Variations of Balloon-occluded Retrograde Transvenous Obliteration (BRTO): Balloon-occluded Antegrade Transvenous Obliteration (BATO) and Alternative/Adjunctive Routes for BRTO

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ABSTRACT

Alternative routes for transvenous obliteration are often sought in the management of gastric varices, as well as in the management of other nongastric varices (ectopic varices) such as duodenal and mesenteric varices. These alternative routes can be classified into A-portal venous access routes and B-systemic venous access routes. Anecdotally, alternative routes are more commonly required with duodenal and mesenteric varices compared with gastric varices. Twelve percent (2–19%) of patients with gastric varices require alternative/adjunctive variceal access routes. The most common alternative route described for transvenous obliteration of gastric varices is the percutaneous transhepatic route, which is commonly referred to in the Japanese literature as percutaneous transhepatic obliteration (PTO). The percutaneous transhepatic obliteration route can be performed alone or in combination with the more traditional balloon-occluded retrograde transvenous obliteration (BRTO) transrenal route. Percutaneous transhepatic obliteration by itself is successful in 44–100% of cases for obliterating gastric varices and is rarely unsuccessful when it is combined with BRTO. Other alternative routes are less commonly described and as a result, their clinical outcomes are relatively anecdotal. However, they are technically more challenging and are less commonly successful. These routes include, but are not confined to transphrenic, transileocolic, trans-TIPS (transvenous intrahepatic portosystemic shunt), transgonadal, transazygous, and transrenal capsular vein approaches.

KEYWORDS: Transvenous obliteration, duodenal varices, gastric varices, balloon occlusion, transhepatic, trans-TIPS, phrenic vein

Objectives: Upon completion of this article, the reader should be able to recall the indications and varying techniques that are alternative and/or adjunctive to the traditional BRTO procedure.

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Management of Gastric Varices: Endoscopic, BRTO, and TIPS;

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Hemorrhage from portosystemic varices remains a major cause of morbidity and mortality in patients with portal hypertension.¹ Shunting procedures, whether surgical or endovascular, are effective at reducing the portal pressure, but may result in serious complications such as encephalopathy and/or hepatic insufficiency.² In addition, high-risk varices such as those found in the gastric antrum may still be at risk of hemorrhage even with lowered portosystemic gradient.³ Embolization of varices using macroscopic coils or glue is commonly recommended, but also fails to eliminate this risk entirely.⁴ Chemical sclerosis methods, although frequently resulting in worsened portal hypertension, have proven to be very effective in eradicating the varices at risk.⁵

Earliest methods to sclerose varices using hypertonic glucose or saline, ethanol, sodium morrhuate, polidocanol, ethanolamine oleate, or sodium tetradecyl sulfate were effective but risky, in part because of possible leakage into the left renal vein, right heart, and pulmonary circulation of the large amount of sclerosant necessary to treat the large-diameter lumen and large-capacity varices.⁶ The varices were usually accessed via the portal system, either by transhepatic, transileocolic vein, transumbilical vein, or transjugular vein route, and the sclerosant was introduced via the feeding vessels anterogradely. Recurrence rates were also high, likely

due to recanalization through untreated collateral channels. With the introduction of balloon-occluded retrograde transvenous obliteration (BRTO) in the 1980s,⁷ there are now additional options of forcing sclerosant into the varices via the exit retrogradely, while occluding the outflow with a balloon. Because many variceal systems have multiple feeding and multiple draining pathways, combinations of antegrade and retrograde techniques are frequently useful. In addition, not all variceal systems drain into the left renal vein, and selection and occlusion of other outflow vessels may be necessary to eradicate varices effectively.

Here we review variations of conventional BRTO, including balloon-occluded antegrade transvenous obliteration (BATO), combined BATO/BRTO, and use of vessels other than the conventional left renal vein.

