</td>
<td>92.0-99.8</td>
</tr>
<tr>
<td>1 (appendix not seen, no signs appendicitis), n = 267</td>
<td>53.2</td>
<td>23</td>
<td>244</td>
<td>91.4</td>
<td>87.3-94.2</td>
</tr>
<tr>
<td>2 (equivocal), n = 31</td>
<td>5.5</td>
<td>9</td>
<td>22</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>3 (appendix not seen, + signs appendicitis), n = 18</td>
<td>3.6</td>
<td>7</td>
<td>11</td>
<td>38.9</td>
<td>18.2-64.5</td>
</tr>
<tr>
<td>4 (appendix seen, appendicitis), n = 144</td>
<td>20.1</td>
<td>103</td>
<td>11</td>
<td>90.4</td>
<td>83.3-94.6</td>
</tr>
<tr>
<td>5 (negative for appendicitis, alternate pathology seen), n = 4</td>
<td>0.7</td>
<td>1</td>
<td>3</td>
<td>75</td>
<td>4.1-99.5</td>
</tr>
</tbody>
</table>

US = ultrasound.
(14%) with colitis, six (9.4%) with ileitis or in included 22 (34.4%) with an ovarian cyst or mass, nine native pathology identified and MR category are listed in Table 4.

Results yielded a different outcome on MRI in 48 cases with 24 presumed management changes. Details results for each US and MR category are listed in Table 4.

There were 64 patients who had evidence of an altered bowel disease, four (6.3%) with ovarian torsion, four (6.3%) with renal stones or hydronephrosis, three (4.7%) with nonovarian masses or cysts, two (3.1%) with ectopic pregnancies, two (3.1%) with epiploic appendagitis, two (3.1%) with choledocholithiasis, and 10 (15.6%) with other distinct pathologies identified.

Analysis was done with the lost to follow-up patients treated as either positive or negative for appendicitis. For US, if the lost-to-follow-up patients are considered positive for appendicitis, the sensitivity is 59.2% (95% CI = 52% to 66.1%) and the specificity is 93.8% (95% CI = 90.8% to 96.1%). If they are considered negative for appendicitis, the sensitivity is 93.3% (95% CI = 93.8% to 99.4%) and the specificity is 99.4% (95% CI = 98.9% to 99.4%). For MRI, if the lost to follow-up patients are considered positive for appendicitis, the sensitivity is 76.4% (95% CI = 63% to 86.8%) and the specificity is 95.2% (95% CI = 98.9% to 98.2%). If they are considered negative for appendicitis, the sensitivity is 95.2% (95% CI = 83.8% to 99.4%) and the specificity is 94.2% (95% CI = 88.9% to 97.5%).

**DISCUSSION**

Magnetic resonance imaging performed with a sensitivity and specificity above 95% for the diagnosis of appendicitis in this study. A moderate correlation between US and MRI results was also demonstrated. The accuracy of MRI was nearly 100% for negative studies, regardless of whether the appendix was visualized. For positive studies, the accuracy was more

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**Table 2**

<table>
<thead>
<tr>
<th>Category</th>
<th>% Total MRIs (n = 192)</th>
<th>No. Positive for Appendicitis (n = 48)</th>
<th>No. With No Appendicitis (n = 144)</th>
<th>% Accuracy</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (appendix normal), n = 70</td>
<td>38.1</td>
<td>2</td>
<td>68</td>
<td>97.1</td>
<td>88.9-99.3</td>
</tr>
<tr>
<td>1 (appendix not seen, no signs appendicitis), n = 31</td>
<td>16.6</td>
<td>0</td>
<td>31</td>
<td>100</td>
<td>NA</td>
</tr>
<tr>
<td>2 (equivocal), n = 25</td>
<td>12.2</td>
<td>6</td>
<td>19</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>3 (appendix not seen, ± signs appendicitis), n = 4</td>
<td>2.4</td>
<td>2</td>
<td>2</td>
<td>50</td>
<td>2.5-97.5</td>
</tr>
<tr>
<td>4 (appendix seen, appendicitis), n = 42</td>
<td>21</td>
<td>38</td>
<td>4</td>
<td>90.5</td>
<td>76.4-96.5</td>
</tr>
<tr>
<td>5 (negative for appendicitis, alternate pathology seen), n = 20</td>
<td>9.8</td>
<td>0</td>
<td>20</td>
<td>100</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>US Result</th>
<th>MRI Result</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive (n = 41)</td>
<td>Negative (n = 8)</td>
<td>Intervention* (n = 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Admit without surgery (n = 3)†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Home (n = 4)†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No intervention (n = 4)†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intervention* (n = 5)‡</td>
</tr>
<tr>
<td>Equivocal (n = 8)</td>
<td>Alternate pathology (n = 4)</td>
<td>Intervention* (n = 20)‡</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No intervention (n = 4)†</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intervention* (n = 1)‡</td>
</tr>
<tr>
<td>Equivocal (n = 14)</td>
<td>Alternate pathology (n = 10)</td>
<td>Intervention* (n = 1)‡</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No intervention (n = 9)</td>
</tr>
<tr>
<td>Equivocal (n = 32)</td>
<td>Negative (n = 8)</td>
<td>Intervention* (n = 0)</td>
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<tr>
<td></td>
<td></td>
<td>Admit without surgery (n = 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Home (n = 4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intervention* (n = 4)</td>
</tr>
<tr>
<td>Positive (n = 4)</td>
<td>Alternative pathology (n = 4)</td>
<td>No intervention (n = 0)</td>
</tr>
</tbody>
</table>

