Doppler Waveforms and Blood Flow Parameters of the Superior and Inferior Mesenteric Arteries in Patients Having Behçet Disease With and Without Gastrointestinal Symptoms

Preliminary Data

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Objective. To evaluate hemodynamic changes in mesenteric arteries in patients with Behçet disease with and without gastrointestinal symptoms. ***Methods.*** Doppler sonography of mesenteric arteries was performed in 25 symptomatic and 15 asymptomatic patients having Behçet disease and in 25 healthy control subjects. The peak systolic, minimal, and mean velocities, resistive and pulsatility indexes, inner diameter, cross-sectional area, and blood flow volume of mesenteric arteries were evaluated. The results were compared between patient groups and controls. ***Results.*** The mesenteric artery flow was significantly greater in patients in the symptomatic group than in those in the asymptomatic group or in controls. In the superior mesenteric artery, mean velocity and mean blood flow volume (0.35 ± 0.18 m/s and 711 ± 404 mL/min, respectively; $P < .0001$) in the symptomatic group were significantly higher than in the asymptomatic group (0.16 ± 0.07 m/s and 305 ± 168 mL/min, respectively) or in controls (0.15 ± 0.07 m/s and 290 ± 123 mL/min, respectively). The mean peak systolic velocity (1.23 ± 0.47 m/s; $P < .005$) in the symptomatic group was significantly higher than in controls (0.93 ± 0.23 m/s). In the inferior mesenteric artery, mean velocity and mean blood flow volume (0.25 ± 0.10 m/s and 139 ± 79 mL/min) in the symptomatic group were significantly higher than in the asymptomatic group (0.16 ± 0.07 m/s; $P < .006$; and 78 ± 26 mL/min; $P < .007$) or in controls (0.17 ± 0.07 m/s; $P < .003$; 83 ± 48 mL/min; $P < .004$). ***Conclusions.*** In this study, symptomatic patients with gastrointestinal Behçet disease were associated with a significant increase in mesenteric artery flow that could be evaluated easily on spectral patterns of arteries during Doppler sonography. The Doppler sonographic findings also revealed that intestinal involvement in patients with Behçet disease without gastrointestinal symptoms is not significantly different from that of healthy controls. ***Key words:*** Behçet disease; Doppler sonography; duplex sonography; gastrointestinal system; mesenteric arteries.

Abbreviations
BD, Behçet disease; BFV, blood flow volume; CT, computed tomography; IMA, inferior mesenteric artery; PI, pulsatility index; PSV, peak systolic velocity; RI, resistive index; SMA, superior mesenteric artery; V_{mean}, mean velocity; V_{min}, minimum velocity

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Behçet disease (BD) is a chronic, recurring, systemic disorder characterized by nonspecific vasculitis in multiple organs. Behçet disease involves the gastrointestinal tract in 3% to 26% of patients; such involvement results from vasculitis in the small vessels of the bowel wall, more frequently in the venules.[1] Any part of the intestine may be affected, but the main sites of involvement are the terminal ileum and cecum.[2] The lesions of gastrointestinal BD are deep, punched-out, penetrating, and discrete mucosal ulcerations.[3] Symptoms of gastrointestinal BD may include diarrhea, abdominal pain, bloody stools, and anorexia.

Although the diagnosis of BD is based primarily on clinical criteria,[4,5] patients with BD usually undergo many invasive and noninvasive procedures according to their clinical signs and symptoms. However, the role of Doppler analysis to assess changes of splanchnic perfusion has not been fully investigated in patients having BD with and without gastrointestinal symptoms. Previous studies have described the Doppler characteristics of the superior mesenteric artery (SMA) and inferior mesenteric artery (IMA) under normal conditions and in the presence of intestinal and extraintestinal diseases.[6–19] To our knowledge, a Doppler sonographic study of the SMA and IMA in cases of BD with and without gastrointestinal symptoms has not been reported. In this study, we tried to evaluate the Doppler sonographic blood flow parameters and spectral patterns in the SMA and IMA in BD that primarily affect the venules of the bowel wall with and without gastrointestinal symptoms.

Materials and Methods

A list of 57 patients, who fulfilled the criteria for diagnosis of BD put forth by the International Study Group for BD[4] and subsequently validated by O'Neill et al,[5] was taken from the departments of dermatology and ophthalmology. A telephone questionnaire was completed for each patient. The symptomatic patient group (n = 27) of our study included those with regular diarrhea, abdominal pain, bloody stools, vomiting, and anorexia. The other patient group, called the asymptomatic patient group (n = 15), included patients having BD without gastrointestinal symptoms. The resultant symptomatic and asymptomatic patient groups of our study consisted of 42 patients. We informed them about B-mode and Doppler sonography and obtained written and oral consent from all patients and the control group. The study was approved by the hospital Ethics Committee. The investigation was carried out between January 2001 and June 2002.

