

White Paper

Intestinal Ultrasound (IUS) Protocol for Diagnosis and Monitoring of Inflammatory Bowel Disease (IBD)

RS Series, V Series

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Introduction

■ Objective

The following protocol and guide include technical requirements, examination technique, and guidance for intestinal ultrasound (IUS) parameter measurements to aid gastroenterologists in obtaining high-quality images and cine loops of both the colon and small intestine for clinical decision-making in patients with inflammatory bowel disease (IBD).

Materials

■ System Requirements

In order to perform IUS in IBD or suspected IBD patients, an ultrasound machine capable of producing crisp, clear, high-resolution images and cine loops of the colon and small intestine is needed, such as the Samsung RS85 Prestige or V8 ultrasound machine. The Samsung RS85;Prestige and V8 systems are supported with convex (CA3-10A) and linear (LA2-14A, LA2-9S) transducers. The microconvex transducer (CA4-10M) can be added for performance of perianal and transperineal ultrasound, the description of which is beyond the scope of this protocol.

Each transducer should have central frequency setting between 5-8 MHz for optimal image acquisition of the bowel as show in Figure 1a. Transducers should be capable of assessing color Doppler signals to detect the presence or absence of bowel wall hyperemia within the frequency range of 5-10 cm/s. Assessment of color Doppler signal within the bowel wall should be easily accessible with the push of a button on the ultrasound machine, as it is a standard part of each bowel segment examination and needs to be performed quickly as illustrated in Figure 1b.

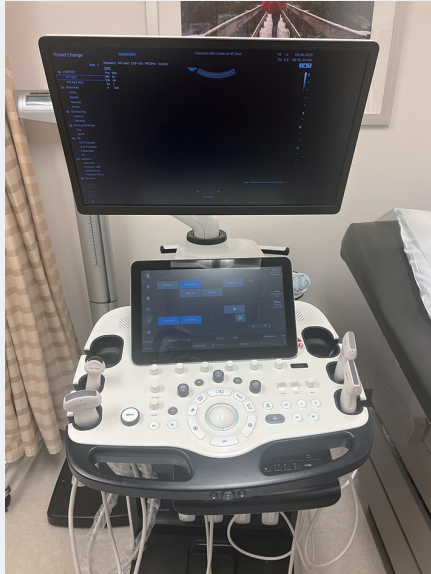


Figure 1. Samsung RS85 Prestige ultrasound machine with CA3-10A, LA2-9S, LA2-14A, and CA4-10M transducers set up in the IBD clinic exam room at optimal height (b) Visualization of power Doppler button on the Samsung V8 ultrasound machine used to assess for the presence of bowel wall hyperemia.

Methods

Intestinal Ultrasound Parameters to be assessed and measured

For a complete evaluation of IBD patients or patients with suspected IBD, it is important to perform the assessment of several parameters and perform the respective measurements as explained below.

■ Bowel Wall Thickness

The most important measure of inflammation for the detection of IBD activity is bowel wall thickness. Bowel wall thickness is measured from the lumen/mucosal interface to the outer muscularis propria/serosa interface as shown in Figure 2.¹ For research, an average of 4 measurements is performed, 2 in the longitudinal plane and 2 in the cross-section, 1 cm apart each. For clinical decision-making, 2 measurements of bowel wall thickness, 1 cm apart, are sufficient in either longitudinal or cross-section, although longitudinal is preferred. Abnormal bowel wall thickness in adult IBD patients is considered to be greater than 3 mm in all segments of the bowel. In children, the abnormal bowel wall thickness is considered greater than 2.5 mm in all segments of the bowel, but there is less evidence to support this cut-off.^{1,2}

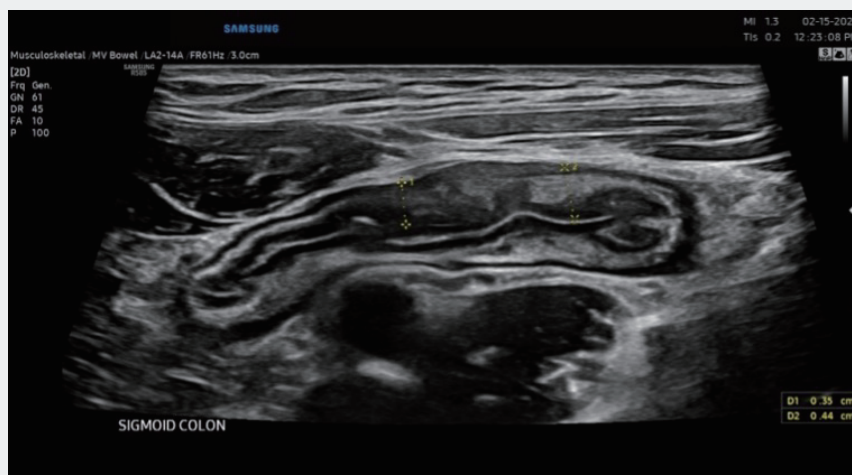
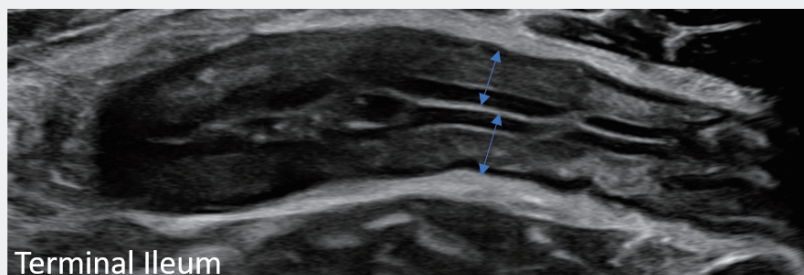


Figure 2. Measurement of bowel wall thickness shown on the Samsung RS85 Prestige Machine.

