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Color Doppler findings of gastric varices compared with findings on computed tomography

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Editorial on page 679

Background. The aim of this study was to evaluate the hemodynamics of gastric varices. ***Methods.*** We evaluated the detection rates of gastric varices, inflowing vessels to gastric varices, and outflowing vessels from gastric varices in 24 patients with gastric varices, using color Doppler sonography, and compared these findings with computed tomography findings. Eighteen patients had F2-type varices and 6 had F3-type, classified according to the Japanese Research Society for Portal Hypertension. Fourteen patients had fundal varices, and 10 had cardiac and fundal varices. ***Results.*** The detection rates of collateral veins using color Doppler sonography were as follows: gastric varices were detected in all 24 patients (100%); inflowing vessels, in 21 of the 24 patients (87.5%); and outflowing vessels, in 18 of the 24 patients (75.0%). The detection rates of collateral veins, using computed tomography, were: gastric varices were detected in all 24 patients (100%); inflowing vessels, in all 24 patients (100%); and outflowing vessels, in 21 of the 24 patients (87.5%). The color Doppler findings agreed perfectly with the computed tomography findings in 13 of the 24 patients (54.2%). ***Conclusions.*** Although color Doppler sonography is a useful, noninvasive modality for evaluating the hemodynamics of gastric varices, it falls short in visualizing the detailed hemodynamics of the inflowing and outflowing vessels of gastric varices in half of the patients when compared with computed tomography.

Key words: gastric varices, color Doppler sonography, computed tomography

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Introduction

Recent technical advances offer us increasingly greater imaging clarity of gastric varices. Hemodynamic studies of gastric varices are performed worldwide.[1,2] We have previously reported the usefulness of endoscopic color Doppler ultrasonography (ECDUS) and an ultrasonic microprobe (UMP) in evaluating the hemodynamics of gastric varices.[3,4] Conventional angiography is commonly used to study the portal venous system. However, this modality has inherent limitations;[5] it is invasive and requires a large amount of iodinated contrast agent, which carries the risk of renal toxicity.

Color Doppler sonography is now widely used to diagnose the collateral veins, but few color Doppler findings of gastric varices have been reported. The aim of this study was to investigate the color Doppler sonographic findings of gastric varices and to determine the role of color Doppler sonography in the diagnosis of gastric varices. Findings from contrast-enhanced computed tomography (CT) scanning were used as standards.

Subjects and methods

Patients

We studied 24 patients with solitary gastric varices diagnosed by color Doppler sonography, compared with computed tomography (CT), between June 1997 and December 1999. These 24 patients (14 men and 10 women; aged 34–80 years [mean, 57.8 years]) were selected for routine endoscopic screening for esophagogastric varices. The underlying pathologies of portal hypertension was liver cirrhosis in 16 patients, and cirrhosis coupled with hepatocellular carcinoma in 8, all cases being diagnosed through imaging. Fourteen patients had Child-Pugh class A, 6 had class B, and 4, class

C. The etiologies of the liver diseases were as follows: hepatitis B surface antigen-positive (HBV) in 6, anti-HCV antibody-positive (HCV) in 11, alcoholic liver diseases in 6, and unidentified in 1 patient.

Endoscopic findings

Endoscopic findings of gastric varices were evaluated according to *The general rules for recording endoscopic findings of esophago-gastric varices*, devised by the Japanese Research Society for Portal Hypertension.[6] The form (F) of the varices was classified as small, straight (F1), enlarged tortuous (F2), and large, coil-shaped (F3). Variceal location (L) was classified as: cardiac (Lg-c; located adjacent to the cardiac orifice); fundal (Lg-f; located far from the cardiac orifice); and cardiac and fundal (Lg-cf; located between the cardiac orifice and the fornix). Eighteen patients had F2-type varices and 6 had F3-type. In terms of location, 14 patients had Lg-f (localized type) varices and 10 had Lg-cf (diffuse type). Three of the 24 patients were complicated with esophageal varices.

