Utility of a 3D Roadmap During Balloon-occluded Retrograde Transvenous Obliteration for Gastric Varices

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Objective: We describe our initial clinical experience regarding the use of a 3D roadmap during balloon-occluded retrograde transvenous obliteration (BRTO) in three patients.
Methods: Between June 2016 and July 2016, three BRTO procedures were performed in three patients with gastric varices. Preprocedural intravenous dynamic CT was performed, and portal venous phase CT images were postprocessed to obtain volume rendering (VR) images. A 3D roadmap was developed by overlaying the VR images onto the real-time X-ray fluoroscopy images. This 3D roadmap was used for interventional guidance during the BRTO procedure.
Results: Using a 3D roadmap, the catheterization of the gastrorenal shunt was successfully accomplished. In addition, in all three patients, the sclerosant could reach the gastric varices without the administration of iodinated contrast medium. Fluoroscopy time and the iodinated contrast dose administered in the present cohort were also substantially lower than in our previous cohorts that did not use a 3D roadmap.
Conclusion: Using a 3D roadmap during BRTO enables easier and faster catheter manipulation, thereby helping to reduce both radiation exposure and the need to administer iodinated contrast medium.

Key words: gastric varices, BRTO, 3D roadmap, foam sclerosant

INTRODUCTION

Balloon-occluded retrograde transvenous obliteration (BRTO) is a common practice in Asia for the management of gastric varices and has recently been applied in the US. BRTO has been considerably effective in controlling gastric variceal bleeding, resulting in low re-bleeding rates. Moreover, unlike transjugular intrahepatic portosystemic shunts (TIPS), BRTO is less invasive and can be safely performed in patients with poor hepatic reserves or encephalopathy [1–4].

For a successful BRTO procedure, it is important to identify all the veins that feed and drain the gastric varices and inject sclerosants into and occlude the entire network of gastric varices. Overlooking collateral vessels can result in insufficient obliteration of gastric varices and may result in dangerous systemic leakage of the sclerosing agent. However, balloon-occluded transvenous venography (BRTV), which typically involves the use of iodinated contrast medium does not always depict the whole vasculature, a problem described as grade 3 or 4 in Hirota's classification [5]. Preprocedural dynamic CT with intravenous iodinated contrast can provide detailed morphologic information regarding gastric varices and collaterals. In recent years, a new technique that enables one to overlay 3D reconstruction obtained from CT angiography with real-time X-ray fluoroscopy has been developed to provide a 3D roadmap [6–8]. In the present study, we report our initial clinical experience using this 3D roadmap technique for interventional guidance during BRTO.

MATERIALS AND METHODS

The present investigation conformed to the principles outlined in the Declaration of Helsinki.

Three BRTO procedures were performed between June 2016 and July 2016 in three patients. Three women with gastric varices resulting from liver cirrhosis with a mean age of 65.7 years (range: 48–78 years).

Pre-procedural intravenous dynamic CT scans were performed (Sensation Cardiac, Siemens, Erlangen, Germany) less than one month before the scheduled BRTO procedure, with an intravenous bolus injection of 100 mL of 350 mg I/mL iodinated contrast medium at a flow rate of 3 mL/s. The portal venous phase axial CT images (Fig. 1) were postprocessed on an independent workstation (Advantage Windows VolumeShare 4.5; GE Healthcare) connected to the angiographic equipment (Innova 4100; GE Healthcare) to obtain volume rendering (VR) images that included the inferior vena cava, left renal vein, gastric varices and their feeding and drainage veins. We used dedicated software (Innova Vision; GE Healthcare) to overlay

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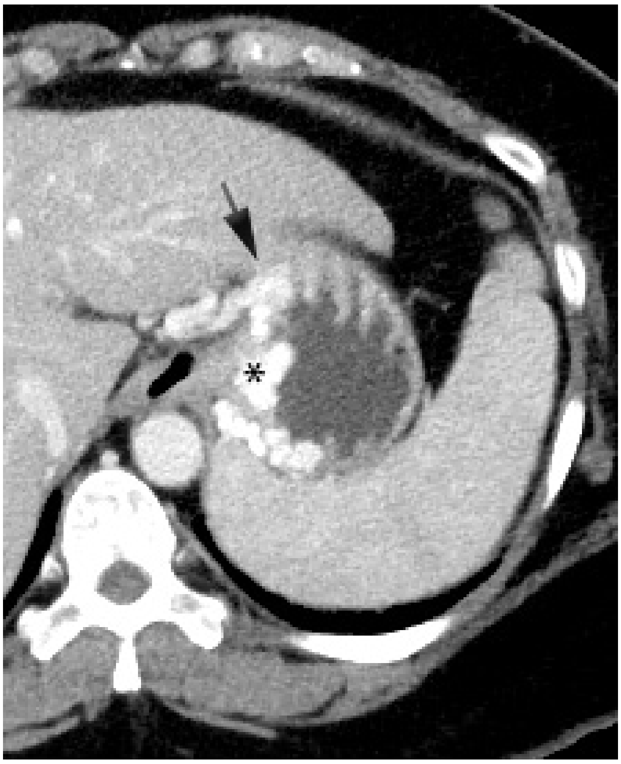

