

Feasibility of Bedside Bowel Ultrasound Performed by a Gastroenterologist for Detection and Follow-Up of Inflammatory Bowel Disease

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ABSTRACT: **Background:** Bowel ultrasound has several possible uses in inflammatory bowel disease (IBD), including the initial evaluation of suspected IBD, monitoring of therapeutic response, detection of relapse, and diagnosis of complications as well as of extra-intestinal manifestations. However, its use has been limited mainly to countries where it is performed by the attending physician.

Objectives: To investigate the feasibility and sensitivity of bedside bowel ultrasound performed by a gastroenterologist for assessing disease activity and complications in IBD.

Methods: We performed a feasibility study to compare the results of bowel ultrasound examination with those of another cross-sectional imaging modality (computed tomographic enterography or magnetic resonance enterography) in Crohn's disease, or with colonoscopy in ulcerative colitis.

Results: Between May 2015 and March 2016, 178 bowel ultrasound examinations were performed in 178 patients with suspected or established diagnosis of IBD. In 79 cases the results of another cross-sectional imaging or endoscopic examination performed within 3 months prior to the ultrasound exam were available. The sensitivity for detection of intestinal bowel thickening (a surrogate of inflammation) was 90%, and for detection of Crohn's disease complications, namely bowel stenosis and inflammatory mass, 94% and 75%, respectively.

Conclusions: Bowel ultrasound is a useful and feasible bedside imaging tool for the detection of inflammation and complications in IBD patients. Bedside bowel ultrasound can be a valuable non-invasive tool to assess disease activity and complications in IBD patients when performed by the attending physician.

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KEY WORDS: inflammatory bowel disease (IBD), Crohn's disease, ulcerative colitis, bowel ultrasonography, cross-sectional imaging, endoscopy

(e.g., tissue harmonic imaging and color Doppler) together with the growing experience of ultrasonographers have contributed to the establishment of ultrasound as a clinically important, non-invasive imaging modality in inflammatory bowel disease (IBD). Current technological standards permit high resolution assessment of the mucosal, submucosal and muscular layers. Furthermore, submucosal pathologies, especially in a transmural disorder such as Crohn's disease, can be clearly visualized using bowel ultrasound [1-4]. Complications of IBD, such as stenosis, abscesses or fistulas, are often accessible with ultrasound assessments and monitoring [5,6].

Bowel ultrasound is included as a diagnostic modality in the European Crohn's and Colitis organization (ECCO) guidelines for the management of Crohn's disease and ulcerative colitis [7,8]. Ultrasound has multiple possible uses in IBD: for the initial evaluation of patients with clinically suspected IBD, for monitoring the therapeutic response, for suspicion of relapse, for the detection of complications (fistula, abscess, etc.), and for the diagnosis of an extra-intestinal manifestation (nephrolithiasis or cholangiolithiasis). Ultrasonographic signs of IBD include thickening of the bowel wall, pseudostratification of the bowel wall, mesenteric and adipose hypertrophy, enlargement of lymph nodes, and enhancement of blood flow in the bowel wall (measured by color Doppler) [Table 1]. Bowel ultrasound can also be used to detect IBD-related complications such as abscesses, fistulas and bowel strictures [9].

Bowel ultrasound is widely used in countries where traditionally the examination is conducted by the attending physician. However, in many countries, including Israel, ultrasound is usually performed by a technician or a radiologist and, therefore, the possibility of confirming the clinical impression directly from the ultrasound results is limited.

We decided to utilize bowel ultrasound as a complementary real-time bedside tool in our multidisciplinary IBD clinic and trained a gastroenterologist (D.C.) accordingly. The aim of this study was to examine the feasibility and accuracy of bedside bowel ultrasound performed by a gastroenterologist for assessing disease activity and complications in IBD.

Traditionally, abdominal ultrasound is used for examination of the hepatobiliary-pancreatic and urogenital systems. Technological advances in the field of ultrasonography

PATIENTS AND METHODS

Bowel ultrasound was performed by a single examiner. Initially, the examiner participated in 100 general ultrasound exams performed by a radiologist. This was followed by 200 bowel ultrasound exams under the direct supervision of an ultrasound gastroenterologist specialist (Prof. Christian Masser) at Luneberg Municipal Hospital, Germany, during a 5 week training period. Having completed this training, the examiner began to perform bowel ultrasound examinations at the Sheba Medical Center, Israel.

