Utility of Bowel Ultrasound and Elastography in assessment of Ulcerative Colitis activity and response to treatment

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Abstract

Background Ulcerative colitis (UC) is a chronic remittent gastrointestinal disease affecting the colon. Ileocolonoscopy and histopathology are the mainstay tools for diagnosis and monitoring response to treatment which are invasive. There is unmet need for non-invasive tools for diagnosis and monitoring UC patients.

Objectives: Bowel Ultrasound (BUS) and elastography are a promising non-invasive tool for this issue. We studied the validity of BUS in UC diagnosis and prediction of response to treatment.

Patients and methods 48 participants were included, classified into 18 patients with active UC, 15 UC patients in remission and another 15 participants as a control group. BWT, WLS, CDS, pericolic lymph nodes presence and pericolic fat echogenicity had revealed a clinical significance in UC diagnosis and prediction of response to treatment.

Results: BWT had a perfect agreement at UC diagnosis and prediction of response to treatment at a cut off point 0.3 cm with 94.0% accuracy, 94.4% sensitivity, 93.3% specificity, 94.4% PPV and 93.3% NPV with P value <0.001. bowel shear wave elastography showed a clinical significance in UC diagnosis. Using shear wave elastography E1 comparing active UC patients vs. patients in remission with cut off value 1 kPa had 0.750 AUC, 95% CI with 88.9% sensitivity, 53.3% specificity, 69.6% PPV and 80.0% NPV with P value 0.004, but SR didn't show any significance either in diagnosis or monitoring UC patients.

Conclusion: BUS can be used in diagnosis and monitoring UC patients instead of or beside ileocolonoscopy and histopathology to decrease the burden of the disease. Further research is needed to study shear wave elastography to get its benefit and to use in scoring systems for diagnosis and disease monitoring.

Keywords: Bowel ultrasound; Ulcerative Colitis; Elastography.
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Introduction

Ulcerative colitis (UC) is a chronic relapsing inflammatory disease affecting the colon causing organ damage and affecting quality of life **(Gros and Kaplan, 2023)** UC incidence is about 0.75% in western countries and there is accelerated increase in incidence in western and eastern countries **(Buie et al., 2023)** Diagnosis of UC is challenging and there is no standard tool of diagnosis, ileocolonscopy and histopathology are the main diagnostic tools. However, they are invasive and costly tools **(Li et al., 2024)**.

Bowel ultrasound (BUS) is a non-invasive, cheap and easily repeatable tool which is increasingly used in gastrointestinal diseases in the recent years **(Malik et al., 2024)** Its role in diagnosis and follow-up of UC patients is prominent and occupy an attention from gastroenterologists nowadays **(Malik et al., 2024)** BUS is considered as a tool for initial evaluation of inflammatory bowel disease (IBD) patients and monitoring the treatment response according to the European Crohn's and Colitis Organization (ECCO) **(Kucharzik et al., 2022)** A new software technology is added to bowel ultrasound, shear wave elastography which has transformed the BUS from a basic preliminary technique to a sophisticated technique competing other modalities as CT and MRI **(Merrill and Wilson, 2024; Zhu et al., 2024).**

We aimed to assess the accuracy of BUS and shear wave elastography to diagnose and follow up UC patients for response to treatment.

Patients and methods

Sample size: The sample size was calculated using G power software version 3.1.3, using ANOVA test for comparison difference of bowel wall thickness between the three studied groups (controls, active UC and remission UC), assuming medium effect size 0.49, alpha error prob 0.05, power (1-beta error prob) 0.80. The minimum required sample size was 45 participants (15 participants in each group)

Ethical approval: The study protocol was approved by the Medical Ethics Committee of the Institutional Review Board of the Faculty of Medicine, South Valley University, Egypt with number SVU/MED/MED018/2/21/8/222. Informed and written consent were obtained from all participants according to the declaration of Helsinki.

Patients' selection : A Prospective case-control study was conducted at the Gastroenterology Clinic from October 2022 to October 2023.

Inclusion criteria: All patients aged 12 years and more diagnosed as UC either newly diagnosed or in remission.

Exclusion criteria: Patients with known colorectal cancer (CRC), or patients with history of resection anastomosis surgery.

Study participants: 33 patients with ulcerative colitis based on laboratory, colonoscopy, and histopathological data were enrolled (18 patients have active UC and 15 patients are in remission according to endoscopic mayo score). In addition, the control group (n = 15) are included for comparative purposes. Patients in this group were subjected to colonoscopy, but for purposes other than UC.

All patients are subjected to full history evaluation in addition to baseline laboratory parameters such as complete blood picture, serum albumin, iron level, ferritin level, C-reactive protein (CRP), and erythrocyte sedimentation rate (ESR). Based on standard guidelines, the management plan was performed. Based on the results of colonoscopy and histopathology, participants were subgrouped into the study

(those with confirmed active and in remission UC) and control groups.

Bowel ultrasound: All the BUS examinations are performed by an experienced radiologist and an endoscopist, both were blinded with the results of BUS and colonoscopy. Frequency, focus and gain settings are optimized to get the best images. The examination is performed after at least 4 h of fasting with the patient in the supine position. The rectosigmoid is examined by logic p8 using convex (1–7 MHz) and linear (1–15 MHz) probes.

The following BUS parameters are recorded during the procedure: bowel wall thickness (BWT), Color Doppler signal (CDS), presence of fat wrapping (hyperechoic fat around the bowel), wall layer stratification (WL), presence of enlarged lymph nodes (short axis > 5 mm), and shear wave elastography measuring in two areas of the rectosigmoid colon E1 and E2 and strain ratio (SR).