Two of the 27 symptomatic patients were excluded from the study because of inadequate visualization of the SMA and IMA. Therefore, the symptomatic patient group consisted of 25 patients (12 female and 13 male; age range, 14–55 years; mean age ± SD, 34 ± 12 years). The mean duration of BD was 5.5 years (range, 1 month–18 years). All the symptomatic patients had abdominal pain. The sites of the pain were the epigastrium in 3, the right lower abdomen in 2, the left abdomen in 1, and the entire abdomen in 19. In addition to the abdominal pain, 11 patients had diarrhea, and 8 had anorexia and vomiting. One patient had a history of ileocolic intussusception 10 years before. Another patient had undergone an operation for a polypoid lesion in the descending colon 5 years ago. There were eye problems in 10 of 25 patients. Nineteen patients had been using colchicine and steroid drugs during exacerbations of the symptoms related to gastrointestinal BD. Patients were taking medication (analgesics and antidiarrheal drugs) for gastrointestinal conditions considered symptomatic if they had any of the aforementioned symptoms. Although a barium study or computed tomography (CT) of the gastrointestinal tract was planned, we could not get informed consent for these invasive procedures except from 6 symptomatic patients. There were no specific findings on small-bowel follow-through and double-contrast barium enema studies of the colon and CT images of the gastrointestinal tract in these 6 patients. The asymptomatic patient group consisted of 15 patients (9 female and 6 male; age range, 25–50 years; mean age, 38 ± 14 years). The mean duration of BD was 7.3 years (range, 4–16 years). All these patients except 1 had been using steroid drugs. Two of 15 patients had blindness. During routine systemic evaluation, all the patients were evaluated for possible cardiac manifestations of BD such as myocarditis, intracardiac thrombus, and arrhythmias and for depressed cardiac output to minimize alterations in mesenteric Doppler parameters.

During the same period, 25 healthy, asymptomatic subjects without any history of renal, cardiovascular, or intestinal disease served as a control group. The control group consisted of 15 women and 10 men with an age range of 19 to 57 years (mean, 37 ± 11 years).

B-mode and duplex Doppler sonography was performed with scanners (HDI 5000 and HDI 3500; Philips Medical Systems, Bothell, WA) equipped with convex 2- to 5-MHz and linear 4- to 7-MHz probes. All patients and control subjects were examined in a resting condition after approximately 8 hours of fasting in the supine position. The entire abdomen was first examined to rule out any aneurysm, thrombus, or occlusive or stenotic abnormality in both the aorta and inferior vena cava with their main branches[16] and any possible abnormality related to the gallbladder, kidneys, and small and large bowels. The SMA and IMA were identified on B-mode sonography, and the origin of the IMA was searched at a distance of 3 to 5 cm from the aortic bifurcation.[19] Gas in the overlying intestine and obesity are the 2 important limiting factors in the identification of both the SMA and IMA. After detection of both arteries, duplex Doppler examination was performed. Angle-corrected Doppler spectral patterns were obtained from the subsequent straight segment, instead of the curved proximal segment, of both the SMA and IMA to avoid motion artifacts caused by aortic pulsations. The Doppler angle was kept below 60° with respect to the long axis of the artery. The Doppler sample volume was adjusted to the SMA and IMA diameter and positioned at the center of the vessel. The pulse repetition frequency was set to avoid aliasing, and the wall filter was optimized as low as possible to detect slow diastolic flow. The patients were instructed to suspend respiration during Doppler recordings. The peak systolic velocity (PSV), minimum velocity (V_{min}), mean velocity (V_{mean}), resistive index (RI), and pulsatility index (PI) were measured and calculated automatically by the spectral analyzer of the sonographic system. The Doppler evaluation and technique for blood flow volume (BFV) measurement were performed as described.[16,17,19,20] Although it could have been possible to calculate the BFV automatically by the sonographic system, we preferred to measure the inner diameters of the SMAs and IMAs at the site of Doppler interrogation manually. The built-in software determined the cross-sectional area. The BFV (in milliliters per minute) was calculated by multiplying V_{mean} (in meters per second) by cross-sectional area (in square millimeters) and 60. Three consecutive Doppler samplings showing tracings with the best technical characteristics obtained for each patient and control subject were then averaged. The same operator who was blinded to the patient's symptoms at the time of the sonographic study performed all the sonographic studies together with data analysis. The Doppler findings were compared between the patient groups and the control subjects.