Fig. 1 Axial image of pre-procedural intravenous contrast-enhanced CT.
The target gastric fundic varices (*) projecting into the gastric lumen and the feeding gastric coronary vein (arrow) are identified.

the VR images onto the real-time X-ray fluoroscopy by semiautomatic registration to provide the 3D roadmap. In most cases, the deviation between a 3D roadmap image and a real-time X-ray fluoroscopy is few millimeters to less than 10 mm. When an alignment error was detected between two images, the re-registration would be made manually while referring to the position of blood vessel and catheter. After registration was performed, the X-ray table and C-arm could be moved into any position or angulation because the software automatically maintained the registration and tracked the geospatial location.

For the BRTO procedures, we followed the method of Kanagawa *et al.* [2]. Briefly, a 5.2- or 6- French balloon catheter with an 11- or 20-mm balloon diameter (Terumo-clinical Supply, Tokyo, Japan) was inserted from the right femoral vein to the left renal vein and wedged into the gastrorenal shunt. The catheterization of the gastrorenal shunt (Fig. 2a) via the left renal vein was performed using the 3D roadmap for interventional guidance. After the balloon catheter reached into the gastrorenal shunt (Fig. 2b), the occlusion balloon was inflated and the BRTV procedure was performed using gaseous CO_2 (Fig. 2c). After achieving appropriate visualization of the gastric varices (Fig. 2d), foam sclerosant was injected into the target varices (Fig. 2e). The foam sclerosant was prepared by mixing 2 mL of 3% polidocanol (Polidocasklerol, Zeria Pharmaceutical, Tokyo, Japan) and 8 mL of air using the Tessari method [9]. C-arm CT (Innova 4100; GE Healthcare) was performed to confirm the satisfactory filling of gastric varices by the polidocanol foam. If the varices were not filled by gas, additional foam sclerosant was injected under digital subtraction angiography (DSA), and C-arm CT acquisition was repeated to confirm the full sclerotherapy of the entire gastric varices. After sclerotherapy, a 50% NBCA plug (Fig. 2f) was injected into the gastrorenal shunt, the occlusion balloon was deflated, and the catheter was removed. The three patients underwent follow-up contrast-enhanced CT examination (Fig. 3) and endoscopy one week after BRTO. Fluoroscopy time and the dose of iodinated contrast medium used for BRTO with the 3D roadmap were compared to those of BRTO without a 3D roadmap in the previous 20 patients at our institution [10].

RESULTS

In all the three patients, the catheterization of the gastrorenal shunt was accomplished successfully, and the sclerosant could reach the gastric varices without the administration of iodinated contrast medium under the 3D roadmap. The fluoroscopy time (16.9 ± 2.4 min) and the iodinated contrast medium dose (0 ± 0 mL) were substantially reduced as compared with the values (29.0 ± 12.1 min and 171.6 ± 52.7 mL, respectively) corresponding to our previous cohort [10] for which we did not use a 3D roadmap. Full variceal thrombosis was confirmed using contrast-enhanced CT one week after BRTO. No procedure-related complications occurred, and none of the three patients experienced variceal bleeding during a 12-months follow up.

DISCUSSION

Although gastric varices bleed less often than esophageal varices, the mortality rate of gastric variceal bleeding is higher than that of esophageal variceal bleeding. A variety of treatment options, including endoscopic procedures, endovascular treatment, and surgery, are typically performed, but there is no widely accepted optimal method or standard algorithm.

BRTO was first coined by Kanagawa *et al.* [2] to embolize gastric varices through a gastrorenal shunt, and it has been performed in Asia during the past

