Carbon Dioxide (CO_2) vs Iodinated Contrast Digital Subtraction Angiography during Balloon-occluded Retrograde Transvenous Obliteration (BRTO) Using Foam Sclerosant for Gastric Varices

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ABSTRACT

Purpose: To compare the visualization of the target gastric varices (GV) on balloon-occluded retrograde transvenous venography (BRTV) using iodinated contrast material vs carbon dioxide (CO_2) in preparation for subsequent balloon-occluded retrograde transvenous obliteration (BRTO) using foam sclerotherapy.

Materials and Methods: In 16 consecutive patients with nonruptured GV, BRTV was performed first using iodinated contrast material and then with CO_2. BRTV was repeated whenever there were changes in the catheter or patient position or when coil embolization of collaterals was needed. Each visualization grade of GV (grade 1 = GV only; grade 2 = GV > collaterals; 3 = GV < collaterals; grades 4–5 = collaterals only) was determined by two observers in consensus. During foam BRTO, the GV visualization grade was recorded again and confirmed by C-arm computed tomography (CT).

Results: In 38 pairs of BRTV, GV grades were significantly ($P < .0001$) lower (ie, favoring BRTO) on CO_2 BRTV (mean ± standard deviation, 1.8 ± 0.8) than on iodine BRTV (3.4 ± 0.8). GV grades on foam BRTO (1.4 ± 0.7) were similar to the grades obtained on the most recent CO_2 BRTV (1.3 ± 0.5) but were significantly smaller ($P < .0001$) than on iodinated BRTV (3.1 ± 0.9). GV were opacified by foam on initial C-arm CT in 14 patients (87.5%), and complete thrombosis of GV was obtained without any complication in all 16 patients (100%). CO_2 reached the GV even when iodinated contrast material could not (grade 4) in seven of our 16 patients (43.8%), leading to successful BRTO.

Conclusions: CO_2 BRTV visualized GV better than did iodine BRTV and changed the management of more than 40% of patients by enabling successful foam BRTO in patients in which conventional liquid BRTO could not be performed.

ABBREVIATIONS

BRTO = balloon-occluded retrograde transvenous obliteration, BRTV = balloon-occluded retrograde transvenous venography, CO_2 = carbon dioxide, DSA = digital subtraction angiography, GV = gastric varices

Balloon-occluded retrograde transvenous obliteration (BRTO) (1,2) has been used extensively as a sclerotherapy method to occlude pressurized gastric varices (GV) (as seen in portal hypertension), which are at risk of rupturing

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(3) and bleeding severely (4). During BRTO procedures, balloon-occluded retrograde transvenous venography (BRTV) is performed before starting the infusion of the sclerosing agent to obtain venous mapping. This mapping allows the identification of the GV, the path leading to them, and potential collaterals in which sclerosant leakage would be undesirable. To date, BRTV has traditionally been performed by using iodinated contrast material.

However, new developments in BRTO have improved the technique's safety and efficacy, notably by introducing the use of foam sclerotherapy (5,6) in place of liquid sclerosants. The foam used in modern BRTO is lighter than blood, whereas traditional liquid iodinated contrast agents used during BRTV are heavier; thus the anatomic distribution of the two agents is different. Because the gastrorenal shunt is often more dependent (dorsal) than the target GV in a supine patient, the foam may ascend upstream into the less dependent (more ventral) GV (5). Iodinated contrast material, conversely, would remain in the dependent gastrorenal shunt and not reach the GV unless given in large amounts and in the absence of systemic leaks through collaterals. One possible significant risk of this technique is to infuse too much foam, which could accumulate upstream and eventually overflow into the portal venous system (7), where it could cause thrombosis. Moreover, the visualization of foamed sclerosants is difficult under fluoroscopy, so the approach used thus far in foam BRTO has been based on imaging confirmation by C-arm CT acquisition conducted just after sclerosant administration (5,7).

Previous reports have demonstrated the usefulness and superiority of carbon dioxide gas (CO_2) in diagnostic and interventional procedures in the portal circulation (8). In an attempt to better predict the distribution of sclerosing foam immediately before its intravenous delivery, we introduced digital subtraction BRTV using CO_2 as an alternative to iodinated contrast–based BRTV and compared the visualization of the target GV on BRTV using iodinated contrast material versus CO_2 before the administration of foam sclerotherapy BRTO.