Color Doppler and CT scans

All 24 patients were examined by color Doppler sonography and CT. All sonographic examinations were performed with a 2.5 to 4.0-MHz sector transducer (Acuson, Sequoia CA, USA). The patients fasted for 5 h before the sonographic examinations. After drinking 300 ml of deaerated water, each patient was examined while lying in the supine position. Gastric varices were scanned through the spleen. The color Doppler sonography examination was performed by one physician. We evaluated the vessel images of gastric varices, inflowing vessels, and outflowing vessels, utilizing color Doppler sonography. The outflowing vessels of gastric varices were reported to be the gastrorenal shunt (GRS) and the subphrenic vein, with angiographic findings showing the inflowing vessels to be the left gastric vein (LGV), the short gastric vein (SGV), and the posterior gastric vein (PGV). Next, we calculated the velocity of blood flow in the gastric varices. The velocities were assessed by a pulsed Doppler method, by positioning a sample volume of 1–3 mm in the center of the vessels. If a venous waveform was obtained, the angle was kept below 60° to minimize ambiguity in measurements. The mean velocity was obtained from the gastric varices for a total of two tracings, and these measurements were averaged.

Helical CT scans (150 ml of contrast material was injected at 5 ml/s with a 45-s scan delay, with 300 mg iodine in the contrast agent) were done in all 24 patients. The images were used for the detection of gastric varices, inflowing vessels, and outflowing vessels. Magnetic resonance (MR) angiography was also done in 21 of the 24 patients, and conventional arterial portography was performed in 3 of the 24 patients. These findings matched well with the CT findings. We compared the vessel images detected by color Doppler sonography with those detected by CT scans.

Statistical analysis

Values for results are presented as means ± SD. The distribution of the velocities of blood flow in gastric varices measured using color Doppler sonography were analyzed by employing the Mann-Whitney *U*-test. A difference in mean values was regarded as significant when the two-tailed P value was less than 0.05.

