Crohn's & Colitis 360, 2023, **5**, 1–8
https://doi.org/10.1093/crocol/otad027
Advance access publication 15 May 2023
Observations and Research

Utility of Intestinal Ultrasound in Clinical Decision-Making for Inflammatory Bowel Disease

Adam Saleh, BS,*[,] and Bincy P. Abraham, MD, MS†

From the
*Engineering Medicine, Texas A&M Health Science Center, Houston, Texas, USA
†Division of Gastroenterology and Hepatology, Department of Medicine, Lynda K and David M Underwood Center for Digestive Disorders, Houston Methodist Hospital, Houston, Texas, USA

Address correspondence to: Adam Saleh, BS, Engineering Medicine, Texas A&M Health Science Center, 1020 Holcombe Boulevard, Houston, TX 77030, USA (adamsaleh@tamu.edu).

Background: There is a clinical need to improve the monitoring of inflammatory bowel disease (IBD) activity. Despite being used regularly in European countries, intestinal ultrasound (IUS) has been implemented less in the United States for unclear reasons.

Aims: The aim of this study is to illustrate how IUS can be used as a clinical decision-making tool in an American IBD cohort.

Methods: This retrospective cohort analysis evaluated patients with IBD seen at our institution who underwent IUS as part of routine evaluation of their IBD from July 2020 to March 2022. To evaluate the clinical utility of IUS for different patient populations and against more frequently used measures of inflammation, we compared patient demographics, inflammatory markers, clinical scores, and medications between patients in remission and those with active inflammation. Treatment plans between the 2 groups were compared and we analyzed patients with follow-up IUS visits to validate treatment plan decisions at initial evaluation.

Results: Out of 148 total patients with IUS, we found that 62.1% ($N = 92$) of our patients had active disease and 37.9% ($N = 56$) were in remission. Ulcerative colitis activity index and Mayo scores were both significantly correlated with IUS findings. The treatment plan was significantly correlated with IUS findings ($P = .004$). At follow-up, we observed an overall decrease in intestinal thickening, improvements in vascular flow, and mural stratification.

Conclusions: Clinical decisions incorporating IUS findings effectively reduced inflammation in our IBD patients. IUS should be strongly considered by IBD clinicians in the United States for monitoring disease activity in IBD.

Lay Summary

Intestinal ultrasound for the management of inflammatory bowel disease has limited implementation in the United States. We demonstrate how intestinal ultrasound can be used to inform clinical decisions as a real-time evaluation of disease activity in our American population.

Key Words: intestinal ultrasound, inflammatory bowel disease, point-of-care

Introduction

For patients with inflammatory bowel disease (IBD), the effectiveness of medical therapy is typically evaluated via clinical assessment in combination with inflammatory biomarkers. However, reported symptoms often do not represent the level of mucosal inflammation, and biomarkers are correlative, at best, to disease activity.[1] As such, there is a clinical need to improve the monitoring of IBD activity.

Intestinal ultrasound (IUS) has been used increasingly in the management of IBD. Despite being used regularly in European countries such as Italy and Germany, it has been implemented less in the United States for reasons that remain unclear. However, the convenience of point-of-care testing at office visits, the ability to detect disease without sedation and bowel prep, the lack of radiation exposure, and the noninvasiveness of the procedure have prompted a growing interest in its use.[2,3]

Endoscopic evaluation provides the most accurate information on the morphology of the intestinal mucosa but cannot evaluate the morphology of all layers of the intestinal wall. Tissues and organs surrounding the intestines can be evaluated by cross-sectional imaging techniques such as magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound, each of which has its own benefits. Ultrasound is advantageous because it is noninvasive, less expensive than other imaging modalities such as CT and MRI, and allows real-time imaging without the use of ionizing radiation. Additionally, results from the METRIC trial and the development of the International Bowel Ultrasound Segmental Activity Score demonstrate that there is similar operator dependency with IUS.[4,5] Unlike colonoscopy, which assesses only the mucosal layer, ultrasound can evaluate submucosa and muscularis, as well as surrounding areas, to assess disease activity (Figure 1). Pathologic processes can be seen with ultrasound via measurement of wall thickness, which has been the most validated assessment of inflammation, along with adjunct evaluation of mural stratification, Doppler flow, surrounding mesenteric fat, free fluid, and lymph nodes (Figure 2). In stricturing disease, dilation of the proximal lumen may be seen, and in more complicated Crohn's disease (CD), conglomerations of loops, adjacent fistulas, and

Received for publication: January 24, 2023. Editorial Decision: April 24, 2023

abscesses can also be visualized. Doppler ultrasound can be used to examine intramural blood flow and to help differentiate active inflammation from fibrotic mucosa (Figure 3), though contrast-enhanced ultrasound can further distinguish fibrosis from active inflammation.[6]

Although studies have established a correlation between ultrasound and other modalities for identifying inflammation, few studies have evaluated the use of IUS for making clinical management decisions in patients with IBD.