TECHNIQUE

The first choice of access BRTO of gastric varices is the traditional transrenal route^{7–10} (Fig. 1A) (please see “Balloon-occluded Retrograde Transvenous Obliteration (BRTO): Technique and Intraprocedural Imaging” in this issue). Alternative routes are utilized for gastric varices when there is no gastroduodenal shunt^{11–14} (Fig. 1B) or as an adjunct access to the traditional transrenal

Figure 1 Illustration demonstrating the basic anatomy of a gastric varix with the portal circulation shaded gray and the systemic circulation shaded black and both overlaying the stomach and first part of the duodenum. (A) Illustration demonstrates the balloon-occlusion catheter being advanced from a transfemoral (systemic venous) approach and positioned and inflated in the gastroduodenal shunt near its base at the left renal vein (RV). This is the classic balloon positioning for a traditional balloon-occluded retrograde transvenous obliteration (BRTO) procedure. (B) Illustration demonstrates the balloon-occlusion catheter being advanced from a transhepatic (portal venous) approach and positioned and inflated in the left gastric vein (LGV) or coronary vein near its base at the main portal vein (PV). This is the most common approach for a balloon-occluded antegrade transvenous obliteration (BATO) procedure and is also given the name percutaneous transhepatic ablation (PTO). PTO is a subtype of BATO; the other subtype is the trans-TIPS BATO approach (see Figs. 5 and 6). (C) Illustration demonstrates two balloon-occlusion catheters for a combined transhepatic BATO (PTO) and BRTO procedure. IVC, Inferior vena cava; MV, mesenteric vein; SV, splenic vein; GV, gastric varix.

BRTO route^{15,16} (Fig. 1C). In addition, alternative routes for transvenous obliteration are used in the management of nongastric varices (ectopic varices) such as duodenal, mesenteric, and stomal varices^{17–28} (Fig. 2). Anecdotally, alternative routes are more commonly required with duodenal and mesenteric varices compared with gastric varices.

Alternative/adjunctive routes can be classified into A-portal venous access routes and B-systemic venous access routes. The most common alternative route described for transvenous obliteration of gastric varices is the percutaneous transhepatic route which is commonly referred to in the Japanese literature as percutaneous transhepatic obliteration (PTO)

(Figs. 1B, 3A–D, 4A–H).^{15,16} Other alternative routes are less commonly described and include but are not confined to transcaval, transphrenic, transileocolic, trans-TIPS (transvenous intrahepatic portosystemic shunt), transgonadal, transazygous, and transrenal capsular vein approaches (Fig. 5–7).^{17–28} Percutaneous transhepatic obliteration (PTO) is actually the first described route utilized solely for the obliteration (embolization) of gastric and esophageal varices (practiced in the 1970s) predating the transjugular intrahepatic portosystemic shunt (TIPS) era.^{29–33} With the advent of BRTO in the early 1990s it has been used as a second choice approach or an adjunct to the traditional transrenal BRTO approach.^{15,16}

Figure 2 A 64-year-old woman with cirrhosis underwent cystectomy and ileal conduit for urethral adenocarcinoma. She presented one year later with a one-month history of fatigue, increasing hematuria with passage of clots, and anemia. (A) A computed tomography (CT) scan showed prominent vessels in and around the urostomy (arrows), which could be traced to branches of the superior mesenteric vein. (B) Patient underwent transvenous intrahepatic portosystemic shunt (TIPS) for portal decompression. Despite lowering of the portosystemic gradient to 6 mm Hg, selective venography of the jejunal branch leading to the peristomal varices confirmed persistent portosystemic shunting into subcutaneous systemic veins, and active extravasation at the stoma. Note inverted nephroureteral drain traversing anastomotic stricture with hub protruding from stoma (arrow). (C) Balloon-occluded sclerotherapy with 3 mL of ethanolamine oleate-gelatin sponge slurry was performed, followed by coil embolization. Note accumulation of extravasated contrast medium in the ileal loop. (D) Completion venogram confirmed restoration of hepatopetal flow and no filling of the peristomal varices. Patient has been free from ulceration and hemorrhage at 7-month follow-up.