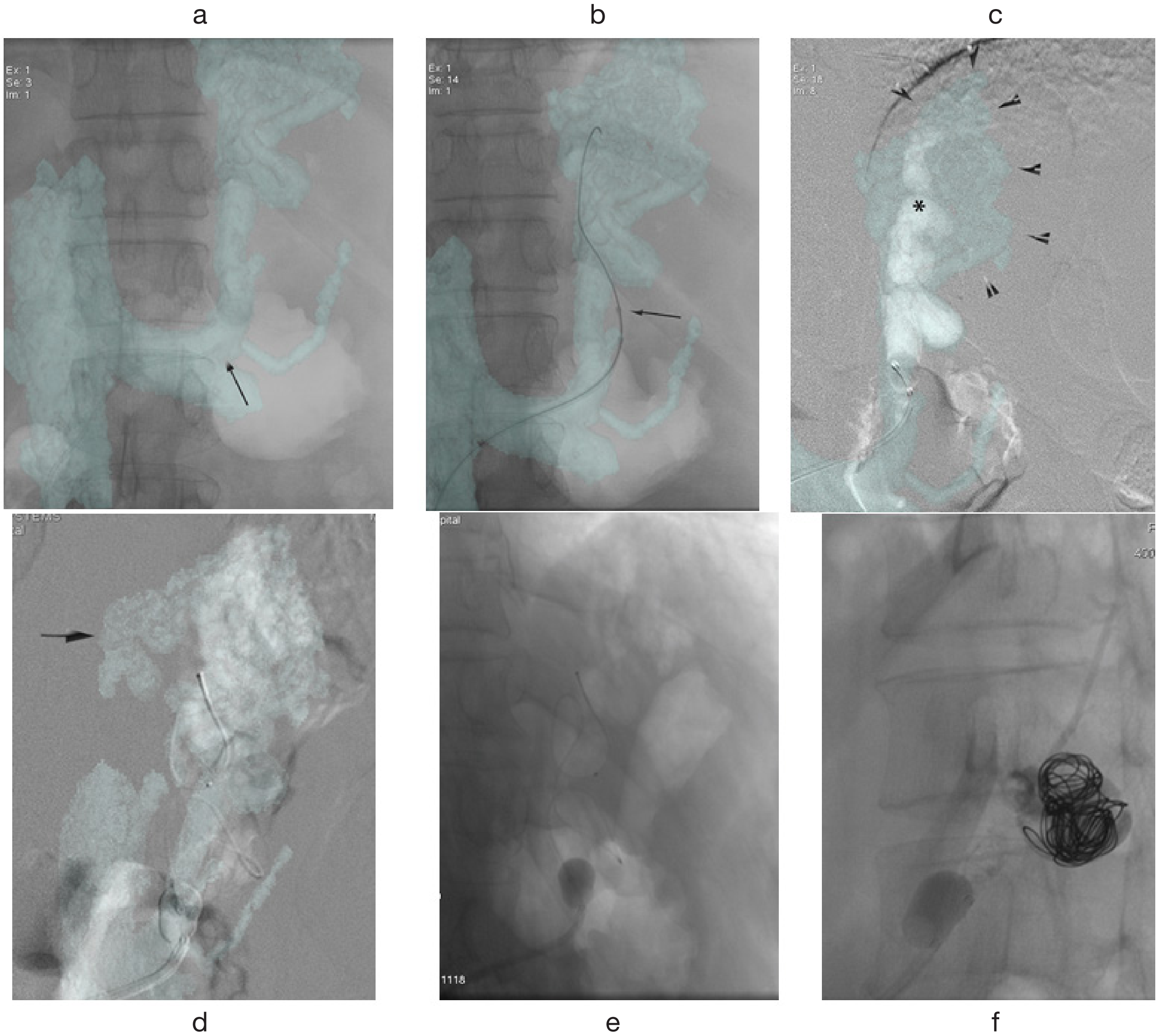

Fig. 2 Catheterization under 3D roadmap (faint blue color).
After the reach into the confluence of the inferior phrenic vein (Fig. 2a; arrow), the balloon catheter (Fig, 2b; arrow) was advanced over the guidewire into the gastrorenal shunt without any iodinated contrast medium. Balloon-occluded retrograde transvenous venography (BRTV) with CO2 in supine position allowed only partial visualization (Fig. 2c; *) of the gastric varices (Fig. 2c; arrowheads). BRTV with CO2 via a microcatheter deeper into the gastrorenal shunt in right lateral decubitus position (Fig, 2d) showed the entire gastric varices corresponding to 3D roadmap with the feeding gastric coronary vein (arrow). Foam sclerosant was injected into target vessels in right lateral decubitus position (Fig, 2e; circle). NBCA plug (Fig, 2f; circle) was injected into the coils a few centimeters above the balloon at the gastrorenal shunt, the occlusion balloon was deflated, and the catheter was removed.

two decades. BRTO has been considerably effective in managing gastric variceal bleeding. The reported success rates for controlling bleeding reach and re-bleeding rates remain in the 87%-100% 0%-10% range, respectively [2, 10, 11]. Moreover, compared to TIPS, BRTO is less invasive and safe to perform in patients with poor hepatic reserves or encephalopathy [2-4].