This study aims to provide a descriptive analysis of the utility of IUS in clinical decision-making in a retrospective cohort of patients with IBD seen in a tertiary IBD center in the United States.

Materials and Methods

This study was approved by the institutional review board at our institution. This retrospective analysis evaluated

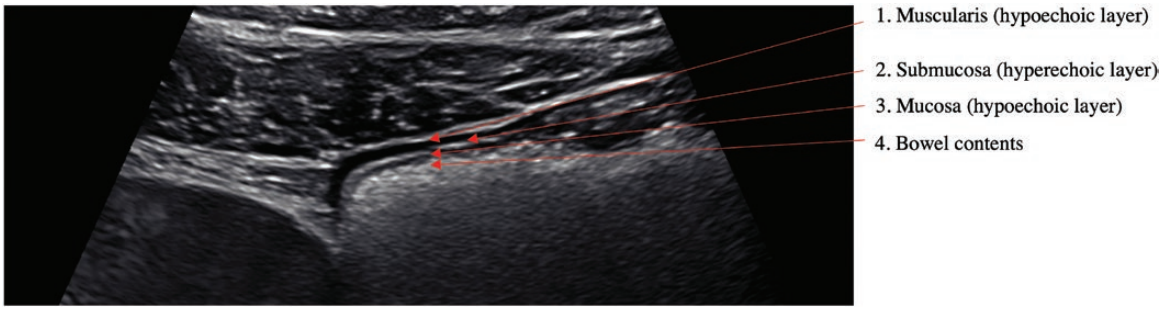

Figure 1. Intestinal ultrasound images demonstrating mural stratification obtained from patients with inflammatory bowel disease using the Canon i700 machine. The image is from the sigmoid colon of Crohn's disease patient in remission. The arrows point to the beginning of each layer moving in an external to internal direction.

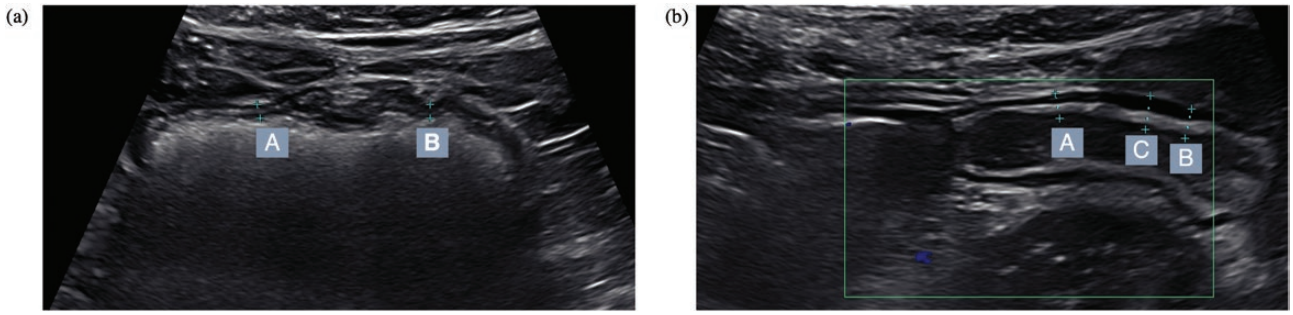

Figure 2. Intestinal ultrasound images comparing patients with inflammatory bowel disease using the Canon i700 machine. (A) Normal sigmoid colon from Crohn's disease patient in remission with mucosal measurements denoted at points along the sigmoid colon with line A measuring 0.2 cm and B measuring 0.3 cm. (B) Inflamed sigmoid in a Crohn's patient with mucosal measurements A, B, and C measuring 0.25 cm, 0.3 cm, and 0.34 cm, respectively. Mural stratification is intact.