Results

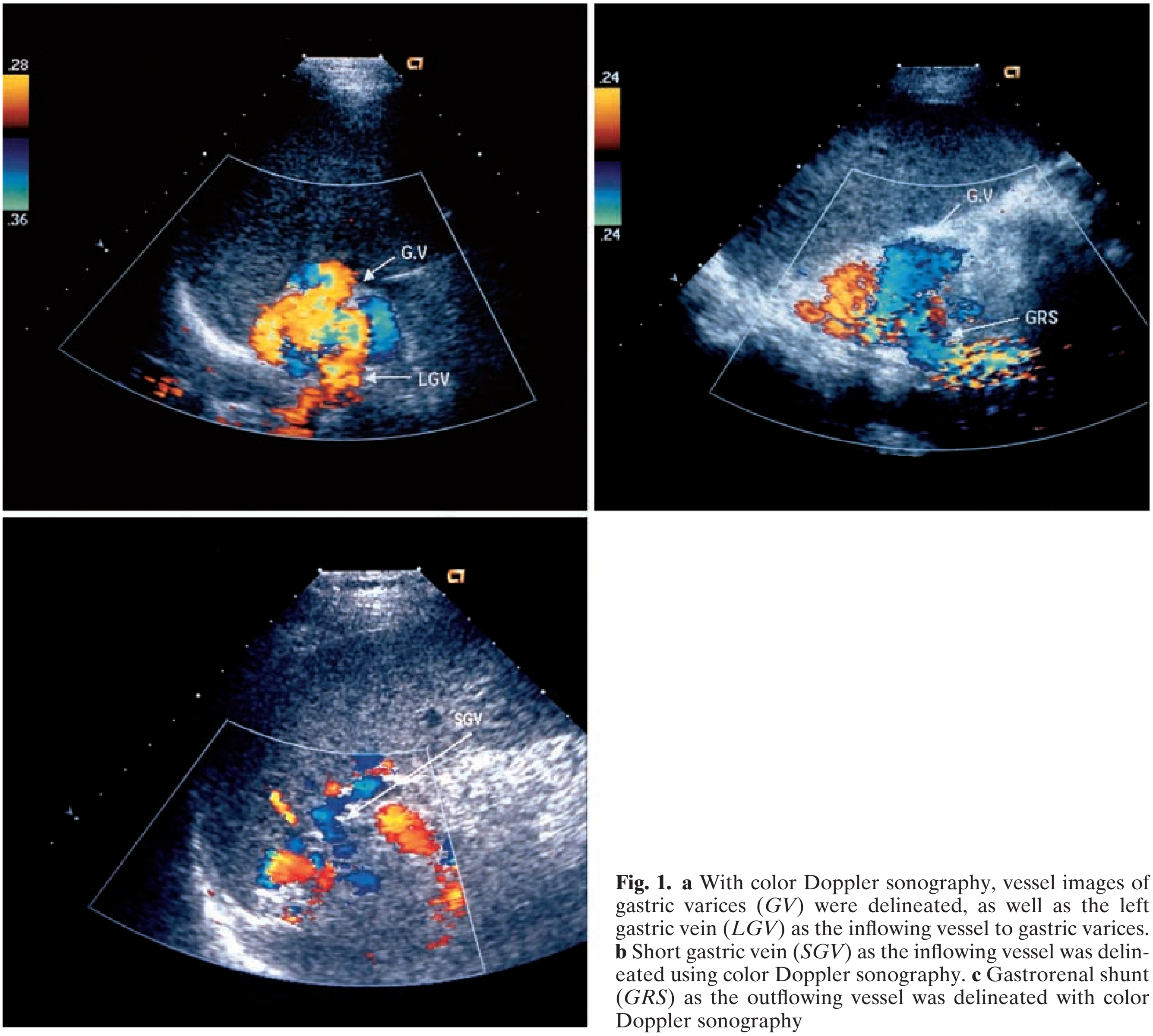
Color Doppler findings

The detection rates of collateral veins with color Doppler were: gastric varices in all 24 patients (100%), inflowing vessels in 21 of the 24 patients (87.5%), and outflowing vessels in 18 of the 24 patients (75.0%). These inflowing vessels were categorized as SGV in 11 patients, SGV and LGV in 2, SGV and PGV in 2, LGV in 3, and PGV in 3. The outflowing vessels were found to be GRS in all 18 patients. Next, we evaluated the velocity of blood flow in the gastric varices. Six of the F3-type gastric varices had velocities in the 17.7 to 34.6 cm/s (25.9 ± 5.6 cm/s) range, and 18 of the F2-type gastric varices had velocities in the 8.5 to 24.2 cm/s (14.1 ± 4.5 cm/s) range. The mean velocity of the F3-type varices was significantly higher than that of the F2 type varices ($P < 0.01$). Moreover, 14 of the localized-type varices had velocities in the 8.5 to 24.2 cm/s (14.3 ± 4.8 cm/s) range, and 10 of the diffuse-type varices had velocities in the 11.0 to 34.6 cm/s (20.9 ± 7.4 cm/s) range. The mean velocity in the diffuse-type varices was significantly higher than that in the localized-type varices ($P < 0.05$).

Representative color Doppler sonography findings for case 1, a 34-year old man, whose endoscopic view showed Lg-f, F3-type varices, are shown in Fig. 1. With the color Doppler sonography, vessel images of the gastric varices were clearly delineated, as well as the LGV (Fig. 1a) and the SGV (Fig. 1b) as the inflowing blood vessels to gastric varices, and the GRS was delineated as the outflowing blood vessel (Fig. 1c).

CT findings

The detection rates of collateral veins with CT were as follows: gastric varices were detected in all 24 patients



a b c

Fig. 1. **a** With color Doppler sonography, vessel images of gastric varices (*GV*) were delineated, as well as the left gastric vein (*LGV*) as the inflowing vessel to gastric varices. **b** Short gastric vein (*SGV*) as the inflowing vessel was delineated using color Doppler sonography. **c** Gastrorenal shunt (*GRS*) as the outflowing vessel was delineated with color Doppler sonography

(100%); inflowing vessels, in all 24 patients (100%); and outflowing vessels, in 21 of the 24 patients (87.5%). The inflowing vessels were categorized as SGV in 12 patients, SGV and LGV in 5, SGV and PGV in 4, LGV in 2, and PGV in 1 patient. The outflowing vessels were categorized as GRS in 20 patients, and as GRS and subphrenic vein in 1 patient. Images of inflowing blood vessels, as detected using CT; are shown in Fig. 2 (LGV), Fig. 3 (SGV), and Fig. 4 (PGV). Gastric varices and GRS, as the outflowing vessel, as delineated using CT, can be seen in Fig. 5.