The bowel wall thickness of a bowel segment of 1 mm or less is almost always normal with near-perfect accuracy to the gold-standard of ileocolonoscopy.³ When a thickened bowel segment is identified, the continuous length of the segment should be noted, particularly in the terminal ileum, as shown in Figure 3. If a colonic segment is entirely thickened, it is sufficient to note the thickening of the entire segment rather than measuring the continuous length of that segment. The estimated length of a thickened bowel segment should be included to the best of the proceduralist ability in a still image and a cine loop, noting that IUS has a tendency to underestimate the continuous length of an affected segment compared to MRI for the small intestine.⁴

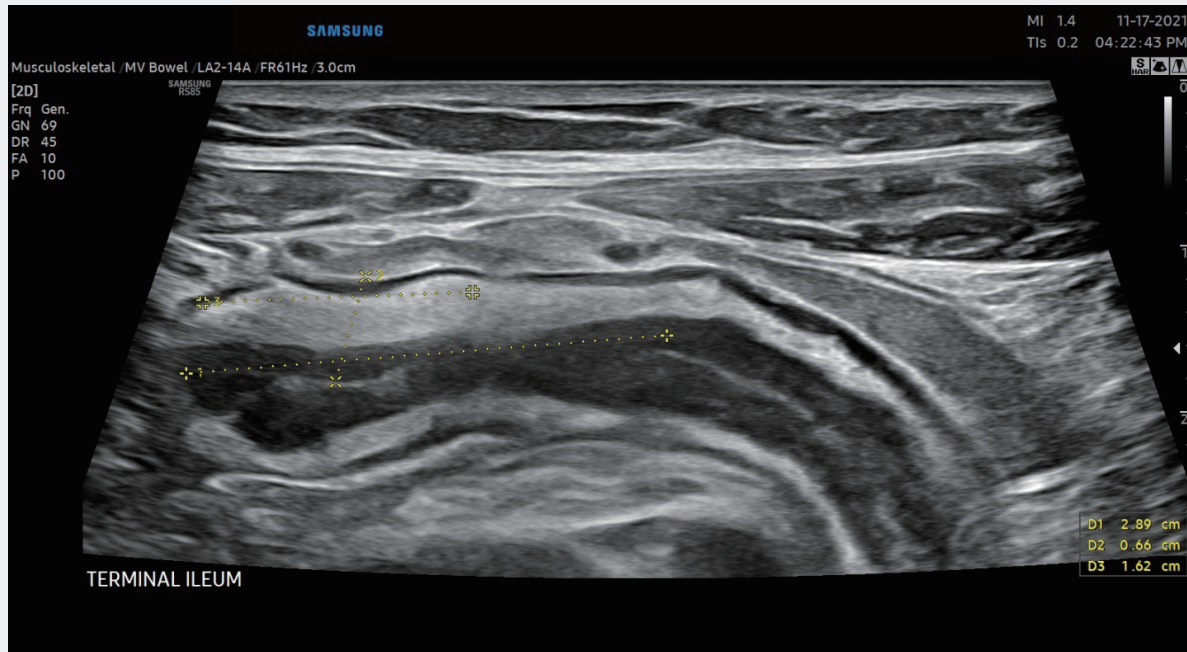


Figure 3. Bowel Segment Length Measurement of Inflammation in the Terminal Ileum.

■ Bowel Wall Hyperemia

For any segment of the bowel with a thickness greater than 2 mm in adults or 1.5 mm in children, or the appearance of thickening or prominence of the submucosal layer with hypoechoic spots within the submucosa, assessment with color Doppler signal for the presence of bowel wall hyperemia should be performed. It is important to note the bowel depth at the time of color Doppler assessment, as a bowel depth > 5 cm may reduce the reliability of the assessment. Flow velocity for color Doppler imaging should be set between 5-10 cm/s on the ultrasound machine for the bowel specifically, using the setting closest to 5 cm/s when possible. The Doppler box or area of interest should include the complete wall of the bowel segment being assessed and an additional portion of the mesentery, usually 1 cm beyond the bowel wall for the complete assessment. For IBD assessment, a semiquantitative score is used most commonly, termed the modified Limberg score. This is scored from 0 to 3, with 0 equal to no Doppler signal, 1 equal to single vessels within the bowel wall (often < 5 vessels), 2 equal to stretches of vessels within the wall, and 3 equal to stretches of vessels extending beyond the bowel wall into the mesentery (Figure 4).²

