MR imaging of Crohn’s disease: the experience at the Royal Melbourne Hospital

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Abstract Until recently, magnetic resonance imaging (MRI) has had little to offer the physician or surgeon in the area of small bowel gastro-intestinal (GI) tract imaging. Long scan times leading to motion artifacts and poor image quality as well as a lack of good quality imaging coils have all contributed to this fact. However, in the last 5–10 years, these problems have been overcome by the creation of very fast sequences enabling breath-hold scan times, as well as increases in surface coil technology (phased-array abdominal coils) to increase signal-to-noise ratio and image quality. In the light of these new advances, MRI is being used increasingly to aid in the diagnosis of certain GI tract diseases. This paper looks at the ability of MRI to diagnose the chronic inflammatory bowel condition known as Crohn’s disease, with a discussion on the experience of our department to date.

Introduction
Crohn’s disease is a chronic inflammatory bowel disease affecting the gastro-intestinal (GI) tract anywhere from the mouth to the anus. The small bowel is affected in 80% of cases, most commonly at the terminal ileum. The large bowel is also affected (20% of the time alone and 50% of the time with the small bowel). The disease is characterised by ‘skip’ lesions of normal and diseased bowel, epitheloid cell granulomas and transmural inflammation of the affected areas.

Symptoms include abdominal pain, diarrhoea, rectal bleeding, fevers and weight loss and gross pathologic findings include: inflamed bowel wall, enlarged mesenteric lymph nodes and the formation of abdominal and pelvic fistulas.

It is a characteristic of Crohn’s disease for sufferers to undergo periods of remission and relapse, and it is also not unusual for these patients to undergo surgery to remove affected segments of bowel. The cause of the disease is unknown and it most commonly affects young adults.

The medical management of Crohn’s disease depends upon the severity and status of the disease. Medication given to help manage the inflammatory response of the bowel as well as bacterial over-growth include: immunosuppressants, antiinflammatorys and antibiotics.

Hospital practice and methodology
Our protocol for a comprehensive magnetic resonance imaging (MRI) examination of the small bowel includes both T1 and T2 weighted imaging sequences and post-contrast T1 weighted images. As with a computerised tomography (CT) examination of the abdomen and pelvis, it is very important to utilise oral contrast prior to the scan in order to adequately distend the bowel loops, thus allowing for correct assessment of disease activity within the bowel wall. At our department the patient drinks 1L of a barium-sulphate suspension (Redicat®-2) which appears as low-signal intensity on T1-weighted images and high-signal intensity on T2-weighted images. We also distend the large bowel with 700 ml of water administered as an enema. The patient must also be nil orally for 8 hours prior to the scan.

In order to reduce the artifact from bowel peristalsis, we administer 20 mg of intravenous buscopan just prior to the first sequence, and another 20 mg just prior to the contrast injection. This is in keeping with standard MR abdominal protocols and significantly reduces bowel motion artifact.

We use a phased-array abdominal coil which increases the signal to noise ratio over the larger body coil and results in overall improved image quality. The patient lies supine, feet first in the scanner and all the sequences performed are breath-holding of about 25 seconds in duration. We hyperventilate the patient before each sequence and discuss beforehand the importance of taking the same size breath in each time.

Our protocol involves pre-contrast T1 weighted axial and coronal sequences and T2 coronal and axial sequences with and without fat-suppression (our scanner is a GE Signa Horizon Echo Speed 1.5T). We then perform a dynamic T1 weighted coronal sequence during the administration of IV contrast, followed by T1 weighted axial images of the entire abdomen and lastly a 5-minute delayed T1 weighted coronal sequence. All post-contrast sequences employ fat-suppression. This greatly increases the ability to visualise areas of enhancing inflamed bowel which appear hyper-intense, with non-enhancing, non-involved structures remaining of low signal intensity.