MATERIALS AND METHODS

Informed consent was obtained for this institutional review board–approved research study, including collection of the clinical data and reporting of the study results. From December 2009–October 2011, BRTO using foam sclerosants was attempted in 16 consecutive patients (10 men and 6 women; 67 ± 9 y) (**Table**) with nonruptured GV. A previous report demonstrating the efficacy of foam sclerosant in BRTO included four of these patients (7). We routinely obtained multidetector row CT (**Fig 1a**) or magnetic resonance (MR) imaging to identify the target varicose veins and portosystemic shunt and to plan the access routes. Before the interventions, celiac or superior mesenteric arteriography or splenic artery portography were performed in all patients with C-arm CT and volume renderings (AXIOM Artis FD system and DynaCT, Siemens, Erlangen, Germany) to evaluate visceral anatomy and flow directionality and to identify the veins feeding and draining the GV.

The BRTO procedures were performed following the method of Kanagawa et al (1). Briefly, an 8F, Simmons-type long sheath (Medikit Co, Ltd, Tokyo, Japan) was

Table. Patient Demographics

Patient	Age (Y)	Sex	Child's Class	GV	EV	Previous Treatments	Comorbidities
1	58	M	B	Lg-cF2	(–)	(–)	LC(C)
2	70	M	A	Lg-cF3	(+)	(–)	LC(B)
3	63	M	A	Lg-fF3	(+)	EIS, PSE	LC(Alc)
4	72	F	A	Lg-cfF2	(–)	(–)	Sarcoidosis
5	74	F	A	Lg-cF3	(+)	(–)	LC(C)
6	65	F	A	Lg-fF3	(–)	RFA	LC(C), HCC
7	67	M	B	Lg-cfF3	(+)	TACE, PSE	LC(C), HCC
8	76	M	B	Lg-cF3	(+)	EIS, PSE	LC(Alc)
9	70	M	A	Lg-cfF2	(+)	PSE	PBC
10	63	F	A	Lg-cfF3	(–)	(–)	CH(B)
11	52	M	A	Lg-cF2	(+)	PSE	LC(C)
12	76	M	B	Lg-cfF2	(+)	(–)	LC(C4), Gca
13	45	F	A	Lg-cF2	(+)	(–)	LC(Alc)
14	75	F	A	Lg-fF2	(–)	(–)	(–)
15	74	M	A	Lg-cF2	(+)	EIS	LC(Alc)
16	65	M	B	Lg-cfF2	(+)	EVL	LC(C)

GV = endoscopic classification of gastric varices, EV = esophageal varices, EIS = endoscopic injection sclerotherapy, RFA = radiofrequency ablation, TACE = transcatheter arterial chemoembolization, PSE = partial splenic embolization, LC = liver cirrhosis, Alc = alcoholic, C = type C virus, B = type B virus, Gca = gastric carcinoma.

The gastric varices were classified based on gastroendoscopic criteria according to the system adopted in Japan; Lg-c = adjacent to the cardiac ring, Lg-f = separated from the cardiac ring, Lg-cf = extending from the cardiac ring to the gastric fundus, F1 = small straight, F2 = slightly enlarged tortuous, F3 = large coil-shaped varices.