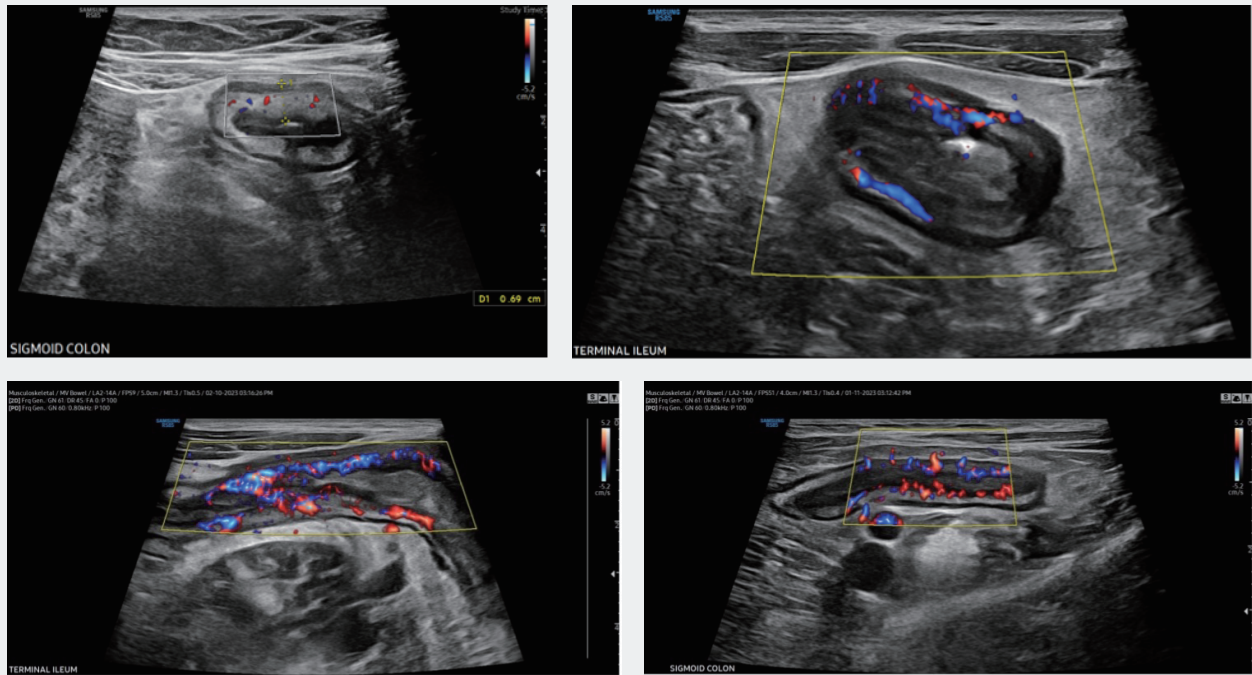


Figure 4. Assessment of Bowel Wall Hyperemia by color Doppler signal.

Figure 4 (Left, Top) demonstrates a modified Limberg score equal to 1 in the sigmoid colon with single vessels in the submucosal layer of a thickened bowel wall. (Right, Top) Modified Limberg score equal to 2 with stretches of hyperemia by color Doppler signal that is almost beginning to stretch into the mesentery (note the Doppler box extends approximately 1 cm around the outside of the bowel segment of interest to assess for mesenteric expansion of Doppler signal. (Bottom) Modified Limberg score equal to 3 with stretches of hyperemia by color Doppler signal extending along the entire submucosa and into the mesentery in multiple places along the bowel segment of both the terminal ileum and sigmoid colon.

■ Bowel Wall Layer Stratification

To investigate the bowel wall layer stratification, the patient should be assessed in all bowel segments that are found to have increased thickness. It is imperative that a firm pressure be applied using graded compression to ensure clear visualization of the segment when assessing the individual layers and subsequent stratification. Loss of stratification can be assessed in either longitudinal or cross-sectional views of the bowel segment and is described as either normal or preserved, focal disruption (< 3 cm in segment length of disruption) or extensive disruption (> 3 cm in length of disruption) as illustrated in Figure 5.

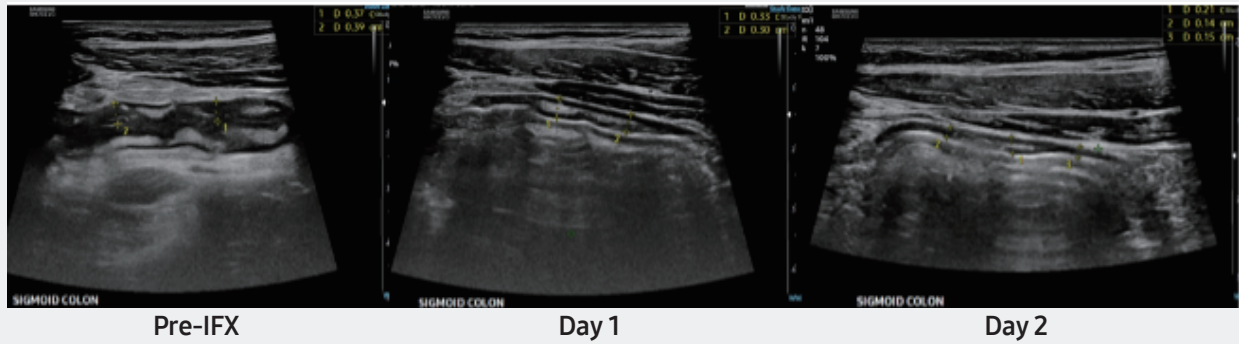


Figure 5. Extensive disruption, improving to focal disruption, in the sigmoid colon, and almost normalization of the bowel wall layer stratification in an IBD patient being treated with Infliximab for acute severe ulcerative colitis.

