



Beyond Mucosal Healing in Inflammatory Bowel Disease: Bowel-Wall Imaging, Transmural Inflammation, and the Emerging Concept of Ultrasound Remission

Elsayed Mohammed Elsayed, Abeer Mohammed Nafee, Nabila Hassan Ahmed, Mohammed Foad Mostafa

Department of Hepatology, Gastroenterology and Infectious Diseases, Faculty of Medicine - Zagazig University

Corresponding Author: Elsayed Mohammed Elsayed

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Abstract

Background: Inflammatory bowel disease (IBD) management has moved from symptom control toward objective suppression of intestinal inflammation. Endoscopic healing is a major long-term target, yet endoscopy is limited to the mucosal surface and may not capture residual mural or extramural disease. This limitation is particularly relevant in Crohn disease, but increasing evidence also shows measurable bowel-wall abnormalities in ulcerative colitis. **Aim:** To critically review bowel-wall imaging as an extension of treat-to-target care, with emphasis on intestinal ultrasound, endoscopic and rectal ultrasonography, transmural inflammation, and the emerging concept of ultrasound remission. **Methods:** Evidence published through 2024 was synthesized from international guidance, prospective cohorts, validation studies, systematic reviews, and key studies evaluating bowel-wall thickness, Doppler vascularity, wall stratification, mesenteric inflammatory changes, endoscopic activity, histology, biomarkers, and clinical outcomes. **Results:** Bowel-wall thickness is the most consistent sonographic marker of active inflammation, while color Doppler signal, loss of stratification, inflammatory mesenteric fat, and complications improve phenotyping. In Crohn disease, normalization of mural abnormalities is associated with favorable outcomes and may identify a depth of response beyond endoscopic healing. In ulcerative colitis, ultrasound correlates with endoscopic and histological activity and can detect early treatment response, while rectal endoscopic ultrasound provides high-resolution layer-specific assessment. Composite scores such as IBUS-SAS, the UC-ultrasound index, Milan Ultrasound Criteria, and EUS-UC support standardization, although definitions of remission remain heterogeneous. **Conclusion:** Ultrasound remission is a clinically attractive, noninvasive concept that complements rather than replaces endoscopic and histological targets. Standardized thresholds, segment-specific criteria, and outcome-based validation are required before it can become a universal treatment endpoint.

Keywords: Inflammatory bowel disease, Intestinal ultrasound, Transmural healing, Ultrasound remission

Introduction

Inflammatory bowel disease comprises ulcerative colitis and Crohn disease, two chronic immune-mediated disorders in which inflammatory activity fluctuates over time and may continue despite partial symptomatic improvement. The therapeutic objective has therefore evolved from short-term relief toward prevention of progressive bowel damage, disability, hospitalization, surgery, and neoplasia. This change is reflected in treat-to-target strategies that place objective assessment alongside patient-reported outcomes. Endoscopic healing remains a central long-term target because persistent mucosal ulceration predicts adverse outcomes, but modern disease monitoring increasingly asks whether mucosal appearances alone are sufficient to define biological control. Cross-sectional techniques provide information that conventional endoscopy cannot: the thickness and architecture of the bowel wall, vascularity, surrounding mesentery, fistulas, abscesses, and strictures. In that context, intestinal ultrasound has moved from a niche imaging tool toward a repeatable point-of-care method that can be incorporated into longitudinal clinical decision-making. [1,2]

The conceptual shift is particularly important in Crohn disease because inflammation is transmural by definition. A patient may achieve symptomatic and even endoscopic remission while mural thickening,



hypervascularity, inflammatory fat, or penetrating complications persist. Ulcerative colitis has historically been viewed as a mucosal disease, but structural and vascular bowel-wall abnormalities can also be detected during active disease, and some changes persist despite apparently mild surface activity. Ultrasound therefore occupies an intermediate biological space between biomarkers and endoscopy: it is objective, repeatable, radiation-free, and capable of visualizing the wall rather than the mucosal surface alone. These properties have supported growing interest in transmural healing and, more recently, in the broader idea of ultrasound remission. [3,7]

Research Gap

Despite rapid adoption of intestinal ultrasound, there is no universally accepted definition of ultrasound remission across inflammatory bowel disease phenotypes. Thresholds for normal bowel-wall thickness vary by bowel segment and technique; color Doppler grading is equipment dependent; the significance of residual mesenteric fat, wall stratification abnormalities, or isolated vascularity is incompletely defined; and the relationship between sonographic normalization and long-term outcomes differs between Crohn disease and ulcerative colitis. Rectal and endoscopic ultrasound offer high-resolution mural assessment but remain less standardized and less widely available than transabdominal intestinal ultrasound. A clinically useful framework is therefore needed to connect mucosal healing, histological remission, transmural healing, and ultrasound remission without treating these related concepts as interchangeable endpoints.