For all our axial sequences, we use a 3/4 field of view (FOV) in the AP direction, so as to reduce the duration of the sequence. The FOV is measured from an initial coronal localising sequence. We inject 30 ml of Gadolinium GTPA at 2 ml/sec followed by a saline flush of 15 ml @ 2 ml/sec The total time of the examination is 30–45 minutes.

Experience at our hospital department
During the period October 2001 to November 2004, we performed 80 MRI examinations on 73 patients (seven had two scans) for Crohn’s disease. Forty-eight of the patients were female (66%) and 25 patients male (34%). The average age of the female patients was 38 years (range 17–81) and the male
average age was 43.3 years (range 20–71). Of the 73 patients, 36 (49%) had had previous imaging at our department (either CT abdomen and pelvis or a barium study), 18 patients (25%) had follow-up scans at our department subsequent to the MRI (either CT, barium study or another MRI). Examples of two patients that we have scanned are now discussed.

**Example 1**
The first example is that of a 44-year-old male who presented for an abdominal MRI complaining of abdominal pain. The standard protocol was performed using both oral and IV contrast. The MR images showed multiple areas of inflamed small bowel, particularly at the terminal ileum, where a long segment of approximately 35 cm was identified (Fig. 1–3). The patient subsequently underwent a right hemi-colectomy to remove the affected bowel.

About 6–8 weeks after surgery the patient presented for a repeat MRI following a bout of severe abdominal pain. The scan this time revealed a large segment of bowel at the terminal ileum that showed abnormal enhancement, indicating that there was still diseased bowel present. As in the patient’s initial scan, the post-contrast fat-suppressed scans proved the most useful at diagnosing the diseased bowel segment (Fig. 4).

**Example 2**
The second example is that of a 39-year-old female with known Crohn’s disease, who developed a fistula from a diseased bowel segment into her psoas muscle, causing a psoas abscess. Fistula formation is just one complication of Crohn’s disease, these may be entero-enteric, entero-colic or form between affected areas of bowel and other abdominal structures.

In this case, the psoas abscess was very well depicted on the post-contrast axial fat-suppressed images. As expected, the abscess highlighted with the IV gadolinium and was seen clearly against the nullified signal from the surrounding fat. This can be seen in Fig. 5 and 6.

**Discussion**

**Advantages over CT and barium studies**

There are several advantages that MRI has over CT in the evaluation of Crohn’s disease. These include:

a) The lack of ionising radiation which is particularly important
since many of these patients are young and may have multiple follow-up scans to monitor disease activity.
b) The ability to directly scan in multiple planes, which makes correlation with barium studies easier.\(^6\)
c) The superb contrast resolution of MRI in the depiction of inflammatory activity.\(^7\)
d) The higher contrast enhancement produced by the gadolinium versus the iodinated contrast agents.\(^6\)

The ability of MRI to assess the degree of disease activity using more than one parameter (eg. contrast enhancement and the amount of T2 signal) can also be seen as an advantage over CT.\(^6\)

Studies have shown MR to be more accurate in showing normal and abnormal bowel segments compared to CT. Low and Francis\(^8\) reported that post oral and IV contrast MR imaging depicted more than 90% of bowel segments with mural thickening or enhancement compared with 60% for CT. A separate study by the same authors\(^7\) revealed that MRI was superior to single-phase helical CT in the depiction of mural thickening and/or enhancement of abnormal bowel segments (85% vs 65%). MRI was also preferred over helical CT for depicting normal bowel wall, mural thickening, mural enhancement and overall GI tract evaluation.\(^8\)

Both conventional barium studies and endoscopy are limited in their ability to demonstrate the transmural and extramural extent of Crohn’s, as well as other extra-intestinal complications. MRI has the advantage of being able to demonstrate the transmural nature and severity of bowel wall inflammation, as well as revealing affected segments of bowel beyond areas of severe bowel stenosis. The other main advantage of MRI over conventional barium studies and endoscopy is its ability to look at the entire abdomen and pelvis, thus visualising other areas of pathology such as enlarged lymph nodes and abscess formation.