Bowel wall layer stratification can also be represented in the colon by a loss or flattening of the normal haustration pattern. This is demonstrated in Figure 6, which shows a normal sigmoid colon, with a normal, curved haustral pattern at regular intervals in the colon in a patient with ulcerative colitis who has achieved complete endoscopic, histologic, and transmural healing (Left) in comparison to a patient with moderate to severely active ulcerative colitis, where there is not only an increase in bowel wall thickness, but a flattening or loss of the normal haustral pattern (Right and Bottom).

One of the most common findings indicative of severely active and chronic inflammation in Crohn's disease patients with long-standing inflammation of the terminal ileum is extensive disruption of the bowel wall layer stratification. There can also be evidence of submucosal spiculations, or stellate distortions of the submucosal layer extending into the muscularis propria layer, potentially indicating a more severe level of chronic inflammation and submucosal fibrosis as shown in Figure 7.

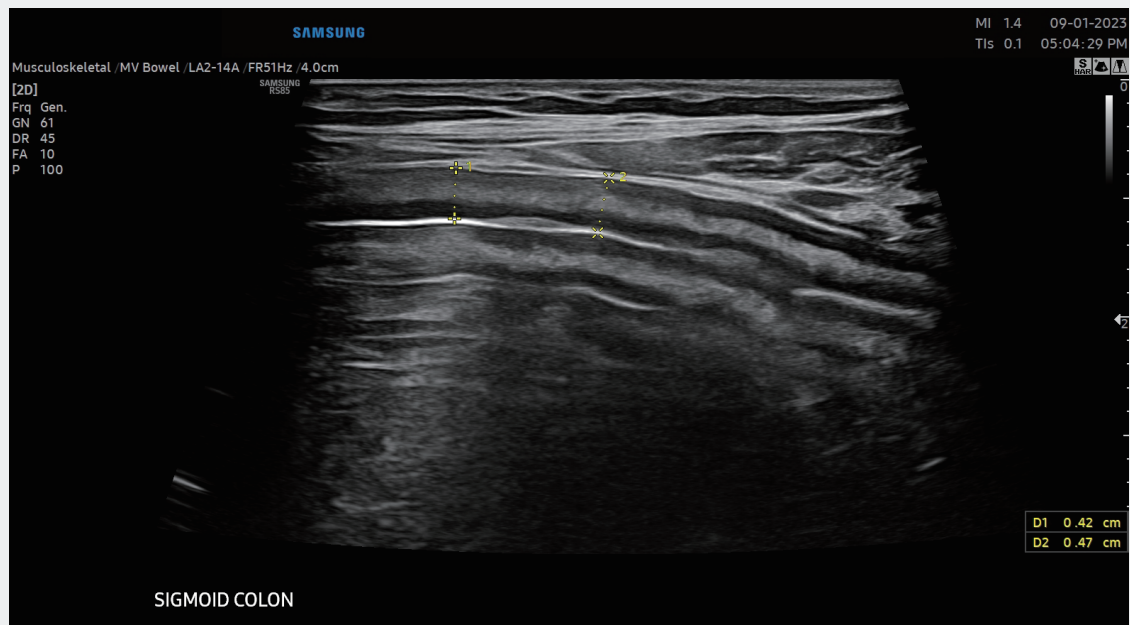
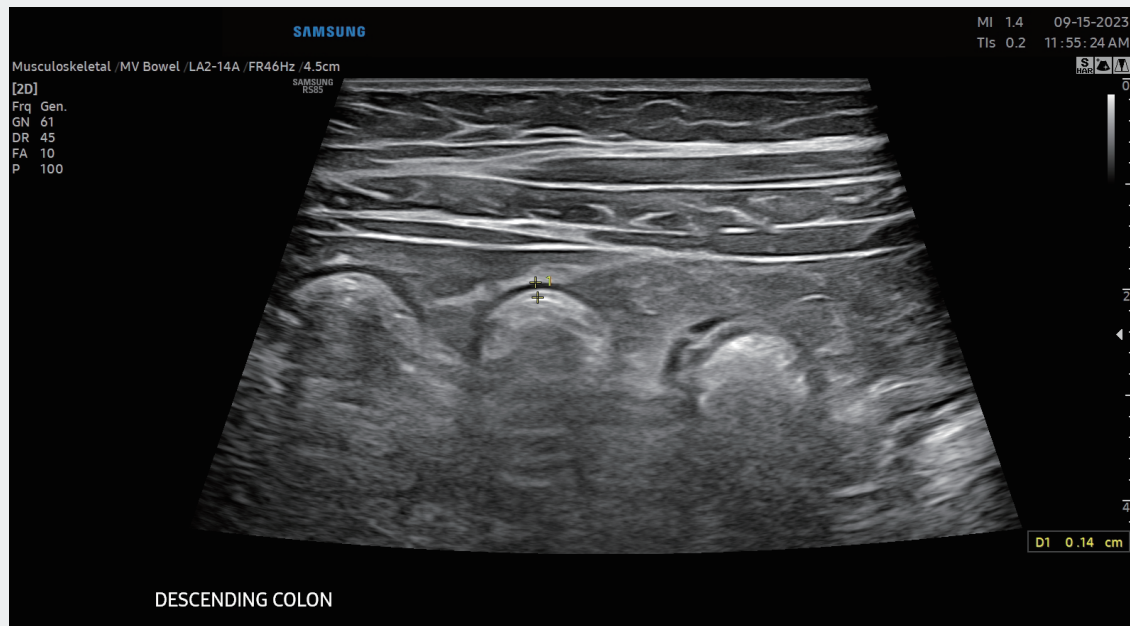


