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Taking advantage of chemical shift imaging: using opposed-phase images to locate the normal appendix on MR

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Abstract

Multiple sequences of 50 consecutive adult pelvic MRI exams were retrospectively reviewed by two radiologists to determine if opposed-phase T1 gradient echo imaging can assist in locating the normal appendix on pelvic MRI. If the appendix was visualized, it was always seen on the T2 sequence, except for one exam. The opposed-phase sequence had the second highest visualization rate, and the appendix was identified the least on the post-gadolinium sequence. The presence of a "button nose" sign was also assessed and was present in one third of cases.

Keywords: Appendix; Appendicitis; Magnetic resonance imaging; Chemical shift imaging

1. Introduction

Chemical shift imaging, consisting of in-phase and opposed-phase T1 gradient echo (GRE) sequences, is routinely performed in abdominal magnetic resonance (MR) imaging for diagnosing pathology containing microscopic fat, such as hepatic steatosis or adrenal adenomas. The routine use of chemical shift imaging on pelvic MR imaging varies by institution and is less commonly performed, but can be helpful in evaluation of adnexal masses [1] or bone neoplasms [2]. Its utility for appendicitis has not been well investigated, although it has been noted that blooming artifact in an air-filled appendix can help identify the normal appendix on in-phase images [3].

Appendicitis is the most common cause of acute abdominal pain to require surgery in the Western world [4]. CT is the most commonly utilized imaging study in the diagnosis of appendicitis in the adult population. However, in certain patient populations, CT is not optimal, such as in pregnant women and children, when minimizing radiation exposure is important. Identification of a normal appendix is important, as it effectively excludes the diagnosis of appendicitis. Studies over the past 10 years have shown a variety of sequences helpful in localizing the appendix, predominantly concentrating on T2 sequences. However, none have evaluated the opposed-phase sequence. This sequence may be helpful in outlining the appendix secondary to the "India ink" artifact, which creates an outline between the pelvic solid organs and macroscopic fat.

The purpose of this study is to determine if the opposed-phase T1 GRE imaging sequence is helpful in locating the normal appendix on pelvic MR examinations and is worth including in standard pelvic MR protocols in evaluation of clinically suspected appendicitis.

2. Materials and methods

Institutional review board approval was obtained for this study, which was Health Insurance Portability and Accountability Act compliant. Consecutive adult pelvic MR examinations performed between 8/1/2008 and 8/11/2008

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Table 1
Parameters for MRI sequences

Sequence	TR	TE	FOV (cm)	Slice thickness (mm)	Matrix	Echo train length	Pixel bandwidth (Hz/pixel)
Axial T2 HASTE	1000	65	30	5	147/256	256	590
Coronal T2 HASTE	1000	65	30	5	205/256	256	590
Coronal T2TSE	3600	108	30	5	230/384	17	200
Axial in-phase T1GRE	238	4.8	30	6 gap 2	115/256	1	650
Axial opposed-phase T1 GRE	238	2.4	30	6 gap 2	115/256	1	350
Axial post-gadolinium T1 FS	204	2.5	30	6 gap 2.1	104/256	1	475

were retrospectively reviewed independently by two abdominal MR fellowship trained radiologists. Studies were excluded if there was a history of appendectomy documented in the patient's medical record (four exams), if the entire cecum was not included in the field of view (four exams), or if the cecum was surgically removed (one exam). Review of consecutive examinations was performed until a total of 50 studies was reached.

These adult pelvic MR examinations were ordered by the patients' physicians as part of the patient's routine care, for indications such as uterine fibroids (21 exams), cancer diagnosis, staging, or follow-up (19 exams), or other indications (10 exams), such as perirectal fistulas or urethral diverticula. None of the studies was performed for acute abdominal pain. The patients included 41 women and 9 men, with a mean age of 53 (age range 30–85).

MR examinations were performed using 1.5-T MR systems (Magnetom Espree or Avanto, Siemens Medical Solutions, Erlangen, Germany). The gradient strengths were 33 mT/m (Espree) and 45mT/m (Avanto) with a slew rate of 100T/m/s (Espree) and 200T/m/s (Avanto). Each scan was performed utilizing a phased-array body coil with four channels and without parallel imaging, in accordance with the case-appropriate pelvis protocol.

Axial T2-weighted half-Fourier acquisition single-shot turbo spin echo (HASTE), coronal HASTE or turbo spin echo (TSE), axial in-phase and opposed-phase T1 GRE, and axial postcontrast T1-weighted fat-saturated (FS) sequences were examined by each reader to locate the appendix. The scanning parameters for these sequences are listed in Table 1.

The two radiologists reviewed the MR exams in independent reading sessions on a PACS workstation (GE Centricity 1.0 CSR3, GE Healthcare, Milwaukee, WI). Images were reviewed in the stack mode scrolling through the different axial and coronal sequences. The MR sequences were reviewed consecutively in the reading sessions to simulate the traditional clinical scenario of finding the appendix.

A "yes" or "no" answer was given for each sequence indicating if the appendix was confidently identified or not. Equivocal cases were recorded as failure of visualization.

The presence of a "button nose" sign, a characteristic appearance of the India ink artifact outlining both the base of the cecum and a small nubbin of the base of the appendix, was also assessed for in cases in which the appendix was identified on the opposed-phase image (Fig. 1A and B). Button noses can be seen in a wide variety of cartoon characters. An example of a cartoon button nose is shown in Fig. 1C. It was also subjectively noted whether there was fat surrounding the cecum.

3. Results

Out of 50 exams reviewed, the appendix visualization rate was 82% (41/50) for Reader 1 and 80% (40/50) for Reader 2. For both readers, if the appendix was visualized, it was always seen on either axial or coronal T2 (80%, 40/50), except for one case, in which one of the readers saw the appendix only on the opposed-phase sequence. The appendix was only seen on the axial or coronal T2 sequences in 12% (6/50) for Reader 1 and in 16% (8/50) for Reader 2.

The opposed-phase T1 GRE sequence had the second highest visualization rate, seen in 68% (34/50) of exams for Reader 1 and in 61% (31/50) of exams for Reader 2. The appendix was identified the least on the post-gadolinium sequence, seen in 42% (21/50) of exams for Reader 1 and in 46% (23/60) of exams for Reader 2. On the axial in-phase T1 GRE sequence, the appendix was visualized in 58% (29/50) of exams for Reader 1 and in 48% (24/50) of exams for Reader 2 (Table 2).

The McNemar statistical test was used to assess agreement between Readers 1 and 2 with regard to finding appendix on each of the sequences. Readers 1 and 2 had no different probability in terms of localizing the appendix on each sequence separately, with P values for all sequences $<.05$ (Table 3).

In the exams in which the appendix was seen on opposed-phase imaging, the button nose sign (Fig. 1A and B) was identified in 15/34 (44%) for Reader 1 and in 18/31 (58%) for Reader 2. The button nose sign was also seen in 30% (15/50) and in 36% (18/50) of the total number of exams reviewed for Readers 1 and 2, respectively.

The appendix was not identified on any sequence in 18% of exams (9/50) for Reader 1 and in 20% of exams (10/50) for Reader 2. In cases in which appendix was not identified, 4/9 (44%) and 4/10 (40%) did not have fat surrounding the cecum.