Figure 3 Illustration demonstrating the basic anatomy of a gastric varix with the portal circulation shaded gray and the systemic circulation shaded black and both overlaying the stomach and first part of the duodenum (A). The gastroduodenal shunt is rudimentary (compare with illustration of Fig. 1A). (B) Illustration demonstrates the balloon-occlusion catheter being advanced from a transhepatic (portal venous) approach and positioned and inflated in the left gastric vein (LGV) or coronary vein which comes off the main portal vein (PV). The posterior (PGV) and short (SGV) gastric veins are coil embolized from the transhepatic approach. (C) Illustration demonstrates the balloon-occlusion catheter being advanced from a transhepatic (portal venous) approach and positioned and inflated in the posterior gastric vein (PGV), which comes off the main portal vein (PV). The left (LGV) and short (SGV) gastric veins are coil embolized from the transhepatic approach. (D) Illustration demonstrates the balloon-occlusion catheter being advanced from a transhepatic (portal venous) approach and positioned and inflated in the short gastric vein (SGV) which comes off the splenic vein (SV). The left (LGV) and posterior (PGV) gastric veins are coil embolized from the transhepatic approach. IVC, Inferior vena cava; MV, mesenteric vein; GV, gastric varix.

Portal Venous Access Routes

PERCUTANEOUS TRANSHEPATIC OBLITERATION (PTO)

This is the most commonly described alternative/ad-junctive access^{15,16} (Fig. 4). This access is similar to a right-sided percutaneous transhepatic cholangiogram (PTC) (Fig. 4) and can be performed under moderate

sedation. General anesthesia may be used in patients who cannot tolerate such procedures under moderate sedation or if the operator predicts a long procedure possibly involving a combined PTO and BRTO. The patient is placed supine with his or her arm at mid-abduction. The right hemithorax is prepared and draped in the standard surgical manner.

Figure 4 A 45-year-old male liver transplant recipient with a mesogastorenal (mesenterico-gastorenal) shunt undergoing transhepatic portography. (A) Image demonstrates a peripheral (PTC-style) portogram (hollow arrow) through a transhepatic 21-gauge needle (solid arrows). (B) Image demonstrates a 0.018-inch guidewire (white arrows) being advanced through the 21-gauge needle (black arrow) and into the main portal vein in a retrograde fashion. (C) Image is a limited portogram through a sheath (black arrow) as a guidewire is maintaining main portal vein (PV) access (white arrows). The main portal vein (PV) branches into the right portal vein (RPV) and Left portal vein (LPV). (D, E) Images are two sequential (D: early and E: Late) images of a superior mesenteric vein (MV) venogram showing a meandering (black arrows) meso-gastorenal shunt (or mesenterico-gastorenal shunt) (black arrows). Some contrast does go from the mesenteric vein (MV) to the portal vein (PV). The hollow arrow is a directional arrow signifying the inflow of additional mesenteric vein tributaries (inferior mesenteric vein tributaries). The asterisk in (E) denotes the site of the portosystemic venous shunt site where contrast enters the systemic venous system (LRV: left renal vein) and inferior vena cava (IVC).

Figure 4 (Continued) (F, G, H) Three sequential (F: earliest and H: latest) images of a selective venogram of the meso-gastrorenal shunt (or mesenterico-gastrorenal shunt) (black arrows). The hollow arrow is a directional arrow signifying the inflow of additional mesenteric vein tributaries (inferior mesenteric vein tributaries). The asterisk in Fig. 4G denotes the site of the portosystemic venous shunt site where contrast enters the systemic venous system into the left renal vein (LRV) and IVC (compare with images from D and E).

Certain operators utilize real-time ultrasound to access a right-sided portal vein radical. We utilize real-time fluoroscopy in an attempt to access smaller, more peripheral portal vein branches that may not be visual-

Figure 5 Illustration demonstrating the basic and surgical anatomy of a gastric varix with the portal circulation shaded gray and the systemic circulation shaded black with a dual BATO and BRTO access. The balloon-occluded antegrade transvenous obliteration (BATO) access is via a transjugular intrahepatic portosystemic shunt (trans-TIPS BATO). The balloon-occluded retrograde transvenous obliteration (BRTO) access is via the traditional transfemororenal access. MV, Mesenteric vein; SV, splenic vein; PV, main portal vein; RPV, right portal vein; TIPS, transjugular intrahepatic portosystemic shunt; HV, hepatic vein; IVC, inferior vena cava; RV, left renal vein; LGV, left gastric vein; GV, gastric vein.