The results are reported as mean ± SD. The normal distribution of the values for each parameter was determined by the Kolmogorov-Smirnov test. Doppler parameters for the symptomatic and asymptomatic patients and control subjects were compared by the Tukey test of post hoc multiple comparisons in 1-way analysis of variance. $P < .05$ was considered statistically significant.

Results

The Doppler parameters of the SMAs and IMAs in the symptomatic and asymptomatic patient and control groups are shown in Table 1.

The V_{mean} (0.25 ± 0.10 m/s) and mean BFV (139 ± 79 mL/min) in the IMA were significantly higher in the symptomatic patient group than in the asymptomatic patient group (0.16 ± 0.07 m/s; $P < .006$; and 78 ± 26 mL/min; $P < .007$, respectively) and were significantly higher in the symptomatic patient group than in the control group (0.17 ± 0.07 m/s; $P < .003$; 83 ± 48 mL/min, $P < .004$, respectively). The mean PSV (1.23 ± 0.47 m/s; $P < .005$) in the SMA was significantly higher in the symptomatic patient group than in the control group (0.93 ± 0.23 m/s). The V_{mean} and mean BFV (0.35 ± 0.18 m/s and 711 ± 404 mL/min, respectively) in the SMA were significantly higher in the symptomatic patient group than in the control group (0.15 ± 0.07 m/s and 290 ± 123 mL/min, respectively; $P < .0001$) and were significantly higher in the symptomatic patient group than in the asymptomatic patient group (0.16 ± 0.07 m/s and 305 ± 168 mL/min, respectively; $P < .0001$).

Table 1. Inferior and Superior Mesenteric Artery Flow Parameters in Patients Having Behçet Disease With and Without Gastrointestinal Symptoms and Control Subjects

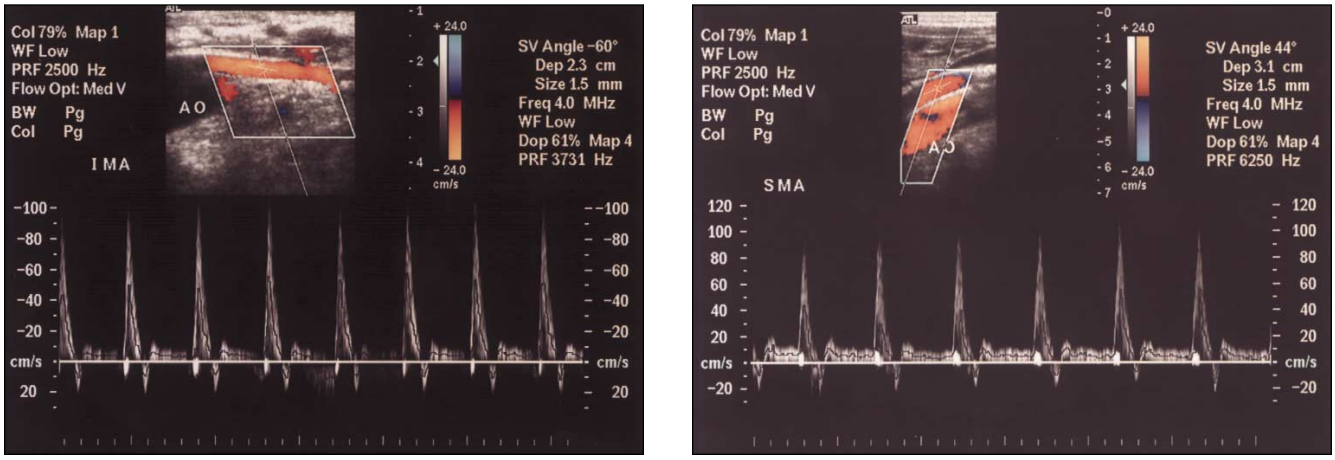
Group	Mean BFV, mL/min	Mean PSV, m/s	Mean V_{min}, m/s	V_{mean}, m/s	Mean PI	Mean RI	Mean D, mm	Mean A, mm^2
IMA								
Symptomatic patient group (n = 25)	139 ± 79	1.08 ± 0.4	–0.11 ± 0.09	0.25 ± 0.10	5.13 ± 2.02	1.08 ± 0.06	3.37 ± 0.73	9.32 ± 4.04
Control (n = 25)	83 ± 48 ($P < .004$)*	1.18 ± 0.35	–0.09 ± 0.14	0.17 ± 0.07 ($P < .003$)*	5.34 ± 2.68	1.05 ± 0.12	3.2 ± 0.66	8.37 ± 3.47
Asymptomatic patient group (n = 15)	78 ± 26 ($P < .007$)†	1.28 ± 0.38	–0.11 ± 0.07	0.16 ± 0.07 ($P < .006$)†	4.65 ± 1.03	1.09 ± 0.07	3.34 ± 0.47	8.92 ± 2.46
SMA								
Symptomatic patient group (n = 25)	711 ± 404	1.23 ± 0.47	–0.06 ± 0.21	0.35 ± 0.18	3.86 ± 1.54	1.04 ± 0.14	6.6 ± 1.12	35.1 ± 12
Control (n = 25)	290 ± 123 ($P < .0001$)*	0.93 ± 0.23 ($P < .005$)*	–0.1 ± 0.11	0.15 ± 0.07 ($P < .0001$)*	4.52 ± 1.29	1.08 ± 0.15	6.61 ± 1.14	35.3 ± 12.2
Asymptomatic patient group (n = 15)	305 ± 168 ($P < .0001$)†	1.17 ± 0.35	–0.12 ± 0.14	0.16 ± 0.07 ($P < .0001$)†	4.24 ± 1.48	1.11 ± 0.12	6.27 ± 0.88	31.4 ± 8.73