Figure 6. Normal Colon (Top) vs. Loss of Colonic Haustrations (Bottom).

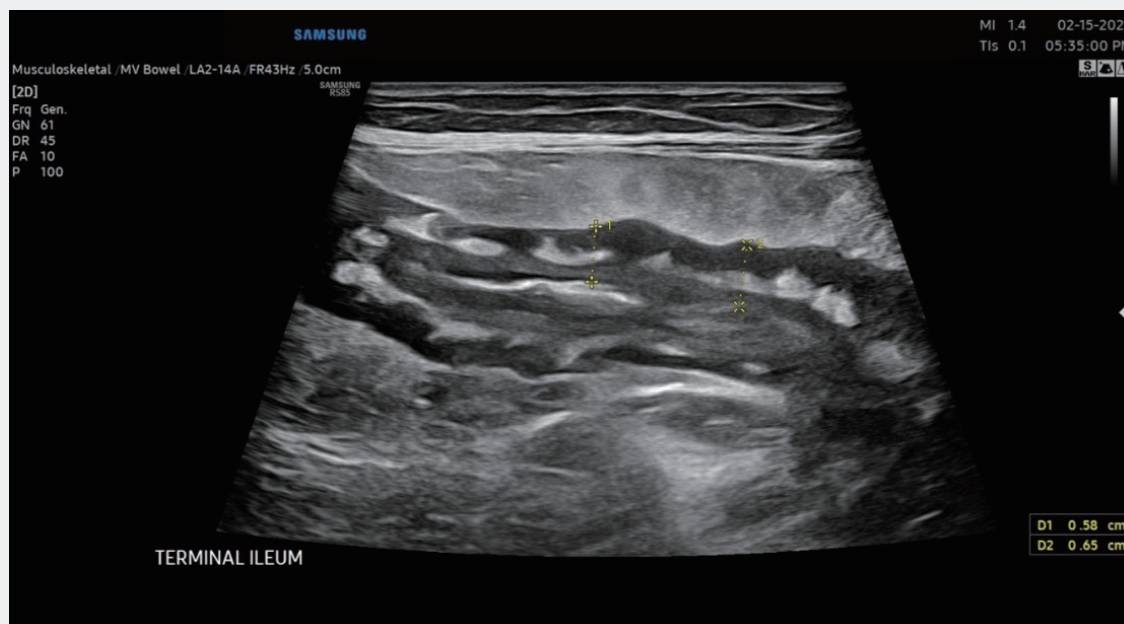


Figure 7. Extensive Disruption of the Terminal Ileum Bowel Wall Stratification with Submucosal Spiculations.

■ Inflammatory Mesenteric Fat

All bowel segments with increased bowel wall thickness should be assessed for the presence of inflammatory fat that is often best visualized in cross-sectional segments, however, it can be viewed in the longitudinal plane as well. Inflammatory fat appears as a bright, white/grey, homogeneous mass often surrounding or “wrapping” the thickened bowel segment as shown in Figure 8. This should be rated as absent or present, and the subjective severity (mild, moderate, severe) can be noted, although there is no formal quantitative scoring system for objective assessment.

