Prospective Comparison of a Contrast-Enhanced MRI Protocol with Contrast-Enhanced MDCT for the Primary Diagnosis of Acute Appendicitis in the General Population

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Target audience: Researchers and clinicians interested in imaging for abdominal emergencies (emergency physicians, surgeons, and radiologists).

Introduction: MDCT is very accurate for the diagnosis of appendicitis[1]; however it exposes patients to ionizing radiation and iodinated contrast[2]. Alternatively, MRI does not have either of these exposures. The purpose of this work is to determine the accuracy of a novel MRI protocol including unenhanced, contrast-enhanced, and diffusion weighted imaging to diagnose appendicitis, using MDCT and surgery as reference standards.

Methods: This is a HIPAA-compliant, IRB-approved prospective study of patients presenting with abdominal pain to the emergency department of an academic medical center in the upper Midwest. Patients were eligible for enrollment if they were over 11 years old and had a CT ordered to evaluate for possible appendicitis. Patients underwent CT and MR imaging serially, within approximately 1 hour of each other.

MDCT scans of the abdomen and pelvis were performed using a 64 x 0.625 detector configuration 64 slide VCT, (GE Healthcare, Waukesha, WI) following oral contrast and IV iohexol (Omnipage-300, GE Healthcare, London, UK) administration in the portal venous phase. Size specific protocols for small, medium, and large body habitus range from 100-140 kV_p, NI = 15-21, and Smart mA with mA range = 30-600. Images were reconstructed with 5 mm slice thickness at 3 mm interval using a 40% ASiR blend in the axial, sagittal, and coronal planes.

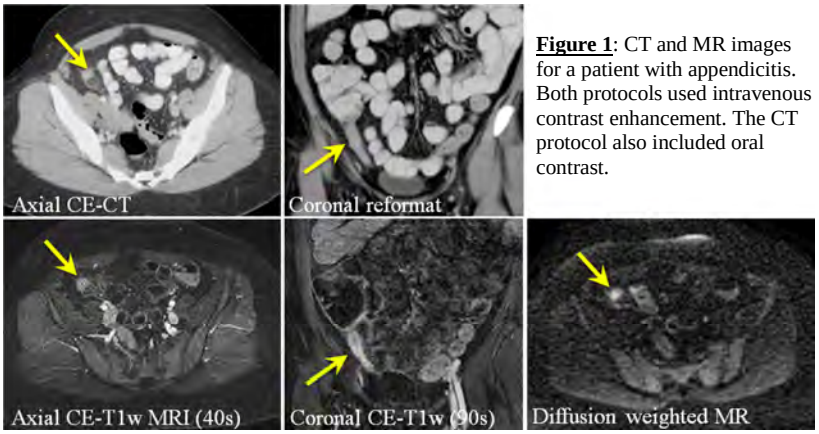

Figure 1: CT and MR images for a patient with appendicitis. Both protocols used intravenous contrast enhancement. The CT protocol also included oral contrast.

MRI was performed on clinical 1.5T scanners (Signa HDxt CRM or TwinSpeed, Discovery MR450w) using an 8-channel body phased array coil. For contrast enhanced T1w imaging, 0.1mmol/kg of gadobenate dimeglumine was administered at 2ml/s, followed by a 20ml saline flush injected at the same rate. The MR protocol consisted of the following sequences:

1. T2w-SSFSE with (axial) and without fat-suppression in axial, coronal, and sagittal planes with the following imaging parameters: 320 x 256 matrix, 36cm FOV, 4mm slice/0mm gap, TR/TE=min/80ms, BW=±83kHz, and ARC parallel imaging (R=2) to minimize blurring.
2. 3D T1w fat-suppressed spoiled gradient echo images (LAVA) acquired during a 22s breath-hold, prior to contrast (axial), 40s after contrast (axial), 90s after contrast (coronal) and 3min after contrast (axial), with the following imaging parameters: 256 x 192 x 100 matrix, 256 x 192, 38cm x 30cm FOV, 3mm slice thickness, TR/TE=3.6/1.7, ARC parallel imaging (R=2.75).
3. Diffusion weighted imaging (DWI) in the axial plane with the following imaging parameters: 128 x 128 matrix, 35cm FOV, 5mm slice/1mm gap, and b=50, b=500 (8 signal averages), acquired using respiratory triggering.

