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BOWEL ULTRASOUND ELASTOGRAPHY IN ULCERATIVE COLITIS: A COMPREHENSIVE REVIEW

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Abstract

Ulcerative colitis (UC) is a chronic inflammatory bowel disease affecting the large intestine. Accurate assessment of disease activity is crucial for optimal management and treatment decisions. Bowel ultrasound elastography (BUE) is an emerging non-invasive technique that measures tissue stiffness and can provide valuable insights into the inflammatory status of the bowel wall in patients with UC. This review aims to provide a comprehensive overview of the current literature on bowel ultrasound elastography in UC, discussing its principles, advantages, limitations, and potential clinical applications.

Kewords: Bowel ultrasound, Elastography, Ulcerative Colitis, activity, fibrosis

Introduction

Ulcerative colitis is a debilitating condition characterized by periods of relapse and remission, leading to chronic inflammation and damage to the colonic mucosa (1). Accurate evaluation of inflammation severity and extent is essential for determining appropriate therapeutic strategies (2). Colonoscopy and histopathology are the mainstay tool for diagnosis and monitoring of UC (3). Traditional imaging modalities, such as CT and MRI enterography, have been widely used in the evaluation of ulcerative colitis. However, these techniques have limitations in assessing disease activity and severity, as they primarily rely on structural changes in the bowel (4–8). In recent years, ultrasound elastography has emerged as a promising tool for evaluating tissue stiffness and inflammation in various medical conditions, including ulcerative colitis (9,10). Bowel ultrasound elastography (BUE), a non-invasive technique that provides quantitative information

about tissue stiffness, has shown promising potential in assessing disease activity and monitoring response to treatment in UC patients (9,11,12). We aim in this review to sailor among the valuable use of BUE in uc patients, principles, advantages, benefits and research points of BUE in UC.

Principles of BUE

Elastography is a specialized ultrasound technique that measures tissue stiffness. It operates on the principle that healthy tissues have different elastic properties compared to inflamed or fibrotic tissues (13,14). In the context of ulcerative colitis, elastography can help distinguish between active inflammation and chronic disease-related changes (15–17). BUE measures tissue stiffness by assessing shear wave propagation through the bowel wall. This technique utilizes ultrasound waves to generate two-dimensional or three-dimensional images representing tissue stiffness, evaluated through elastograms. The stiffness of the bowel wall is measured and calculated using different elasticity indices, providing information about its inflammatory status (14,18,19).

Strain elastography (SE) and shear wave elastography (SWE) are the two technologies currently used US machines. **(Figure 1).** They differ in the way used to measure tissue deformation in response to the applied force. The applied force could be a mechanical internal or external pressure **(Figure 1)**. In SE, the induced tissue displacement is traced between pairs of echo frames and then the strain is calculated from their gradient. Using a color map, the different strains are encoded within a two-dimensional image that can be instantly visualized together with the conventional B-mode US image. The SE is a semi-quantitative technique that cannot measure the elasticity of the examined tissue as an absolute value, since the absolute value of the applied stress is unknown. In SWE, the dynamic stress induces shear waves that propagate perpendicular to the US beam. The speed of the generated shear waves is measured and returns quantitative estimates of the tissue elasticity (20).

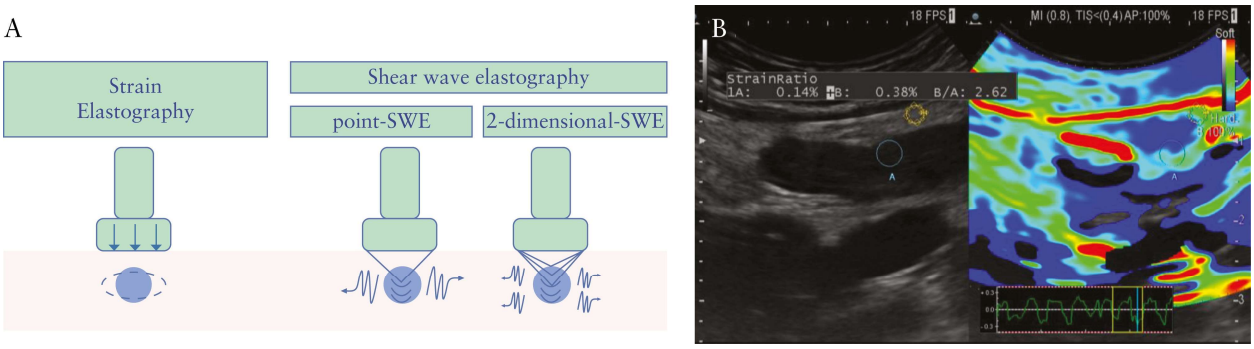

Figure 1. Technique and principles of ultrasound elastography. A. The technologies currently used and commercially available in ultrasound [US] machines are divided into two main types: strain [SE] and shear wave elastography [SWE]. In SE, the induced tissue displacement is traced between pairs of echo frames, then the strain is calculated from their gradient. Technically, two SWE methods can be distinguished: the point-SWE [pSWE] and the 2-dimensional-SWE [2D-SWE]. In the p-SWE, the speed of shear wave is measured in a single specific location [ROI]; the 2D-SWE produces a quantified colour map of the distribution of shear wave velocities in a wider region. B. An example of SE applied to bowel wall is shown. SWE: shear wave elastography (20).

Advantages of BUE

BUE demonstrates several advantages over conventional methods of disease assessment in UC. It is non-invasive(21), radiation-free (13), and readily available, making it a valuable tool for frequent monitoring of disease activity (13). Additionally, this technique allows real-time visualization of the bowel wall, providing a dynamic assessment of inflammatory changes (22,23).