ized clearly by ultrasound. A 21- or 22-gauge needle is passed into the right hepatic lobe (Fig. 4A). Contrast is injected as the needle is pulled back until a portal vein radical is visualized (Fig. 4A). A 0.018-inch guidewire (a 0.018-inch glidewire is used by some operators) is advanced into the more central portal vein branches (Fig. 4B). A transitional graduated dilator (Accustick[®], Boston Scientific, Natick MA; or Neph-set[®], Cook Inc., Bloomington, IN) usually with a metal stiffener is advanced over the wire (Fig. 4C). This is used to upsize the wire to a 0.035-inch wire. The transitional dilator is then exchanged for a vascular sheath that is appropriate for the occlusion catheter to be used. Planning for what type and size occlusion catheter is based on prior imaging, which is usually computed tomography (CT) venography and/or magnetic resonance (MR) venography (please see “Balloon-occluded Retrograde Transvenous Obliteration (BRTO): Preprocedural Evaluation and Imaging” in this issue). The ideal reformats/projections for planning for gastric variceal obliteration are the coronal reformats. Usually, a 7-French sheath is required to accommodate most 10- to 11-mm occlusion catheters, which are usually the maximum required to occlude afferent (portal venous side) feeders to gastric varices and ectopic varices (duodenal and mesenteric varices; see below). Once the adequately sized vascular sheath is placed, a splenic, mesenteric, and/or portal venogram is performed that is pertinent to the varix that needs obliteration (Fig. 4C-H).

TRANSJUGULAR INTRAHEPATIC PORTOSYSTEMIC SHUNT (TIPS) APPROACH

This is the least described alternative/adjunctive access to the portal venous system^{26,34–36} (Figs. 5–6). It is usually preexisting as a transjugular intrahepatic

Figure 6 A 52-year-old man with hepatitis C, hemochromatosis, cirrhosis, and gastroesophageal hemorrhage underwent a magnetic resonance imaging-guided transjugular intrahepatic portosystemic shunt (TIPS) procedure, along with minimal coil embolization. He presented with hepatic encephalopathy, recurrent hemorrhage, and ascites. (A) A computed tomography (CT) scan showed large gastroesophageal varices draining into the left renal vein (arrow), despite an apparently patent TIPS shunt. (B) Splenic venography showed no flow through the TIPS shunt and preferential flow through the large splenogastrorenal shunt. A smaller portion of the outflow was directed into esophageal varices (arrow), but the majority of flow exited through the left renal vein (arrowheads). Portosystemic gradient measured 12 mm Hg. Previously placed embolization coils were clearly ineffective. (C) A 14-mm occlusion balloon was placed in the outlet of the varix (black arrow) and a 16-mm balloon was placed in the coronary vein (white arrow). After measurement of intravascular volume and confirmation of near-stasis by injection of contrast medium, the outlet balloon was temporarily deflated, 16 mL of 5% ethanolamine oleate prepared as a thick gelatin sponge slurry were injected into the inlet, followed by immediate reinflation of the outlet balloon. Because of the large diameter of the varix, a combination of embolization coils and a 0.035" moveable core guidewire with the core removed were used to embolize the inflow and the outflow. (D) Final venogram after caudal extension of stent showed rapid flow through the TIPS with no filling of the varices. Portosystemic gradient measured 10 mm Hg. The encephalopathy resolved within a few days, allowing chemoembolization of hepatocellular carcinoma one month later. Follow-up CT scan 6 months later confirmed complete disappearance of the varices, as well as resolution of ascites. Despite no venographic evidence of intrahepatic hepatopetal portal flow, and despite undergoing two sessions of chemoembolization, the patient's MELD score decreased from 20 to 11 during these 6 months and he has been free from hemorrhage and encephalopathy in 14 months of follow-up.