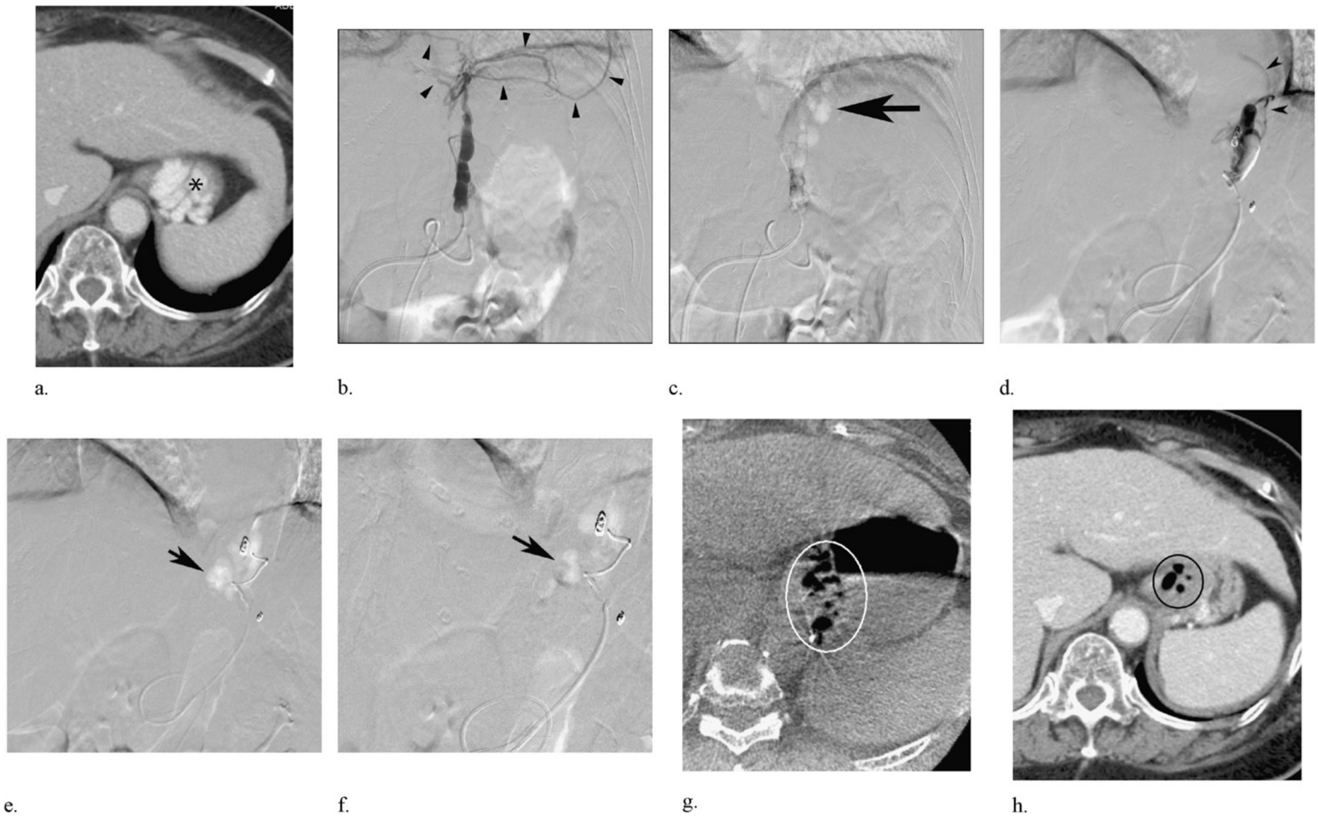


Figure 1. Patient 5. After contrast CT **(a)** and before balloon-occluded retrograde transvenous obliteration (BRTO), the target gastric varices (GV) (*) are revealed projecting into the gastric lumen. The first balloon-occluded retrograde transvenous venography (BRTV) at the orifice of the gastrorenal shunt using iodine **(b)** does not demonstrate the GV (grade 4) because of rich collaterals (arrowheads), whereas CO_2 BRTV **(c)** partially demonstrates the GV (arrow) and is graded as a 3. After advancing a microcatheter deeply into the gastrorenal shunt and coil embolization of the collateral, BRTV in the right lateral decubitus position using iodine **(d)** does not show the GV with remnant collaterals (arrowheads) and is graded as a 4, whereas CO_2 BRTV **(e)** opacifies the entire GV (arrow) and is graded as a 1. BRTO using foam polidocanol under digital subtraction angiography **(f)** (arrow) is also graded as a 1, and C-arm CT confirms that foam stays in the GV **(g)** (circle) without collateral filling. Postcontrast CT 1 week after BRTO **(h)** demonstrates totally thrombosed GV (circle) including a small amount of gas.

inserted from the right femoral vein to the left adrenal vein through the left renal vein, and a 5.2 or 6F balloon catheter with a 10- or 20-mm balloon diameter (Terumo Clinical Supply, Gifu, Japan) was wedged into the gastrorenal shunt (ie, the largest collateral). After temporary balloon occlusion of the gastrorenal shunt, digitally subtracted BRTV was performed using conventional liquid iodinated contrast material first (**Fig 1b**) and immediately thereafter with gaseous CO_2 (**Fig 1c**). The rationale for this order (contrast first, CO_2 next) was that CO_2 tends to remain entrapped in the varices, even after balloon deflation, and CO_2 contamination of the GV could cause a vapor lock phenomenon, which itself can influence hemodynamics if iodinated contrast material was injected thereafter. Both injections were performed manually by using a 10- or 20-mL syringe with the goal of visualizing the target GV. After every iodine/CO_2 BRTV pair, as well as before BRTO, the occlusion balloon was deflated transiently to empty the GV of any residual CO_2.