Aim

This review examines bowel-wall imaging as an extension of contemporary treat-to-target care in inflammatory bowel disease, focusing on the biological meaning and clinical measurement of transmural inflammation, the performance of intestinal and endoscopic ultrasound, the relationship of ultrasound with endoscopy, histology and biomarkers, and the evidence supporting ultrasound remission as an emerging monitoring endpoint.

From Symptom Control to Objective Disease Modification

The original treat-to-target framework redirected inflammatory bowel disease management away from isolated symptom control and toward prespecified therapeutic goals assessed at planned intervals. STRIDE-II retained clinical remission and endoscopic healing as major targets while recognizing normalization of C-reactive protein and fecal calprotectin as intermediate objectives. Importantly, transmural healing in Crohn disease and histological healing in ulcerative colitis were acknowledged as measures of remission depth rather than formal universal targets. This distinction remains useful: a deeper biological response may provide prognostic information even when evidence is not yet sufficient to mandate treatment escalation solely to normalize every measurable layer of inflammation. [1,2]

Tight-control trials have shown why objective reassessment matters. In CALM, treatment decisions incorporating biomarkers in addition to symptoms improved endoscopic outcomes in early Crohn disease compared with symptom-driven management. STARDUST did not demonstrate superiority of a particular ustekinumab treat-to-target algorithm, reminding clinicians that the value of monitoring depends on the target, drug, timing, and escalation strategy rather than on repeated testing alone. These data support a pragmatic interpretation: objective measurements should expose occult inflammation and reduce therapeutic inertia, but the clinical consequence of an abnormal result must be evidence-based. Ultrasound is attractive within this framework because it can be repeated frequently without bowel preparation, sedation, radiation, or procedural recovery. [3,4]

Why Mucosal Healing May Be an Incomplete Endpoint

Endoscopic healing is strongly associated with favorable outcomes, yet the bowel is a three-dimensional organ. Ileocolonoscopy directly depicts the luminal surface and permits biopsy, but cannot determine the full depth of inflammatory infiltration or characterize most extramural disease. This limitation is most obvious in Crohn disease, where fistulas, abscesses, mesenteric inflammation, fibrosis, and transmural thickening can remain clinically relevant after mucosal improvement. ECCO-ESGAR guidance therefore positions cross-sectional imaging as an essential complement to endoscopy for defining disease



distribution, complications, and monitoring response. [5,6]

The incompleteness of mucosal healing is also evident in ulcerative colitis. Patients with a Mayo endoscopic subscore of 1 relapse more often than those with complete endoscopic normalization, and microscopic neutrophilic activity may persist when mucosa appears healed. Histological remission adds prognostic information, with systematic reviews demonstrating lower relapse risk when microscopic inflammation resolves. Thus, the modern remission hierarchy extends from symptoms to biomarkers, endoscopic healing, histological quiescence, and, where relevant, normalization of bowel-wall abnormalities. These levels overlap but are not synonymous, and discordance should trigger clinical interpretation rather than automatic categorization as treatment failure. [27,28]

Transmural Inflammation: Biological Rationale

Crohn disease is characterized by inflammation that may extend from mucosa through submucosa and muscularis propria to the serosa and adjacent mesentery. The consequences of this biology are visible on ultrasound as increased bowel-wall thickness, hyperemia, disruption of wall stratification, hyperechoic inflammatory mesenteric fat, reduced motility, stricturing, fistulas, and abscesses. These features represent different components of the inflammatory and structural phenotype. A thick wall with marked Doppler activity may indicate active inflammatory disease, whereas a persistently thick, poorly compliant segment with limited vascularity and prestenotic dilation raises concern for a greater fibrotic contribution. No single parameter perfectly separates inflammation from fibrosis, which is why multiparametric interpretation remains necessary. [8,32]

Ulcerative colitis is classically limited to the mucosa and superficial submucosa, but chronic inflammation can produce measurable changes beyond the epithelial surface. Histological and imaging studies have demonstrated submucosal thickening, vascular changes, and fibrosis associated with disease severity and chronicity. This does not reclassify ulcerative colitis as a transmural disorder in the Crohn disease sense; instead, it shows that a mucosal diagnosis can still have a mural imaging phenotype. The practical consequence is that bowel-wall measurements can function as objective markers of activity even when the disease process originates at the mucosal surface. [13,38]