The technical success of a BRTO procedure requires the following: (a) identification of the gastric varices and all their feeding and draining veins, (b) injection of the sclerosant into the entire network of gastric varices. Overlooking collateral vessels can result in insufficient obliteration of gastric varices or may result in dangerous systemic leakage of the sclerosing agent. To avoid the risk of leakage and increase safety, an improved technique that includes BRTV with gaseous CO_2 and foam sclerotherapy using polidocanol, has been shown to decrease the iodinated contrast load and facilitate intraprocedural management, while maintaining high success and low complication rates [5, 10, 12]. In addition to these methods, the present study introduced further refinement by adding a 3D roadmap obtained from preprocedural CT images for interventional guidance during BRTO.

3D C-arm CT angiography has been widely used, and many reports have demonstrated its utility in various interventional treatments. In recent years, the new technique which enables one to overlay 3D reconstructions obtained from CT angiography with real-time X-ray fluoroscopy has been developed to provide a 3D roadmap. The latest studies indicate the feasibility and efficacy of a 3D roadmap in several fields, such as neurovascular interventions, cardiovascular interventions, and transarterial treatments of hepatocellular

Fig. 3 Contrast enhanced CT examination obtained one week after BRTO.
Complete thrombosis of the gastric varices (*) is shown.

carcinoma [6–8]. Glockler *et al.* reported the utility of a 3D roadmap during cardiovascular interventions in 78 patients with congenital heart disease [6]. They demonstrated that a 3D roadmap facilitated catheterization and accelerated interventions, thereby significantly reducing fluoroscopy time. Bargellini *et al.* reported the feasibility of a 3D roadmap in the transarterial chemoembolization of hepatocellular carcinoma [7]. Under 3D roadmap guidance, they performed the catheterization of the proper hepatic artery with no requirement for intra-arterial contrast injection or DSA acquisitions of the celiac trunk, which potentially reduced radiation exposure and contrast medium administration. In the present study, we applied this new technique to BRTO procedures.

We consider that using a 3D roadmap during BRTO has several advantages. First, a 3D roadmap provides detailed morphologic information regarding gastric varices and the surrounding vasculature. Prior to sclerotherapy, it is necessary to have sufficient visualization of the target varices upon venography. However, BRTV does not always depict the entire gastric varices owing to the leakage of contrast medium into collaterals [5]. Conventional arterial portography can demonstrate gastric varices and gastrorenal shunts, but it requires arterial puncture. Matsumoto *et al.* demonstrated the usefulness of intravenous contrast-enhanced 3D CT portography in patients with gastric varices for evaluating portosystemic collaterals [13]. They demonstrated that a comparison of the findings of 3D CT portography and conventional arterial portography revealed close agreement and, with respect to depicting the posterior gastric veins/short gastric veins, 3D CT portography was found to be superior to conventional arterial portography. These results suggest that a 3D roadmap obtained from preprocedural CT may provide more useful information about the entire vasculature with a less invasive approach. Further, the 3D roadmap is continuously displayed at any angulation of the C-arm and at any table position. Operators can understand the anatomical pathway from the gastrorenal shunt to gastric varices, which increases the safety and accuracy of catheter manipulation and helps to determine the appropriate position for balloon occlusion. In addition, the injection of iodinated contrast medium for confirming the catheter or wire position is not needed. In the present study, we were able to catheterize the gastrorenal shunt without using iodinated contrast medium. In addition, BRTV using CO_2 injected at an appropriate position in the gastrorenal shunt revealed the entire gastric varices corresponding to the VR images (grade 1 or 2 in Hirota's classification). In experienced hands, it may take no more than 10 minutes for post-processing CT images and registration; thus, the use of a 3D roadmap also reduces the overall procedure time.

As a limitation, one technical issue persists in this system; the inaccuracy of registration should not be disregarded. Although the VR image was semi-automatically registered by real-time X-ray fluoroscopy, with the lumbar vertebrae used as the reference, some deviation between the two images is inevitable because CT was performed under breath holding conditions, while fluoroscopy was performed under free breathing conditions. However, we do not consider the imperfection of registration to be a major disadvantage. Even though some deviation exists between the two images, the 3D roadmap helps operators to comprehend vascular structure, and it is a sufficiently useful guide for catheterization. Because the most expiratory phase is longer than other phases of the respiratory cycle, intravenous contrast-enhanced CT prior to BRTO is now performed at the expiratory phase in our institution to minimize this respiratory gap.

In conclusion, our preliminary experience suggests that a 3D roadmap is feasible and enables accurate catheter manipulation during BRTO, thus helping to reduce procedure time, radiation exposure, and iodinated contrast medium load.

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