Each variceal visualization grade was determined independently by two observers (T. Hashimoto, K.M.), with 11 and 10 years of interventional radiology experience, respectively, using Hirota's classification (2) (grade 1 = GV are well opacified without collateral veins visualized; grade 2 = GV remain opacified despite some contrast leakage showing a few small collateral veins; grade 3 = GV are opacified partially, along with visualization of medium to large collaterals; grade 4 = GV are not opacified because all the contrast material went into many large collaterals; grade 5 = the left adrenal vein/gastrorenal shunt cannot be occluded with a balloon catheter because of the large caliber of the gastrorenal shunt, with rapid blood flow through it.

If satisfactory filling of the target varices was not reached, foam BRTO was postponed to avoid nontarget sclerotherapy, and additional maneuvers were performed, including changes in the patient's position (from supine to right lateral decubitus), changes in the catheter tip position (advanced deeper into the gastrorenal shunt toward the target varices), or coil embolization of collaterals (mostly branches of the left inferior phrenic vein) (9) (**Fig 1d, e**). These maneuvers can optimize delivery of the CO_2 in the target varices during BRTV (with the goal of optimizing subsequent distribution of foamed sclerosant into the GV during BRTO). After any of these maneuvers were performed, the occlusion balloon was deflated transiently to promote contrast washout, and then was reinflated, and digitally subtracted BRTV was repeated, again with iodinated contrast material first followed by CO_2.

Therapeutic foam BRTO was initiated only after achieving appropriate GV filling (ie, grade 1 or 2) with CO_2 BRTV. The sclerosing agent, foam polidocanol, was made by mixing 2 ml of 3% polidocanol (Polidocasklerol, ZERIA Pharmaceutical, Tokyo, Japan) and 8 ml of air by using the Tessari method with two syringes on a three-way stopcock (10). The occlusion balloon was reinflated and the sclerosing foam was slowly injected manually under digital subtraction angiography (DSA) guidance with the goal of fully filling the GV with foam, and the Hirota's grade of GV visualization was recorded again (**Fig 1f**). C-arm CT (AXIOM Artis FD system and DynaCT, Siemens) was then immediately performed (with the occlusion balloon still inflated) to confirm satisfactory filling of the target vessels by the sclerosing foam **(Fig 1g)**. If the varices were not filled by gas, additional foam sclerosant was injected under DSA, and C-arm CT acquisition was repeated. After venographic confirmation of stasis at the time of the final balloon deflation, the catheter was removed. All patients underwent contrast-enhanced CT imaging **(Fig 1h)** and follow-up endoscopy 1 week after the BRTO procedure.

Interobserver agreement on variceal grades was estimated with the Cohen κ statistic for both iodine-based BRTV and CO_2 BRTV findings. After the consensus of two interventional radiologists, iodine BRTV and CO_2 BRTV findings were compared with the variceal grades seen on foam BRTO DSA by using the Wilcoxon signed rank test on a per patient basis. Only the most recent BRTV obtained in any given patient was considered in the final per patient analysis. All statistical analyses were performed by using Excel Statistics 2010 (SSRI, Tokyo, Japan). Values are presented as means and corresponding standard deviations. A P value less than 0.05 was considered significant in two-tailed tests.

RESULTS

Technical Success of BRTO and Follow-up Information

In 14 of 16 patients (87.5%), adequate filling of the GV by foam was seen on the initial C-arm CT during BRTO. In two patients in whom foam was thought to have filled the GV on DSA (grade 1 or 2), it was evident on the initial C-arm CT that foam did not fill the target GV (**Fig 2**) and additional foam was required to fill them, which became visible on subsequent C-arm CT acquisition (**Fig 2**). Complete thrombosis of the GV was confirmed in all patients (16/16 [100%]) on a postcontrast CT scan obtained 1 week after BRTO. No complications were found intraprocedurally or during follow-up (8.1 ± 6.5 mo).