BWT is measured from, but not including the central hyperechoic line of the lumen to the end of the outer hypoechoic margin of the wall (representing the muscularis propria). All BWT measurements were performed in duplicate on longitudinal sections because it is easiest to notice the thickest wall section in longitudinal direction, CDS is categorized as absent, small spots or large spots/stretches, fat wrapping (hyperechoic fat around the bowel) either present or absent and reactive mesenteric lymph nodes either present or absen **(Gilja, 2017; Zarmehri et al., 2023; Nishida et al., 2023; Steinsvik et al., 2021)** .

Shear wave elastography is calculated automatically by integrated software in rectosigmoid region and expressed as the mean values (E1, E2 and SR) **(Ślósarz et al., 2021; Xia et al., 2023; Yamada et al., 2022)**.

Follow-up: Follow up colonoscopy and BUS are done for the study participants (active and in remission groups) after 3 months.

Statistical analysis

Data was analyzed using SPSS version 26. Categorical data were presented in the form of frequencies and percentages. Numerical data were checked for normality by Shapiro-walk test and presented by mean and standard deviation or median and range according to their distribution.

The independent Sample T test was used to compare mean difference between two groups. The One-Way ANOVA/ Kruskal Wallis test compares mean/median difference between more than two groups, post hoc test for pairwise comparison with Bonferroni correction was used to compare significance between each two groups. The chi square test was used to compare proportions between cases and controls.

Receiver operating characteristic (ROC) curve analysis was done, AUC, accuracy, sensitivity, specificity, positive and negative predicted value was calculated for the discriminatory ability of BWT and Elastography in differentiation between types of ulcerative colitis and controls.

Diagnostic accuracy for BWT in comparison to colonoscopy was done, the degree of agreement between them is measured by Cohen's kappa (k), accuracy, sensitivity, specificity, positive and negative predicted value was calculated. The level of significance was considered at P value < 0.05.

Results

Baseline characteristics and laboratory data among the study population

There was no significance difference between the three groups as regard age, gender, residence and smoking. Baseline laboratory data showed that the active group has lower HB level versus remission and control groups (9.88±1.45 vs. 10.84±0.77

and 12.59±1.04 g/dl, P value <0.001), mean corpuscular volume (MCV) (78.67±8.07 vs. 83.20±7.64 and 90.60±4.83 fl, P value <0.001), serum albumin level (32.28±5.07 vs. 37.53±3.60 and 39.87±3.441 mg/dl, P value <0.001), serum iron level (22.22±6.40 vs. 65.00±11.47 and 103.00±20.45 mcg/dl, P value <0.001) and serum ferritin level (15.00 (4-568) vs. 56.00 (21-124) and 97.00 (67-146) ng/ml, P value <0.001). patients with active UC had significantly higher levels of CRP and ESR than both remission and control groups. ESR, first hour was (47.72±12.81 vs. 23.53±5.33 and 10.60±4.05 ml, P value <0.001) and CRP level was (32.06±6.30 vs. 10.47±4.10 and 8.07±3.78 mg/dl, P value <0.001). the other patients' characteristics and laboratory data are summarized in **(Table.1).**

Table 1. Baseline characteristics and laboratory data of the studied groups

Variables	Control (n=15)	Active (n=18)	Remission (n=15)	P-Value
Age (years)				
Mean ± SD (range)	30.87±6.91 (21-42)	31.94±9.05 (21-46)	26.53±6.53 (19-39)	0.124*
Gender				
▪ Male	10 (66.7%)	7 (38.9%)	7 (46.7%)	0.270**
▪ Female	5 (33.3%)	11 (61.1%)	8 (53.3%)	
Residence				
▪ Urban	6 (40.0%)	5 (27.8%)	5 (33.3%)	
▪ Rural	9 (60.0%)	13 (72.2%)	10 (66.7%)	0.760**
Smoking				
▪ Yes	7 (46.7%)	9 (50.0%)	5 (33.3%)	0.607**
▪ No	8 (53.3%)	9 (50.0%)	10 (66.7%)	
Hb (g/dl)				
▪ Mean ± SD	12.59±1.04	9.88±1.45	10.84±0.77	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission=0.022**	**Controls. vs remission<0.001**	
MCV (fl)				
▪ Mean ± SD	90.60±4.83	78.67±8.07	83.20±7.64	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	Active vs remission=0.074	**Controls. vs remission=0.006**	
Platelets (10^3/ul)				
▪ Median (range)	328.00 (156-455)	327.50 (129-872)	329.00 (121-432)	0.855
▪ P-Value***	Controls. vs Active=0.134	Active vs remission=0.061	Controls. vs remission=0.710	
WBC (10^3/ul)				
▪ Mean ± SD	7.57±1.33	8.28±2.17	8.75±1.33	0.172
▪ P-Value***	Controls. vs Active=0.239	Active vs remission=0.434	Controls. vs remission=0.064	

CRP (mg/dl)				
▪ Mean ± SD	8.07±3.78	32.06±6.30	10.47±4.10	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission=0.022**	Controls. vs remission=0.193	
ESR (ml)				
▪ Mean ± SD	10.60±4.05	47.72±12.81	23.53±5.33	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission<0.001**	**Controls. vs remission<0.001**	
Albumin (mg/dl)				
▪ Mean ± SD	39.87±3.441	32.28±5.07	37.53±3.60	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission=0.001**	Controls. vs remission=0.133	
Serum Iron (mcg/dl)				
▪ Mean ± SD	103.00±20.45	22.22±6.40	65.00±11.47	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission<0.001**	**Controls. vs remission<0.001**	
Ferritin level (ng/ml)				
▪ Median (range)	97.00 (67-146)	15.00 (4-568)	56.00 (21-124)	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	Active vs remission=0.231	**Controls. vs remission=0.008**	

Hb: Hemoglobin; MCV: mean corpuscular volume; WBC: white blood cells; CRP: C reactive protein; ESR: erythrocyte sedimentation rate.Data were expressed as mean ± SD or median (range).*One Way ANOVA test/Kruskal Wallis test compare mean/median difference between groups.**Chi Square test compare proportion between groups.***Post hoc test for pairwise comparison with Bonferroni correction compare significance between each two groups.