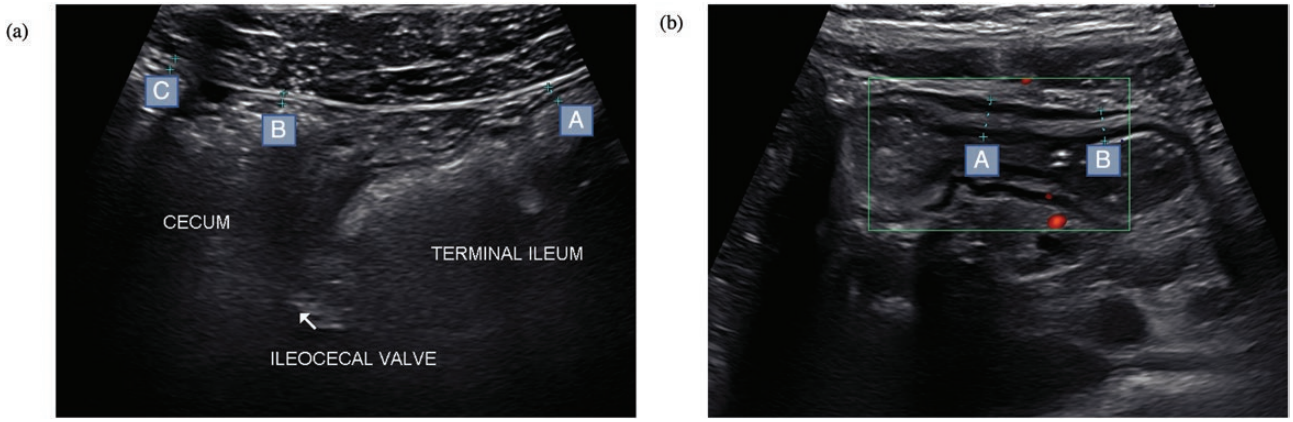

Figure 3. Intestinal ultrasound images demonstrating the use of Doppler ultrasound and other adjunct measures of inflammation using the Canon i700 machine. (A) Normal terminal ileum, cecum, and ileocecal valve from Crohn's disease patient in remission. Points A, B, and C measure the bowel wall thickness at 0.23 cm, 0.13 cm, and 0.16 cm, respectively. (B) Inflamed terminal ileum in a Crohn's disease patient in an active flare. Points A and B measure at 0.53 cm and 0.43 cm, respectively. There is mural stratification is minimally disrupted and a Limberg score of 1 can be seen by the active blood flow in the area.

patients with IBD seen at our institution who underwent IUS as part of routine evaluation of their IBD from July 2020 to March 2022. All ultrasound exams utilized the Canon i700 machine. IUS was performed by a single ultrasonographer, an IBD-specialized gastroenterologist that has been certified and trained by the international bowel ultrasound group. The quality of the examination was assessed by the ultrasonographer. Only studies with adequate quality were included in the analysis. This was defined as clear images after optimization of focus, depth, and the use of an appropriate ultrasound probe.

The patients were segmented into 2 groups based on IUS findings: those in remission and those with active inflammation. Intestinal thickening was defined as a wall thickness of ≥3 mm. Additional parameters of inflammation such as the presence of mesenteric fat, Doppler flow (Limberg score ≥ 1), presence of lymph nodes, and disrupted mural stratification were identified on IUS as well. A positive IUS finding included, at minimum, an increase in bowel wall thickness. If this was found, additional parameters such as Limberg score, presence of mesenteric fat, assessment of mural stratification, lymph nodes/free fluid assessment, abnormalities in haustrations, and motility were noted.

The clinical decision was made immediately following the results of the IUS in conjunction with the patient's lab results and symptoms, and a discussion with the patient. The various clinical decisions made were subcategorized into maintenance of therapy, change in therapy, or de-escalation of therapy. No change in IBD-specific medication following IUS was defined as maintaining therapy. De-escalation of therapy was defined as reducing the dosage, increasing the interval between biologic treatments, or the discontinuing of their IBD-specific medication. A change in therapy was defined as switching drug classes, increasing dosage, decreasing the interval between biologic treatments, or adding an additional IBD-specific drug.

To evaluate the clinical utility of IUS for different patient populations and against more frequently used measures of inflammation, we compared patient demographics, inflammatory markers, clinical scores, and medications between patients in remission and those with active inflammation. Any laboratory values were only included if collected within 1 month of IUS being performed. To evaluate the impact of IUS findings on clinical decision-making, we compared treatment plans between the 2 groups.

To evaluate the efficacy of adjunct measures of inflammation, the sensitivity and specificity of a combined clinical and biomarker remission were compared to IUS findings. Clinical remission was defined as ulcerative colitis activity index (UCAI) ≤ 5 and partial Mayo ≤ 2 or Harvey–Bradshaw index (HBI) ≤ 5. Biomarker remission was defined as erythrocyte sedimentation rate (ESR) ≤ 40 mm/h; C-reactive protein (CRP) ≤ 8 mg/L; fecal calprotectin ≤ 125 μg/mg; and fecal lactoferrin ≤ 30 μg/mL. Combined remission was defined as both clinical and biomarker remission. Additionally, in patients with positive IUS findings, the CRP, ESR, Mayo, UCAI, and HBI scores were compared between the different treatment plans to elucidate adjunct considerations when selecting a treatment plan.

Additionally, a subset of our patient population underwent reevaluation with IUS at a later follow-up date. To validate treatment plan efficacy at the initial IUS evaluation, we compared the changes in ultrasound findings between visits.

Statistical Methodology

Comparisons were made by using an independent *t*-test for continuous variables or χ^2 analysis for categorical to identify statistical significance, as defined by a *P*-value < .05. A Bonferroni correction was applied to groups of statistical comparisons. Patient characteristics and demographics, disease characteristics and treatment, inflammatory markers, and clinical scores were treated as separate families for Bonferroni correction.