CO_2 vs Iodine-based BRTV findings

Thirty-eight pairs of BRTV were performed in 16 patients (**Table E1**) (available online at *www.jvir.org*). In all 16 patients (100%), the first BRTV was begun in the ostium of the gastrorenal shunt. Catheter repositioning, patient repositioning, and coil embolization of the collaterals were then performed in 9 (56.3%), 9 (56.3%), and 4 (25.0%) patients respectively. In only two patients (12.5%) was BRTV performed in the ostium of the gastrorenal shunt sufficient. Nine patients (56.3%) required two pairs, two patients (12.5%) three pairs, and three patients (56.3%) four pairs of BRTV to identify the GV. Overall (n = 38) there was good interobserver agreement in both iodine BRTV (κ value of 0.74; 95% confidence interval, 0.54–0.95) and CO_2 BRTV (κ value of 0.79; 95% confidence interval, 0.62–0.96). The variceal grades documented by CO_2 BRTV (1.8 ± 0.8) were significantly ($P < .001$) smaller than the grades found on iodine BRTV (3.4 ± 0.8).

The following results correspond to a per patient analysis considering only the last performed iodine-based BRTV and CO_2 BRTV in each patient. CO_2 BRTV showed variceal grades that were lower than those seen with iodine-BRTV by at least one grade in all 16 patients and grades lower by 2 grades or more in 10 of these patients (62.5%). On a per patient basis (n = 16), the grades found on foam BRTO (1.4 ± 0.7) were similar to the most recent grades seen on the last CO_2 BRTV obtained just before BRTO was performed (1.3 ± 0.5), whereas they were significantly ($P < .001$, Wilcoxon signed rank test) different from the last grades observed on iodine BRTV (3.1 ± 0.9). On the first C-arm CT obtained immediately after foam injection, the presence of gas filling in the target GV was found in 14 patients, all of whom had grades 1–2 on previous CO_2 BRTV; only five of them (36%) had grades 1–2 on iodine BRTV, however. In the two patients with no gas filling of the varices on their first C-arm CT, the variceal grades were 2 and 2 on CO_2 BRTV and 4 and 3 on iodine BRTV, respectively.

Influence of Adjunct Maneuvers

The variceal grades decreased after changing patient position (from 2.1 ± 0.5–1.6 ± 0.3; $P = 0.169$), repositioning the catheter deeper into the gastrorenal shunt (2.3 ± 0.5–1.9 ± 0.4; $P = .304$), and embolization of collaterals using coils (2.3 ± 0.5–1.3 ± 0.5; $P = .0975$) but without significant differences. Reflux of CO_2 into the portal venous system (**Fig 3**) was observed on CO_2 BRTV in five of 16 patients (31%), without splenic or portal venous thrombosis found on follow-up CT imaging.

DISCUSSION

CO_2 DSA has been used successfully and safely in many vessels other than cerebral and coronary arteries since 1971 (11). Compared with liquid iodinated contrast agents, CO_2 gas has several advantages: *(a)* no hypersensitivity

