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The application of transabdominal 3D ultrasound for the diagnosis of gastric varices: A preliminary study

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ABSTRACT

Objective: The aim of this study was to determine the feasibility of using transabdominal three-dimensional (3D) colour Doppler ultrasound as a non-invasive tool to demonstrate and quantify gastric varices.

Subjects and methods: A phantom study compared the 3D water flow volume data in a hose with the actual volume inside the hose at three different flow velocities. The prospective clinical study examined the reliability and reproducibility of 3D volume data for gastric varices (mild 28, moderate 26, large 8) in 62 patients. The 3D images were acquired using the colour Doppler with both convex and micro-convex probes.

Results: The phantom study showed a 12.4–17.6% difference between the 3D data and the actual volume with no difference between the two types of probes or three velocities. The detectability of gastric varices was identical between the two probes (54/62, 87.1%). However, the scanning efficiency was significantly greater for the micro-convex probe ($66.9 \pm 14.1\%$) than the convex probe ($57.3 \pm 14\%$, $p = 0.012$). Body mass index was the only factor that had a significant relationship with the detectability of varices. The mean volume (mL) of the 3D signal was 0.82 ± 0.74 for mild varices, 5.48 ± 3.84 for moderate varices, and 10.63 ± 6.67 for large varices with significant differences between different grades. The intra-/inter-rater reliability was excellent.

Conclusion: The method of 3D colour Doppler ultrasound is reliable and reproducible in the quantitative assessment of vascular volume and is applicable for grading gastric varices. This study may offer a practical usefulness for 3D ultrasonography as an alternative to endoscopy.

1. Introduction

In addition to being a simple technique, ultrasound is non-invasive and enables observations in real-time. Therefore, this technique shows potential as a frequently used first line imaging procedure for investigating abdominal problems. Recent developments in digital technology have resulted in the wider application of a three-dimensional (3D) ultrasound system that provides stereoscopic volume data [1]. Investigators have reported clinical data on the efficacy of 3D ultrasound for quantitative assessment, e.g., the volume of the gallbladder [2] and the volume of the vascularity of the placenta [3].

Gastric varices are one of the major complications in cirrhosis. They occur and develop according to the severity of portal hypertension, and the bleeding from gastric varices can cause serious consequences [4,5]. Endoscopy may be the primary tool for the diagnosis of gastric varices and for follow-up. However, this procedure presents two problems: its invasiveness and discomfort and its subjective nature of assessment. Imaging modalities that can detect and quantify blood flow may be preferable for the diagnosis of gastric varices, which are vascular abnormalities based on relatively large collateral vessels [6].

Keeping the previous findings in mind, two facets of ultrasound technology were studied. First, the accuracy of 3D colour Doppler ultrasound for the measurement of vascular space with the phantom model was examined. Second, the reliability and reproducibility of colour Doppler-based volume data of gastric varices in clinical subjects were examined. The aim of this study was to determine the feasibility of using transabdominal 3D colour Doppler ultrasound as a non-invasive tool to detect and quantify gastric varices.

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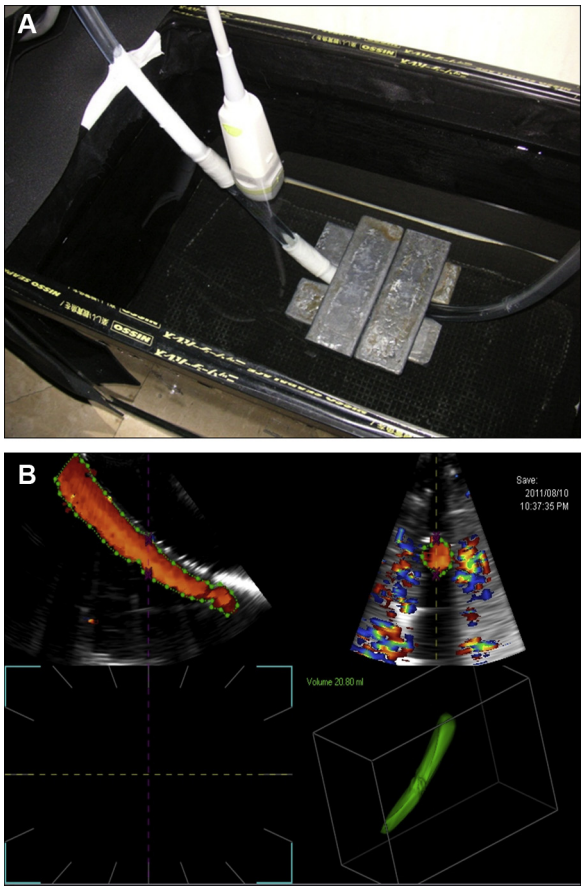

Fig. 1. Phantom model for 3D vascular image. A. Phantom model. A vinyl hose with an inside diameter of 12 mm was placed in a tank filled with water. One end of the hose was connected to the faucet and the flow velocity of the water was adjusted to 10, 15 and 20 cm/s. A probe was also placed in the water tank to take 3D images of the hose, at an angle of 35° between the probe and the hose. B. 3D sonogram. The volume of 3D color image for the water flow in the hose was compared with the actual volume inside the hose (10 cm length) at each velocity.