Correlation of color Doppler with CT

The correlation of color Doppler findings with CT findings for the inflowing vessels is shown in Table 1, and that for the outflowing vessels is shown in Table 2. The color Doppler findings agreed perfectly with the CT findings in 13 of the 24 patients (54.2%). Color Doppler findings did not agree with CT findings in regard to the following points: some of the inflowing vessels were not detected in 5 patients by color Doppler sonography, the inflowing vessels were not detected in 2 patients by color Doppler sonography, the outflowing vessels were not detected in 2 patients by color Doppler sonography, the inflowing and outflowing vessels were not detected in 1 patient by color Doppler sonography, and some of

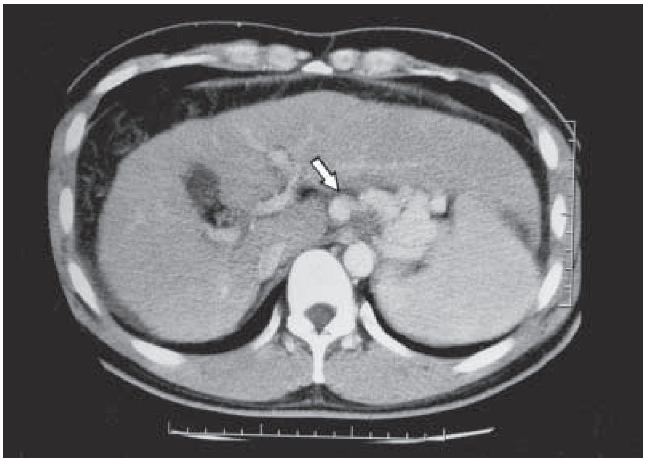


Fig. 2. Left gastric vein (*arrow*), as the inflowing vessel, was detected with computed tomography (CT)

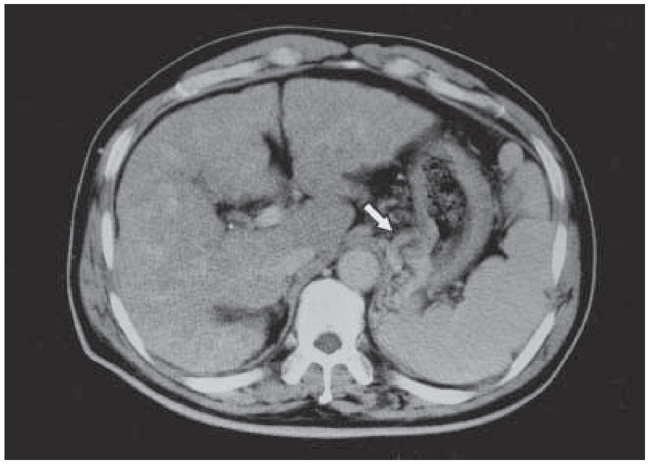


Fig. 4. Posterior gastric vein (*arrow*), as the inflowing vessel, was detected using CT

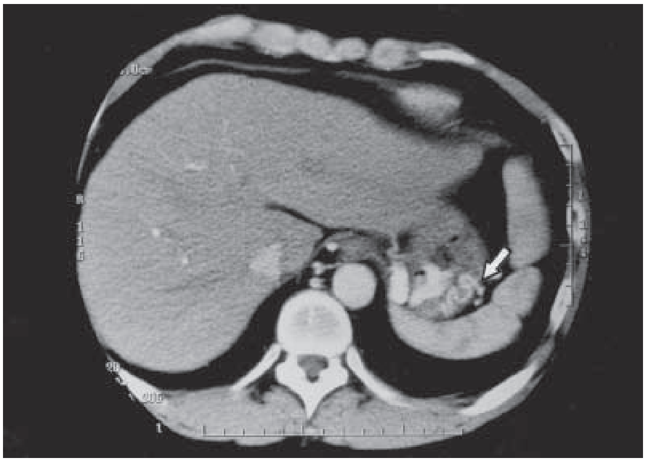


Fig. 3. Short gastric vein (*arrow*), as the inflowing vessel, was detected with CT