Non-Invasive: BUE is a non-invasive imaging technique that does not require the use of ionizing radiation or contrast agents.

Real-Time: The procedure provides real-time images of the bowel wall, allowing for immediate assessment of disease activity and treatment response.

Cost-Effective: Compared to other imaging modalities such as MRI or CT scans, ultrasound elastography is generally more cost-effective (23).

Quantitative measurements: BUE provides quantitative measurements of tissue stiffness, which can be used to objectively assess disease activity and response to treatment in ulcerative colitis patients (11).

High sensitivity: BUE has been shown to have high sensitivity in detecting subtle changes in tissue stiffness, even in the absence of structural abnormalities seen on conventional imaging modalities (24).

Reproducibility: BUE is a highly reproducible technique, enabling clinicians to monitor disease activity and progression over time with minimal variability (14).

That's why BUE is superior to CT/MRI enterography in evaluating UC activity and response to treatment as shown in (Table 1).

Table (1): Comparison of BUE with Traditional Imaging Modalities

Parameter	BUE	CT/MRI Enterography
Radiation exposure	None	Yes
Contrast agents	Not required	Sometimes required
Real-time imaging	Yes	No
Quantitative measurements	Yes	Limited
Sensitivity	High	Variable
Reproducibility	High	Variable
Cost-effectiveness	Cost-effective	Expensive

Clinical Applications of BUE

I. ***Evaluation of Disease Activity***

BUE has shown promise in differentiating active inflammation from fibrosis in UC, aiding in early detection of disease relapse (25–29).

II. ***Monitoring Treatment Response***

Long-term monitoring of the bowel wall stiffness can assist in assessing treatment response and optimizing therapy in UC patients (30). Colonoscopy is the cornerstone of UC mucosal healing monitoring (31). Although, colonoscopy is invasive tool with high-cost burden (32). Also, colonoscopy assesses only mucosal healing, and recently, treatment target

is to achieve histological healing and beyond (33), which makes the unmet need for another tool for assessment. BUE is the promising one in achieving this target (25).

III. ***Prediction of Complications***

BUE may help predict the risk of developing strictures or perforations in UC patients by assessing the presence of fibrotic changes in the bowel wall (23,34,35).

IV. ***Assessment of Mucosal Healing***

Elastography-derived parameters can provide a comprehensive evaluation of mucosal healing, allowing for timely adjustments in treatment strategies (36,37).

V. **Differentiating between Inflammation and Fibrosis**

BUE can help in distinguishing between active inflammation and fibrosis in the bowel wall (10,20). This is important in guiding treatment decisions, as fibrosis may require a different approach than active inflammation (38,39).

Research on BUE in Ulcerative Colitis

As research and technology advance, the integration of elastography into routine clinical practice for UC is becoming more common. Its ability to provide additional parameters beyond conventional imaging enhances the comprehensive assessment of the disease. Several studies have evaluated the utility of bowel ultrasound elastography in ulcerative colitis either alone or collectively with Crohn's disease. Here we concerned with publications studied UC rather than inflammatory bowel disease (IBD), collected in **(Table 2).**

A study published in the Journal of Crohn's and Colitis found that BUE is effective in differentiating between active inflammation and fibrosis in the bowel wall of ulcerative colitis patients (11). Another study revealed that BUE is a reliable tool for monitoring disease activity and response to treatment in ulcerative colitis patients (40).

Table (2): Research publications about BUE

Study	Year of publication	Type of study	Number of patients	Aim and conclusion	Used device
Feng Zhu et al, (11)	2024	Prospective	56	BUE predict the degree of colonic fibrosis in UC	Na
Yamada et al, (40)	2022	Prospective	26	BUE in monitoring disease activity	Aplio i900 ultrasound system
Marin et al, (41)	2021	Prospective	44	BUE IN evaluating the degree of inflammation, differentiating between remission and relapse, following up on treatment response and guiding therapy, assessing prognosis	Acuson S2000

				and diagnosing complications	
Goertz et al, (42)	2019	Prospective	20	BUE assess disease activity	Acuson S2000 ultrasound device
Rustemovic et al, (43)	2011	Retrospective	25	TRUS in differentiating between UC and Crohn's disease	linear echo-endoscope (Pentax FG-38 UX) with probes of 7.5−12 MHz (Hitachi EUB 8500)
Ishikawa et al, (44)	2011	Prospective	37	Correlation between BUE and colonoscopy	a Hitachi EUB-8500 US system

Limitations and Challenges

Despite its potential, BUE also has certain limitations. Operator dependency, variations in measurement techniques, and the lack of standardized protocols hinder its widespread utilization (14,20). Additionally, its accuracy in differentiating between active inflammatory changes and fibrosis requires further validation (45-47).

Future Perspectives

The development of standardized protocols and guidelines, along with advanced imaging technologies and machine learning algorithms, holds promise for overcoming the limitations of BUE and enhancing its clinical utility in UC management.

Conclusion

BUE is a valuable imaging modality for assessing disease activity and severity in patients with ulcerative colitis. Its non-invasive nature, real-time imaging capabilities, and ability to provide quantitative measurements make it a superior alternative to traditional imaging modalities such as CT and MRI enterography. Clinicians can rely on BUE to monitor disease activity, guide treatment decisions, and assess response to therapy in ulcerative colitis patients. Further research is needed to validate the utility of BUE in the management of ulcerative colitis and to establish standardized protocols for its use in clinical practice.

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