Intestinal Ultrasound: What the Examination Measures

A structured intestinal ultrasound examination evaluates bowel segments systematically and records both mural and extramural findings. Bowel-wall thickness is the foundational variable because it is quantitative, reproducible, and responsive to change. Color Doppler signal reflects intramural hyperemia, while wall stratification describes preservation or loss of the normal layered echo pattern. Additional observations include inflammatory mesenteric fat, mesenteric lymph nodes, free fluid, motility, luminal narrowing, prestenotic dilation, fistulas, and collections. The relative importance of each feature depends on disease phenotype: complications and mesenteric findings are especially relevant in Crohn disease, whereas colonic wall thickness and vascularity carry much of the monitoring signal in ulcerative colitis. [7,9]

Technique directly influences interpretation. Probe frequency, transducer pressure, bowel distension, patient habitus, Doppler settings, and operator experience can change apparent wall thickness and vascularity. The rectum is less accessible to transabdominal ultrasound than more proximal colonic segments because of pelvic depth and surrounding structures, a limitation that is particularly relevant to distal ulcerative colitis. Transperineal ultrasound, endoanal ultrasound, and rectal endoscopic ultrasound can partially address this blind spot. International training consensus has therefore focused not only on recognizing pathology but also on standardized acquisition, segment identification, measurement technique, and reproducible Doppler assessment. [9,10]

Bowel-Wall Thickness: The Core Sonographic Biomarker

Bowel-wall thickness is the most extensively studied sonographic marker of inflammatory activity. In healthy bowel, thickness is generally low, while active inflammation increases mural edema and cellular infiltration. A threshold around 3 mm is commonly used for small bowel and many colonic segments in Crohn disease studies, although normal values vary with segment, distension, and methodology. The diagnostic value of bowel-wall thickness is strengthened when interpreted with Doppler signal and wall



stratification rather than as an isolated number. Importantly, serial reduction in thickness can be more informative than a single absolute threshold because it captures within-patient response and reduces the impact of baseline anatomical variability. [8,16]

Longitudinal data support the responsiveness of bowel-wall thickness to effective therapy. In the TRUST program for Crohn disease and TRUST&UC for ulcerative colitis, early sonographic improvement paralleled clinical and biochemical response. Similar work in ulcerative colitis found that bowel-wall thickness correlated with endoscopic and histological activity and decreased in patients achieving endoscopic improvement. These observations explain why modern ultrasound response definitions often use a relative decline in thickness, sometimes in combination with improved Doppler activity, rather than requiring immediate complete normalization. [11,12]

Doppler Vascularity and Bowel-Wall Stratification

Active intestinal inflammation increases regional perfusion and intramural vascularity, making color Doppler a biologically plausible activity marker. In Crohn disease, Doppler grades correlate with endoscopic activity and can improve the discrimination of active from inactive thickened bowel. In ulcerative colitis, intramural flow has long been associated with active disease, and early transrectal studies demonstrated that submucosal vascular signals add diagnostic value to wall-thickness measurements. Because Doppler is sensitive to machine settings, pulse repetition frequency, wall filter, gain, and transducer pressure, reproducible protocols are essential if serial examinations are used to judge remission. [31,40]

Wall stratification adds structural context. Preserved layers with modest thickening may indicate a different inflammatory state from marked thickening with loss of the submucosal interface. In Crohn disease, loss of stratification is included in composite indices such as IBUS-SAS, while restoration of stratification contributes to many definitions of transmural healing. In ulcerative colitis, the relative thickness of the submucosa has been explored as a quantitative marker of endoscopic remission. These observations suggest that ultrasound remission should not be reduced to thickness alone, even if thickness remains the most practical and reproducible anchor variable. [14,41]

Mesenteric and Extramural Features

Inflammatory mesenteric fat is a characteristic feature of active Crohn disease and is incorporated into IBUS-SAS because it provides information beyond the bowel wall. Fistulas, abscesses, phlegmon, and strictures further define the penetrating or obstructive phenotype and can alter management even when symptoms are modest. Ultrasound is particularly useful for repeated assessment of superficial and terminal ileal disease, while magnetic resonance enterography remains valuable for comprehensive mapping of the small bowel, deep pelvis, and complex penetrating disease. A normal luminal surface cannot exclude these extramural abnormalities, which is one reason cross-sectional healing may represent a deeper level of disease control. [5,19]

