

## Original Article

# The practical value of energy doppler ultrasound in evaluating active degree of inflammatory bowel disease

Shoujuan Luo, Xiaomei Sun, Lan Zhu, Jiannan Lv, Feng Chao

Department of Color Ultrasound Room, Disease Hospital of Heilongjiang Province Hospital, Haierbin 150001, Heilongjiang, China

Received January 10, 2019; Accepted June 5, 2019; Epub July 15, 2019; Published July 30, 2019

**Abstract:** Ultrasonography is a simple and effective method to determine the prognosis of inflammatory bowel disease (IBD). The power Doppler ultrasound examination is not affected by the speed of sound, direction of blood vessels, and velocity of blood flow. Therefore, it is considered to be of value in the diagnosis of intestinal diseases. Therefore, this study explored the practical value of power Doppler ultrasound in assessing IBD activity. In this study, 50 patients with clinically diagnosed IBD including ulcerative colitis and Crohn's disease and 50 healthy volunteers were selected. They were divided into three groups: ulcerative colitis group and Crohn's disease group, and normal control. All subjects underwent ultrasonography during the treatment period, and the power Doppler ultrasound technique was used to evaluate the disease activity in combination with the Limberg grading method. Colonoscopy was applied as control. Among 50 patients enrolled, the accuracy of ultrasonic diagnosis was 86% for ulcerative colitis and 94% for Crohn's disease. The Limberg grading method was used to classify the intestinal wall and blood flow. In patients with ulcerative colitis, the Limberg grading of active and remission patients showed a statistically significant difference ( $\chi^2=26.325$ ,  $p < 0.05$ ). In patients with Crohn's disease, the Limberg grading of patients with active and remission was also statistically different ( $\chi^2=22.345$ ,  $p < 0.05$ ). In conclusion, power Doppler has a high diagnostic accuracy for IBD and can be used to assess IBD activity.

**Keywords:** Gray scale ultrasound, power Doppler, ulcerative colitis, Crohn's disease

## Introduction

Inflammatory bowel disease (IBD) is divided into Crohn's disease (CD) and ulcerative colitis (UC) [1, 2]. IBD is a chronic and non-specific intestinal inflammatory disease with abnormal intestinal immune function. Treatment and prevention of IBD should be highly valued since it affects not only the quality of life, but it also has a high risk of transformation into malignances [3, 4].

At present, the diagnosis of IBD is mainly based on the combination of clinical manifestations, pathological examinations, imaging and endoscopy. However, due to similar results of endoscopic examination and clinical manifestations, the poor positive rate of biopsy, the diagnosis and typing of IBD, especially the identification of colonic CD and UC is still difficult [5]. The power Doppler ultrasound is featured as a sim-

ple and safe technique, thus widely used in clinical practice. This technique can clearly show changes in the structure of the alimentary canal wall and the surrounding conditions, which can greatly improve the accuracy of the diagnosis when combined with endoscopic examination [6]. In addition, ultrasound does not have radiation and trauma, and has relatively good repeatability. It has been widely used in the diagnosis and treatment of various diseases in clinical practice [7]. Since the number of patients with IBD in our hospital has been increased year by year, we expect that the use of intestinal ultrasonography should be an effective complement to endoscopy for patients' detection and follow-up, especially for the severe IBD patients that cannot tolerate conventional endoscopy and radiology. In addition, ultrasound can also perform regular follow-up on a part of remission cases, which is a simple and effective method to judge the prognosis of IBD.

**Table 1.** Limberg grading

Grade 0	Normal intestinal wall.
Grade I	Only the wall thickens.
Grade II	Intestinal wall thickening and the appearance of short blood vessels.
Grade III	Intestinal wall thickening and the appearance of short blood vessels.
Grade IV	Intestinal wall thickening and the appearance of short blood vessels connecting to the mesentery.

**Table 2.** Clinical information comparison

Item		UC (n=50)	CD (n=50)	Normal control (n=50)
Age (year)		39.1±7.2	38.9±6.8	39.5±6.2
Gender (cases)	Man	28	27	26
	Female	22	23	24
Active stage (cases)		29	27	–
Remission stage (cases)		21	23	–

colonoscopy to determine the extent and activity of IBD.

*Ultrasonography*

Ultrasonography and bowel endoscopy were performed on the two continuous working days. After the endoscopy was completed, fasting ultrasound was performed in the early morning of the next day.