2. Methods

2.1. Phantom study

A vinyl hose with an inside diameter of 12 mm was placed in a tank filled with water (Fig. 1A). One end of the hose was connected to the faucet, and the flow velocity of the water was adjusted to 10, 15 and 20 cm/s, according to the blood flow related to gastric varices in the literature [7]. We estimated the flow velocity of the tap water by the time it took to fill up a measuring cup (500 mL) and accordingly adjusted the velocity to the three different velocities of 10, 15 and 20 cm/s. A probe was also placed in the water tank to take 3D images of the hose at an angle of 35° between the probe and the hose. 3D ultrasonography took a 10-cm long image of the hose, and the volume of the 3D colour image for the water flow in the hose was compared with the actual volume inside the hose (volume in the 10 cm of the hose) at each velocity (Fig. 1B). This procedure was performed by HK.

2.2. Clinical study

2.2.1. Participants

This was a prospective study performed from April 2011 through April 2012 and was approved by the ethics committee of the institutional review board of our department. Informed written consent was obtained from all participants. The study included patients with chronic liver diseases who previously had gastric varices that were detected by routine upper gastrointestinal endoscopy. The presence of chronic liver disease was diagnosed using biochemistry data with two different imaging findings (ultrasound and computed tomography/magnetic resonance imaging). The study had the following exclusion criteria: (i) patients with a treatment history of gastric varices, (ii) patients with a surgical history of the stomach. Patients who could not hold their breath for more than 5 s were excluded from the study because of difficulty of 3D image acquisition. The endoscopic findings of the gastroesophageal varices were classified according to the General Rules for Recording Endoscopic Findings: mild, moderate, and large [8].

2.2.2. Patient characteristics

There were 62 patients of which 37 were males and 25 were females. Other characteristics were: age 64 ± 11.3, 20–81; body mass index (BMI) 24.5 ± 4.6, 15.2–35.6; chronic liver disease (cirrhosis 54, non-cirrhotic portal hypertension 8); gastric varices: 28 mild, 26 moderate, and 8 large as evaluated by endoscopy. Twenty-nine patients had esophageal varices, and 16 patients had mild to moderate ascites. The median time interval between ultrasound and endoscopy for the diagnosis of gastric varices was 44.7 days.

2.3. Ultrasound examination

2.3.1. Equipment and setting

The APLIO-XG (Toshiba, Tokyo, Japan) with a convex type probe (375 MV) and a micro-convex type probe (382 MV) was used in this study. Both probes were specialised for 3D image acquisition by mechanical scanning with linear arrays. The dimensions were 50 mm × 84 mm × 160 mm in the former and 40 mm × 42 mm × 188 mm in the latter (Fig. 2); the frequency of the former was 3.0 ± 0.6 MHz and that of the latter was 3.5 ± 0.7 MHz. The following settings were used: the depth was to include the deepest wall of the upper stomach, the maximum colour gain was set to avoid producing excessive noise, the minimum velocity range

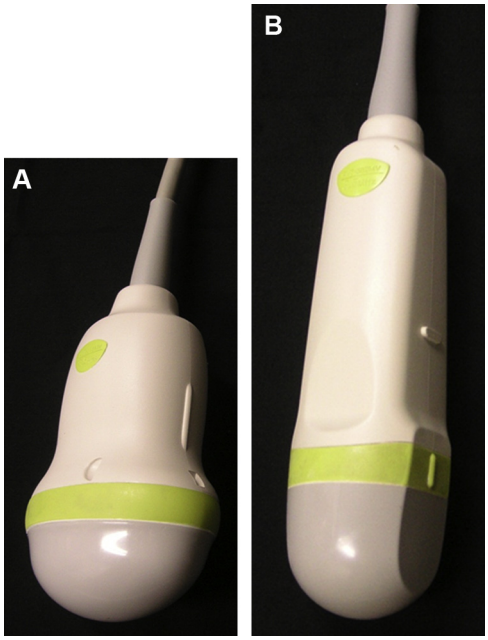

Fig. 2. Images for probes. A. Convex type probe (375 MV). B. Micro-convex type probe (382 MV). Both probes were specialized for 3D image acquisition. The dimensions were 50 mm × 84 mm by 160 mm in the former, and 40 mm × 42 mm × 188 mm in the latter; frequency of the former was 3.0 ± 0.6 MHz and that of the latter was 3.5 ± 0.7 MHz.