Standardized Ultrasound Activity Scores in Crohn Disease

The need for reproducible reporting has driven development of formal activity scores. The International Bowel Ultrasound Segmental Activity Score was derived through expert consensus and reliability testing and incorporates bowel-wall thickness, color Doppler signal, bowel-wall stratification, and inflammatory mesenteric fat. Its development was important because it transformed descriptive ultrasound into a structured quantitative framework with excellent inter-rater reliability under standardized acquisition conditions. External studies have since demonstrated associations between IBUS-SAS and endoscopic activity, biomarkers, and therapeutic response. [15,17]

Simpler tools have also been developed. The Bowel Ultrasound Score emphasizes practical assessment of response and has shown good performance during therapy. The existence of several scores is scientifically useful but creates a challenge for universal definitions of remission. A clinically deployable target must balance biological completeness with feasibility; scores that require many variables may be informative in trials but cumbersome in routine visits, while a thickness-only definition risks oversimplifying residual disease. Current consensus therefore favors a small set of reproducible core variables, with bowel-wall



thickness and Doppler activity at the center. [18,20]

Ultrasound in Ulcerative Colitis

Ulcerative colitis presents a different technical and biological problem because inflammation is continuous, predominantly colonic, and usually begins in the rectum. Transabdominal ultrasound performs well in the sigmoid, descending, transverse, and ascending colon, but rectal assessment may be limited. The TRUST&UC study demonstrated that ultrasound can monitor disease activity and therapeutic response across routine clinical settings. Subsequent prospective work confirmed that bowel-wall thickness correlates with endoscopic and histological indices, supporting its use as an objective bedside marker rather than merely a screening test. [12,21]

The Milan Ultrasound Criteria were developed to translate colonic ultrasound findings into a practical disease-activity tool and were externally validated with strong discrimination for active versus inactive ulcerative colitis. Prospective follow-up has also suggested prognostic value, with abnormal Milan criteria during clinical remission associated with subsequent relapse. The UC-ultrasound index provides another structured approach based on segmental activity. These tools indicate that the field is moving from descriptive statements such as 'thickened bowel' toward reproducible thresholds that can be tested against endoscopic remission and long-term outcomes. [22,23]

Rectal and Endoscopic Ultrasound: Layer-Specific Assessment

Rectal endoscopic ultrasound has a particular advantage in distal disease because the transducer is positioned close to the rectal wall, allowing high-resolution visualization of mural layers. Early catheter-probe and transrectal studies established normal wall dimensions and showed significant thickening of the mucosa and submucosa in active ulcerative colitis. The ability to visualize five wall layers provides information that conventional mucosal inspection cannot offer and may help distinguish superficial from deeper involvement. [33,34]

Later studies expanded this concept into formal EUS indices. The EUS-UC score integrates wall thickening, depth of inflammation, and vascularity, and reliability studies have demonstrated that standardized endoscopic ultrasound assessment can identify inflammatory activity. EUS has also been investigated for differentiating Crohn colitis from ulcerative colitis based on the distribution of mural thickening, with greater muscularis propria involvement tending to favor Crohn disease. Such differentiation is not sufficiently accurate to replace the integrated clinical, endoscopic, histological, and imaging diagnosis, but it illustrates the unique layer-specific information produced by endoluminal ultrasound. [35,36]

Endoscopy, Histology, and Ultrasound: Complementary Rather Than Competing Targets

Endoscopy remains indispensable because it directly evaluates ulceration, extent, dysplasia risk, and mucosal response and permits biopsy. Histology adds microscopic resolution and identifies residual neutrophilic inflammation that may persist despite an endoscopically healed surface. The Nancy Histological Index and Robarts Histopathology Index provide validated frameworks for quantifying ulcerative colitis activity and have improved standardization in trials and clinical research. Ultrasound contributes a different dimension: the wall, vascularity, mesentery, and complications. The most informative monitoring strategy therefore triangulates these modalities rather than selecting a single winner. [24,25]

Discordance is clinically meaningful. Persistent symptoms with normal biomarkers, endoscopy, and ultrasound may suggest functional overlap, bile acid diarrhea, pelvic floor dysfunction, or another noninflammatory driver. Conversely, symptom resolution with abnormal fecal calprotectin, residual ulceration, or persistent sonographic thickening indicates incomplete biological control. Histological activity in ulcerative colitis predicts relapse even when endoscopy suggests remission, while sonographic abnormalities in Crohn disease can persist after mucosal healing. These patterns support the concept of multidimensional remission and reinforce the need to interpret each target according to the compartment it measures. [26,29]