Therefore, in this study, routine ultrasound imaging on patients was performed with clinically diagnosed IBD during the treatment period, and power Doppler ultrasound technique was used to assess the disease activity in combination with Limberg grading and colonoscopic findings.

**Materials and methods**

*Study objects*

Patients with IBD who were treated in Disease hospital of Heilongjiang Province Hospital and healthy volunteers were enrolled in the study. They were excluded from other intestinal diseases and signed informed consent. This study was approved by the Institutional Ethics Committee.

*Case collection*

In this study, 50 patients were selected with clinically diagnosed IBD including ulcerative colitis and Crohn’s disease and 50 healthy volunteers. Clinical data were compared based on age, gender, and activity.

*Endoscopy*

Intestinal biopsy combined with biopsy was the gold standard for IBD. Endoscopic findings were compared with ultrasound findings. Prior to endoscopy, bowel preparation was performed using polyethylene glycol, followed by routine

Before the ultrasound examination, the patients were required to exhaust and defecate. An abdomen probe of color Doppler ultrasound was used to test the bowel from the rectum to the ascending colon. After determining the site of increased bowel thickness, two-dimensional gray-scale ultrasound was applied to observe and measure the thickness of the intestinal wall, and then the blood flow conditions were determined and recorded in the power Doppler mode. Finally, in the pulse mode, the blood flow of the internal wall was recorded and the arterial resistance index was measured. The thickness and blood supply of the same patient at different stages of the intestine were examined. The disease activity was assessed using the Limberg grading method. Grades I and II indicated remission, while grades III and IV indicated active periods. Newly-diagnosed cases: For the first time, detailed records were taken of the distribution, extent, echo, and structural hierarchy of the intestine in the diseased segment, especially the blood flow of intestinal wall. Ultrasonography was repeated every 2 months during the medication (**Table 1**).

*Statistical analysis*

SPSS 20.0 software was used for statistical analysis. The student t-test was used to compare the means of the two groups. One-way ANOVA analysis was adopted to compare the differences among multiple groups. The rates were compared using  $\chi^2$  tests via two-tailed

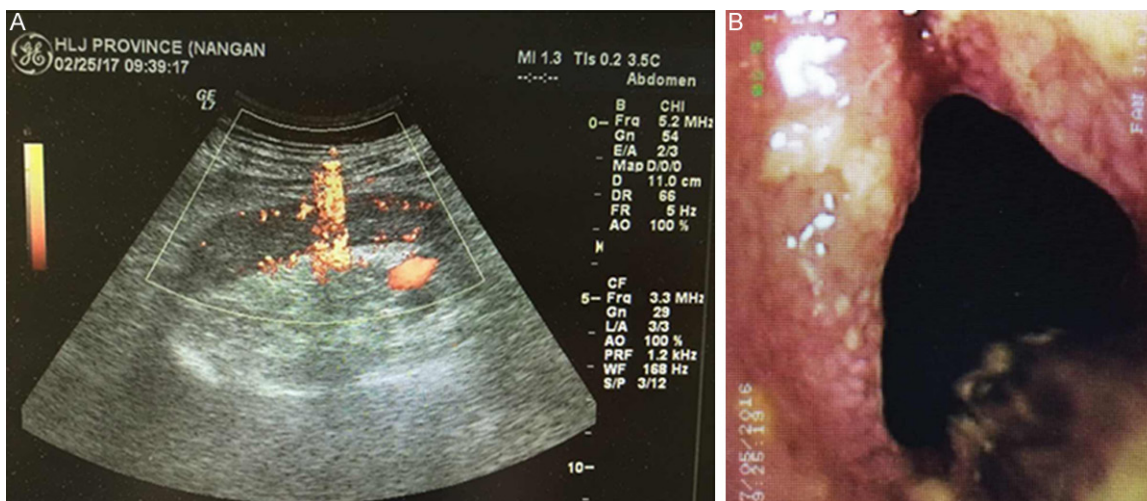


Figure 1. Ultrasonography and endoscopy.