Three attending radiologists, masked to the original CT read, interpreted all MR and CT images independently and in random order, using a standardized data collection form. Multiple parameters were documented for each image set including characteristics of the appendix (size, location, etc), the likelihood of appendicitis, possible alternative diagnoses, and the time required to interpret the images. Follow-up consisted of a chart review for pathological/surgical findings for patients who underwent appendectomy and follow-up phone interview with chart review for all others.

Continuous variables were summarized with descriptive statistics including 95% confidence intervals. Receiver operating characteristic (ROC) curves for the likelihood of appendicitis are reported with pair-wise comparisons of area under the curve (AUCs). Cohen's kappa with quadratic weights was used to assess inter-reader agreement.

Results: We enrolled 165 patients from 2/2012 to 2/2014 with a mean age of 32.6 years (range 13-75), including 100 women (60%). The prevalence of appendicitis was 29.7% (49/165). Summary sensitivity and specificity (95% CI) were 95.7% (84.7-99.5%) and 88.8% (81.4-93.6%) for unenhanced MRI with DWI, 95.7% (84.5-99.5%) and 88.1% (80.2-93.2%) for CE-MRI, and 97.9% (88.1-100%) and 92.7% (85.9-96.4%) for MDCT. ROC and AUC are shown in figure 2. Mean total interpretation times were 4.75 minutes for MR and 2.30 minutes for MDCT. Kappa values for inter-observer agreement were 0.700-0.824 for unenhanced MRI with DWI, 0.767-0.818 for CE-MRI, and 0.904-0.959 for MDCT.

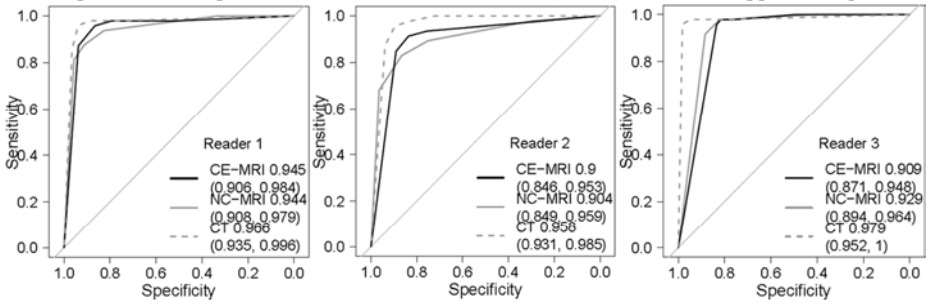

Figure 2: ROC curve for each of the radiologists. CE = contrast enhanced MRI, NC = non-contrast MRI with DWI. Point estimates (95% CI) for the area under the curve are shown.

Discussion: This study is novel for several reasons. First, the general population was studied rather than targeted populations (eg. pregnant women). Additionally, all patients underwent both CT and MRI, allowing for direct and prospective comparison of contrast-enhanced MRI to the standard imaging test for appendicitis (contrast-enhanced MDCT). Finally, the MRI protocol used incorporates both intravenous contrast enhancement and DWI, which has not been previously reported.

Conclusion: The accuracy of this novel, contrast-enhanced MRI protocol for suspected appendicitis in the general population approaches that of CE-MDCT and appears to be a suitable primary test for the diagnosis.

References: 1) Pickhardt PJ. Ann Int Med 2011 154:789-796; 2) Brenner DJ. N Eng J Med 2007 357:2277-84.

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