Values are mean ± SD. A indicates cross-sectional area; and D, diameter.
*Statistically significant values between symptomatic patient and control groups.
†Statistically significant values between symptomatic and asymptomatic patient groups.

Discussion

The pathogenesis of BD has yet to be fully elucidated. The diagnosis is based primarily on clinical criteria because of the nonspecific histopathologic findings. Behçet disease involves the intestine in 3% to 26% of cases, with a high rate of complications such as intestinal stenosis, perforation, fistulation, hemorrhage, and peritonitis.[1,21–24] Although barium studies and CT are useful in showing the characteristic radiographic features of gastrointestinal BD and in identifying the complications that are likely to occur,[3] these invasive procedures may be more appropriate during exacerbations. Doppler sonography is a noninvasive method for the evaluation of splanchnic hemodynamics that can reveal pathologic alterations characteristic of intestinal or extraintestinal diseases.[6–13,16–19] To our knowledge, no studies have been published on SMA and IMA blood flow hemodynamics in patients having BD with and without gastrointestinal symptoms.

The spectral patterns of the SMA and IMA in healthy subjects during a fasting state consist of an initial high-velocity forward component during systole and then a reversed flow of short duration before the appearance of a low-velocity forward flow during diastole. This triphasic spectral pattern was detected in 10 of 25 symptomatic patients, in 12 of 15 asymptomatic patients, and in 23 of 25 control subjects in our study (Fig. 1). The SMA supplies blood from the distal duodenum up to the splenic flexure. The distal third of the transverse colon, descending colon, sigmoid colon, and rectum are supplied by the smallest vessel among the mesenteric arteries, namely, the IMA.[25] In 3 of 5 symptomatic patients with pain in the epigastric and right lower abdomen, 6 of 19 symptomatic patients with entire abdominal pain, diarrhea, and anorexia, 2 of 15 asymptomatic patients, and 1 of 25 control subjects, there was loss of early diastolic reversed flow with increased forward flow during systole and diastole. This indicates an increase in PSV and V_{min} values in the SMA (Fig. 2) and also reflects moderately severe and multiple symptoms in addition to the abdominal pain in the symptomatic patients. However, there was a statistically significant difference only in the mean PSV, not the mean V_{min}, in the SMAs between the symptomatic patient and control groups. There was no statistically significant difference in the mean PSV and mean V_{min}



A B

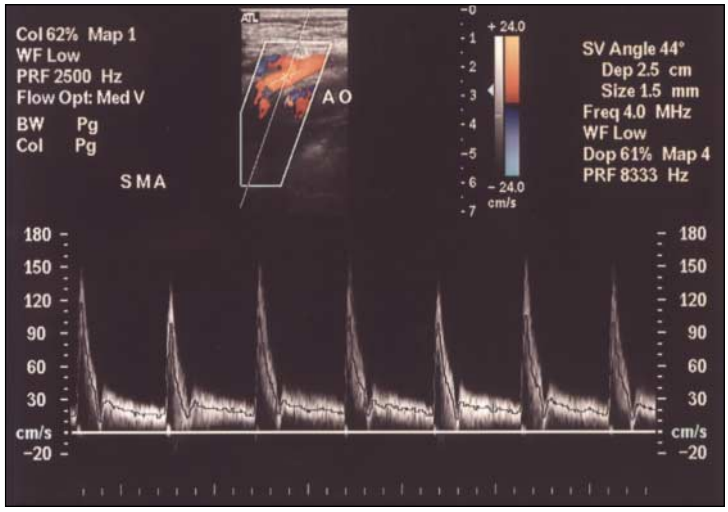
Figure 1. Behçet disease, 3-year history, with entire abdominal pain and anorexia in a 20-year-old-man. Doppler sonograms of the IMA (**A**) and SMA (**B**) show a normal triphasic spectral pattern (estimated BFVs, 30.78 and 326.2 mL/min, respectively). AO indicates aorta.