Table 3. Intestine wall Limberg grading

Grade	UC				CD				Healthy control	
	Active		Remission		Active		Remission		Case	Proportion (%)
	Case	Proportion (%)	Case	Proportion (%)	Case	Proportion (%)	Case	Proportion (%)		
Grade 0	0	0.0	10	47.6	0	0.0	8	34.8	37	74.0
Grade I	6	20.7	7	33.3	2	7.4	9	39.1	13	26.0
Grade II	7	24.1	3	14.3	10	37.0	5	21.7	0	0.0
Grade III	9	31.0	1	4.8	13	48.1	1	4.3	0	0.0
Grade IV	4	13.8	0	0.0	2	7.4	0	0.0	0	0.0

method.  $P < 0.05$  was considered as a statistical difference.

## Results

### General information comparison

There were no statistical differences on the age, gender, and activity among the three groups (Table 2).

### The accuracy rate comparison between ultrasound and endoscopy in IBD

According to the described method, patients were diagnosed by ultrasound and endoscopy, respectively. Figure 1A showed a representative picture of a CD patient that a marked thickening of the intestinal wall with a marked increase of the blood flow signal upon power Doppler. Figure 1B was representative of the enteroscope. The enteroscope entered the anus and followed the lumen in patient under

anesthesia. The contrast agent showed three strictures on the mouth side accompanied by stenosis mucosa laceration, thus the patient was diagnosed as CD with multiple small intestine stenosis. Then the accuracy of ultrasound diagnosis in CD and UC was calculated, respectively. Among 50 patients in each group, the accuracy of ultrasonic diagnosis was 86% for UC and 94% for CD. Power Doppler ultrasound exhibited high accuracy in the diagnosis of IBD, and had good clinical value. Moreover, its accuracy on CD was higher than that on UC.

### Limberg grading condition in IBD

In this study, Limberg grading was used to rank the thickness of the intestinal wall and the blood flow in each group (Table 3). The  $\chi^2$  test was performed among the groups. In UC patients, the Limberg grading of active and remission patients showed statistically significant differences ( $\chi^2=26.325$ ,  $P < 0.05$ ). Active

patients had higher proportion in grade I, II, and III, whereas, remission patients were mainly in grade 0 and I. In CD patients, the Limberg grading of patients with active and remission was statistically different ( $\chi^2=22.345$ ,  $P < 0.05$ ). Most active patients were in grade II and III, whereas remission patients were mainly in grade 0 and I. There was a significant difference in Limberg grading between active UC and CD patients compared with the healthy controls ( $P < 0.05$ ). However, there was no statistical difference in Limberg grading in UC patients at remission stage ( $P > 0.05$ ).

### Discussion

IBD usually shows the characteristics of chronic relapsing and remission. Thus, patients need to receive repeated imaging examinations. According to the disease activity and severity, the appropriate treatment plan should be guided in real time [8, 9].

Intestinal ultrasound through the abdominal wall is an important part of IBD imaging diagnosis, which is featured as non-invasive, non-radioactive, and well toleration. In addition, as an important examination method in IBD diagnosis and treatment, it has received more and more attention [10]. Therefore, this study aimed to investigate the value of power Doppler ultrasound in evaluating IBD activity.

Ultrasonography does not require bowel preparation. The patient was first subjected to conventional abdominal ultrasonography to understand the pathological changes of the bowel, and then received a high-frequency linear array probe for detailed examination. This method achieved better spatial resolution and clearly showed intestinal peristalsis, intestine narrowing or expansion, and the level and thickness of the intestinal wall [10, 11]. The microcirculation of the intestine wall was increased in the IBD. Small and low-velocity minute blood flow in the intestinal wall, the vascularization of the intestinal wall, and the disease activity in the evaluation of IBD can be observed in the power Doppler ultrasound examination [12, 13]. Moreover, since power Doppler ultrasound examination is not affected by the speed of sound, the direction of blood vessels, and the velocity of blood flow [14]. Therefore, it has a certain value in the diagnosis of intestinal diseases.

At present, the main diagnostic methods for IBD are ultrasonography, endoscopy, and histopathology [15]. Pathological diagnosis is the gold standard for IBD. However, because of its invasive examinations, it has certain limitations in clinical application. Endoscopy can only observe some changes in the intestinal wall surface. The diagnostic value of ultrasonography for IBD has been confirmed by several studies [16]. In previous studies, transabdominal ultrasound has certain advantages in the observation of intestinal wall resuscitation, structural hierarchy, and intestinal thickness in IBD lesions [17]. The sensitivity and specificity of ultrasound examination to determine the activity of CD were 84% and 92%, respectively, which was similar to those of CT and MRI. Ultrasound could be repeatedly used during the course of treatment without radioactivity. It exhibited advantages in intestinal wall thickness, structure level, and blood supply observation [18-21]. In the previous period, IBD was diagnosed based on ultrasound and was confirmed by colonoscopy. After retrospective analysis, the characteristic ultrasound features of IBD were summarized and laid a good foundation for the future development of the technique.