### Table 1 Sequences used at our department and their parameters

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Thickness/ Spacing (mm)</th>
<th>TE (ms)</th>
<th>TR (ms)</th>
<th>Matrix</th>
<th>NEX</th>
<th>Phase Direction</th>
<th>Time (sec)</th>
<th>No. of slices</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 FSPGR coronal localiser</td>
<td>8/2</td>
<td>Min</td>
<td>150</td>
<td>256/192</td>
<td>1</td>
<td>R &gt; L</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>T2 SSFSE Axial (for entire abdo/pelvis)</td>
<td>8/2</td>
<td>Eff TE = 90</td>
<td>NA</td>
<td>256/192</td>
<td>1</td>
<td>A &gt; P</td>
<td>26</td>
<td>19 per acquisition Repeat 2/3 times to cover A/P</td>
</tr>
<tr>
<td>T2 SSFSE coronal with &amp; without fat sat</td>
<td>8/2</td>
<td>Eff TE = 90</td>
<td>NA</td>
<td>256/192</td>
<td>1</td>
<td>R &gt; L</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>T1 FSPGR coronal pre- &amp; post-dynamic with fat sat</td>
<td>8/2</td>
<td>In phase</td>
<td>220</td>
<td>256/128</td>
<td>1</td>
<td>R &gt; L</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>T1 FSPGR axial post with fat sat</td>
<td>8/2</td>
<td>In phase</td>
<td>220</td>
<td>256/128</td>
<td>1</td>
<td>A &gt; P</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>T1 FSPGR delayed coronal with fat sat</td>
<td>8/2</td>
<td>In phase</td>
<td>220</td>
<td>256/128</td>
<td>1</td>
<td>R &gt; L</td>
<td>23</td>
<td>19</td>
</tr>
</tbody>
</table>

GE terminology FSPGR – Fast spoiled gradient-echo recalled. SSFSE – Single shot fast-spin echo. FA – Flip angle
Disadvantages of MRI
As with most diagnostic imaging tools, there are some shortcomings of MRI. First, people with pacemakers, internal defibrillators and aneurysm clips are not able to be scanned, for obvious safety concerns, while those people who suffer from claustrophobia may not be able to tolerate the enclosed space of the magnet bore. Second, the spatial resolution of MRI is well below that of CT\(^9\) and third, CT is more widely available, has a shorter examination time (reducing motion artifact) and is cheaper than MRI.\(^6,8\)

MR enteroclysis
Rather than the patient drinking the oral contrast, it can be infused into the small bowel via a naso-jejunal catheter. This is known as MR enteroclysis.\(^10\) The main advantage of this technique is the more uniform filling and distention of the small bowel, thus potentially increasing the ability to detect abnormal bowel segments. This technique, however, is not used at our department for three reasons.

First, as stated by Maglinte et al.,\(^11\) naso-jejunal intubation in the absence of conscious sedation is uncomfortable and less well tolerated than oral administration of contrast. Second, the placement of the naso-jejunal catheter and the infusion of the contrast often occurs in a separate room, where delays resulting from coordination of examinations can occur (an average time gap of 26 minutes until commencing the MR being reported by Schreyer et al.\(^12\)). Third, evidence suggests that conventionally administered oral contrast gives excellent results in the depiction of Crohn’s. Schreyer et al.\(^13\) reported excellent correlation between MR enteroclysis and MR after conventional oral ingestion of contrast. A separate study by Wold et al.\(^14\) where they compared a noninvasive peroral water CT enterographic technique with CT enteroclysis on patients with known or suspected Crohn’s disease supports this finding.

Conclusion
At the present time, the role of MRI in the diagnosis and characterisation of Crohn’s disease is still evolving. That it is not very widely used at present is due to a variety of factors including low availability, increased cost and low specialist awareness of the role of MRI. It does seem likely however, that it will play an increased role in the future due to its very high accuracy of diagnosing diseased bowel segments, the lack of ionising radiation, its multi-planar capabilities and its ability to look at the entire abdomen and pelvis in the one examination.

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References