portosystemic shunt (TIPS)^{34–36} and the access is rarely created for the sole purpose of the varices obliteration procedure. In a study by Park et al, 6.7% of BRTO cases ($N = 5/75$) were performed with a combined preexisting trans-TIPS approach and a traditional transrenal BRTO approach.³⁰ It is performed with the standard TIPS-technique.^{26,34–36} Once the 9–10 TIPS sheath is placed

a splenic, mesenteric, and/or portal venogram is performed that is pertinent to the varix that needs obliteration. The advantages of this approach is that it is usually preexisting as a TIPS and no additional access risk is taken^{34–36} (Figs. 56). The disadvantages of this access is that it is an invasive route and takes time and resources (potentially requiring general anesthesia

Figure 7 Illustration demonstrating the basic anatomy of a gastric varix with the portal circulation shaded dark gray and the systemic circulation shaded light gray with overlaying the esophagus, stomach, the first part of the duodenum, and left hemidiaphragm. (A) The illustration demonstrates the para- and supradiaphragmatic portosystemic venous circulation as alternative accesses to the balloon-occluded retrograde transvenous obliteration (BRTO) procedure. The gastroduodenal shunt is rudimentary (compare with illustration of Fig. 1A). (B) Illustration demonstrates the balloon-occlusion catheter being advanced from a transfemoral approach and positioned and inflated in the transverse portion of the inferior phrenic vein (TtIPV) and filling of the gastric varix (GV) with contrast (black). (C) Illustration demonstrates the balloon-occlusion catheter being advanced from a transfemoral approach and positioned and inflated in the transverse portion of the inferior phrenic vein (TtIPV) via the left brachiocephalic vein (LtBCV) and pericardial vein (Peric V) and ultimately filling of the gastric varix (GV) with contrast (black). (D) Illustration demonstrates the balloon-occlusion catheter being advanced from a transfemoral approach and positioned and inflated in the descending portion of the inferior phrenic vein (DpIPV) via the azygous arch (AzA) and azygous-paraesophageal (AZ) venous system and ultimately filling of the gastric varix (GV) with contrast (black). IVC, Inferior vena cava; SVC, superior vena cava; RtBCV, right brachiocephalic vein; LtBCV, left brachiocephalic vein; LtSV, left subclavian vein; Peric V, pericardial or pericardiophrenic vein; AzA, azygous arch; AV, azygous venous system or azygo-paraesophageal venous system; IPV, inferior phrenic vein: descending portion (DpIPV) and transverse portion (TtIPV); GV, gastric varices (varix); MV, mesenteric vein; SV, splenic vein; PV, portal vein.

in some institutions) to establish. In addition, it is a long and indirect access route (especially when compared with the percutaneous transhepatic route), particularly when the target vessel is a distance from the liver such as gastric varices and distal colonic varices.

TRANS-TIPS OR PERCUTANEOUS TRANSHEPATIC BALLOON-OCCLUDED TRANSVENOUS OBLITERATION

Once the portal venous branches leading to the varices in question are identified occlusion of these branches are planned for. If there are multiple veins (for example for a gastric varix), the largest of these portal venous branches is left for the balloon-occlusion catheter (Fig. 3). The smaller veins are coil embolized or occluded utilizing Amplatzer vascular plugs. Once the “debranching” of the gastric varix is performed, the major (largest) portal venous branch is occluded utilizing the balloon-occlusion catheter (Fig. 3). If the access to the portal circulation is via an established TIPS, two balloon-occlusion catheters can be passed through the TIPS and occlude the two major portal venous branches (if any) (Fig. 3).

After the varix has been “trapped” by coil embolizing, smaller portal venous branches (debranching) and balloon occlusion of the main portal venous branch with (Figs. 1C, 5) or without (Fig. 1B) balloon occlusion of the shunt from the renal vein (traditional BRTO), the sclerosant is instilled (please see “Balloon-occluded Retrograde Transvenous Obliteration (BRTO): Technique and Intraprocedural Imaging” in this issue). Coaxially placed microcatheters to instill the sclerosant deeper with the varix are less commonly required, especially if the varix is “trapped” from the portal venous side (BATO) and from the systemic venous side (BRTO) with occlusion balloons. Usually, balloons placed at both the portal and systemic venous sides enable adequate sclerosant distribution without the need for additional microcatheter extensions.