However, there are few studies on the evaluation of power Doppler ultrasound in combination with Limberg classification. In this study, power Doppler ultrasound technology was used for diagnosis of IBD, and the results found that the accuracy rate of power Doppler ultrasound for UC and CD was 86% and 94%, respectively. The Limberg grading of UC and CD in active and remission phases was statistically significant compared with the control group, which was in accordance with the previous study on the gray-scale ultrasound for the assessment of intestinal blood flow and intestinal wall thickness. In this study, it was confirmed that the diagnostic accuracy of IBD using power Doppler ultrasound is high and the IBD activity can be evaluated. Power Doppler ultrasound can be used as an effective method for the diagnosis and activity assessment of IBD.

In this study, the power Doppler ultrasound technique was used to assess the degree of IBD activity, breaking the rule that IBD patients rely only on colonoscopy as a means of follow-up. The traditional concept considered that transabdominal ultrasound cannot observe the

intestinal inflammatory lesions. However, power Doppler ultrasound technology can not only observe the small blood flow in the intestinal wall, but also can't be limited by the direction of blood flow, while observing the parenteral complications to make up for the lack of colonoscopy. Due to limited number of patients enrolled in the present study, large cohort clinical studies are required to confirm the value of power Doppler ultrasound technology in the diagnosis of IBD.

### Conclusion

Power Doppler has a high diagnostic accuracy for IBD and can be adopted to assess IBD activity.

### Acknowledgements

This work was supported by the Technological Innovation Special Foundation of Harbin Science and Technology Bureau (No. 2016-RAQXJ162).

### Disclosure of conflict of interest

None.

**Address correspondence to:** Dr. Feng Chao, Department of Color Ultrasound Room, Disease Hospital of Heilongjiang Province Hospital, No. 405, Gogol Street in Nangang District, Haierbin 150001, Heilongjiang, China. Tel: +86-0451-88025125; Fax: +86-0451-88025125; E-mail: yazhilu918@163.com

### References

- [1] de Lange KM, Barrett JC. Understanding inflammatory bowel disease via immunogenetics. *J Autoimmun* 2015; 64: 91-100.
- [2] Zhang YZ, Li YY. Inflammatory bowel disease: pathogenesis. *World Journal of Gastroenterology* 2014; 20: 91-9.
- [3] Rosen MJ, Dhawan A, Saeed SA. Inflammatory bowel disease in children and adolescents. *JAMA Pediatr* 2015; 169: 1053-60.
- [4] Voutilainen M, Hutri-Kahonen N, Tossavainen P, Sipponen T, Pitkanen N, Laitinen T, Jokinen E, Ronnema T, Viikari JSA, Raitakari OT, Juonala M. Low childhood high density lipoprotein cholesterol levels and subsequent risk for chronic inflammatory bowel disease, digestive and liver disease. *Official Journal of The Italian Society of Gastroenterology and The Italian Association for The Study of The liver* 2018.
- [5] Cohen S, Martinez-Vinson C, Aloï M, Turner D, Assa A, de Ridder L, Wolters VM, de Meij T, Alvisi P, Bronsky J, Kopylov U. Cytomegalovirus infection in pediatric severe ulcerative Colitis-A multicenter study from the pediatric inflammatory bowel disease porto group of the European society of pediatric gastroenterology, hepatology and nutrition. *The Pediatric Infectious Disease Journal* 2018; 37: 197-201.
- [6] Terracciano F, Scalisi G, Bossa F, Scimeca D, Biscaglia G, Mangiacotti M, Valvano MR, Perri F, Simeone A, Andriulli A. Transperineal ultrasonography: first level exam in IBD patients with perianal disease, digestive and liver disease. *Official Journal of The Italian Society of Gastroenterology and The Italian Association for The Study of The Liver* 2016; 48: 874-9.
- [7] Hansson NH, Sorensen J, Harms HJ, Kim WY, Nielsen R, Tolbod LP, Frokiaer J, Bouchelouche K, Dodt KK, Sihm I, Poulsen SH, Wiggers H. Metoprolol reduces hemodynamic and metabolic overload in asymptomatic aortic valve stenosis patients: a randomized trial, circulation. *Circ Cardiovasc Imaging* 2017; 10.
- [8] Lim HS, Kim SK. Food elimination diet and nutritional deficiency in patients with inflammatory bowel disease. *Clin Nutr Res* 2018; 7: 48-55.
- [9] Kotze PG, Magro DO, Saab B, Saab MP, Pinheiro LV, Olandoski M, Ayrizono MLS, Martinez CAR, Coy CSR. Comparison of time until elective intestinal resection regarding previous anti-tumor necrosis factor exposure: a Brazilian study on patients with Crohn's disease. *Intestinal Research* 2018; 16: 62-68.
- [10] Novak K, Tanyingoh D, Petersen F, Kucharzik T, Panaccione R, Ghosh S, Kaplan GG, Wilson A, Kannengiesser K, Maaser C. Clinic-based point of care transabdominal ultrasound for monitoring crohn's disease: impact on clinical decision making. *Journal of Crohn's & colitis* 2015; 9: 795-801.
- [11] Kucharzik T, Petersen F, Maaser C. Bowel ultrasonography in inflammatory bowel disease. *Digestive Diseases (Basel, Switzerland)* 2015; 33 Suppl 1: 17-25.
- [12] Dai C, Jiang M, Sun MJ, Cao Q. Fecal immunochemical test for predicting mucosal healing in ulcerative colitis patients: a systematic review and meta-analysis. *J Gastroenterol Hepatol* 2018; 33: 990-997.
- [13] Eliakim R, Magro F. Imaging techniques in IBD and their role in follow-up and surveillance, *Nature reviews. Nat Rev Gastroenterol Hepatol* 2014; 11: 722-36.
- [14] Raymond SB, Gee MS, Anupindi SA, Shailam R, Kaplan JL, Nimkin K. CT and MRI of rare extraintestinal manifestations of inflammatory bowel disease in children and adolescents.