Baseline BUS parameters and shear wave elastography among the study population

There was significant difference between the study population either active vs. remission or control group as regard bowel wall thickness (BWT), wall layer stratification (WLS), color doppler score (CDS), pericolic lymph node presence and fat wrapping. BWT was 0.40±0.09 cm in active UC patients vs. 0.25±0.03 cm in remission group and 0.23±0.05 cm in control group with P value <0.001. WLS was lost in 66.7% of patients with active UC but it was preserved in 80% of remission group and 100% of control group with P value <0.001, pericolic lymph nodes were present in 44.4% of active UC patients, on the contrary, they were absent in 80.0% of the remission group and 93.3% of the control group with P value 0.038. CDS showed normal distribution only in 11.1% of the active UC patients, but it was normal in most of UC patients in remission group and control group with P value <0.001. Hyperechoic pericolic fat was present in 88.9% of active UC patients, while it was absent in 66.7% of UC patients in remission group and 100.0% of control group with P value <0.001.

Shear wave elastography showed a clinically significant difference in strain elastography E1 among the study participants. E1 was higher in active UC patients vs. remission and control groups (2.90 (0.4-6.0) vs. 1.00 (0.3-4.3) and 0.90 (0.3-6.0) kPa, P value 0.044). While E2 and SR didn't show significant difference among the studied groups. Details were mentioned in **(Table.2).**

Table 2. Baseline BUS parameters and shear wave elastography of the studied groups

BUS	Controls (n=15)	Active (n=18)	Remission (n=15)	P-Value*
BWT				
Mean ± SD	0.23±0.05	0.40±0.09	0.25±0.03	**<0.001**
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission<0.001**	Controls. vs remission=0.325	
WLS				
▪ Yes	15 (100.0%)	6 (33.3%)	12 (80.0%)	**<0.001**
▪ No	0 (0.0%)	12 (66.7%)	3 (20.0%)	
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission=0.018**	Controls. vs remission=0.224	
Pericolic lymph nodes				
▪ Yes	1 (6.7%)	8 (44.4%)	3 (20.0%)	**0.038**
▪ No	14 (93.3%)	10 (55.6%)	12 (80.0%)	
▪ P-Value***	**Controls. vs Active=0.036**	Active vs remission=0.265	Controls. vs remission=0.597	
CDS				
▪ Absent	14 (93.3%)	2 (11.1%)	14 (93.3%)	**<0.001**
▪ Small spots	1 (6.7%)	10 (55.6%)	1 (6.7%)	
▪ Large spots	0 (0.0%)	6 (33.3%)	0 (0.0%)	
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission<0.001**	NA	
Fat wrapping				
▪ Absent	15 (100.0%)	2 (11.1%)	10 (66.7%)	**<0.001**
▪ Present	0 (0.0%)	16 (88.9%)	5 (33.3%)	
▪ P-Value***	**Controls. vs Active<0.001**	**Active vs remission=0.002**	**Controls. vs remission=0.042**	
Bowel elastography				**P-Value****
E1 (kPa)				
▪ Median (range)	0.90 (0.3-6.0)	2.90 (0.4-6.0)	1.00 (0.3-4.3)	**0.044**
▪ P-Value***	Controls. vs Active=0.054	**Active vs remission=0.022**	Controls. vs remission=0.783	
E2 (kPa)				
▪ Median (range)	3.20 (0.4-6.0)	2.90 (0.7-6.0)	2.30 (0.4-5.3)	0.331
▪ P-Value***	Controls. vs Active=0.786	Active vs remission=0.121	Controls. vs remission=0.360	
SR				
▪ Median (range)	1.40 (0.8-4.70)	1.0 (0.3-4.10)	1.20 (0.80-4.70)	0.119
▪ P-Value***	Controls. vs Active=0.072	Active vs remission=0.090	Controls. vs remission=0.660	

BUS: bowel ultrasound; BWT: bowel wall thickness; WLS: wall layer stratification; CDS: color doppler score; E1: strain elastography area 1; E2: strain elastography area 2; SR: strain ratio. Data were expressed as mean ± SD or median (range).*One Way ANOVA test compare mean between groups. ** Kruskal Wallis test compare median difference between groups.***Post hoc test for pairwise comparison with Bonferroni correction compare significance between each two groups. Chi square test compare proportion between each two groups.

Follow up colonoscopic findings and BUS parameters among UC patients

Out of 33 UC patients, follow up colonoscopy revealed that 23 (69.7%) patients showed normal colonoscopic findings i.e. achieved complete remission, 6 (18.2%) patients were Mayo score 1 and 4 (12.1%) patients were Mayo score 2. Among the 33 patients, BWT, WLS, CDS, pericolic lymph nodes and pericolic fat wrapping showed clinical significance difference between patients in activity and who were in remission in follow up and monitoring UC patients. BWT was 0.39±0.07 (0.30-0.52) cm in active UC patients vs. 0.25±0.04 (0.16-0.32) cm in remission patients with P value <0.001, WLS was lost in 9 (90.0%) of patients with activity vs. 4 (17.4%) in remission patients with P value <0.001, CDS was increased in all patients with activity while was normal distribution in 20 (87.0%) of patients in remission with P value <0.001, pericolic lymph nodes were present in 8 (80.0%) of patients with activity, while they were absent in 19 (82.6%) of patients in remission with P value <0.001 and pericolic fat wrapping hyperechoic in 8 (80.0%) of patients with activity but was normal in 20 (86.9%) of patients who were in remission with P value <0.001.