US = ultrasound.
*Intervention includes surgery or nonoperative management of appendicitis.
†Presumed management changes.
‡One was not appendicitis upon pathology.

result on MRI as on the US, and 17.2% were thought positive on MRI. For the nonvisualized appendices by US in which there were secondary findings of appendicitis, 28.5% were positive with visualized appendices on MRI, 5.2% had no change in the result, and 50% were thought negative on MRI. Positive US results yielded a different outcome on MRI in 20 cases (48.8%), with 18 presumed management changes. Negative US results yielded a different outcome on MRI in 48 cases (41%), with 24 presumed management changes. Details are listed in Table 3. The specific results for each US and MR category are listed in Table 4.

There were 64 patients who had evidence of an alternative pathology identified on imaging or surgery. This included 22 (34.4%) with an ovarian cyst or mass, nine (14%) with colitis, six (9.4%) with ileitis or inflammatory bowel disease, four (6.3%) with ovarian torsion, four (6.3%) with renal stones or hydronephrosis, three (4.7%) with nonovarian masses or cysts, two (3.1%) with ectopic pregnancies, two (3.1%) with epiploic appendagitis, two (3.1%) with choledocholithiasis, and 10 (15.6%) with other distinct pathologies identified.

Analysis was done with the lost to follow-up patients treated as either positive or negative for appendicitis. For US, if the lost-to-follow-up patients are considered positive for appendicitis, the sensitivity is 59.2% (95% CI = 52% to 66.1%) and the specificity is 93.8% (95% CI = 90.8% to 96.1%). If they are considered negative for appendicitis, the sensitivity is 93.3% (95% CI = 93.8% to 99.4%) and the specificity is 99.4% (95% CI = 98.9% to 98.2%). If they are considered negative for appendicitis, the sensitivity is 95.2% (95% CI = 83.8% to 99.4%) and the specificity is 94.2% (95% CI = 88.9% to 97.5%).
dependent on actual identification of the appendix. For US, negative studies in which a normal appendix was visualized were 99% accurate. When the appendix was not directly visualized by US, nearly 9% of patients had appendicitis, indicating the need for potential further study or observation, depending on the clinical situation. With the inclusion of these patients typically classified as “nondiagnostic,” the MRI sensitivity and specificity mirrored other studies; however, US performed more poorly.

For the purposes of research, a definitive radiographic study has typically required visualization of a normal or abnormal appendix. Little is written on the rates or interpretation of nonvisualization for MRI. In this study, no patient with an MRI demonstrating nonvisualization of the appendix without other radiographic evidence of appendicitis was ultimately diagnosed with appendicitis. For RLQ US, visualization rates of normal appendices in children have been reported as low as 2% to 17%, which limits the utility of US in the evaluation of appendicitis. In this study, 23.6% of normal appendices were visualized by RLQ US. In screening for appendicitis in children, a nonvisualization of the appendix can be expected in one-third of all patients.

One paper examining this population noted appendicitis in 12.6% of patients with equivocal US. Means by which to further risk stratify these patients with nondiagnostic US include further radiographic study, with a few studies emerging to integrate laboratory findings and clinical scoring systems into the algorithm. This study indicates that some further risk stratification may be possible by using the features of the US itself. However, 8.6% of patients with nonvisualization of the appendix by US but no secondary signs of appendicitis were ultimately diagnosed with appendicitis.

To the best of our knowledge, few papers have studied correlation between US and MRI findings. In a study of 81 children, 30 of whom had appendicitis, there was substantial agreement between the two modalities, with a kappa of 0.77 (95% CI = 0.63 to 0.9). A small study of 42 patients showed a significant association when MRI was compared with pooled data from both US and CT, without distinction between the modalities. In this study, a moderate association was demonstrated between the modalities; however, following an US with MRI resulted in a number of presumed management changes.

**LIMITATIONS**

The retrospective nature of this study introduces a number of limitations. The follow-up rate of nearly 90%, while high for the follow-up duration, still represents the loss of data on 64 patients. Our protocols for radiologic studies are standardized, but the final reading on the radiographs, as well as the pathology, is dependent on the attending radiologist or pathologist involved and may be subject to human error. We performed our MRIs without contrast. There are some data that contrast enhanced sequences may improve diagnostic accuracy for appendicitis. It is unknown how the addition of contrast would have altered the results.

**CONCLUSIONS**

Negative magnetic resonance images are effective in excluding appendicitis regardless of whether the appendix is directly visualized, while almost 9% of patients in which an otherwise negative right lower quadrant ultrasound failed to identify the appendix ultimately had appendicitis. Results of magnetic resonance imaging and ultrasound correlated moderately well.

Sincere gratitude is expressed to ChunNok Lam for his assistance with the statistics.

**References**