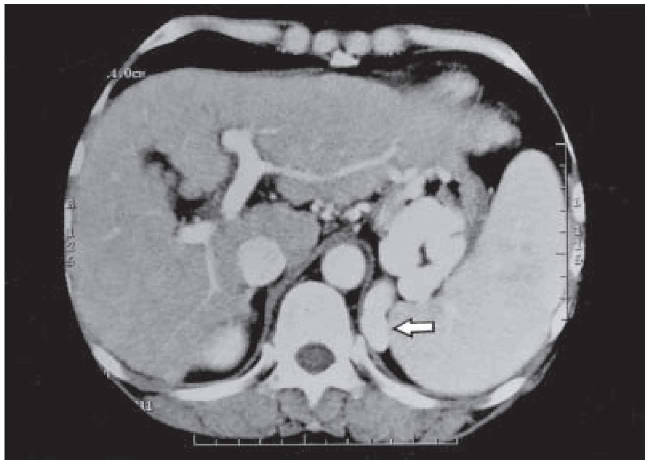


Fig. 5. Gastric varices and gastrorenal shunt (*arrow*), as the outflowing vessel, were detected with CT

Table 1. Evaluation of the correlation of color Doppler sonography with CT for inflowing vessels

	CT					
CD	SGV	SGV+LGV	SGV+PGV	LGV	PGV	None
SGV	9	2	—	—	—	—
SGV+LGV	—	2	—	—	—	—
SGV+PGV	—	—	2	—	—	—
LGV	—	1	—	2	—	—
PGV	—	—	2	—	1	—
None	3	—	—	—	—	—

SGV, Short gastric vein; LGV, left gastric vein; PGV, posterior gastric vein; CD, color Doppler sonography; CT, computed tomography

Table 2. Evaluation of the correlation of color Doppler sonography with CT for outflowing vessels

	CT		
CD	GRS	GRS+SV	None
GRS	17	1	—
GRS+SV	—	—	—
None	3	—	3

GRS, Gastrorenal shunt; SV, subphrenic vein; CD, color Doppler sonography; CT, computed tomography

the outflowing vessels were not detected in 1 patient by color Doppler sonography.

Discussion

In recent years, we have had increasing success in visualizing gastric varices. Sarin et al.[7] detected gastric varices in 48 (16%) of 309 patients with cirrhosis, noncirrhotic portal fibrosis, and extrahepatic obstruction. In contrast, Watanabe et al.[8] reported the frequency of gastric varices in patients with portal hypertension to be 57%. Gastric varices have been diagnosed by endoscopy, a useful modality for observing gastric varices of a certain size and extent; this modality has a very sensitive predictive value for variceal hemorrhage.[9] Endoscopy, however, is a limited modality for detecting gastric varices, given how deep the submucosal or extramural collateral veins of gastric varices are.

Recently, endoscopic ultrasonography (EUS) has become a very useful modality for the diagnosis of esophagogastric varices.[10,11] EUS not only visualizes the surface of gastric varices but also provides detailed information about their internal structure. ECDUS can be used to detect color signals and to measure the velocity of gastric variceal flow.[3,12]

The usefulness of MR angiography has been reported for diagnosing collateral veins in patients with gastric varices.[13,14] MR angiography has been found to be a favorable modality, because of its noninvasive nature, and because it allows for the evaluation of the whole images of gastric varices. Balthazar et al.[15] reported on the usefulness of CT examinations for gastric varices, and described a method for obtaining a detailed diagnosis in most patients with gastric varices. Overall findings of the portosystemic collateral channel in patients with portal hypertension could be obtained by CT scans. In the present study, findings from CT scanning were used as standards. CT scanning allowed for the detection of the SGV (flow from the hilus of the spleen to gastric varices), the LGV (flow through the curvatura ventriculi minor of the gastric body wall from the portal vein to gastric varices), and the PGV (flow from the splenic vein about 3 cm proximal from the hilus of the spleen to gastric varices) as the inflowing vessels to gastric varices. We could also observe the GRS (flow from the gastric varices to the left renal vein), and the subphrenic vein as the outflowing vessels from gastric varices.