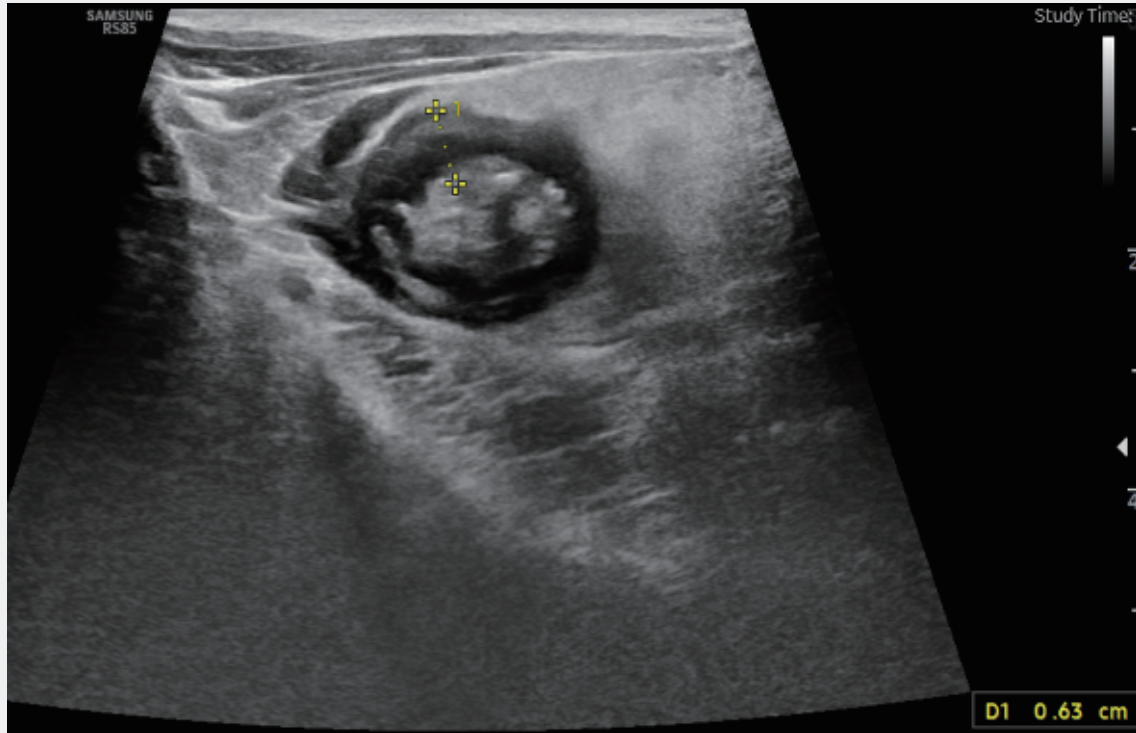


Figure 8. Inflammatory mesenteric fat pictured as bright white/grey surround the terminal ileum.

■ Lymphadenopathy

The presence of lymph nodes should be evaluated, with reactive lymphadenopathy up to 1.5 cm in diameter, particularly in children with active IBD, commonly found in the mesenteric areas surrounding the affected bowel segment.¹ Lymph nodes are often found as black or dark grey, round to oval shapes within the mesentery. In order to differentiate enlarged lymph nodes from blood vessels, the color Doppler can be used to confirm no activity by applying the signal to the suspected black or dark grey, round or oval shape. Graded compression can also be used to elucidate the “wink” sign as enlarged lymph nodes will flash in and out of view whereas blood vessels will maintain their presence in the field of view. From Figure 9, the presence or absence of lymphadenopathy should be noted, the largest lymph node, measured by its shortest axis in diameter, should be noted and the size should be documented.

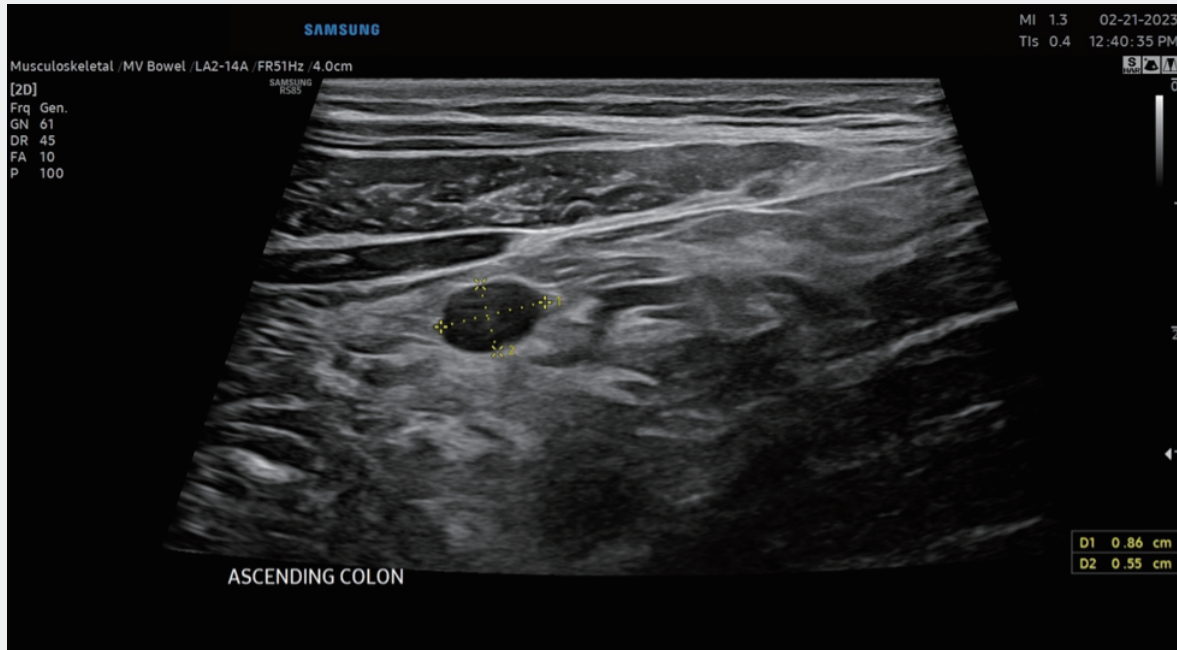


Figure 9. Presence of Lymphadenopathy in the Mesentery.