Results

Patient and Disease Characteristics

Patient and disease characteristics are outlined in Table 1. We identified 148 patients seen for IBD and evaluated by IUS at our center. Within this population, the median age was 41 years, and the range was 18–81. The mean duration of disease was 11.5 years, with a median duration of 8 years and a range of 0–43 years. Among these patients, 108 (73%) had CD, 39 (26.3%) had ulcerative colitis (UC), and 1 (0.7%) had IBD-undetermined (IBD-U). The 1 patient with IBD-U was excluded from only the analysis of disease subtype's relationship with disease activity to allow for a statistical comparison between CD and UC.

No differences in body mass index (BMI) were noted between patients with active disease and those in remission (mean BMI 25.78 vs 25.48, respectively; *P* = .74). Additionally, 44% of our patients presented with a BMI greater than 25 (overweight or obese). When broken down by subgroup, 32% of obese patients (BMI ≥ 30), 33% of overweight patients (BMI from 25 to 30), 40% of patients with normal BMI (BMI from 18.5 to 25), and 33% of underweight patients (BMI ≤ 18.5) had positive IUS findings. This distribution was not statistically significant, per χ^2 analysis.

A majority of our patients were Caucasian (*N* = 111, 75%); 69 (62%) of whom had positive IUS findings. Ten patients (6.8%) were Hispanic; all 10 (100%) had positive IUS findings. Fourteen patients (9.5%) were Black; 6 (42%) of them had positive IUS findings. Finally, 13 patients (8.7%) were Asian; 7 (53%) of whom had positive IUS findings. Per χ^2 analysis we had a *P*-value of .034 which was not considered significant after Bonferroni correction was applied with a modified α-value of .008.

Medications

The majority of our patients (*N* = 113, 94.1%) were on biologic or small molecule therapy, and only 7 (5.8%) were on mesalamine for treatment of their IBD. There was not a statistically significant difference in IUS findings between biologics, small molecules, or mesalamine per χ^2 analysis (Table 1).

Disease Activity

On IUS, we found that 62.1% (*N* = 92) of our patients had active disease and 37.9% (*N* = 56) were in remission (Table 1).

No differences in ESR were found between those in remission and those with active disease found on IUS. CRP trended toward higher levels in the active disease subgroup, but this trend was not statistically significant (Table 1).

Table 1. Patient and disease characteristics and inflammatory metrics by IUS findings of disease activity.

	In remission ($N = 56$)	Active disease ($N = 92$)	Total N	P-value
Mean age, years	39.99 ($N = 56$)	40.94 ($N = 92$)	148	.711
Sex				
Male	15	34	148	.202
Female	41	58		
Race and ethnicity				
Caucasian	42	69	148	.034
Hispanic	0	10		
Black	8	6		
Asian	6	7		
BMI (kg/m^2)	25.478 ($N = 53$)	25.78 ($N = 91$)	144	.739
Underweight (<18.5)	2	4	144	.771
Normal (18.5–25)	30	44		
Overweight (25–30)	12	24		
Obese (>30)	9	19		
Medication use				
Infliximab	8	10	120	
Adalimumab	9	11		
Certolizumab	2	4		
Vedolizumab	8	13		.605
Ustekinumab	12	28		
Tofacitinib	3	4		
Golimumab	1	0		
Mesalamine	3	4		
Disease subtype				
Crohn's disease	42	66	147	.742
Ulcerative colitis	14	25		
Disease duration (years)	10.24 ($N = 56$)	12.32 ($N = 92$)	148	.253
Inflammatory markers				
ESR (mm/h) (mean, SD)	13.02 (15.1) ($N = 43$)	13.28 (15.2) ($N = 72$)	115	.931
CRP (mg/L) (mean, SD)	4.87 (13.5) ($N = 43$)	7.43 (9.2) ($N = 74$)	117	.221
Fecal calprotectin (µg/mg)	239.5 ($N = 2$)	1156.8 ($N = 5$)	7	.273
Fecal lactoferrin (µg/mL)	72.45 ($N = 14$)	217.6 ($N = 18$)	32	.103
Clinical scores				
Mayo score	1.54 ($N = 14$)	5.34 ($N = 25$)	39	**.002**
UCAI	1.13 ($N = 14$)	4.42 ($N = 25$)	39	**.014**
HBI score	2.95 ($N = 41$)	3.67 ($N = 67$)	108	.369

Abbreviations: BMI, body mass index; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; HBI, Harvey–Bradshaw index; IUS, intestinal ultrasound; SD, standard deviation; UCAI, ulcerative colitis activity index. Bold values indicate statistical significance defined by $P < .05$.

UC clinical scores (UCAI and Mayo) were both significantly correlated with IUS findings, even after Bonferroni correction (modified α-value of .016). The average Mayo clinical score for patients with positive IUS findings was 5.24, compared to 2.14 for patients with negative IUS ($P = .002$). The average UCAI clinical score for patients with positive IUS findings was 4.42, compared to 1.13 for patients with negative IUS findings ($P = .014$). HBI score in patients with CD was not significantly correlated with IUS findings.

