Small intestinal contrast ultrasonography for the detection of small bowel complications in Crohn's disease: correlation with MR enterography and surgical findings

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Aims and objectives

To evaluate the clinical utility of small intestinal contrast ultrasonography (SICUS) and magnetic resonance enterography (MRE) in routine clinical practice to detect and quantify small bowel lesions in Crohn’s disease (CD) by correlating the results directly with intraoperative findings.

To compare the diagnostic accuracy between SICUS and MRE in locating disease and complications related to CD.
Methods and materials

All patients assessed by SICUS between June 2007 and December 2012 were retrospectively identified. Of these, patients with CD requiring bowel resection within 6 months of undergoing SICUS or MRE were identified from electronic patient records. Demographic data, CRP and platelet count within two weeks of SICUS and surgery were collated. Data on the radiological findings and operation notes were compared to assess the accuracy and agreement of SICUS to detect the site of bowel lesions related to CD; in particular, stricture length, fistulae, abscesses and mucosal thickening. A subset of patients who had been evaluated by both SICUS and MRE were identified to compare the accuracy in detecting and defining intestinal complications of CD.

SICUS

After a 6 hour fast, a baseline ultrasound of the abdomen and pelvis was performed using either an Aplio XG (Toshiba Medical Systems, Tochigi, Japan) with a curvilinear array (1.5-6 MHz) or a Logic 9 (GE Healthcare, Milwaukee, WI, USA) with a curvilinear array (2-5 MHz) to assess solid organs for pathology which may explain the presenting symptoms. Initial small bowel evaluation was also undertaken looking for any areas of bowel wall thickening, loss of normal wall stratification, or mesenteric thickening, using a combination of high-frequency curvilinear and linear transducers (3-9 and 6-11 MHz on the Aplio and 4-12 MHz on the Logic 9). After this, the patient consumed the contrast medium, polyethylene glycol (one sachet of Klean Prep® (Norgine) dissolved in 1 litre tap water) in preparation for SICUS. Scans were performed at intervals of 10 to 15 minutes to map the small bowel until the contrast agent had reached the ascending colon. The average time to perform the scan was 30 minutes. The small bowel was acknowledged by its location, mucosal fold pattern, and its motility. Other bowel loops were displaced by graded compression and this also permitted bowel wall stiffness to be ascertained. Power doppler was used in assessing intramural and adjacent mesenteric vascularity when assessing abnormal loops of small bowel. For both ultrasound systems, the parameters were optimised towards low-volume flow while trying to avoid excessive flash artefact. A pulse repetition frequency (PRF) of 800 Hz was used, with a low-medium wall filter and the gain adjusted to just below the noise floor.

MR enterography

Scans were performed in a Siemens 1.5T scanner with an 8-channel body coil. All patients attended 90 minutes prior to the scan and were asked to drink 1750 ml of water followed by 250 ml of 20% mannitol and take metoclopramide 10mg. A drug history was taken to verify that there were no contraindications to antimuscarinics such as hyoscine butylbromide (Buscopan®), given to reduce intestinal motility. Patients were also made
aware of potential adverse effects of Mannitol and asked to empty their bladder prior to scanning.

The following 3 sequences were obtained initially: 3 plane localisation, calibration scan and coronal 2D FIESTA BH. When intraluminal contrast reached the terminal ileum, Buscopan was given intravenously and the following sequences obtained: coronal T2 SSFSE FATSAT BH, 3D coronal BH LAVA, axial T2 SSFSE abdomen and pelvis, and coronal T2 SSFSE FATSAT - through the terminal ileum. The following sequences were added to the above following intravenous gadolinium injection (0.2ml/kg): 3D coronal LAVA BH post contrast, 3D axial LAVA BH post contrast and 3D axial LAVA BH post contrast - through the terminal ileum.

**Statistical analysis**

The sensitivity and specificity of SICUS in identifying the presence of small bowel lesions and complications of CD were calculated according to the final intraoperative diagnosis. In the comparison of SICUS versus MRE, the calculations were performed using the MRE findings as the reference standard. Consistency between SICUS and surgical findings, and between SICUS and MRE to detect the site and length of strictures, fistulae, abscesses and mucosal thickening, was tested using the concordance index by Cohen's kappa coefficient statistical analysis (#). Stricture lengths, CRP and platelet count were compared using paired Student's $t$-test.
Results

**SICUS vs surgery**

A total of 25 patients (12 male) with a mean age of 27.9 years ± 11.5 (mean ± SD) underwent SICUS and subsequent resective bowel surgery.

Mean time from SICUS to resective bowel surgery was 89.6 ± 66.7 days (Range 5-176).

Inflammatory markers at time of SICUS (CRP 44.1 ± 61.1, platelet count 431.2 ± 146.7) and surgery (CRP 39.9 ± 56.5, platelet count 426.6 ± 172.9) were not significantly different (p = 0.419 and 0.808).

