http://dx.doi.org/10.1016/j.ultrasmedbio.2017.04.028

● *Review*

SMALL BOWEL ULTRASOUND BEYOND INFLAMMATORY BOWEL DISEASE: AN UPDATED REVIEW OF THE RECENT LITERATURE

FEDERICA CAVALCOLI,*† ALESSANDRA ZILLI,*† MIRELLA FRAQUELLI,*† DARIO CONTE,*†
and SARA MASSIRONI*

*Gastroenterology and Endoscopy Unit, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Milan, Italy; and
†Postgraduate School of Gastroenterology, Department of Pathophysiology and Transplantation, Università degli Studi di
Milano, Milan, Italy

Abstract—The use of bowel ultrasonography (US) for the evaluation of gut diseases has increased in recent years and has been proven to provide a widely available, non-invasive and inexpensive method for the initial work-up and follow-up of different intestinal diseases, limited mostly by technical challenges posed by the patient's anatomy. The present review aims to provide an extensive overview of the main pathologic features at US examination of intestinal diseases other than inflammatory bowel disease, both acute (*e.g.*, acute appendicitis, colonic diverticulitis, infectious diseases and ischemic conditions) and chronic (*e.g.*, celiac disease, cystic fibrosis and other enterocolites). The identification of typical US features may help in the diagnostic process and guide the treatment approach. Therefore, the application of knowledge of the US appearance of gastrointestinal diseases is of relevance in enabling greater diagnostic performance and better patient management. (E-mail: sara.massironi@policlinico.mi.it)   © 2017 World Federation for Ultrasound in Medicine & Biology.

Key Words: Bowel ultrasound, Small intestine, Imaging, Gastrointestinal disease, Celiac disease, Appendicitis, Diverticular disease, Intestinal neoplasm, Intestinal ischemia.

INTRODUCTION

The use of transabdominal ultrasonography (US) to assess gastrointestinal tract disorders is a recent development and has been focused primarily on the assessment of acute and chronic inflammatory conditions, such as appendicitis, diverticulitis, ulcerative colitis and Crohn's disease (Conti et al. 2017). Over the past few years, the technical evolution of US equipment, combined with the use of oral and intravenous contrast agents and increased operator expertise, has led to greater enthusiasm for assessment of the gut by means of US. Modern ultrasound devices with high-frequency (high-resolution) probes and harmonic imaging significantly improve the small bowel (SB) examination by offering better overall image quality and better visualization of bowel pathology and associated changes in real time (Schmidt et al. 2005). Therefore, intestinal US is being used more and more often for the initial evaluation and follow-up of various gastrointestinal disorders, such as diverticulitis, appendicitis, celiac disease and other inflammatory diseases. This review describes the literature available on the use of bowel US in several intestinal diseases except inflammatory bowel disease (IBD).

An extensive bibliographical search was performed in PubMed to identify guidelines and primary literature (retrospective and prospective studies, systematic reviews, case reports and case series) published mostly between 2000 and November 2016, using both medical subject heading (MeSH) terms and free-language key words about the role and accuracy of intestinal US in the following contexts: acute appendicitis, celiac disease, diverticular disease, intestinal neoplasms, infections or ischemia, cystic fibrosis, graft-versus-host-disease, transplanted bowel and other less frequent enterocolites (*e.g.*, Whipple's disease, eosinophilic gastroenteritis and intestinal lymphangiectasia). However, further studies of clinical relevance between 1980 and 2000 have been reported. This review considered only the studies that

Address correspondence to: Sara Massironi, Gastroenterology and Endoscopy Unit, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Via F. Sforza 35, 20122 Milan, Italy. E-mail: sara.massironi@policlinico.mi.it

received informed consent from each study participant and protocol approval by an ethics committee or institutional review board. Conference abstracts were not considered for inclusion.

TECHNIQUE

The SB sonographic examination is usually performed after the standard examination of the solid abdominal organs. The choice of probe for bowel assessment depends mainly on the patient's body habitus: a 7.0- to 12.0-MHz linear transducer, which facilitates high-resolution sonography, is used for average-size or thin patients and generally for the assessment of superficial abnormalities, whereas a 2.5- to 5.0-MHz curvilinear probe is preferred for heavier patients (Kuzmich et al. 2009). Gentle but adequately graded compression is applied to decrease the distance between the probe and the area of interest and to displace gas and fecal material.