There were 125 patients with both biomarker and clinical data. Fifty-four of these patients met criteria for a combined remission, of which only 46% (25/54) had a normal IUS while 54% (29/54) had positive IUS findings. Of the other 71 patients in a combined flare, 32% (23/71) had a normal IUS while 68% (48/71) had positive IUS findings. Combined remission sensitivity to disease activity based on IUS was 62% and specificity was 52% (Figure 4).

Treatment Plan

Treatment plans were analyzed for all patient ultrasounds obtained for a total of 184. This number includes the repeat IUS obtained on the same patient. For patients found to have active inflammation on IUS ($N = 127$), 37 (29%) escalated therapy for their IBD, 15 (13.3%) required a change in drug mechanism, and 71 (56%) continued maintenance therapy.

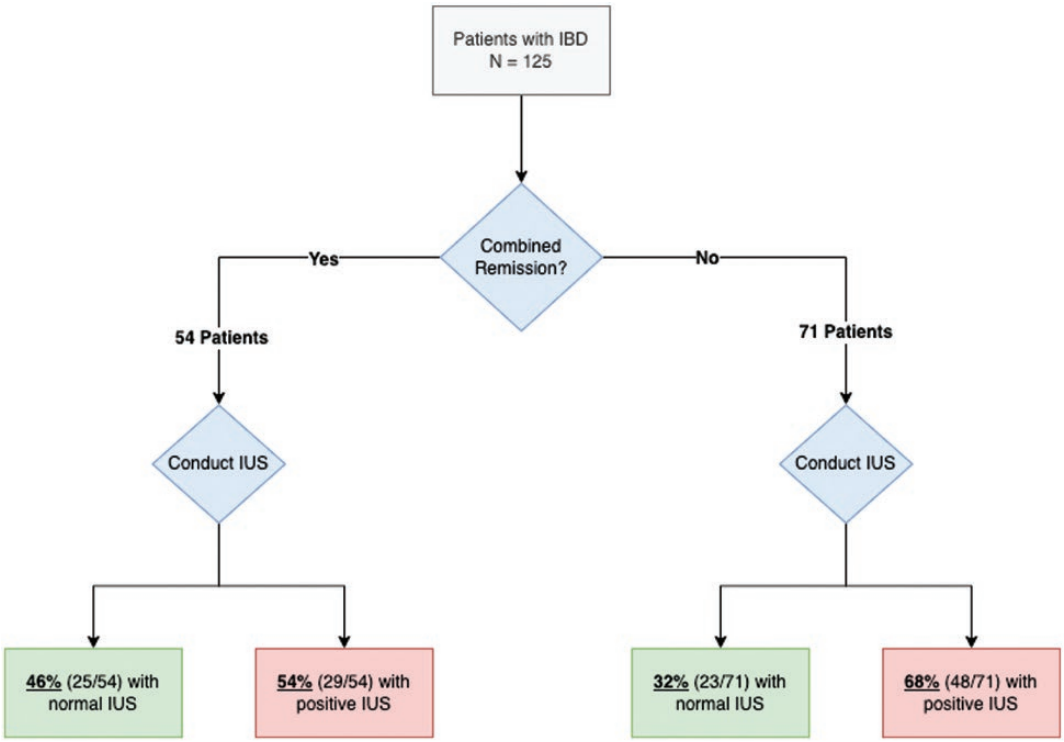

Figure 4. IUS results for patients with both biomarker and clinical score data (N = 125) found to be in a combined remission defined as both a clinical remission (UCAI ≤ 5 and partial Mayo ≤ 2 or HBI ≤ 5) and biomarker remission (ESR ≤ 40 mm/h and CRP ≤ 10 mg/L and fecal calprotectin ≤ 50 μg/mg and fecal lactoferrin ≤ 30 μg/mL). CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; HBI, Harvey–Bradshaw index; IUS, intestinal ultrasound; UCAI, ulcerative colitis activity index.

For patients in remission (N = 57), the majority (N = 46, 80.7%) continued maintenance therapy for their IBD, and 5.2% (N = 3) de-escalated therapy. The remaining 14% (N = 8) of patients required a change in therapy.

The treatment plan choice was significantly correlated with IUS findings (P = .002), per χ^2 analysis, as significantly more patients with positive than negative IUS findings escalated or changed their drug's mechanism of action (41% vs 14%, respectively). This was especially true when patients were further stratified by bowel wall thickness. About 75.8% of patients with bowel wall thickness ≤ 3 mm maintained therapy, 69.2% of patients with bowel wall thickness between 3 and 5 mm maintained therapy while only 49.4% of patients with bowel wall thickness ≥ 5 mm maintained therapy. About 18.8% of patients with bowel wall thickness ≤ 3 mm underwent a change in therapy, 28.2% of patients between 3 and 5 mm changed therapy, while 46.8% of patients with bowel wall thickness ≥ 5 mm changed therapy. χ^2 analysis in this subgroup was significant with P = .002 (Figure 5A).