Systemic Venous Access Routes

SYSTEMIC VENOUS ACCESS VEINS/ROUTES FOR GASTRIC VARICES

These systemic access veins are difficult to access and are a second choice to the gastroduodenal shunt (Fig. 7A). They are accessed when (1) there is no other alternative (no gastroduodenal shunt), or (2) in addition to the gastroduodenal shunt if they provide “escape routes” for the sclerosant to escape into the systemic circulation from the gastric varices.^{9–16,19} In a study by Araki et al, 14.5% ($N=11/76$) of patients presenting with gastric varices did not have the typical gastroduodenal shunt and alternative systemic venous access routes were used in an attempt to perform a BRTO via them¹⁴; 82% ($N=9/11$) had identifiable systemic venous access routes and the re-

maining (18%, $N=2/11$) had numerous innominate collaterals (as we would say, more like a retroperitoneal plexus of veins).¹⁴ The identifiable systemic veins (systemic venous access routes to the gastric varices) include (1) the left inferior phrenic vein, which empties into the inferior vena cava (IVC) (Fig. 7B); (2) the pericardial vein, which anastomoses with the inferior phrenic vein and empties into the left subclavian/left brachiocephalic vein (Fig. 7C); and (3) paraesophageal veins, which empty into the azygous and hemiazygous system and then empty to the superior vena cava (SVC) via the azygous arch (Fig. 7D).

These alternative veins are difficult to access from the major systemic venous access veins (the IVC, left brachiocephalic vein and SVC, respectively) (Fig. 7). They also require smaller balloons to occlude them. Intuitively, if these veins are small and difficult to cannulate, the risk of extravasation is higher. The BRTO procedures performed solely from these veins (no additional BRTO from the gastroduodenal shunt) require smaller volumes of sclerosants compared with traditional BRTO via a gastroduodenal shunt: 12 mL (usually <20 mL) versus an average of 20–30 mL (usually <40 mL), respectively.^{14,16,37–40}

SYSTEMIC VENOUS ACCESS VEINS/ROUTES FOR DUODENAL VARICES

These systemic access veins are also difficult to access. The gastroduodenal shunt is not an option in duodenal varices. These systemic veins include the renal capsular veins (right and/or left), gonadal veins (right and/or left), and right renal vein.^{23,24,28} Over 50% of duodenal variceal transvenous obliteration cases in the literature are performed utilizing the BRTO technique from the systemic venous side of the portosystemic varices.^{21–28} The remaining cases have been approached from the antegrade portal venous side (BATO-technique) via a TIPS-approach, or more commonly by a percutaneous transhepatic approach (PTO; see above).

RESULTS

BATO by Percutaneous Transhepatic Obliteration for Gastric Varices

In three studies evaluating BRTO for gastric varices (196 patients in the three studies), 2.2–19.4% of cases (12.2%, $N=24/196$) required balloon-occluded antegrade transvenous obliteration (BATO) via a percutaneous transhepatic approach (PTO: percutaneous transhepatic obliteration); either alone or in unison with the traditional BRTO approach. Percutaneous transhepatic obliteration by itself is successful in 44–100% of cases.^{15,16} However, it is rarely unsuccessful when combined with BRTO for the management of gastric varices.^{15,16}

BRTO via Alternate Systemic Venous Routes for Gastric Varices

Araki et al had a 67% success rate in cannulating these identifiable veins and performing a BRTO of the gastric varices.¹⁴ When considering all comers with gastric varices and without gastroduodenal shunts, the intent-to-treat success rate (including noncandidates) of cannulation and subsequent BRTO was 55% ($N=6/11$).¹⁴

BRTO and/or BATO for Duodenal Varices

This experience is scant in the literature.^{21–28} Approximately 12 to 15 case reports and short case series have been reported.^{21–28} Most have been successful, either utilizing a BATO and/or a BRTO technique.

CONCLUSION

Modifications and alternatives to the traditional BRTO technique, including a BATO from the portovenous side (trans-TIPS or PTO) and a BRTO from unconventional systemic veins, are valuable techniques that can potentially improve the technical and clinical results of transvenous obliteration of gastric, duodenal, and other ectopic varices.

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