■ Assessment of Complications

Stricture or luminal narrowing can be appreciated in both cross-sectional and longitudinal bowel segments but is often best visualized in the longitudinal segment. Strictures can be appreciated when there is a significant increase in bowel wall thickness and luminal narrowing, often with evidence or the beginning evidence of dilation of the bowel proximally, a pre-stenotic dilation (dilation of the bowel to greater than 2.5 cm in diameter) can be seen most commonly in obstructive strictures as illustrated in Figure 10. Pre-stenotic dilation is not always visualized and can be difficult to measure as the posterior bowel wall is often obscured by overlying bowel gas. However, luminal narrowing in the absence of pre-stenotic dilation is almost always a stricture. The length of the stricture and maximum bowel wall thickness in this region should be noted. Visualization of “to and fro” peristalsis or turbulent flow of the luminal contents attempting to pass through the luminal narrowing is often visualized and should be captured on a Cine Loop and noted in the IUS examination report.

The presence of fistula(e), often found as linear, hypochoic breaks within the bowel wall in the direction of the mesentery, abdominal wall, or adjacent bowel segment, can be visualized with IUS as shown in Figure 11. In the setting of severe inflammation, similarly hypochoic sinus tracts that terminate in the mesenteric fat can be seen, particularly in the terminal ileum.

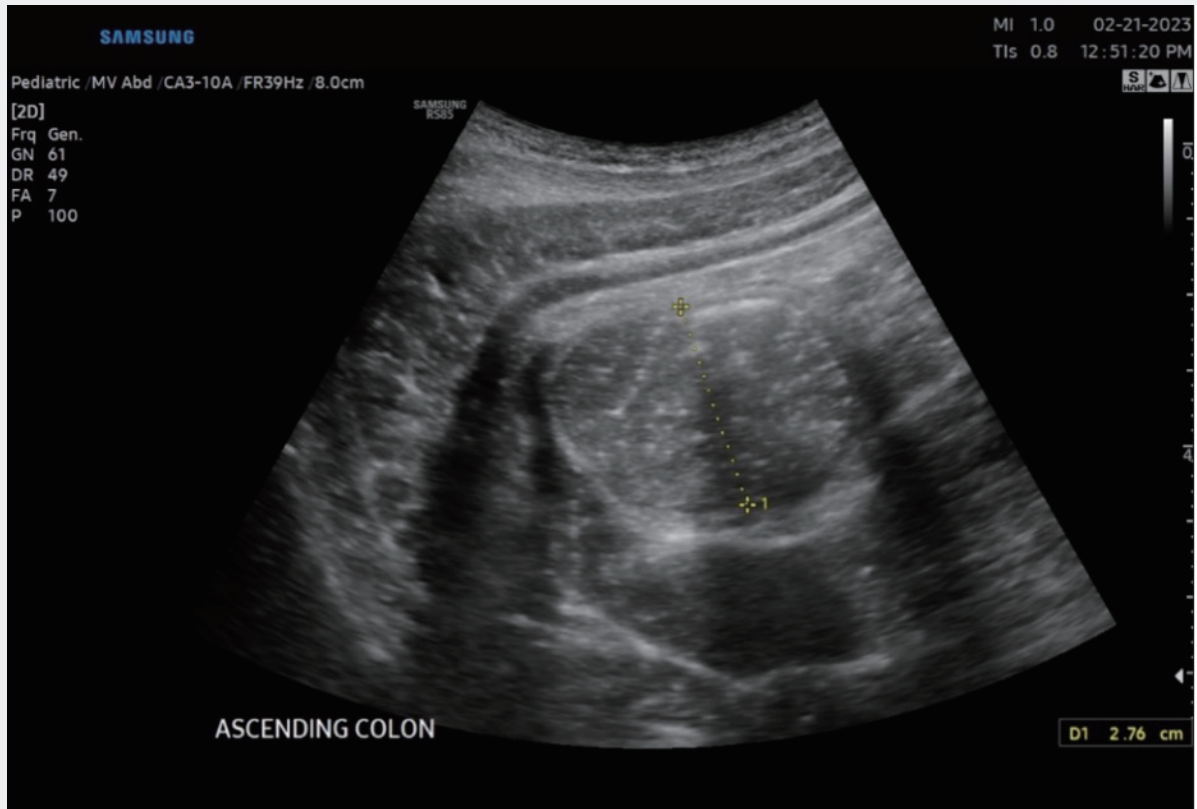
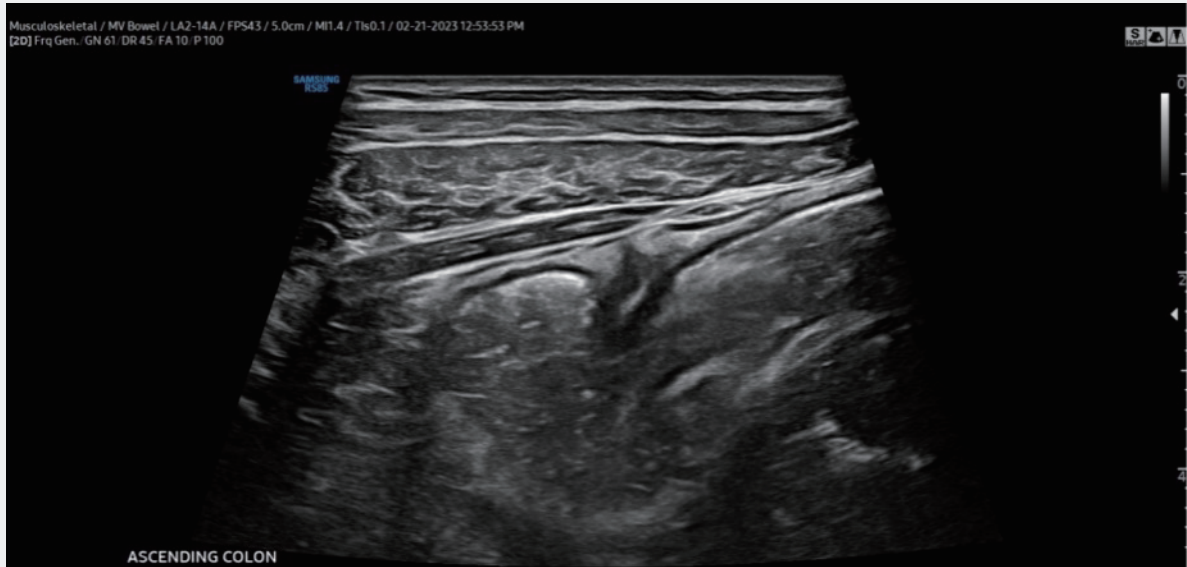