Patients were further stratified according to Limberg scoring with Limberg score of 0 being 1 group, Limberg score = 1 being another, and Limberg score ≥2 being another. About 70.1% of patients with Limberg = 0 maintained therapy while 42.3% of patients with Limberg = 1 maintained and 35.7% of patients with Limberg ≥ 2 maintained. About 25.9% of patients with Limberg = 0 underwent a change in therapy while 57.7% of Limberg = 1 changed therapy and 57.1% of patients with Limberg ≥ 2 changed therapy. The treatment plans were compared between the 3 groups using χ^2 analysis with P = .001. Separate χ^2 analysis between Limberg = 1 and Limberg ≥ 2 was not significant (Figure 5B).

In patients with a positive IUS finding, there were 2 with decisions to de-escalate, 36 with the decision to change their current plan (through change in drug mechanism or drug dose escalation), and 36 with the decision to maintain the current plan. Due to the limited number of patients with the decision to de-escalate, this group was not compared with statistical tests to the other treatment groups. The results are outlined in Table 2. The difference in ESR, CRP, Mayo, and UCAI was not statistically significant between patients with the decision to change plan or continue plan. HBI scores were found to be statistically significant (P = .004) with patients with a change in plan having an average value of 5.32 (N = 28) and patients with the decision to continue their current plan having a value of 2.33.

IUS Follow-up

There was a total of 39 repeat ultrasounds with 34 of the 39 repeat IUS being conducted on a patient with active disease noted on initial IUS. The average amount of time between initial IUS and follow-up IUS was 213 days. Specifically, for patients that continued with current therapy, the mean was 186 days while those that changed therapy had a mean follow-up time of 238 days. Inflammation was improved at repeat IUS, measured by a decrease in overall bowel wall thickness in 77% (30/39) patients for a mean of 0.121 cm reduction of thickness. Vascular flow improved in 79% (15/19) of patients with abnormal Doppler at initial IUS, and mural stratification improved in 80% (20/25) of patients with mural

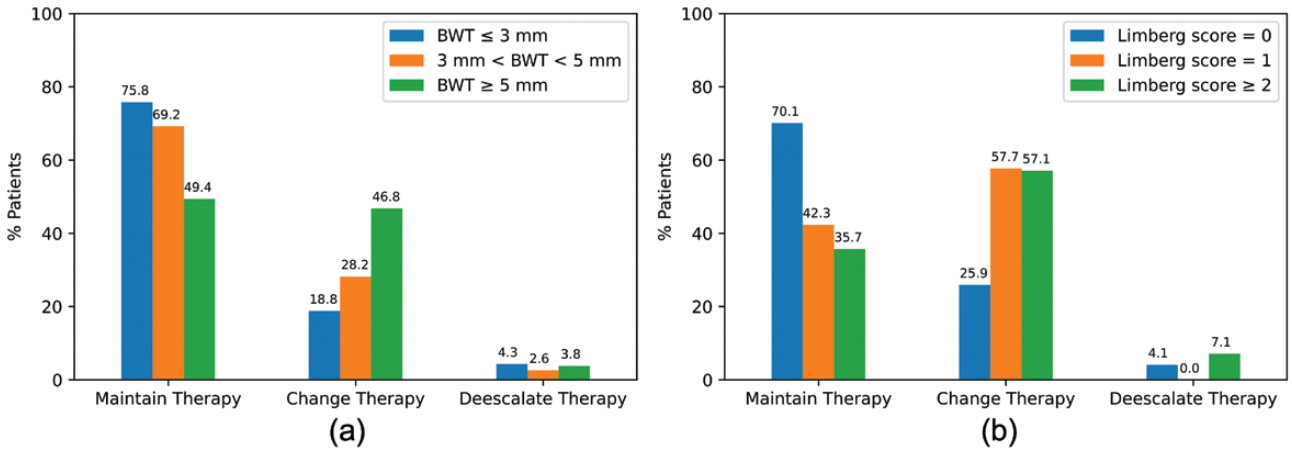

Figure 5. Clinical decisions made based on intestinal ultrasound findings. Bar graphs compare percentage of patients who maintained, changed, or de-escalated therapy. (A) Patients were stratified according to bowel wall thickness (BWT) with the 3 categories of BWT ≥ 5 mm (green), 3 mm < BWT < 5 mm (orange), and BWT ≤ 3 mm (blue). The treatment plans were compared between the 3 groups using χ^2 analysis with $P = .002$. (B) Patients stratified according to Limberg scoring with Limberg score of 0 being 1 group, Limberg score = 1 being another, and Limberg score ≥ 2 being another. The treatment plans were compared between the 3 groups using χ^2 analysis with $P = .001$. Separate χ^2 analysis between Limberg = 1 and Limberg ≥ 2 was not significant.

Table 2. In patients with a positive IUS, the differences in inflammatory markers and clinical scores between selected treatment plans are compared.