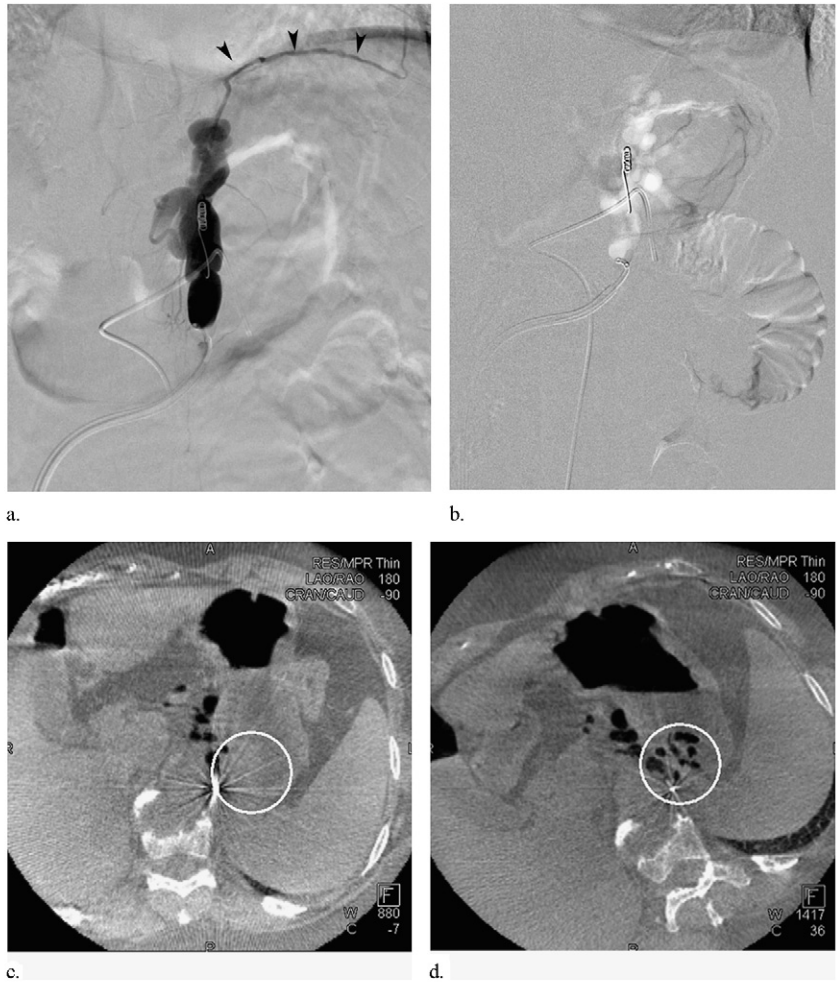
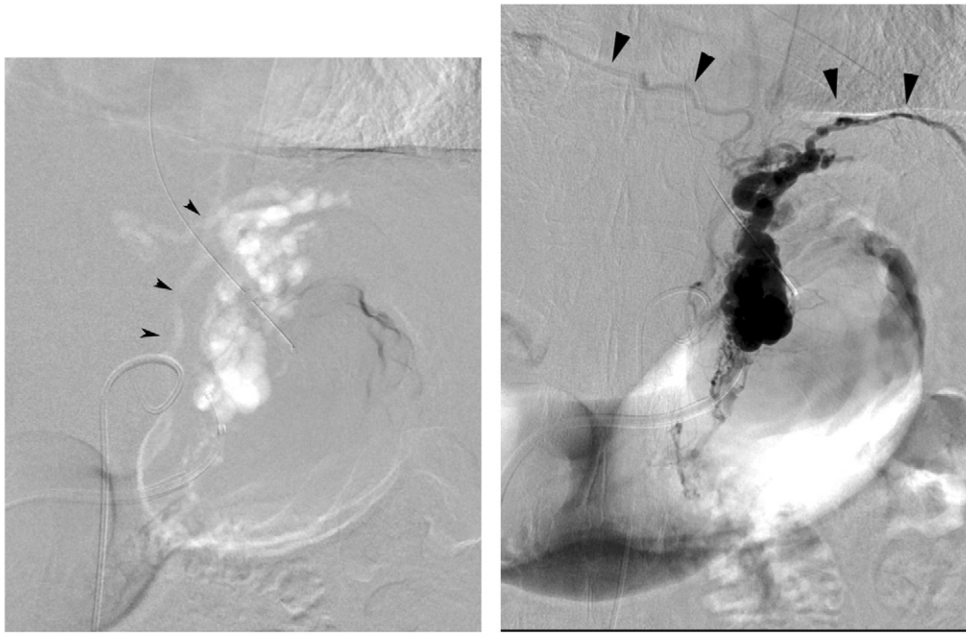


Figure 2. Patient 10. BRTV using iodine contrast material **(a)** does not show the gastric varices (GV) with remnant collaterals (arrowheads) and is graded as a 4, whereas CO_2 BRTV **(b)** seems to demonstrate the GV and is graded as a 2. Initial C-arm CT **(c)** after the same dose (10 mL) of foam as in the previous CO_2 BRTV shows inadequate filling of foam in the GV (circle). C-arm CT after additional foam administration **(d)** reveals full filling of the GV by the foam (circle).

reactions; *(b)* limited toxicity, permitting multiple large-volume injections; *(c)* very low viscosity (about 1/400th that of ionic contrast material), which enables injections of large volumes through very small catheters; and *(d)* minimal patient discomfort. In addition, the buoyancy of CO_2 gas allows for consistent and uniform vessel filling, which in turn improves visualization during angiography (12). If the area of interest is in a less dependent location than the injection site, satisfactory filling of the vascular lumen by the gaseous CO_2 can be expected.