Biomarkers and Ultrasound

Fecal calprotectin is the most useful widely available noninvasive biomarker of intestinal neutrophilic inflammation and correlates particularly well with colonic endoscopic activity. Low concentrations are associated with endoscopic and histological remission in ulcerative colitis, although optimal cutoffs vary by assay and clinical purpose. C-reactive protein is less bowel-specific and may remain normal despite active localized disease. Ultrasound can therefore complement biomarkers by localizing inflammation and distinguishing a focal abnormal segment from a generalized biochemical signal. [30,42]

The combination is clinically appealing because both tools can be repeated frequently. A patient with low fecal calprotectin and normalized ultrasound has concordant noninvasive evidence of deep control, whereas discordant results identify a group that may benefit from endoscopy, cross-sectional imaging, or closer follow-up. In Crohn disease, this paired strategy is particularly useful when ileal disease is poorly represented by fecal calprotectin. In ulcerative colitis, fecal calprotectin may be more sensitive to subtle mucosal inflammation than ultrasound, while ultrasound can demonstrate the anatomical distribution and mural response. [43,44]

Transmural Healing in Crohn Disease

Transmural healing generally describes normalization of cross-sectional inflammatory abnormalities after therapy. Early bowel-sonography studies showed that some patients receiving biologic therapy achieve normalization of bowel-wall thickness, and subsequent work demonstrated good agreement between bowel ultrasound and magnetic resonance enterography for identifying transmural healing. The proportion achieving this endpoint is usually lower than the proportion achieving clinical remission, reflecting the greater biological stringency of wall normalization. [45,46]

The prognostic signal is clinically important. Patients achieving transmural healing have shown higher rates of steroid-free remission and lower risks of hospitalization and surgery than patients with mucosal healing alone or persistent disease. Sonographic healing in patients already in clinical remission has likewise been associated with reduced need for treatment escalation and corticosteroids. These observational data do not prove that escalating therapy solely to obtain sonographic normalization improves outcomes, but they support transmural healing as a marker of disease depth and a candidate future target. [47,48]

Early Ultrasound Response as a Dynamic Treatment Marker

Ultrasound can show treatment response before a scheduled follow-up colonoscopy. Multicenter Crohn disease studies demonstrated that improvement in wall thickness, Doppler activity, and contrast-enhanced vascularity during induction predicts later sonographic response. In ulcerative colitis, early reduction in bowel-wall thickness can predict subsequent clinical and endoscopic response, and drug-specific kinetics have been observed. This rapid responsiveness makes ultrasound particularly suited to an adaptive monitoring strategy in which failure of objective improvement prompts earlier reassessment rather than waiting several months for symptoms or complications to declare themselves. [16,49]

The interpretation of early change requires caution. Residual thickening may reflect edema, chronic remodeling, or fibrosis rather than uncontrolled active inflammation, and complete normalization may lag behind mucosal response. For this reason, relative reduction in thickness and Doppler signal may be a more realistic early target than strict transmural healing. A useful framework separates ultrasound response from ultrasound remission: response indicates meaningful improvement from baseline, whereas remission implies that residual sonographic activity has fallen below a validated threshold associated with favorable outcomes. [8,18]

Ultrasound Remission: An Emerging Concept

Ultrasound remission can be understood as a standardized state in which predefined sonographic markers of active inflammation have normalized or fallen below validated cutoffs. It is related to, but not necessarily identical with, transmural healing. The latter often implies complete normalization of bowel-wall thickness with absent Doppler signal and restoration of other mural or extramural features. Ultrasound remission may ultimately prove more pragmatic if composite score thresholds can identify



patients with low risk of relapse even when minor residual structural abnormalities persist. The distinction is clinically useful because chronic bowel-wall remodeling may prevent anatomical normalization despite effective inflammatory control. [8,15]

Evidence available through 2024 supports the prognostic relevance of early ultrasound remission in Crohn disease. Prospective data have shown that early normalization of ultrasound parameters after biologic induction predicts later endoscopic remission, while baseline and post-induction sonographic findings can predict long-term transmural and mucosal healing. These findings strengthen the rationale for ultrasound as an intermediate objective target, but they also underline the need for validated, treatment-agnostic thresholds before a universal remission definition can be adopted. [49,50]