between the symptomatic and asymptomatic patient groups (Table 1). In 1 symptomatic patient with pain in the left lower abdomen and diarrhea, 5 of 19 symptomatic patients with entire abdominal pain, 1 of 15 asymptomatic patients, and 1 of 25 control subjects, there was loss of early diastolic reversed flow with increased forward flow during diastole, indicating an increase in V_{min} values in the IMA (Fig. 3). Nevertheless, there was no statistically significant difference in the mean V_{min} between the patient and control groups (Table 1).

Although we planned to evaluate any association between hemodynamic changes in the SMA and IMA and the symptom location statistically, this could not be accomplished because of nonspecific symptom locations. Hemodynamic changes were found only in the SMA in 3 of 5 symptomatic patients with pain in the epigastric and right lower abdomen, and only the IMA blood flow was affected in 1 symptomatic patient with left lower abdominal pain in our study. It may therefore be reasonable to assume that symptom location is consistent with the areas of hemodynamic changes, although the SMA and IMA hemodynamics were also affected in 11 of 19 symptomatic patients with entire abdominal pain. Further studies are needed to evaluate the association between symptom location and SMA and IMA blood flow changes.

Behçet disease involving the gastrointestinal tract causes vasculitis with lymphocytic infiltration of the small veins and venules rather than arteries of the bowel wall.[26] Although it has been reported that the inflammation primarily affects the venules in gastrointestinal BD, in our study, Doppler findings of the inflammation were reflected by the SMA as an increase in mean PSV, V_{mean}, and mean BFV and by the IMA as an increase in V_{mean} and mean BFV.

Figure 2. Behçet disease, 6-year history, with pain in the right lower abdomen in a 38-year-old man. This Doppler sonogram of the SMA reveals elevated PSV (1.52 m/s), V_{min} (0.27 m/s), and V_{mean} (0.22 m/s). The spectral pattern shows loss of early diastolic reversed flow and increased forward flow in both systole and diastole, indicating low-resistance flow (estimated BFV, 507.67 mL/min). A Doppler sonogram of the IMA showed a normal flow pattern (not shown). AO indicates aorta.



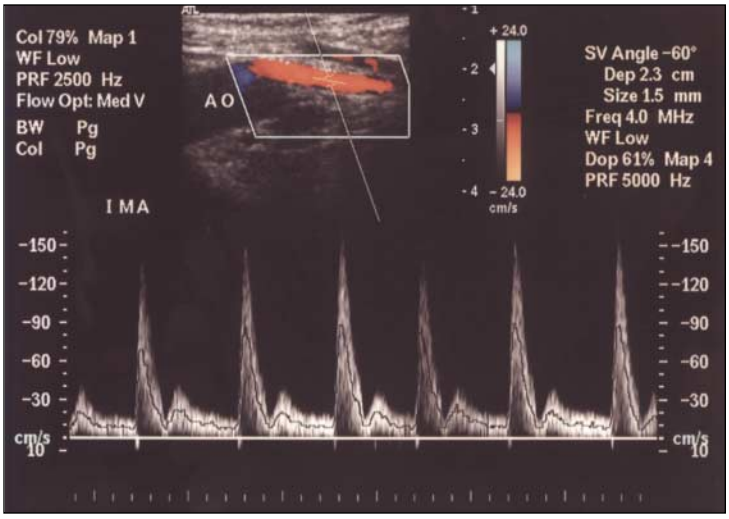


Figure 3. Behçet disease, 5-year history, with pain in the left lower abdomen and diarrhea in a 30-year-old woman. This Doppler sonogram of the IMA shows loss of the triphasic spectral pattern and increased PSV (1.49 m/s), V_{min} (0.11 m/s), and V_{mean} (0.21 m/s), with estimated BFV of 101.3 mL/min. A Doppler sonogram of the SMA showed a normal flow pattern (not shown). AO indicates aorta.

In our study, statistically significant differences in calculated V_{mean} and mean BFV were found despite no significant difference in the mean PI and mean RI of both SMA and IMA between the symptomatic and asymptomatic patient groups and between the symptomatic patient group and control subjects (Table 1). The expected result was a decrease in the downstream resistance that appears as low PI and RI in the affected vascular area due to an inflammatory process in the bowel wall. This suggested that the higher V_{mean} values obtained in the symptomatic patients reflected an increased heart rate, as determined in our symptomatic patient group. Therefore, during clinical examination, the measurement of mesenteric blood flow in the patient group provides more information than simply measuring the heart rate as a nonspecific indicator of the presence of inflammation. The other suggestion may be primary vasculitis of small veins and venules or moderate involvement of the SMA and IMA in BD.

