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● *Review Article*

ROLE OF BOWEL ULTRASOUND IN THE DIAGNOSIS AND FOLLOW-UP OF PATIENTS WITH CROHN'S DISEASE

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Abstract—Crohn's disease (CD) is an inflammatory chronic bowel disorder; it can involve the whole gastrointestinal tract, but its localization in the ileum or colon is most common. The reference standard for the diagnosis of CD is ileocolonoscopy with histologic assessment. The reference standard for the detection of any complications is surgery. However, imaging techniques have an important role both in the detection/localization of CD and in the follow-up of CD patients. In the last few years, the technical development of ultrasound equipment, the advent of new technologies such as elastography and mostly the increased expertise of sonographers have boosted the role of bowel ultrasound in assessment of the gastrointestinal tract. In fact, bowel ultrasound is particularly attractive thanks to its widespread availability, non-invasiveness, low cost and good reproducibility, as it can be easily repeated during follow-up. The aim of this article is to provide an extensive overview of the actual role of bowel ultrasound in the detection and follow-up of patients with CD. (E-mail: Mfraquelli@yahoo.it) **© 2017 Published by Elsevier Inc. on behalf of World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Bowel ultrasound, Crohn's disease, Inflammatory bowel disease, Contrast-enhanced ultrasound, Elastography, Imaging techniques.**

INTRODUCTION

Crohn's disease (CD) is an inflammatory bowel disease that may involve many different parts of the gastrointestinal (GI) tract from the mouth to the anus, although ileal/colonic involvement is the most frequent: Involvement of the terminal ileum is observed in 90% of patients with small intestine CD (Travis et al. 2006).

The reference standard for CD diagnosis is ileocolonoscopy with histologic examination, but the combined use of various imaging and endoscopic techniques increases the accuracy of the diagnosis, staging and follow-up of CD patients. Recent advances in US techniques with their advantages of non-invasiveness, low cost and availability for repeat examinations have widened the application of bowel US in this setting (Panes et al. 2013; Travis et al. 2006).

The aim of this review article is to provide an overview of the actual role of bowel ultrasound in CD diagnosis and definition of the disease's localization, activity and extension, including the detection of the most frequent CD complications, such as stenosis and penetrating disease.

METHODS

The article was written by performing an extensive bibliographic search in PubMed *via* MeSH using the following key words and free terms: inflammatory bowel disease, Crohn's disease, bowel ultrasound, elastography, CEUS, color-Doppler ultrasound, abscesses, stenosis, disease activity, fistulae, complications, recurrence, diagnosis, follow-up. The reference lists from the selected studies were manually examined to identify further relevant reports. Non-English-language papers were excluded.

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ROLE OF US IN SUSPECTING CROHN'S DISEASE

Bowel ultrasound has become the first-line imaging technique for patients with suspected Crohn's disease (Panes et al. 2013). The ultrasonographic signs usually searched for when suspecting CD are detailed and explained in Table 1 (Astegiano et al. 2001; Bozkurt et al. 1994; Fraquelli et al. 2005; Horsthuis et al. 2008; Panés et al. 2011; Reimund et al. 1999; Sheridan et al. 1993; Solvig et al. 1995; Sonnenberg et al. 1982; Tarjan et al. 2000). Some signs, for example, bowel loop elasticity (*i.e.,* the capability of the bowel wall to collapse on the bowel lumen and return to the original size and shape after manual compression and decompression) and compressibility at probe contact and peristalsis (usually impaired), are not specific, whereas other signs, such as the characteristics of the bowel wall, are more specific. Among the latter, the most important sign is bowel wall thickening (BWT) (Fig. 1a). Also important are bowel wall echo pattern characteristics (BWP) (Fig. 1b), the presence of any margin irregularity and the grade of vascularity at echo color Doppler or power Doppler (Fig. 2). Other yet less frequent signs are the luminal alterations, such as the distension or any luminal stenosis. Other possible findings outside the bowel loop are mesenteric hypertrophy (Fig. 3a), enlarged mesenteric lymph nodes (Fig. 3b) and free fluid in the abdominal cavity or among the bowel loops (Fig. 3c).