Figure 10. Ascending Colon Stricture with Proximal Dilatation.

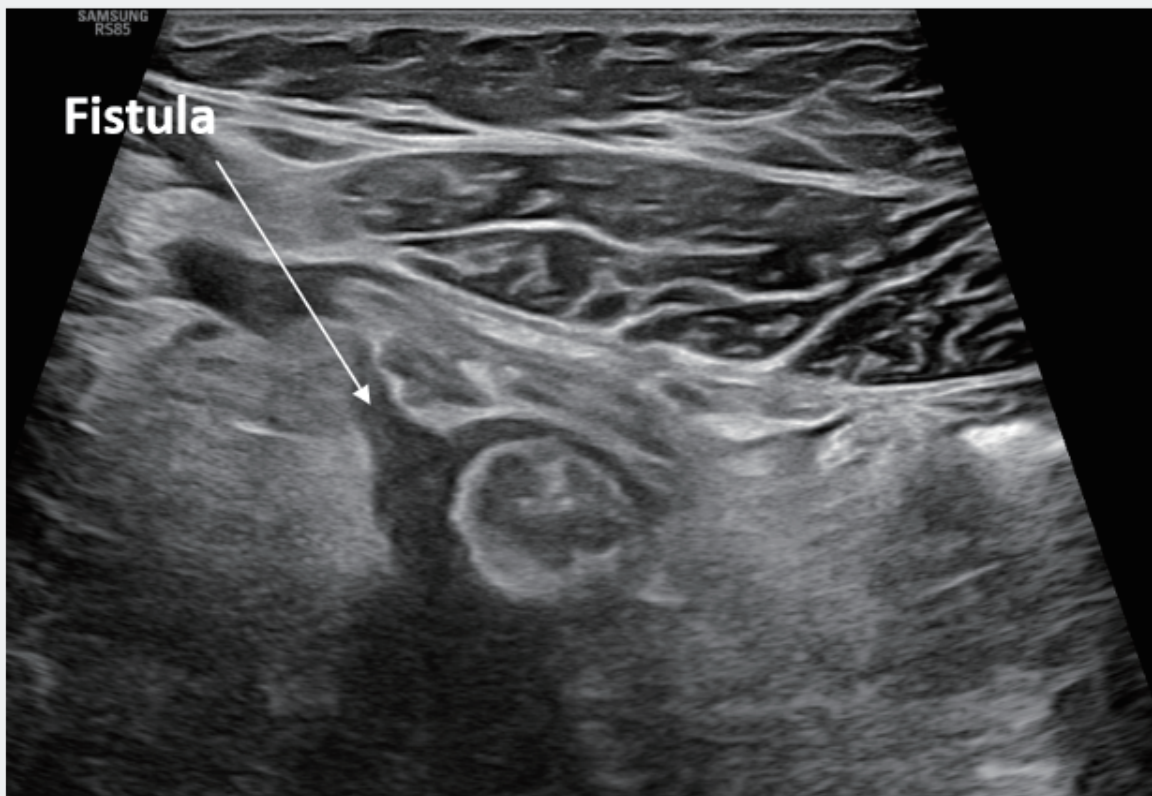


Figure 11. The Presence of a fistula is noted in a severely inflamed segment of the terminal ileum.

Conclusion

IUS is performed utilizing a high-end ultrasound machine in a standardized and systematic approach to visualize the colon and small intestine in order to detect inflammation or healing in the evaluation of IBD patients or those with suspected IBD. As the only modality capable of visualizing the individual bowel wall layers and precisely characterizing inflammation and its severity, IUS has the capability to revolutionize the diagnosis and monitoring of IBD.

Supported Systems

- RS85 Prestige, RS85
- RS80 EVO, RS80A
- V8, V7, V6

References

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