On the contrary, shear wave elastography didn't show clinical significance in monitoring and prediction of response to treatment either E1, E2 or SR with P value 0.138, 0.253 and 0.828 respectively. Details were mentioned in (**Table.3)**.

Table 3. Follow up BUS parameters and shear wave elastography of both active and remission UC patients after 3 months.

BUS	Active (n=10)	Remission (n=23)	P-Value*
BWT			
▪ Mean ± SD	0.39±0.07 (0.30-0.52)	0.25±0.04 (0.16-0.32)	**<0.001**
WLS			
▪ Yes	1 (10.0%)	19 (82.6%)	**<0.001**
▪ No	9 (90.0%)	4 (17.4%)	
Pericolic lymph nodes			
▪ Yes	8 (80.0%)	4 (17.4%)	**0.001**
▪ No	2 (20.0%)	19 (82.6%)	
CDS			
▪ Absent	0 (0.0%)	20 (87.0%)	**<0.001**
▪ Small spots	8 (80.0%)	3 (13.0%)	
▪ Large spots	2 (20.0%)	0 (0.0%)	
Fat wrapping			
▪ Absent	2 (20.0%)	20 (86.9%)	**<0.001**
▪ Present	8 (80.0%)	3 (13.1%)	
Bowel elastography			**P-Value****
E1			
▪ Median (range)	2.65 (0.6-4.1)	0.90 (0.3-6.0)	0.138
E2			
▪ Median (range)	3.20 (0.5-5.9)	1.40 (0.4-6.0)	0.253
SR			
▪ Median (range)	1.40 (0.8-2.20)	1.30 (0.80-4.70)	0.828

BUS: bowel ultrasound; BWT: bowel wall thickness; WLS: wall layer stratification; CDS: color doppler score; E1: strain elastography area 1; E2: strain elastography area 2; SR: strain ratio. *Independent Sample T test compare

mean between active and remission. **Mann Whitney U test compare median between active and remission. Chi square test compare proportion between groups.

Diagnostic accuracy of the baseline BUS and shear wave elastography findings in UC diagnosis

Comparing patients with UC activity vs. control group with cut off value >0.3 cm had the best area under curve (AUC), 95% confidence interval (95%CI) 0.956 for UC diagnosis with 94.4% sensitivity, 93.3% specificity, 94.4% positive predictive value (PPV) and 93.3% negative predictive value (NPV) with P value <0.001.

Using shear wave elastography E1 comparing active UC patients vs. patients in remission with cut off value 1 kPa had 0.750 AUC, 95% CI with 88.9% sensitivity, 53.3% specificity, 69.6% PPV and 80.0% NPV with P value 0.004. Data were illustrated in **Tables (4&5)** and **Figs (1, 2, 3 & 4)**.

Table 4. Accuracy of BWT in UC diagnosis

Variables	BWT		
	UC in comparison to controls	**Active UC in comparison to controls**	**Active UC in comparison to remission UC**
AUC, 95% CI	0.834 (0.699 -0.926)	0.972 (0.846 -0.999)	0.956 (0.821-0.997)
Cut off	>0.23	>0.3	>0.31
Accuracy	79.0%	94.0%	91.5%
Sensitivity, %	90.9%	94.4%	83.3%
Specificity, %	66.7%	93.3%	100.0%
PPV %	85.7%	94.4%	100.0%
NPP %	76.9%	93.3%	83.3%
P Value	**<0.001**	**<0.001**	**<0.001**

PPV: positive predictive value; NPV: negative predictive value; AUC: area under curve; 95% CI: 95% confidence interval.

Table 5. Accuracy of shear wave elastography in UC diagnosis

Variables	E1
	Active UC in comparison to remission UC
AUC, 95% CI	0.750 (0.569-0.884)
Cut off	>1
Accuracy	71.0%
Sensitivity, %	88.9%
Specificity, %	53.3%
PPV %	69.6%
NPP %	80.0%
P Value	**0.004**

PPV: positive predictive value; NPV: negative predictive value; AUC: area under curve; 95% CI: 95% confidence interval.

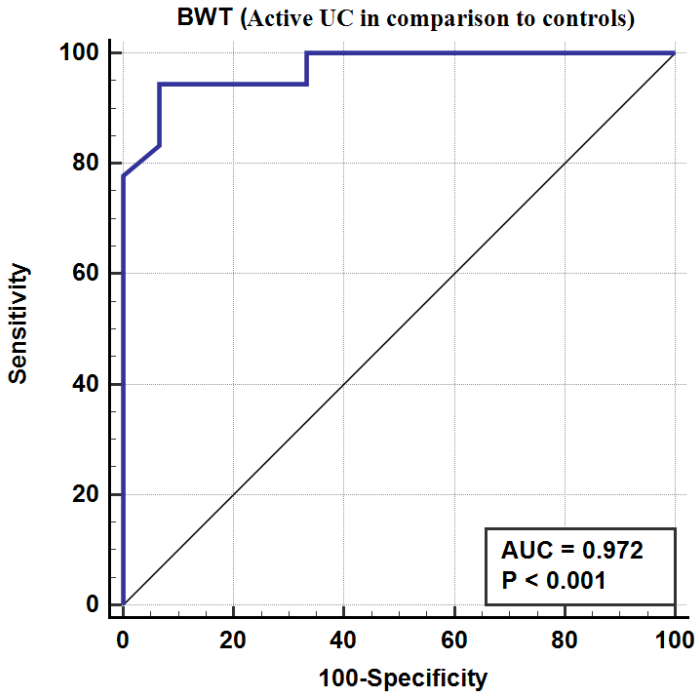

Fig.1. Accuracy of BWT in UC diagnosis comparing active UC patients vs. control group.