STUDY POPULATION

The study population included all patients who underwent bowel ultrasonography in our institute after establishment of the bowel ultrasound service in May 2015 until the end of March 2016. The ultrasound exams were performed by a single gastroenterologist (D.C.) solely in cases with suspected or established IBD (Crohn's or ulcerative colitis). The decision to send a patient for bowel ultrasound was at the discretion of the treating gastroenterologist. The main indications were to determine disease severity or in the case of suspected complications. Demographics and other medical data were collected from the medical files of the study population.

BOWEL ULTRASOUND

All examinations were performed using a Toshiba Xario (Japan) ultrasound machine with a low frequency (2.5–4.5 MHz) curved-array transducer enabling all abdominal quadrants to be examined for potential pathological distension, motility and para-intestinal structures such as abscesses. This was followed by examination using a high resolution linear-array transducer (6.0–8.4 MHz) for detailed examination of the bowel wall structure. All examinations were performed without any preceding preparation and without contrast material, using a consistent

technique and protocol: examination of the proximal to distal colon followed by complete examination of the small bowel. The assessment included features of inflammation such as bowel wall thickness (mm), presence of inflammatory mesenteric fat and lymph nodes (yes or no), presence of hyperemia on color Doppler flow (yes or no), and the number and type of complications (stenosis and/or penetrating complications including fistulas or inflammatory masses) [Table 1].

COMPARISON WITH OTHER IMAGING MODALITIES

We compared the results of the ultrasound exams with those of other cross-sectional imaging modalities – computed tomographic enterography (CTE) or magnetic resonance enterography (MRE) – in Crohn's disease, and with colonoscopy in ulcerative colitis. Only examinations that were performed within 3 months prior to the bowel ultrasound exam were included in the analysis. We focused on bowel wall thickness as a sign of inflammation, and on diagnosis of major complications of Crohn's disease including strictures, fistulas or inflammatory masses.

STATISTICAL ANALYSIS

The results of cross-sectional imaging tests (CTE or MRE) were considered the gold standard technique for calculating sensitivity and specificity in comparison with bowel ultrasound in Crohn's patients. The results of colonoscopy were considered the gold standard technique for calculating sensitivity and specificity in comparison with bowel ultrasound in patients with ulcerative colitis. Statistical analysis was performed using the SPSS software (16.0 version; SSPS Inc., Chicago, IL, USA).

RESULTS

During the period of the study, bowel ultrasound examination was performed in 178 patients with suspected or established IBD (167 with Crohn's disease and 11 with ulcerative colitis). In 79 cases, the results of another cross-sectional imaging or endoscopic examination performed within 3 months prior to the ultrasound exam were available. In 68 cases the exam was performed due to a suspected or established diagnosis of Crohn's, while 11 cases had an established diagnosis of ulcer-

Table 1. Ultrasonographic features of inflammatory bowel disease

Ultrasound findings	Measurement
Mural thickening	Terminal ileum < 2 mm, colon < 3 mm
Mural echo structure	Hypoechoic / hyperechoic
Mural stratification	Present / Absent
Vascularization	Doppler ultrasound in inflamed bowel wall
Mesenteric lymphadenopathy	Enlarged lymph node close to area of disease
Mesenteric adipose expansion	Pale gray cuff surrounding the bowel
Stenosis and pre-stenotic dilatation	No peristalsis No expansion on motility Linear air bubble Widening of bowel prior to stenosis
Fistula	Hypoechoic projections from bowel wall
Abscess	Hypoechoic, irregularly defined formation in direct proximity to the inflamed section of bowel, with air bubble

Table 2. Demographic characteristics of patients undergoing bowel ultrasound

Parameter	No.
No. of patients	79
Age, yrs (range)	27.5 (17–70)
Male / Female	43/36
Crohn's disease	68
Ulcerative colitis	11
Previous abdominal surgery	5

Table 3. Number of other cross-sectional and endoscopic examinations performed in the study population

Exam	No.
Colonoscopy	11
CTE / MRE	67
Capsule endoscopy	6

CTE / MRE = computed tomographic enterography / magnetic resonance enterography

Table 4. Comparison of the results of bowel ultrasonography with those of other imaging modalities

Parameter	Mural thickening	Strictures	Inflammatory mass
True positive	57	17	6
False positive	10	1	0
True negative	7	7	0
False negative	3	1	2
Sensitivity	90%	94%	75%
Specificity	23%	87%	-

ative colitis. Table 2 summarizes the demographic data of the study population.