In a previous study,[27] inflammatory involvement of the intestine in patients with and without symptoms of collagen vascular diseases was investigated noninvasively with granulocyte scanning. It revealed that intestinal involvement was rarely seen in the absence of symptoms. Inflammatory involvement of the intestine is more likely to be found in patients with vasculitis and BD. Fresko et al[28] reported that intestinal permeability following radioactive tracer use after a 72-hour abstinence from all drugs in patients with BD but without any signs and symptoms that could be attributed to gastrointestinal disease was significantly more than that seen among healthy control subjects but not significantly different from that of patients with ankylosing spondylitis, inflammatory bowel disease, and systemic lupus erythematosus, which also shows the nonspecificity of this method in diseases causing inflammatory changes in the bowel wall. In addition, the increase in intestinal permeability in BD was considered secondary to inflammation. There is a certain discrepancy between the study of Fresko et al[28] and that of Keshavarzian et al,[27] which reported the rare gastrointestinal involvement in asymptomatic patients with collagen vascular diseases and BD. In our study, there were statistically significant differences in the mean BFV and V_{mean} in the IMA and in the mean BFV, V_{mean}, and mean PSV in the SMA between the symptomatic patient group and the healthy control subjects as well as between the symptomatic and asymptomatic patient groups. However, there were no statistically significant differences in any of the parameters between the asymptomatic patient group and the control subjects. As reported by Keshavarzian et al,[27] our findings by noninvasive Doppler sonography probably indicate rare involvement or noninvolvement of the intestine in patients with BD but without gastrointestinal symptoms.

Ha et al[29] reported the radiologic findings in BD, systemic lupus erythematosus, polyarteritis nodosa, Henoch-Schönlein purpura, microscopic polyangiitis, rheumatoid vasculitis, Burger disease, and Takayasu arteritis involving the gastrointestinal tract. To our knowledge, there has been no reported comparative Doppler study of the SMA and IMA between collagen vascular diseases and BD in the literature. Ha et al[29] concluded that the radiologic findings in various types of vasculitis often overlap considerably and therefore have limited value in the determination of the primary causes of gastrointestinal manifestations. Doppler assessment of splanchnic flow also is by no means specific for discriminating the diseases causing inflammatory bowel involvement. There are similarities in the clinical manifestations of BD and Reiter disease, Stevens-Johnson syndrome, systemic lupus ery-

thematosus, ulcerative colitis, and especially Crohn's disease. Our patients fulfill the criteria for diagnosis of BD put forth by the International Study Group for Behçet's Disease[4] and subsequently validated by O'Neill et al.[5]

During relapse of symptoms in gastrointestinal BD, patients are generally subjected to repeated invasive or noninvasive investigations. Detection of mucosal ulcers or other signs related to gastrointestinal BD may be very difficult or even impossible because of small lesions or poor image quality.[3,30] This may have been the reason that no positive findings were shown on small-bowel follow-through, double-contrast barium enema studies of the colon and CT images of the gastrointestinal tract in our 6 symptomatic patients. During complete abdominal sonography at the time of the duplex study, the terminal ileum and cecum were also specifically assessed for the presence of wall thickening or hyperemia. In 1 of 5 symptomatic patients with pain in the epigastric and right lower abdomen and 3 of 19 symptomatic patients with entire abdominal pain, there was hyperemia in the terminal ileum with normal findings during small-bowel follow-through studies. Doppler studies of the SMA and IMA[6–13,16–19] have been performed in many diseases, although certain discrepancies have emerged from these studies. The Doppler technique has been considered by some to be a promising noninvasive method for monitoring the activity and the response to treatment of inflammatory bowel disease.[6–11,17–19] Contrary to results from Doppler imaging, the prediction power for bowel disease before symptom occurrence needs further study, with periodic evaluation of asymptomatic patients until clinical signs and symptoms begin to develop.

There are many possible sources of error in Doppler examination of the mesenteric arteries, including physiologic conditions of study subjects,[31,32] adequate maintenance of breath holding, the presence of any occlusive or stenotic lesions in the aorta and iliac arteries,[16] errors in determining the angle of insonation and in measurement of vessel diameter, and anatomic variations in the area supplied by the mesenteric vessels.[33] Mesenteric blood flow will likewise be affected if cardiac manifestations of BD, including myocarditis, intracardiac thrombi, arrhythmias, tachycardia, bradycardia or depressed cardiac output, and inferior vena cava or hepatic vein thrombi, are present. Therefore, we tried to exclude the possibility of cardiac, vena cava, and aortic disease in our study patients. Doppler sonography is also not totally reproducible because of interobserver variability and numerous patient-related factors.[20,34–36] The examiner was aware of the clinical and radiologic data in this study, and all examinations were performed by 1 operator using the same technique.