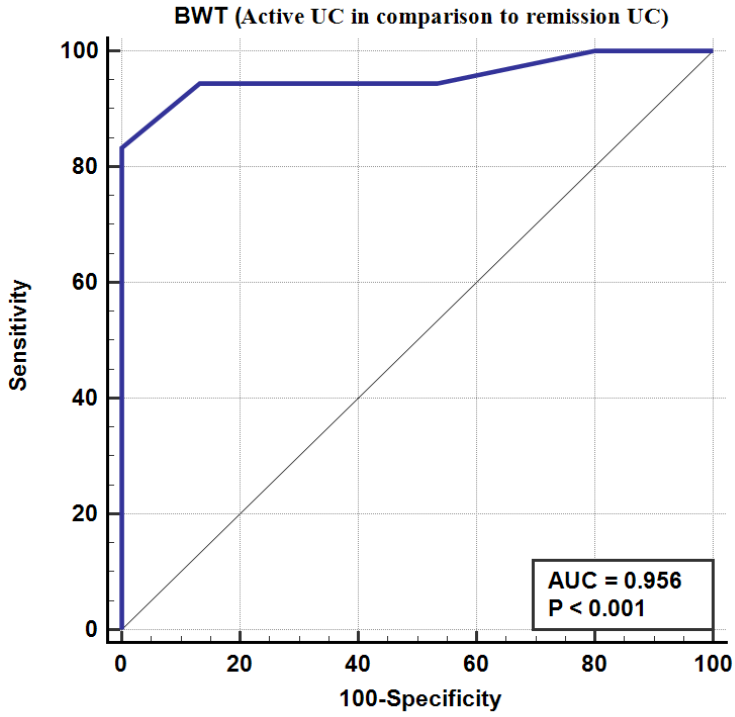

Fig.2. Accuracy of BWT in UC diagnosis comparing active UC patients vs. remission group.

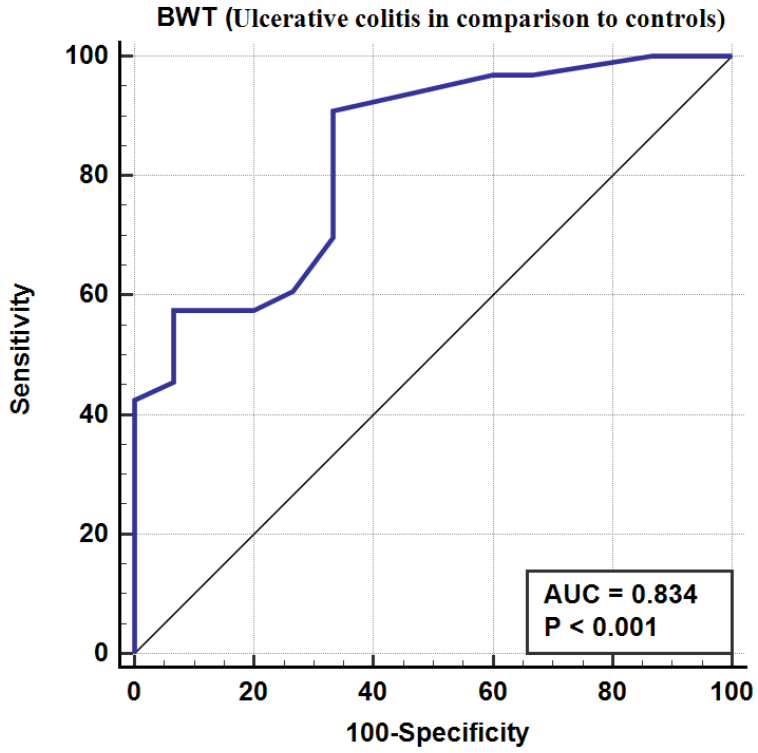

Fig.3. Accuracy of BWT in UC diagnosis comparing UC patients, both active and remission groups vs. control group.

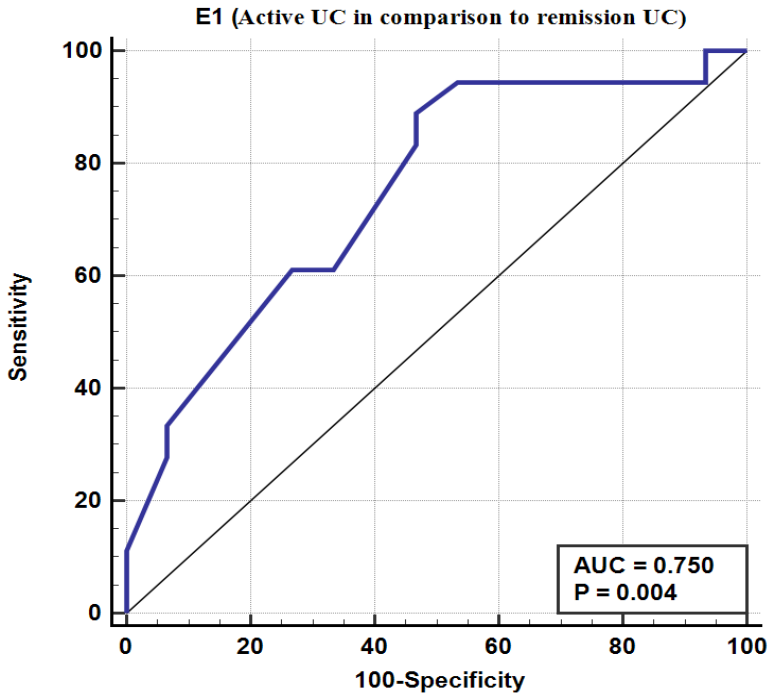

Fig.4. Accuracy of shear wave elastography in UC diagnosis comparing active vs. remission UC patients.

(Fig. 5) demonstrates a 33 year old female patient with ulcerative colitis, comparison between colonscopic appearance, ultrasound findings and shear wave elastography in activity and in remission posttreatment. **(Fig.6)** demonstrates a 41 year old male patient not achieving complete remission, colonscopic appearance, ultrasound findings and shear wave elastography of bowel wall.