	Change in plan	Continue plan	De-escalate therapy	*P*-value
Inflammatory markers				
ESR (mm/h)	15.74 (*N* = 34)	10.58 (*N* = 36)	20 (*N* = 2)	.15
CRP (mg/L)	7.07 (*N* = 36)	6.77 (*N* = 36)	25.6 (*N* = 2)	.87
Clinical scores				
Mayo	5.77 (*N* = 13)	4.27 (*N* = 11)	11 (*N* = 1)	.31
UCAI	5.17 (*N* = 12)	2.57 (*N* = 7)	10 (*N* = 1)	.1
HBI	5.32 (*N* = 28)	2.33 (*N* = 33)	0 (*N* = 1)	**.004**

Abbreviations: CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; HBI, Harvey–Bradshaw index; IUS, intestinal ultrasound; UCAI = ulcerative colitis activity index. Bold values indicate statistical significance defined as $P < .05$.

disruption at initial IUS. We observed no statistically significant difference in change in intestinal thickness based on treatment plan.

A subanalysis on the repeat IUS for patients with active disease on original IUS (*N* = 34) showed similar results with an overall mean reduction in bowel wall thickness of 0.181 cm. For patients with active disease on initial IUS with plans to continue current therapy, the mean reduction in bowel wall thickness was 0.135 cm (*N* = 16) while patients that changed therapy had a mean reduction of 0.225 cm (*N* = 18) (*P* = .37). Eleven out of 16 (68.8%) patients in the continue therapy group had a reduction in bowel wall thickness while 14 out of 18 (77.8%) of patients in the change therapy group saw improvements in bowel wall thickness. Further analysis showed that out of the 16 patients with the decision to maintain therapy after IUS identified active disease, the mean change in HBI (*N* = 11) was −0.54 (range −5 to 4), mean change in partial Mayo score (*N* = 4) was −1.5 (range −4 to 0), and the mean change in UCAI (*N* = 4) was −1 (range −4 to 2). There was 1 CD patient without clinical scores recorded at the follow-up IUS. Inflammatory markers in this same patient group showed similar results. ESR (*N* = 5) had a mean decrease by −0.2 mm/h (range −9 to 7) and CRP (*N* = 3) had a mean decrease by −2.1 mg/L (range −6.9 to 1.2).

Discussion

In this study based in the United States, IUS was useful for informing clinical management decisions in patients with IBD with active inflammation. IUS findings were used to inform clinical decisions such as increasing dose, changing drugs, maintaining therapy, or de-escalating therapy. It should be noted that the patients seen for IBD at this center typically needed additional disease management due to a more active disease course. As such, many patients who lacked active inflammation on IUS still maintained therapy rather than de-escalating. Additionally, changes in therapy (escalation or change in mechanism of action) for patients with negative IUS findings were due to patient requests for alternative routes of administration or clinical suspicion of disease activity despite the negative IUS. For those with active inflammation who maintained therapy, patients were given more time on the drug, as they had newly initiated treatment and were scheduled for follow-up evaluation. It was also demonstrated by our subanalysis that these patients did not experience worsening of their clinical symptoms or increase in their biomarkers prior to follow-up IUS. Even with these considerations however, clinical decisions were still significantly affected by IUS findings. When further stratified by bowel wall thickness, this remained true with

significant thickening of ≥5 mm having higher rates of a change in therapy than patients with bowel wall thickness between 3 and 5 mm. When stratified by Limberg score, we did not observe a significant change in treatment plan between the 2 groups of Limberg score = 1 and Limberg score ≥ 2, suggesting that bowel wall thickness is the most important indicator of disease activity.

In patients with a positive IUS, adjunct measures of inflammation were compared between treatment plans. Out of the clinical scores and inflammatory markers analyzed, only HBI was significantly different between the treatment groups. However, all markers and clinical scores trended in the expected direction with higher measures of inflammation being observed in the change in therapy treatment group.

IUS findings correlated significantly ($P < .05$), as expected, with Mayo and UCAI clinical scoring for UC patients. They did not correlate to HBI scoring, which is not surprising, as HBI scores have not traditionally correlated to more objective assessments of inflammation, such as endoscopic scores in patients with Crohn's disease.[7,8] Since IUS is an objective assessment of inflammatory activity, our findings suggest that IUS may be more useful during a clinic visit than the patient's symptoms alone, especially for those with Crohn's disease. Similarly, IUS findings did not correlate with inflammatory markers such as CRP and ESR. This was also expected because, even though CRP and ESR are useful as a general guide for clinical decision-making, they are not always sensitive and do not give adequate insight into disease severity and extent.[9,10] Finally, our study showed that even when combining biomarker results and clinical scores, the sensitivity for detecting inflammation remained low at 62%. This emphasizes the need for IUS to properly identify and treat patients with active disease.

Our IUS findings and treatment plans were similar to another IUS study of similar magnitude in Europe, with IUS correlating strongly to clinical symptoms in UC, but not CD.[11] However, BMI was not considered as a contributing factor to IUS results in the European study, likely due to differences in BMI distribution in European and American populations. Despite concerns with using IUS in overweight and obese patients, we were able to identify inflammation on IUS in 33% of overweight patients and 32% of obese patients. These rates were similar to other BMI categories. None of the overweight patients in our population required additional testing to confirm disease; they were treated based on IUS findings and clinical presentation.