This study had limitations that should be recognized. First, there were no available small-bowel follow-through, double-contrast barium enema studies of the colon or CT images of the gastrointestinal tract. These invasive procedures were refused by the study group except for 6 symptomatic patients. For this reason, clinical findings and symptoms related to the involvement of the bowel wall in the symptomatic patient group became the reference standard of our study. Although we had planned to document the hemodynamic changes in the mesenteric vessels corresponding to the abdominal area where symptoms were felt, this was not possible, because 19 of 25 symptomatic patients had entire abdominal pain. Another potential limitation is that the drug effects could not be eliminated on the mesenteric vessels because of ethical concerns.

In conclusion, patients with BD who had gastrointestinal symptoms were associated with increases in the V_{mean} and mean BFV in the IMA and increases in the mean PSV, V_{mean}, and mean BFV in the SMA, together with an increased heart rate, which were not observed in the asymptomatic patient group and control subjects. Therefore, measurement of mesenteric blood flow in the patient group may have provided more information than simply measuring heart rate as a nonspecific indicator of the presence of inflammation, especially because the radiologic methods were unable to localize the sites of involvement. These results indicated that intestinal involvement in patients without any signs and symptoms was not significantly different from that of healthy control subjects. The spectral pattern changes of affected mesenteric arteries, which appeared as the loss of early diastolic reversed flow with increased forward flow during diastole, were thought to be more obvious and useful than overall quantitative evaluation. Although Doppler analysis is unlikely to differentiate between different types of inflammatory conditions, in our opinion, Doppler study of the mesenteric arteries may be useful as a noninvasive technique in chronic diseases with frequent exacerbations such as BD involving the gastrointestinal tract.

References

1. Sakane T, Takeno M, Suzuki N, Inaba G. Behçet's disease. N Engl J Med 1999; 341:1284–1291.
2. Lee CR, Kim WH, Cho YS, et al. Colonoscopic findings in intestinal Behçet's disease. Inflamm Bowel Dis 2001; 7:243–249.
3. Chung SY, Ha HK, Kim JH, et al. Radiologic findings of Behçet syndrome involving the gastrointestinal tract. Radiographics 2001; 21:911–926.
4. International Study Group for Behçet's Disease. Criteria for diagnosis of Behçet's disease. Lancet 1990; 335:1078–1080.
5. O'Neill TW, Rigby AS, Silman AJ, Barnes C. Validation of the International Study Group criteria for Behçet's disease. Br J Rheumatol 1994; 33:115–117.
6. van Oostayen JA, Wasser MN, van Hogerzand RA, Griffioen G, de Roos A. Activity of Crohn disease assessed by measurement of superior mesenteric artery flow with Doppler US. Radiology 1994; 193:551–554.
7. Giovagnorio F, Diacinti D, Vernia P. Doppler sonography of the superior mesenteric artery in Crohn's disease. AJR Am J Roentgenol 1998; 170:123–126.
8. van Oostayen JA, Wasser MN, van Hogerzand RA, et al. Doppler sonography evaluation of superior mesenteric artery flow to assess Crohn's disease activity: correlation with clinical evaluation, Crohn's disease activity index and α1 antitrypsin clearance in feces. AJR Am J Roentgenol 1997; 168:429–433.
9. Maconi G, Imbesi V, Bianchi-Porro G. Doppler ultrasound measurement of intestinal blood flow in inflammatory bowel disease. Scand J Gastroenterol 1996; 31:590–593.
10. van Oostayen JA, Wasser MN, Griffioen G, van Hogerzand RA, Lamers CB, de Roos A. Diagnosis of Crohn's ileitis and monitoring of disease activity: value of Doppler ultrasound of superior mesenteric artery flow. Am J Gastroenterol 1998; 93:88–91.
11. Ludwig D, Wiener S, Bruning A, Schwarting K, Jantschek G, Stange EF. Mesenteric blood flow is related to disease activity and risk of relapse in Crohn's disease: a prospective follow-up study. Am J Gastroenterol 1999; 94:2942–2950.
12. Perko MJ, Perko G, Just S, Secher NH, Schroeder TV. Changes in superior mesenteric artery Doppler waveform during reduction of cardiac stroke volume and hypotension. Ultrasound Med Biol 1996; 22: 11–18.
13. Deeg KH, Rupprecht T, Schmidt E. Doppler sonographic detection of increased flow velocities in the celiac trunk and superior mesenteric artery in infants with necrotizing enterocolitis. Pediatr Radiol 1993; 23:578–582.
14. Denys AL, Lafortune M, Aubin B, Burke M, Breton G. Doppler sonography of the inferior mesenteric artery: a preliminary study. J Ultrasound Med 1995; 14:435–439.
15. Mirk P, Palazzoni G, Cotroneo AR, Di Stasi C, Fileni A. Sonographic and Doppler assessment of the inferior mesenteric artery. Abdom Imaging 1998; 23:364–369.
16. Erden A, Yurdakul M, Cumhur T. Doppler waveforms of the normal and collateralized inferior mesenteric artery. AJR Am J Roentgenol 1998; 171:619–627.
17. Mirk P, Palazzoni G, Gimondo P. Doppler sonography of hemodynamic changes of the inferior mesenteric artery in inflammatory bowel disease: preliminary data. AJR Am J Roentgenol 1999; 173:381–387.
18. Ludwig D, Wiener S, Bruning A, et al. Mesenteric blood flow is related to disease activity and risk of relapse in ulcerative colitis: a prospective follow-up study. Gut 1999; 45:546–552.
19. Sigirci A, Baysal T, Kutlu R, Aladag M, Saraç K, Harputluoglu H. Doppler sonography of the inferior and superior mesenteric arteries in ulcerative colitis. J Clin Ultrasound 2001; 29:130–139.
20. Gill RW. Measurement of blood flow by ultrasound: accuracy and sources of error. Ultrasound Med Biol 1985; 11:625–641.
21. Lakhanpal S, Tani K, Lie JT, Katoh K, Ishigatsubo Y, Oholcubo T. Pathologic features of Behçet's syndrome: a review of Japanese autopsy registry data. Hum Pathol 1985; 16:790–795.
22. Kasahara Y, Tananka S, Nishino M, Umemura H, Shiraha S, Kuyama T. Intestinal involvement in Behçet's disease: review of 136 surgical cases in the Japanese literature. Dis Colon Rectum 1981; 24:103–106.
23. Ketch LL, Buerk CA, Liechty RD. Surgical implications of Behçet's disease. Arch Surg 1980; 115:759–760.
24. Tabata M, Tomomasa T, Kaneko H, Morikawa A. Intestinal Behçet's disease: a case report and review