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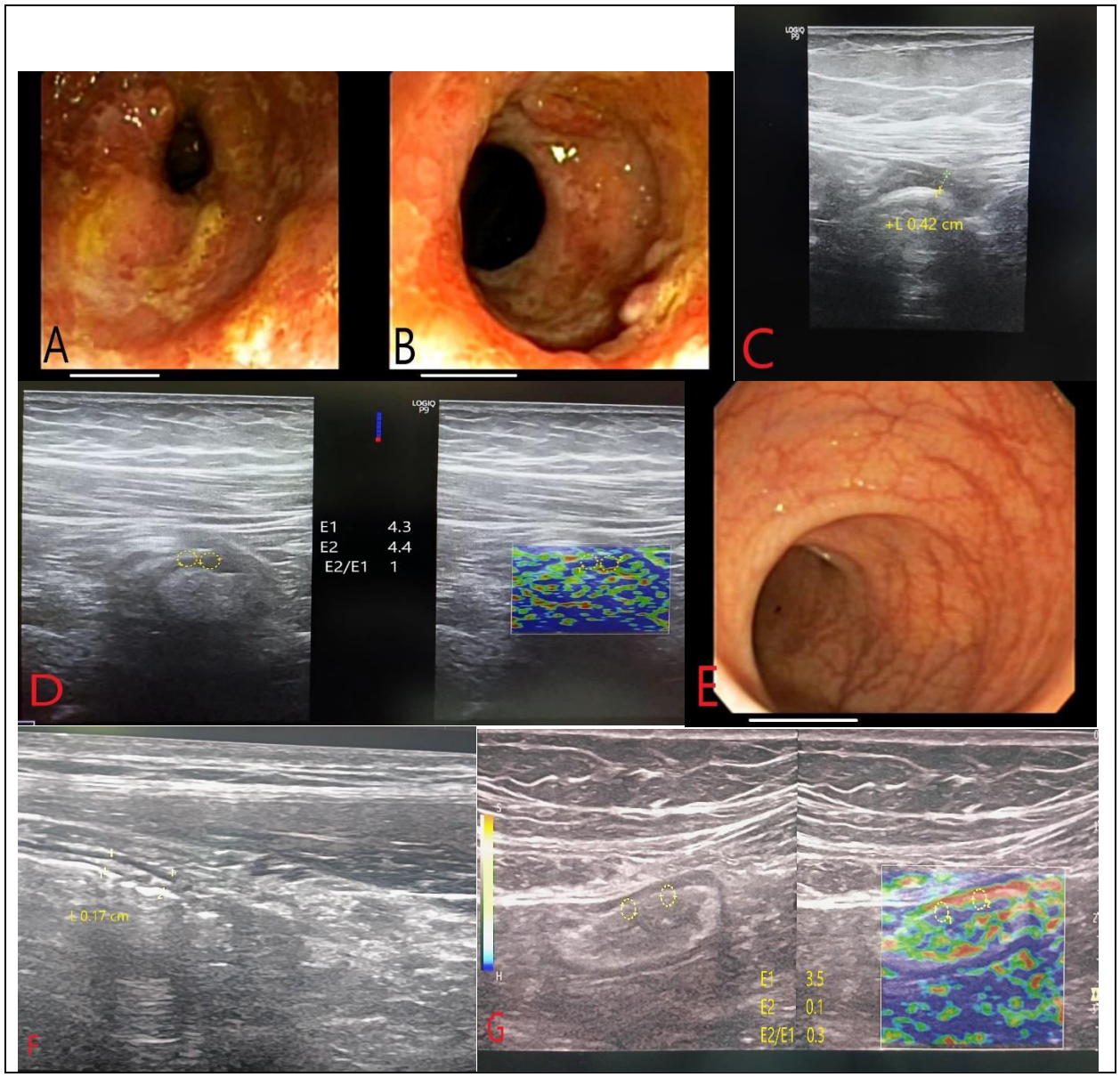

Fig. 5. A 33 year old female patient with ulcerative colitis, (A& B) colonscopic picture of rectosigmoid showing easily bleed hyperemic mucosa with exudation, ulcers, small crypt abscesses formation and pseudopolyp, Mayo score 3, (C) ultrasound appearance of rectosigmoid wall showing thickened wall about 0.42 cm with loss of wall layer stratification, (D) shear wave elastography of the rectal wall measuring elastography wave E1 & E2 & SR, (E) colonscopic picture of the rectosigmoid of the same patient after getting in remission showing normal mucosa, Mayo score 0, (F) ultrasound appearance of the rectosigmoid wall showing normal wall

thickness, 0.17 cm, with well stratification of the layers, (G) shear wave elastography of the rectal wall measuring elastography wave E1 & E2 & SR.