Rarely, the onset of Crohn's disease is concomitant with the onset of one of its major complications, such as stenosis, sinus tracts, fistulas and/or abscesses or inflammatory infiltrates (Parente et al. 2002).

Table 1. Bowel ultrasound parameters usually assessed in patients with suspected Crohn's disease

Ultrasound parameter	Definition
Bowel wall thickness (mm)	reference value<4 (<5 for descending and sigmoid colon)
Bowel wall pattern	A = stratification conserved, or B = stratification disrupted
Bowel wall vascularization	Visualization of flow signals within the bowel wall
Abdominal free fluid	Presence of free fluid between the bowel loops
Mesenteric lymph nodes	When the lymph node short axis is > 5 mm
Mesenteric hypertrophy	Thickened or hyper-echoic mesentery between the altered bowel wall tracts
Stenosis	Presence of thickened bowel wall and luminal narrowing with proximal bowel dilation (>2.5–3 cm)
Fistulas or abscesses	Linear hypo-echoic tracts starting from an altered bowel tract (fistula); rounded or polygonal areas, mixed or prevalently hypo-echoic (abscess)

The accuracy of US in the identification of the disease in patients with the clinical suspicion of inflammatory bowel disease (IBD) was evaluated in several primary studies (Astegiano et al. 2001; Bozkurt et al. 1994; Reimund et al. 1999; Sheridan et al. 1993; Solvig et al. 1995; Sonnenberg et al. 1982; Tarjan et al. 2000) and in some meta-analyses (Fraquelli et al. 2005; Horsthuis et al. 2008; Panés et al. 2011). The diagnostic estimates reported in the primary studies varied widely (Table 2). Such heterogeneity is related mainly to the different spectra of patients included (because of disease prevalence, center or patient selection), the different study designs, patient–control versus cohort studies (Colli et al. 2014), differences in the type and adequacy of the reference standard used and, most importantly, the index test threshold effect (*i.e.,* the different bowel wall thickness cutoff values used to define positive cases) and the technical improvements of its diagnostic performance over time mostly owing to the technical advances in US probes achieved in the last few years. Some meta-analyses (Fraquelli et al. 2005; Horsthuis et al. 2008; Panés et al. 2011) have been published on this topic as well, and their main results are summarized in Table 3.

For our systematic review (Fraquelli et al. 2005), we analyzed the results of seven primary studies (Astegiano et al. 2001; Bozkurt et al. 1994; Reimund et al. 1999; Sheridan et al. 1993; Solvig et al. 1995; Sonnenberg et al. 1982; Tarjan et al. 2000) with overall sensitivity and specificity values ranging from 75% to 94% and from 67% to 100%, respectively. The wide range of specificity in the different studies can be explained by the heterogeneity among the populations studied resulting, first, from the different prevalences of the disease and, second, the different study designs (patient–control and cohort studies), as some studies included patients already diagnosed with CD and others included patients suspected of having the disease. Another cause of heterogeneity among the diagnostic estimates may be related to the different BWT cutoff values chosen in the different studies. Moreover, the studies used different gold standards for CD diagnosis, such as endoscopy plus imaging findings, computed tomography (CT), scintigraphy or the small bowel barium examination, accounting for the great heterogeneity of the study methods. The most important US parameter considered for the diagnosis of CD was BWT in all the studies included. On the basis of this finding, at a cutoff value greater than 3 mm, the sensitivity and the specificity were 88% and 93%, respectively, with a positive likelihood ratio (LR+) of 12.5 and a negative likelihood ratio (LR−) of 0.12; whereas for a thickness greater than 4 mm, these values were 75% and 97%, respectively, with an LR+ of 25 and LR− of 0.25, respectively. The presence of such a