of Japanese reports in children. J Pediatr Gastroenterol Nutr 1999; 29:477–481.

25. Snell RS. The abdomen, part II: the abdominal cavity. In: Snell RS (ed). Clinical Anatomy for Medical Students. 3rd ed. Boston, MA: Little Brown and Co; 1986:236–237.

26. Smith GE, Kime LR, Pitcher JL. The colitis of Behçet's disease: a separate entity? Colonoscopic findings and literature review. Am J Dig Dis 1973; 18:987–1000.

27. Keshavarzian A, Saverymuttu SH, Chadwick VS, Lavender JP, Hodgson HJ. Noninvasive investigation of the gastrointestinal tract in collagen-vascular disease. Am J Gastroenterol 1984; 79:873–877.

28. Fresko I, Hamuryudan V, Demir M, et al. Intestinal permeability in Behçet's syndrome. Ann Rheum Dis 2001; 60:65–66.

29. Ha HK, Lee SH, Rha SE, et al. Radiologic features of vasculitis involving the gastrointestinal tract. Radiographics 2000; 20:779–794.

30. Tolia V, Abdullah A, Thirumoorthi MC, Chang CH. A case of Behçet's disease with intestinal involvement due to Crohn's disease. Am J Gastroenterol 1989; 84:322–325.

31. Qamar MI, Read AE. Effects of exercise on mesenteric blood flow in man. Gut 1987; 28:583–586.

32. Moneta GL, Taylor DC, Helton WS, Mulholland MW, Strandness DE Jr. Duplex ultrasound measurements of postprandial intestinal blood flow: effect of meal composition. Gastroenterology 1988; 95:1294–1301.

33. Abrams HL, Meyerovitz MF. Inferior mesenteric angiography. In: Baum S (ed). Abrams' Angiography: Vascular and Interventional Radiology. Boston, MA: Little Brown and Co; 1997:1587–1614.

34. Qamar MI, Read AE, Skidmore R, Evans JM, Wells PN. Transcutaneous Doppler ultrasound measurement of superior mesenteric artery blood flow in man. Gut 1986; 27:100–105.

35. Walter JP, McGahan JP, Lantz BM. Absolute flow measurements using pulsed Doppler US. Radiology 1986; 159:545–548.

36. Merritt CR. Doppler US: the basics. Radiographics 1991; 11:109–119.