All the patients with Crohn’s disease underwent at least one cross-sectional bowel imaging (CTE or MRE) or video capsule endoscopy. All the patients with ulcerative colitis had undergone a colonoscopy. The imaging modalities used in comparison with the bowel ultrasound are summarized in Table 3.

The comparison between the results of bowel ultrasound and of other imaging modalities is summarized in Table 4. The sensitivity for detection of bowel wall thickening was 90%, and for Crohn’s disease complications, namely bowel stenosis and/or inflammatory mass, it was 94% and 75%, respectively. In one case an abscess was misdiagnosed on CT but not on bowel ultrasound (the abscess was not detected during surgery).

DISCUSSION

To the best of our knowledge, this is the first report from Israel of a gastroenterologist performing bedside bowel ultrasound in IBD patients. In the hands of a dedicated and experienced operator, bowel ultrasound is an accurate imaging tool that enables the acquisition of important objective imaging data by the treating gastroenterologist during a routine outpatient medical examination.

Gastroenterologists have been reluctant to use ultrasound in the assessment of IBD because of difficulties in performing and interpreting the results. However, studies from recent years show that compared to other cross-sectional imaging

modalities (CTE, MRE or small bowel follow-through), bowel ultrasound has high sensitivity and specificity for the diagnosis and follow-up of IBD [10]. Corresponding to the findings of previous studies [11,12], we have demonstrated a high sensitivity for diagnosing bowel inflammation (bowel wall thickening). Small bowel wall thickness of > 2 mm and colonic wall thickness of > 3 mm are accepted as the upper cutoff thickness for normal bowel wall [3]. We also demonstrated a high sensitivity for detecting complications of Crohn’s disease: namely, stenosis and inflammatory mass. These results are in agreement with previously published data that established a sensitivity of 90–98% for detection of stenosis [4], 91% for abscess [13], and 72% for intestinal fistula [14].

In recent years the use of objective means to ascertain response to therapy in IBD patients, especially mucosal healing, has become increasingly important. These include colonoscopy, cross-sectional imaging modalities and video capsule endoscopy. The use of colonoscopy is limited by the prerequisite for the unpleasant procedure of colonic irrigation and the invasive nature of the procedure. Cross-sectional imaging with CT is limited due to its high level of radiation exposure [15]. While both MRE and video capsule endoscopy deliver reliable data, considerable cost and long waiting time limit their use for routine follow-up. In contrast, bowel ultrasound is a readily available bedside diagnostic method that contributes to both the initial diagnostic decision and monitoring of IBD treatment. It does not require preparation, does not involve exposure to potentially harmful irradiation, and is relatively inexpensive. This method does have some drawbacks: it does not enable examination of the whole extent of disease or allow precise topographic determination of disease in the small bowel, it has a rather long learning curve, and is dependent on the examiner’s expertise for quality and outcome.

The main limitation of this study is that the results of the bowel ultrasound were compared with historical (though recent) and varied imaging techniques. However, previous studies noted the substantial accuracy of bowel ultrasound compared to various imaging modalities (including CTE, MRE and colonoscopy). Moreover, our results showed considerable accuracy, although the examinations were performed within 3 months before the bowel ultrasound exam. We surmise that the accuracy might be even higher if the bowel ultrasound was performed earlier. This study did not look at the learning curve of the examiner. In a previously published study, accuracy increased after > 60 examinations [16].

In conclusion, this article summarizes our initial experience with bowel ultrasonography in IBD. We demonstrated that bowel ultrasound is a useful and feasible imaging tool for the detection of inflammation and complications in IBD patients. We suggest that bedside bowel ultrasonography be a part of the growing arsenal of non-invasive examination modalities in IBD patients.

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