Ulcerative Colitis and the Question of “Transmural” Healing

Applying the term transmural healing to ulcerative colitis requires precision. The disease is not defined by transmural inflammation, and the principal therapeutic targets remain clinical, endoscopic, and increasingly histological. Yet bowel-wall thickness, submucosal expansion, Doppler hyperemia, and loss of stratification reflect inflammatory burden and respond to treatment. A normal ultrasound in ulcerative colitis may therefore be better described as sonographic or ultrasound remission rather than transmural healing. This terminology avoids importing Crohn disease biology into a different disease while preserving the value of objective wall assessment. [12,21]

The rectum remains a special challenge. Because rectal disease is central to ulcerative colitis symptoms and classification, a normal transabdominal examination cannot guarantee complete distal healing. Transperineal and rectal endoscopic ultrasound can improve distal visualization, while fecal calprotectin and sigmoidoscopy remain important complementary tools. Future ultrasound remission definitions in ulcerative colitis should therefore specify whether the rectum was adequately assessed and whether the endpoint is segmental or whole-colon. [35,37]

Comparison With Magnetic Resonance Enterography

Magnetic resonance enterography provides broad small-bowel coverage, excellent assessment of penetrating complications, and established activity indices. It is particularly valuable when disease is proximal, deep pelvic, multifocal, or anatomically complex. Intestinal ultrasound offers different advantages: bedside availability, absence of contrast in most examinations, dynamic assessment of peristalsis and compressibility, and easy repetition. Comparative studies show good agreement for many inflammatory findings, although performance depends on disease location and operator expertise. The modalities should therefore be viewed as complementary rather than mutually exclusive. [5,46]

A practical monitoring pathway can use ultrasound for frequent interval assessment and reserve magnetic resonance enterography for incomplete visualization, complex stricturing or penetrating disease, preoperative mapping, or unexplained discordance. This approach reduces repeated radiation exposure from computed tomography and may improve patient acceptance of objective monitoring. The ability to perform ultrasound during the clinic visit also shortens the feedback loop between assessment and treatment decision, a logistical advantage that is difficult to quantify but important in treat-to-target care. [7,19]

Clinical Integration: A Proposed Monitoring Framework

At baseline, ultrasound should document disease location, maximum bowel-wall thickness, Doppler signal, wall stratification, mesenteric inflammatory fat, strictures, fistulas, and collections where applicable. The report should identify segments not adequately visualized. During induction, repeat examination can quantify early change in the most affected segment and reassess complications. In maintenance, normalization or stable low activity can support continued therapy, while new thickening, vascularity, or complications should prompt biomarker assessment and consideration of endoscopy or magnetic resonance imaging. This framework uses ultrasound as an extension of clinical reasoning rather than as an isolated numeric test. [8,10]

For ulcerative colitis, a similar strategy can focus on segmental colonic bowel-wall thickness and Doppler activity, using a validated score where expertise permits. Persistent rectal symptoms despite normal



transabdominal findings require targeted distal assessment. For Crohn disease, the deepest remission state should incorporate both luminal and transmural information, especially in patients with previous penetrating or stricturing disease. Importantly, treatment escalation should not be based on a minor sonographic abnormality without considering symptoms, biomarkers, prior anatomy, drug exposure, and the risk-benefit profile of further therapy. [1,22]

Limitations and Sources of Heterogeneity

Ultrasound is operator dependent, and interobserver variability can arise from segment identification, caliper placement, compression, Doppler settings, and interpretation of mesenteric features. Obesity, bowel gas, postoperative anatomy, deep pelvic loops, and proximal small-bowel disease can limit visualization. Equipment differences also matter, particularly for Doppler sensitivity. Training frameworks and validated scoring systems reduce these problems but do not eliminate them. A remission threshold derived in an expert center cannot automatically be transferred to every machine, operator, and patient population. [9,15]

Definitions remain another source of heterogeneity. Studies have used different bowel-wall thickness cutoffs, combinations of Doppler and stratification, segment-level versus patient-level endpoints, and different reference standards. Some define transmural healing using ultrasound alone, while others require concordant magnetic resonance or endoscopic healing. Timing also varies from early induction to one year or longer. These inconsistencies complicate meta-analysis and explain why ultrasound remission has not yet replaced established STRIDE targets. Harmonized definitions should distinguish response, remission, and complete transmural healing and should be validated against outcomes rather than only against a concurrent endoscopy. [8,20]