The patient's preparation with laxatives and/or anti-flatulent agents is not needed to perform a SB examination. Meals do not significantly modify the wall thickness of the small and large bowel, but increase the flow in the splanchnic vessels; therefore, it is recommended that patients fast > 6 h as well as refrain from extensive physical exercise before the examination, to measure splanchnic blood flow (Nylund et al. 2016).

The sonographic examination should cover the entire intestinal tract. Anatomic landmarks, such as the psoas muscle, iliac vessels, cecum and ileocecal junction, are used to identify the intestinal wall (Kuzmich et al. 2009). The large intestine is identified by visualizing the ascending colon, which is recognized by the absence of peristalsis, fixed position, and presence of haustra. The colonic wall is carefully followed from the cecum along the ascending, transverse and descending parts of the colon through to the distal sigmoid colon into the pelvis. The rectum may be visualized through the distended urinary bladder. The terminal ileum is identified as a loop of the small bowel joining the cecum; the ileocecal junction is also identified. The small bowel loops are scanned in a general sweep from the epigastrium across the middle abdomen down to the pelvis.

Moreover, oral contrast agents, color power Doppler and contrast-enhanced ultrasonography (CEUS) and elastography may be used to better examine intramural blood flow, to identify affected intestinal segments and to differentiate inflammatory, fibrotic and neoplastic conditions, even if these innovative ultrasound techniques have been studied almost exclusively in patients with IBD.

Color power Doppler US is useful for evaluating the presence of vascular signals in the large blood vessels and the smaller vessels of the intestinal wall, by providing semiquantitative information: indeed, three grades of bowel wall vascularity can be subjectively assigned according to the number of vessels detected per square centimeter (Nylund et al. 2016). However, the absence of vascularity in a thickened intestinal wall might be the result of inadequately chosen Doppler parameters, a high body mass index or penetration depth > 40 mm with loss of sensitivity.

By use of US contrast agents consisting of microbubbles that are injected in the peripheral veins, CEUS allows a more precise analysis of bowel wall vascularity. To date, CEUS has been used mostly to study disease activity in IBD and to distinguish between fibrous and inflammatory strictures, although intestinal peristalsis can impair image quality and the measurement of bowel enhancement patterns. However, more studies are needed to establish the role of CEUS in the imaging of other gastrointestinal diseases (Piscaglia et al. 2012).

Furthermore, with small intestine contrast US (SICUS), the ingestion of small amounts (250–500 mL) of an iso-osmolar macrogol solution, which is non-digestible, non-absorbable and well tolerated—also by pediatric patients (Pallotta et al. 2013)—induces the gradual distension of the small bowel by linking the water molecules together and retaining fluid within the lumen, thus facilitating visualization of the entire small bowel. In healthy controls, the wall thickness is ≤ 3 mm and lumen diameter ≤ 25 mm during SICUS (Nylund et al. 2016).

Finally, elastography can evaluate bowel wall stiffness by measuring its elasticity with a colored real-time elastogram (qualitative elastography) in the conventional B-mode ultrasound image (Cosgrove et al. 2013). To date, elastography has been indicated mostly for characterization of bowel wall lesions and differentiation of inflammatory from fibrotic stenosis (strain elastography in IBD patients). Furthermore, elastography may be used to evaluate gastric contractility and gastrointestinal wall strain, especially in patients with functional dyspepsia, through the use of strain rate imaging (SRI), which can discern the contractile activity of the longitudinal from the circular muscle layers, which cannot be appreciated by B-mode. Finally, strain elastography may be used to assess the hardness of focal gastrointestinal lesions.

CLINICAL CONDITIONS

Acute appendicitis

Acute appendicitis is a very frequent condition in both pediatric and adult patients presenting with acute abdominal pain at the emergency department. Bowel US plays a key role in the confirmation or exclusion of acute appendicitis (Drake et al. 2012). Although the appendix cannot always be displayed under normal conditions, several studies have found that bowel US has a sensitivity of 71%–92% and specificity of 94%–100% in the setting of acute appendicitis (Nasiri et al. 2012).