The sensitivity and specificity of SICUS in identifying intra-abdominal complications associated with CD, using surgical findings as the gold standard, are presented in Table 1.

Agreement between SICUS and surgery was substantial for both number of strictures ($# = 0.652$, 95% CI 0.306-0.959) and their location ($# = 0.747$, 95% CI 0.479-1). Stricture length was 7.4 ± 1.5 cm identified at surgery vs 5.8 ± 1.8 cm by SICUS (NS). Agreement for location of fistula ($# = 0.819$, 95% CI 0.580-1) and abscess location ($# = 0.865$, 95% CI 0.608-1.0) were almost perfect.

**MRE vs surgery**

17 patients underwent MRE and surgery. 11 were male, with mean age of the group 30.8 years ± 13.2 (range 18.8 - 72.1).

Mean time from MR imaging to surgical intervention was 77.4 days ± 53.3.

Inflammatory markers at time of MR imaging (CRP 45.8 ± 51.9, platelet count 443.6 ± 170.9) and surgery (CRP 41.1 ± 41.7, platelet count 395.8 ± 173.4) were not significantly different (p = 0.699 and p = 0.111, respectively).

Comparative statistical data are presented in table 2. The agreement between MRE and surgery in recognising strictures was almost perfect ($# = 0.88$, 95% CI 0.64 - 1) with a
sensitivity of 100% and specificity of 90.9%, as was the ability to locate them ($\# = 0.88$, 95% CI 0.66 - 1).

The sensitivity of MRE in detecting fistulae was 66.7% and agreement on location of these was substantial at ($\# = 0.79$, 95% CI 0.52 - 1). The sensitivity of MRE to detect abscesses when compared to surgery was 76.7% and agreement on location was substantial ($\# = 0.77$, 95% CI 0.336 - 1). Its sensitivity to detect bowel wall thickening and dilatation was 81.8% and 66.7%, respectively.

**SICUS vs MR enterography**

25 Crohn's patients were identified (12 male), with a mean age of 29.6 years (SD ± 10.7 years) at time of first investigation.

Mean time between modalities was 71.6 days (range 2-169) (SD ± 49.5).

Inflammatory markers at time of SICUS (CRP 33.8 ± 47.2, platelet count 430.0 ± 307.7) and MR imaging (CRP 30.2 ± 50.8, platelet count 335.0 ± 122.0) were not significantly different ($p = 0.139$ and $p = 0.189$, respectively).

Statistical data are presented in table 3. Agreement between the 2 modalities was almost perfect for the presence of stricturing disease, stricture number and location. Agreement was substantial for the presence of fistulae and mucosal thickening. Whereas agreement in findings for the presence of abscess and fibrotic changes was moderate, changes of acute mucosal inflammation was fair. There was no significant difference in estimating mean stricture length between the two modalities (stricture length by MRE 10.91 cm and by SICUS 10.68 cm, $p = 0.815$).
**Table 1:** Correlation between SICUS and surgical findings in detecting the presence of small-bowel complications. TP = true positive, FN = false negative, TN = true negative, FN = false negative. 95% confidence intervals given in brackets.

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<table>
<thead>
<tr>
<th>Number of patients with CD-related complication</th>
<th>Surgery</th>
<th>TP</th>
<th>FP</th>
<th>TN</th>
<th>FN</th>
<th>kappa</th>
<th>Sensitivity</th>
<th>Specificity</th>
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<td>7</td>
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<td>0.73</td>
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<td>Fistula</td>
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<td>7</td>
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<td>0.82</td>
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<td>Wall thickening</td>
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<td>18</td>
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<td>(0.72-1.00)</td>
<td>(0.14-0.86)</td>
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**Table 2:** Correlation between MRE and surgical findings in detecting the presence of small-bowel complications. TP = true positive, FN = false negative, TN = true negative, FN = false negative. 95% confidence intervals given in brackets.

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<th>Number of patients with CD-related complication</th>
<th>Surgery</th>
<th>TP</th>
<th>FP</th>
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<th>FN</th>
<th>kappa</th>
<th>Sensitivity</th>
<th>Specificity</th>
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<td>6</td>
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**Table 3:** Kappa correlation co-efficient between SICUS and MRE.

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**Fig. 1:** Gross pathology specimen displaying stricturing (arrow) and fistulae (white sticks)

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**Fig. 2:** SICUS image displaying luminal narrowing and thickened mucosa.

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Conclusion

SICUS accurately identifies small bowel complications in CD and offers an alternative in the pre-operative stage of CD complications. SICUS should be made more widely available as it imparts no medical radiation, is relatively inexpensive and well tolerated by patients. Further prospective comparison of SICUS and MRE is required to confirm our findings.
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http://www.ukctg.nihr.ac.uk/trialdetails/ISRCTN03982913.