The detection of esophageal varices by transcutaneous ultrasound is complicated by air in the lungs. In contrast, the gastric varices are relatively easily observed by ultrasound.[16] Recently developed color Doppler sonography enables us to detect small blood flows[17] and to evaluate the portal venous system. Nelson et al.[5] concluded that Doppler sonography was valuable in accurately determining the direction of portal flow and the patency of the vessel. Color Doppler sonography accurately imaged venous flows in the gastric wall in all 24 of the patients (100%) in our study. Gastric varices could be surmised from this flow. Using color Doppler sonography, we could accurately diagnose the inflowing vessels and outflowing vessels of gastric varices in half of the patients, compared with CT findings. Komatsuda et al.[18] reported that the detection of the SGV in patients with gastric varices by color Doppler sonography was difficult. However, we were able to observe easily the color flow images of the SGV on examination through the spleen. Color Doppler sonography may be not successful without a suitable acoustic window. In fact, the use of color Doppler sonography was limited for the detection of collateral veins in patients with gastric varices. Impediments such as bowel gas, body habitus, and cirrhosis limit the value of sonography for assessing the portal venous system. In addition, with color Doppler sonography, it was difficult to observe the collateral veins far from the probe, because of the limitation of Doppler sensitivity. The advantages of color Doppler sonography are as follows: it is simple and noninvasive, and it can be used to calculate the velocity of blood flow in gastric varices. The mean velocity in F3-type varices was significantly higher than that in F2-type varices with ECDUS,[3] a finding in agreement with the color Doppler sonography findings in our study. Using Doppler sonography, Ishii et al.[19] reported that the main feeders of fundic gastric varices were collaterals near the splenic hilum in 82% of the patients, and mean blood flow velocity in the feeding veins was greater in bleeders than in nonbleeders. Iwase et al.[20] reported the differences in hemodynamic features between localized-type gastric varices and diffuse-type varices. According to their article, patients with localized-type varices had a better clinical course, with regard to rates of recurrent bleeding, variceal eradication, and survival, than those with diffuse-type varices, after endoscopic ablation with cyanoacrylate.[20] Our results for color Doppler sonography, showing that the mean blood flow velocity in the diffuse-type varices was significantly higher than that in the localized-type varices may support this report's findings. We suggest that the measurement of blood flow velocity in gastric varices by color Doppler sonography is useful for the prediction of variceal bleeding and of therapeutic effects.

Several therapeutic approaches, including sclerotherapy of varices with tissue adhesion,[21,22] shunt operations to produce artificial collateral vessels,[23–25] and transjugular intrahepatic portosystemic shunting,[26,27] have been used to treat portal hypertension. Recently, a new approach for the obliteration of collateral vessels connecting the portal venous system and systemic circulation, balloon-occluded retrograde transvenous obliteration (B-RTO), has been evaluated for the treatment of gastric varices.[28] Gastric fundal varices are almost always associated with a large GRS,[8] and gastric varices with a GRS are a good indication for B-RTO. Color-flow images of the GRS could be produced at a high rate by color Doppler sonography in our study. This ability is valuable when evaluating the hemodynamics in patients with gastric varices, because of the high morbidity and mortality rates of hemorrhaging gastric varices.[29]

Portal hypertension is a serious complication in cirrhotic patients. The screening of portal hypertension is commonly carried out to observe esophagogastric varices via endoscopy. Color Doppler sonography is a useful noninvasive tool for the delineation of portal hemodynamics, including observation of the blood flow in gastric varices. However, our results show the limitation of current color Doppler techniques. Color Doppler sonography failed to delineate the detailed hemodynamics of the inflowing vessels and outflowing vessels of gastric varices in half of the patients. It is hoped that further technological advances in color Doppler in the near future will increase its effectiveness and scope of use.

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