Location-Specific Performance and the Importance of Segmental Interpretation

The performance of intestinal ultrasound is not uniform across the gastrointestinal tract, and remission should therefore be interpreted segment by segment. The terminal ileum and left colon are usually well suited to high-frequency transabdominal assessment, whereas deep pelvic small-bowel loops, the proximal jejunum, and the rectum may be incompletely visualized. Colonic haustration, luminal contents, and variable distension also influence measurements. A patient-level label of ultrasound remission is therefore most defensible when all previously involved and technically accessible segments are reassessed, with explicit documentation of any area that could not be evaluated. This principle is especially important in Crohn disease, where discontinuous inflammation allows a normal accessible segment to coexist with active disease elsewhere. In ulcerative colitis, continuous disease makes segmental trends easier to interpret, but the rectal blind spot can still lead to underestimation of residual activity. Standardized reporting should identify the worst segment, the distribution of abnormality, and whether the current examination adequately covered the disease territory documented at baseline. [5,8]

Disease location also influences the relationship between ultrasound and biomarkers. Fecal calprotectin generally performs best in colonic inflammation and may be less sensitive for limited ileal Crohn disease, while ultrasound directly visualizes ileal wall abnormalities and can therefore add clinically useful information when stool biomarkers are equivocal. Conversely, subtle mucosal inflammation in ulcerative proctitis may raise fecal calprotectin despite technically normal transabdominal imaging. These complementary strengths argue against a single universal noninvasive test. A rational monitoring pathway uses the modality most sensitive to the patient's known disease phenotype and escalates to endoscopy or magnetic resonance imaging when the anatomical coverage or biological signal is incomplete. [30,42]

Strictures, Fibrosis, and the Limits of “Healing” Terminology

A major challenge in Crohn disease is distinguishing persistent inflammatory activity from fixed structural damage. Bowel-wall thickening can result from edema and cellular infiltration, but chronic disease also produces smooth-muscle hypertrophy, collagen deposition, and fibrosis. A thick segment that becomes less vascular after treatment may represent successful inflammatory control without complete anatomical normalization. Strict definitions of transmural healing that require bowel-wall thickness below a fixed cutoff could therefore misclassify some patients with biologically inactive but remodeled bowel. This



issue is clinically relevant because inflammatory strictures may respond to medical therapy, whereas predominantly fibrotic strictures often require endoscopic or surgical intervention. Ultrasound can suggest the phenotype through vascularity, stratification, luminal narrowing, prestenotic dilation, and dynamic compressibility, yet conventional B-mode and Doppler cannot quantify fibrosis with sufficient precision in every case. Elastography and contrast-enhanced approaches are promising, but they remain adjunctive rather than definitive. [31,32]

For this reason, the term ultrasound remission may be more clinically flexible than complete transmural healing in selected patients. Ultrasound remission could permit minor residual structural changes provided that markers of active inflammation have normalized and the patient remains free of progressive complications. Such a definition would need prospective validation against hard outcomes and should not be used to overlook a clinically significant stricture. The broader lesson is that remission terminology should separate inflammatory activity from accumulated bowel damage. A treatment can suppress active inflammation successfully without reversing every chronic structural consequence of years of disease, and imaging endpoints should reflect that biological reality. [8,47]

Postoperative Crohn Disease and Ultrasound Surveillance

Postoperative Crohn disease provides another setting in which repeated cross-sectional assessment is attractive. Endoscopic recurrence in the neoterminal ileum often precedes symptoms, and ileocolonoscopy remains the reference approach for formal postoperative scoring. Ultrasound can, however, demonstrate recurrent mural thickening, hypervascularity, and associated mesenteric changes without exposing patients to repeated invasive procedures. Meta-analytic evidence supports good diagnostic performance of ultrasonography for postsurgical recurrence, particularly when anastomotic and neoterminal ileal segments are accessible. Its practical role is therefore as a surveillance and triage tool that may identify patients requiring earlier endoscopy or treatment optimization. [7,19]

A postoperative definition of ultrasound remission should be evaluated separately from remission in nonsurgical bowel because anatomy, wall thickness, adhesions, and anastomotic configuration differ after resection. Standardization is especially important if ultrasound is to reduce the frequency of routine invasive reassessment. Future studies should determine how well postoperative sonographic normalization predicts a low Rutgeerts score, whether serial change can identify recurrence before symptoms or biomarker elevation, and whether ultrasound-guided treatment adjustment improves long-term bowel preservation. [5,10]