In this study, the variceal grades observed on CO_2 BRTV were significantly lower (ie, more favorable for BRTO) than the grades found on iodine-based BRTV. This may suggest that CO_2 gas is distributed better in the GV than is iodinated contrast and that CO_2 distribution in the GV during BRTV better mimics the eventual distribution of sclerosing foam during BRTO. This may be very helpful in difficult BRTO cases with variceal grades greater than 3 in Hirota's classification, in which the target GV cannot be seen because of dispersion of heavy iodine contrast material into rich retroperitoneal collaterals, possibly impinging further advancement of the catheter. CO_2 BRTV requires the operator to take into consideration the buoyancy of the CO_2 gas: the catheter tip should be put in the most dorsal portion of the gastrorenal shunt in a supine patient, or the target GV should be placed in the most nondependent location possible by changing the patient's position. This study found that the variceal grades decreased after changing the patient's position, repositioning the catheter deeper into the gastrorenal shunt, and performing coil embolization of collaterals, although none of these effects was statistically significant. The low viscosity of the gaseous CO_2 relative to blood may be another factor that allows better delineation of the target GV compared with the more viscous iodinated contrast agents. CO_2 seems to traverse more easily through the very tortuous shunts and reach the target GV. Although the viscosity (2.0–3.5 cP) and specific gravity (0.195) of foam (13) are different from those of CO_2 (0.015 cP and 0.00187, respectively), foam showed a distribution more similar to CO_2 than to iodinated contrast medium (4.7 cP and 1.328, respectively) (14). Moreover, CO_2 reached the GV even when iodinated contrast material could not (grade 4)



a. b.

Figure 3. Patient 4. Reflux of CO_2 into the portal vein through the left gastric (coronary) vein **(a)** (arrowheads) is observed in the supine position but not on iodine BRTV **(b)** with collaterals (arrowheads).

in seven of 16 patients (43.8%), leading to successful BRTO. When conventional liquid sclerosant is used for BRTO, grade 4 on iodine BRTV requires the obliteration of collaterals using coils or a small amount of sclerosant (9) before commencing BRTO. In other words, CO_2 BRTV enabled foam BRTO in seven of 16 sixteen patients (43.8%) in whom conventional liquid BRTO could not have been performed safely (because of the high risk of sclerosant leakage into nontarget veins and/or systemic circulation). Because the reflux of CO_2 into the portal venous system was seen on CO_2 BRTV in five of 16 patients (31.3%), foam was injected carefully and slowly to avoid reflux. Reflux of foam was not observed during BRTO despite the fact that a foam volume larger than the previously injected CO_2 volume was generally required to fill the GV. The authors speculate that the differences of viscosity and specific gravity between foam and CO_2 may contribute to this observation.

Limitations of this study include its limited sample size in a single-institution setting. In addition, there was no randomization of the order in which the contrast agent was given but rather it was administered in a fixed sequence: iodinated contrast material first and CO_2 second. Injection of iodinated contrast material before CO_2 could potentially dilate the vessels and increase the visualization grade of CO_2. Another limitation was that we did not specifically address the additional radiation dose associated with CO_2 DSA. This small risk has to be weighed against the benefit of better visualization of the target varices by CO_2 than by iodine contrast material. Finally, the recent literature has shown the feasibility and safety of CO_2 gas instead of air to form the foam during sclerotherapy for leg varicosities. This could arguably be applied to BRTO as well, although the duration of the foam's stability is clearly shorter when made with CO_2 than with air.

In conclusion, CO_2 BRTV appears to be a safe and effective imaging modality to demonstrate and determine the grade of GV, which might provide a good simulation of gas behavior in anticipation of the actual injection of foamed sclerosant during BRTO, leading to successful thrombosis of the GV. The possible superiority in diagnostic accuracy of CO_2 BRTV compared with iodinated contrast-based BRTV needs to be further evaluated in future larger studies.