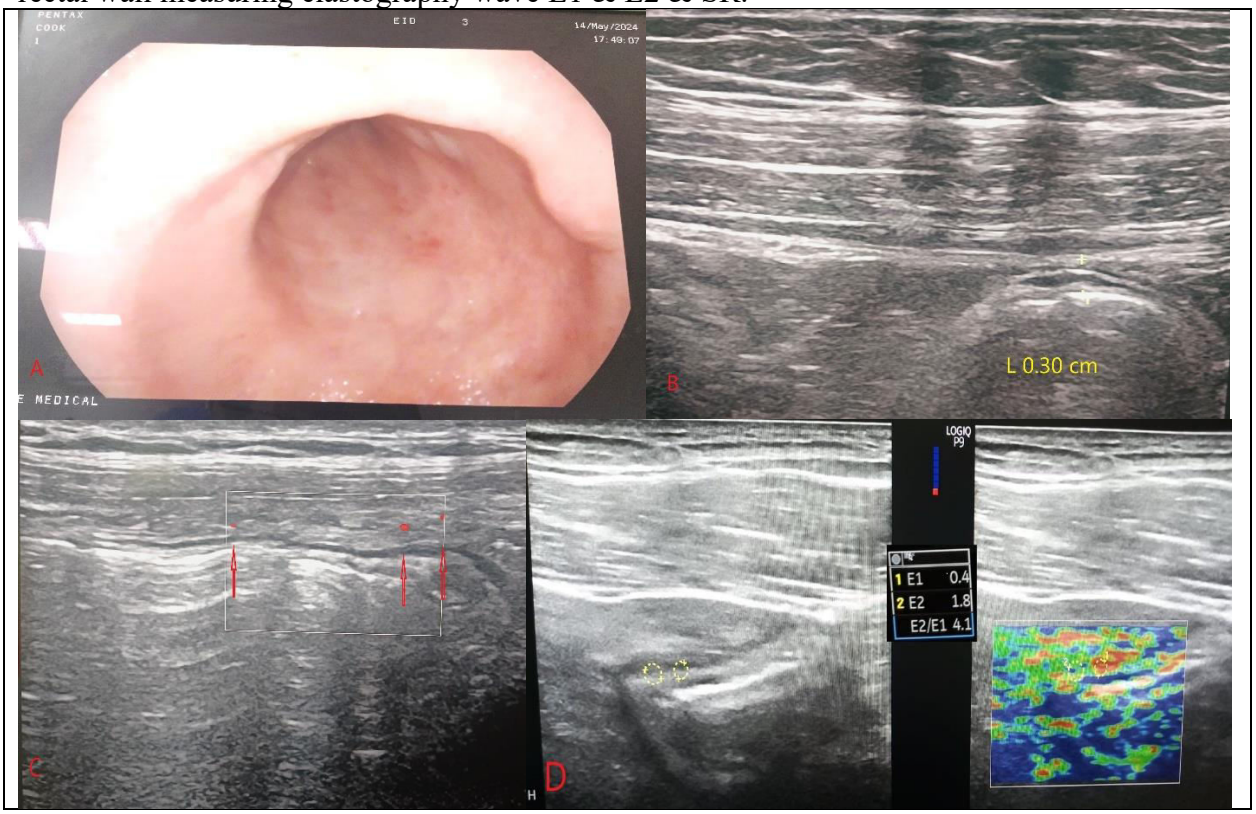

Fig. .6. A 41 year old male patient, known UC on medical treatment not achieving complete remission, (A) colonscopic colonscopic picture of rectosigmoid showing mild erythematous mucosa with no exudation or ulcer, Mayo score 1, (B) ultrasound appearance of rectosigmoid wall showing borderline thickened wall about 0.30 cm with preserved layer stratification, (c) color doppler of pericolic fat showing small spots, (D) shear wave elastography of the rectal wall measuring elastography wave E1 & E2 & SR.

Diagnostic accuracy of the BUS in prediction of response to treatment in UC patients

BWT with a cut off value 0.31 cm in comparison to colonoscopic findings had a perfect kappa agreement 0.820 with 90.9% accuracy, 83.3% sensitivity, 100.0% specificity, 100.0% PPV and 83.3% specificity with P value P <0.001 as shown in (**Table.6**).

Table 6. Diagnostic accuracy for BWT in UC diagnosis and prediction of clinical response in comparison to colonoscopy

Variables		Colonoscopy		Total
		Disease	Normal	
BWT	>0.31	15 (45.5%)	0 (0.0%)	15 (45.5%)
	≤0.31	3 (9.1%)	15 (45.5%)	18 (54.5%)
	Total	18 (54.5%)	15 (45.5%)	33 (100.0%)
Kappa agreement		0.820		P <0.001

Validity measures	Value	
Sensitivity, %	83.3%	
Specificity, %	100.0%	
Positive predictive value %	100.0%	
Negative predictive value, %	83.3%	
Accuracy, %	90.9%	

AUC: area under the curve; 95% CI: 95% confidence interval; P: P value, significant.. levels of agreement: Kappa < 0: No agreement: Kappa between 0.00 and 0.20: Slight agreement: Kappa between 0.21 and 0.40: Fair agreement: Kappa between 0.41 and 0.60: Moderate agreement: Kappa between 0.61 and 0.80: Substantial agreement. Kappa between 0.81 and 1.00: Almost perfect agreement."

Discussion

Decisions for management plan for UC and monitoring patients is determined mainly by colonoscopy and histopathology. There are unmet needs for non-invasive and non-costly maneuvers for assessment of severity of inflammation and response to treatment to reduce the burden of the disease. Imaging techniques are considered as accepted reference for diagnosis and monitoring IBD patients and in detection of complication **(Kucharzik et al., 2022)**. Recently there is a great advance in using BUS **(Mihai et al., 2024)**, despite the paucity of using it in IBD **(Radford et al., 2022)**.

Thirty-three UC patients were enrolled in our study in addition to another fifteen patients as a control group. They were young age with nearly equal in gender distribution. Despite UC is considered an autoimmune disease but it is widely known that there is no female predominance in UC, and these results were consistent with the previous studies **(Gorospe et al., 2024; Weidner et al., 2024; Zhang et al., 2024)**. However, some authors had cleared male predominance in UC incidence **(Goodman et al., 2020; Greuter et al., 2020; Rustgi et al., 2020)** and these data due to changes in age, geographic distribution and number of participants.