For the 39 patients with at least 1 additional IUS evaluation, we observed improvements in inflammation as measured by improvements in bowel wall thickness in 77% of patients by an overall mean of 0.121 cm, vascular flow, and mural stratification. As expected, these improvements observed did not differ based on treatment plan: the decision to maintain or change therapy yielded similar outcomes in the reduction of intestinal thickness. The overall decrease in disease activity based on IUS that we observed highlights the utility of IUS in aiding clinical decision-making in our IBD population. This is especially true when considering the low sensitivity of adjunct measures of inflammation observed in our population.

This study was limited by low numbers of inflammatory markers such as fecal calprotectin and fecal lactoferrin since limited samples were collected within the time frame required for inclusion in this study (within 1 month of completion of IUS). This study also did not evaluate the clinical decision-making process on which IBD patients should be selected for IUS evaluation. As such, future studies should seek to evaluate what qualifies a patient for IUS evaluation and incorporate endoscopic measures of disease activity for additional validation of IUS findings.

Conclusions

As has been demonstrated in multiple European cohorts, IUS can be used in the management of IBD as a noninvasive method for reliably monitoring disease activity to inform clinical decision-making. This remained true in our American population, which had a higher BMI than European populations. Additionally, we show that the clinical decisions incorporating IUS findings were effective in reducing inflammation in our IBD patients while adjunct measures of inflammation inadequately identified patients with active disease. As such, IUS should be strongly considered by IBD clinicians in the United States for monitoring disease activity in IBD.

Acknowledgments

Ethical considerations: This research complies with the guidelines for human studies and was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. *Study approval statement*: This study protocol was reviewed and approved by an institutional review board (IRB). *Consent to participate statement*: Written, informed consent was not required for this retrospective, de-identified review, confirmed by our IRB. The authors would like to thank Dr. Jonathan Feinberg for his help in editing the manuscript in addition to Sarah Crawley and Rachael Whitehead for their help in the generation of the graphical abstract.

Funding

No funding was contributed for this manuscript.

Conflict of Interest

The authors have no conflict of interest to declare.

Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

References

1. Sands BE. Biomarkers of inflammation in inflammatory bowel disease. *Gastroenterology.* 2015;149(5):1275–1285.e2.
2. Fraquelli M, Castiglione F, Calabrese E, Maconi G. Impact of intestinal ultrasound on the management of patients with inflammatory bowel disease: how to apply scientific evidence to clinical practice. *Dig Liver Dis.* 2020;52(1):9–18.
3. Walsh AJ, Bryant RV, Travis SPL. Current best practice for disease activity assessment in IBD. *Nat Rev Gastroenterol Hepatol.* 2016;13(10):567–579.
4. Taylor SA, Mallett S, Bhatnagar G, et al.; METRIC Study Investigators. Diagnostic accuracy of magnetic resonance enterography and small bowel ultrasound for the extent and activity of newly diagnosed and relapsed Crohn's disease

(METRIC): a multicentre trial. *Lancet Gastroenterol Hepatol*. 2018;3(8):548–558.
5. Novak KL, Nylund K, Maaser C, et al. Expert consensus on optimal acquisition and development of the International Bowel Ultrasound Segmental Activity Score [IBUS-SAS]: a reliability and inter-rater variability study on intestinal ultrasonography in Crohn's disease. *J Crohns Colitis*. 2021;15(4):609–616.
6. Bor R, Fábián A, Szepes Z. Role of ultrasound in colorectal diseases. *World J Gastroenterol*. 2016;22(43):9477.
7. Gomes P, du Boulay C, Smith CL, Holdstock G. Relationship between disease activity indices and colonoscopic findings in patients with colonic inflammatory bowel disease. *Gut*. 1986;27(1):92–95.
8. Sandborn WJ, Feagan BG, Hanauer SB, et al. A review of activity indices and efficacy endpoints for clinical trials of medical therapy in adults with Crohn's disease. *Gastroenterology*. 2002;122(2):512–530.
9. Schoepfer AM, Vavricka S, Zahnd-Straumann N, Straumann A, Beglinger C. Monitoring inflammatory bowel disease activity: clinical activity is judged to be more relevant than endoscopic severity or biomarkers. *J Crohns Colitis*. 2012;6(4):412–418.
10. Halpin SJ, Ford AC. Prevalence of symptoms meeting criteria for irritable bowel syndrome in inflammatory bowel disease: systematic review and meta-analysis. *Am J Gastroenterol*. 2012;107(10):1474–1482.
11. Bots S, Voogd FD, Jong MD, et al. Point-of-care intestinal ultrasound in IBD patients: disease management and diagnostic yield in a real-world cohort and proposal of a point-of-care algorithm. *J Crohns Colitis*. 2022;16(4):606–615.