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Table E1. Results

Patient	BRTV at/ after	Iodine (mL)	CO_2 (mL)	Grade Rev1	Iodine Rev2	BRTV Consensus	Grade Rev1	CO_2 Rev2	BRTV Consensus	Reflux to PV	Grade Rev1	Foam Rev2	BRTO Consensus	Foam in GV C-arm CT	Net POL (mL)	Foam POL (mL)	Hemoglobulinuria	CE of GV	FU (mo)
1	GRS	20	20	4	4	4	1	1	1	(–)	1	1	1	(+)	4	20	(–)	(–)	1
2	GRS	20	10	4	4	4	2	2	2	(–)					6	30	(–)	(–)	22
	CR	20	10	4	4	4	2	2	2	(–)	3	3	3	(–)					
34	GRS	20	20	4	4	4	4	4	4	(–)					5	25	(–)	(–)	18
	CR	20	20	4	4	4	3	3	3	(–)									
	PH	20	20	4	4	4	1	1	1	(–)	1	1	1	(+)					
	GRS	10	10	4	4	4	2	2	2	(–)					2	10	(–)	(–)	15
	PH	10	10	3	3	3	1	1	1	GCV	1	2	2	(+)					
5	GRS	10	10	4	4	4	2	2	2	(–)					2	10	(–)	(–)	13
	PH	10	10	4	4	4	2	2	2	(–)									
	CR	5	5	4	4	4	2	2	2	(–)									
	DG	5	5	4	3	4	2	1	1	GCV	1	1	1	(+)					
6	GRS	10	10	4	4	3	1	1	1	(–)	1	1	1	(+)	3	15	(–)	(–)	11
7	GRS	10	10	4	3	3	2	1	1	(–)					2	10	(–)	(–)	1
	PH	10	10	2	3	2	1	1	1	(–)	2	1	2	(+)					
8	GRS	10	10	4	4	4	3	3	3	(–)					8	40	(–)	(–)	10
	CR	10	10	4	4	4	2	2	2	(–)	1	1	1	(+)					
9	GRS	10	10	4	4	4	2	3	3	(–)					2.8	14	(–)	(–)	10
	DG	20	20	4	4	4	2	2	2	(–)									
	PH	20	20	4	4	4	2	2	2	(–)									
	CR	20	20	4	4	4	2	2	2	(–)	1	1	1	(+)					
10	GRS	10	10	4	4	4	3	3	3	(–)					3.2	16	(–)	(–)	1
	PH	10	10	4	3	3	2	2	2	GCV	3	3	3	(–)					
11	GRS	20	20	4	3	3	3	3	3	(–)					4	20	(–)	(–)	8
	PH	15	15	3	3	3	1	2	1	(–)	1	1	1	(+)					
12	GRS	17	17	3	2	2	2	2	2	(–)					2	10	(–)	(–)	7
	CR	10	10	2	2	2	2	1	1	(–)	1	1	1	(+)					
13	GRS	10	10	3	3	3	1	1	2	GCV					1.5	7.5	(–)	(–)	4
	CR	5	5	2	2	2	1	1	1	(–)	1	1	1	(+)					
14	GRS	5	5	3	3	3	1	2	2	GCV					1.2	6	(–)	(–)	4
	DG	5	5	2	2	2	1	1	1	(–)	1	1	1	(+)					
15	GRS	5	5	3	3	3	2	2	2	(–)					2	10	(–)	(–)	3
	CR	5	5	2	3	3	1	2	2	(–)									
	PH	5	5	2	4	3	2	2	2	(–)									
	DG	6	6	2	2	2	1	1	1	(–)	1	1	1	(+)					
16	GRS	10	10	4	4	4	1	2	1	(–)					3	15	(–)	(–)	2
	PH	10	10	4	4	4	2	2	2	(–)									
	CR	10	10	4	4	4	2	2	2	(–)	1	1	1	(+)					

BRTO = balloon-occluded retrograde transvenous obliteration, BRTV = balloon-occluded retrograde transvenous venography, CE = contrast enhancement on CT 1 week after BRTO, CR = catheter reposition, DG = downgrading, FU = follow-up, GCV = gastric coronary vein, GRS = gastrorenal shunt, GV = gastric varices, PH = patient's habitus change, POL = polidocanol, PV = portal vein, rev1 = reviewer 1, rev2 = reviewer 2.