## EDU in evaluating active degree of IBD

- Journal of Pediatric Gastroenterology and Nutrition 2016; 63: e1-9.
- [15] Lee SH, Kwon JE, Cho ML. Immunological pathogenesis of inflammatory bowel disease. *Intestinal Research* 2018; 16: 26-42.
- [16] Park DI, Hisamatsu T, Chen M, Ng SC, Ooi CJ, Wei SC, Banerjee R, Hilmi IN, Jeon YT, Han DS, Kim HJ, Ran Z, Wu K, Qian J, Hu PJ, Matsuoka K, Andoh A, Suzuki Y, Sugano K, Watanabe M, Hibi T, Puri AS, Yang SK. Asian organization for Crohn's and colitis and Asia pacific association of gastroenterology consensus on tuberculosis infection in patients with inflammatory bowel disease receiving anti-tumor necrosis factor treatment. Part 1: risk assessment. *Intest Res* 2018; 16: 4-16.
- [17] Ali F, Al-Kindi SG, Blank JJ, Peterson CY, Ludwig KA, Ridolfi TJ. Elevated venous thromboembolism risk following colectomy for IBD is equal to those for colorectal cancer for ninety days after surgery. *Dis Colon Rectum* 2018; 61: 375-381.
- [18] Atreya R, Neurath MF. Predicting therapeutic response by in vivo molecular imaging in inflammatory bowel diseases. *Digestive Diseases (Basel, Switzerland)* 2016; 34: 552-7.
- [19] Medellin A, Merrill C, Wilson SR. Role of contrast-enhanced ultrasound in evaluation of the bowel. *Abdom Radiol (NY)* 2018; 43: 918-933.
- [20] Gonczi L, Kurti Z, Golovics PA, Lovasz BD, Menyhart O, Seres A, Sumegi LD, Gal A, Ilias A, Janos P, Gecse KB, Bessisow T, Afif W, Bitton A, Vegh Z, Lakatos PL. Quality of care indicators in inflammatory bowel disease in a tertiary referral center with open access and objective assessment policies, digestive and liver disease. *Official Journal of The Italian Society of Gastroenterology and The Italian Association for The Study of The Liver* 2018; 50: 37-41.
- [21] Tonolini M, Magistrelli P. Enterocutaneous fistulas: a primer for radiologists with emphasis on CT and MRI. *Insights Imaging* 2017; 8: 537-548.