Patient-Centered Monitoring and Implementation in Routine Care

The clinical value of intestinal ultrasound extends beyond diagnostic accuracy. Patients with inflammatory bowel disease frequently undergo repeated investigations over decades, and the cumulative burden of bowel preparation, sedation, travel, time away from work, and anxiety can reduce adherence to objective monitoring. A bedside examination that can be performed during a clinic visit allows the clinician to connect symptoms, examination findings, laboratory data, and imaging in real time. The immediate visual feedback can also improve shared decision-making by showing patients whether bowel-wall inflammation is improving or persisting. These advantages are difficult to capture in sensitivity and specificity statistics but are central to the feasibility of a true treat-to-target program. [7,9]

Implementation nevertheless requires investment. Training pathways must ensure competence in segment identification, measurements, Doppler optimization, recognition of complications, and documentation. Services also need governance regarding image storage, reporting standards, quality assurance, and pathways for confirmatory testing when findings are uncertain. Ultrasound should not become a shortcut that substitutes an inexperienced scan for indicated endoscopy or magnetic resonance imaging. Its strongest role is as a high-frequency objective monitoring layer embedded within a multimodal strategy, allowing invasive or resource-intensive procedures to be targeted to the patients and time points where they are most informative. [9,15]

Interpreting Discordant Remission Signals

Discordance between symptoms, biomarkers, endoscopy, histology, and ultrasound should be expected



rather than treated as a technical failure. Each tool samples a different biological compartment and has a different time course of normalization. Symptoms may improve rapidly while the bowel wall remains thickened; fecal calprotectin may normalize before chronic mural remodeling resolves; endoscopic healing may coexist with microscopic neutrophilic activity; and ultrasound may remain abnormal because of fibrosis after active inflammation has subsided. A structured approach first asks whether the abnormal signal is technically reliable, then whether it reflects active inflammation, structural damage, or a noninflammatory symptom mechanism. Escalation of therapy should follow that interpretation rather than the pursuit of numerical normality in isolation. [1,29]

This principle is especially relevant as ultrasound remission enters the literature. A new target is clinically useful only if it changes decisions in a way that improves patient outcomes. The goal should therefore be concordant biological control at the lowest reasonable monitoring burden, not maximal testing. When ultrasound, biomarkers, and symptoms all indicate remission, confidence in disease control increases. When one domain remains abnormal, the pattern should determine the next test: persistent sonographic hyperemia may justify endoscopy or magnetic resonance imaging, isolated symptoms may prompt evaluation for functional disease, and isolated histological activity in ulcerative colitis may influence the intensity of follow-up. Multidimensional interpretation is ultimately more faithful to IBD biology than any single binary remission label. [28,48]

Future Directions

The next phase of research should prioritize outcome-linked thresholds. Studies should test whether an ultrasound remission state independently predicts relapse, hospitalization, surgery, treatment escalation, and bowel damage after accounting for endoscopic and biomarker status. Randomized strategy trials are also needed to determine whether escalating treatment to achieve ultrasound remission improves outcomes compared with established treat-to-target care. Without such evidence, ultrasound remission is best regarded as a powerful measure of remission depth rather than a mandatory universal endpoint. [47,50]

Technical innovation may improve reproducibility. Automated bowel-wall segmentation, quantitative Doppler analysis, shear-wave elastography, contrast-enhanced ultrasound, and artificial intelligence could reduce operator dependence and better distinguish inflammation from fibrosis. Standardized data acquisition will be essential before machine-learning approaches can generalize across centers. Rectal and endoscopic ultrasound also deserve renewed study in distal ulcerative colitis because high-resolution mural imaging may reveal a clinically relevant compartment that is poorly represented by transabdominal ultrasound. [31,35]

Conclusion

The meaning of remission in inflammatory bowel disease is becoming progressively deeper. Symptoms remain central to patient well-being, endoscopy remains indispensable for mucosal assessment, histology identifies residual microscopic activity, and bowel-wall imaging reveals a compartment that neither symptoms nor luminal inspection can fully characterize. Intestinal ultrasound is particularly suited to repeated treat-to-target monitoring because it is noninvasive, radiation-free, responsive, and capable of demonstrating mural and extramural disease. In Crohn disease, transmural and sonographic healing are associated with favorable outcomes; in ulcerative colitis, ultrasound provides a reproducible objective measure of mural inflammatory activity and treatment response. Ultrasound remission is therefore a compelling emerging concept, but its clinical adoption should proceed with precise terminology, standardized acquisition, validated thresholds, and outcome-based evidence. It should complement, not prematurely replace, established endoscopic, histological, and biomarker targets.

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