Baseline laboratory data in our study revealed low hemoglobin level, serum ferritin level, serum iron level and serum albumin level in UC patients in comparison to control group. It is well known that UC patients are prone to iron deficiency anemia **(Farrag et al., 2024; Fiorino et al., 2024; Jain et al., 2023; Ramasamy et al., 2023; Shah et al., 2021)**. Low serum albumin in patients with UC is a well-known finding. Many indices and ratios including serum albumin are used to evaluate the severity of the disease and response to treatment **(Ali et al., 2024; Farrag et al., 2024; Lee et al., 2021; Pan et al., 2023; Wang et al., 2022)**. This could be due to malnutrition either low intake or decreased absorption and/or decreased synthesis by the liver **(Chen et al., 2020)**. Our studied patients had high ESR and CRP levels in active disease which decreased after treatment, these data were agreed by many studies **(Grant et al., 2024; Nguyen et al., 2024; Şahin and Okçu, 2024; El Sharawy et al., 2021; Song et al., 2024)**. On the other hand, another study had shown that ESR level is increased after treatment **(Buran et al., 2024)**. They concluded that ESR is significant marker for activity but no sufficient marker for remission.

BUS parameters were found to have considerable significance in diagnosis of UC at baseline data through using BWT, WLS, CDS, pericolic lymph nodes and pericolic fat changes. These data were agreed by the previously reported studies **(Chavannes et**

al., 2024; El-Nakeep, 2024; Hoffmann and Ungewitter, 2024; Komatsu et al., 2024; Malik et al., 2024). We found a significant accuracy of using BWT in UC diagnosis at baseline data comparing between UC patients either in activity or in remission and control group with cut off value 0.31 cm, AUC 95%CI 0.956, with high sensitivity and specificity 83.3% & 100% respectively. Also, we found perfect agreement of BWT in diagnosis and prediction of response to treatment in comparison to coloscopy findings with cut off value 0.31 cm with high sensitivity and specificity 83.3% and 100% respectively with 0.820 kappa agreement.

Most of previous studies had used BWT with cut off 0.3 cm in evaluating disease activity **(Komatsu et al., 2024; Miyoshi et al., 2022; Otani et al., 2024; Reijntjes et al., 2023; Sagami et al., 2020).** Some authors used a cut off 0.4 cm and beyond **(An et al., 2023; Komatsu et al., 2024; Voogd et al., 2022).** A systematic review and meta-analysis had studied the accuracy of BWT in UC diagnosis revealed sensitivity ranged 71-100%, specificity 64-100%, accuracy 91%, PPV 91% and NPV 69% **(Goodsall et al., 2021)**. Another recent study had demonstrated sensitivity 70.0%, specificity 97.7%, PPV 95.5% and NPV 82.7% with BWT cut off 0.3 cm **(Miyoshi et al., 2022)**. Sagami et al; had used BWT with a cut off more than 0.3cm, revealed 86.4% pooled sensitivity and 88.3% pooled specificity **(Sagami et al., 2021)**.

Using a cut off value more than 0.4 cm BWT had revealed 100% sensitivity and 83% specificity, 78.7% PPV and 100% NPV in a previously published study **(Les et al., 2021).** Some authors had agreed that using a cut off value more than 0.4 cm BWT is more accurate than 0.3 cm to avoid false positive results **(Zhang et al., 2024)**.

BUS revealed a clinical significance at follow up patients in comparison to colonoscopy findings in monitoring UC patients and response to treatment. BWT, WLS, CDS, pericolic lymph nodes presence and pericolic hyperechogenicity showed a clinical significance. These data meet an agreement with many authors **(El-Nakeep, 2024; Gomes et al.,2021; Krugliak et al., 2024; Les et al., 2021; Sagami et al., 2021; Smith et al., 2020; Lalosevic et al., 2022; Yzet et al., 2024; Zhang et al., 2024).** However, BUS has some limitations, including lower accuracy compared to MRE in evaluating the proximal small bowel, lower interobserver reliability for some sonographic parameters (i.e., CDS, pericolic fat inflammation, WLS), and the need for specific training **(Vitello et al., 2024)**. BWT showed a 94.0% accuracy in monitoring response to therapy at a cut off point 0.3 cm with 94.4% sensitivity, 93.3% specificity, 94.4% PPV and 93.3% NPV with P value <0.001. These data were consistent with other authors opinion **(Allocca et al., 2021; Maaser et al., 2020; Sathananthan et al., 2020)**. American Gastrointestinal Association (AGA) had declared that BUS is accurate in prediction of treatment response with 73% sensitivity and 100% specificity **(Dolinger et al., 2024)**.

Unfortunately, bowel ultrasound elastography didn't show clinical importance in predicting the clinical response and monitoring. These findings may be due to the small participants of the study. Another explanation for these findings could be due to that we examined both of two areas from the same bowel wall, make SR inaccurate to compare stiffness, on the contrary some authors tend to measure affected bowel wall to another unaffected either in the same patient or in a normal population **(Dietrich et al., 2019; Gabbiadini et al., 2021)**, which is difficult practice. Other authors compared the inflamed wall with the peri wall fat **(Lo et al., 2017)**, which gives an inaccurate result

as comparing two different tissue elasticity. There is a conflict between the authors either with **(Goertz et al., 2019; Zhu et al., 2024)** or against (**Cebula et al., 2022; Ślósarz et al., 2021).** This could be attributed to the limited cohort of the patients with different devices manufacturers, also, the heterogeneity of the bowel segments analyzed in the mentioned studies **(Dal Buono et al., 2022)**.

Limitations: Our study had some limitations that could affect our findings. First, low number of study participants, large study participants make results reliable. Another limitation is that we did elastography in two regions of the same wall segment, which made SR non reliable, many readings from variable segments is needed for accurate evaluation.

Recommendations : We recommend further research about bowel shear wave elastography as it is a promising technology for non-invasive monitoring of UC patients.

Conclusion

BUS is a non-invasive tool that can be used for UC diagnosis and monitoring patients and response to treatment. Shear wave elastography is a new technique which can be widely used in UC patients, it needs more research on a large scale of population.

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