Management of acute lower gastrointestinal bleeding by pharmaco-induced vasospasm embolization therapy

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Abstract

Background: To report the clinical outcomes of vasospasm embolization technique in treating lower gastrointestinal bleeding (LGIB).

Methods: Fifty LGIB patients (32 men and 18 women; mean age, 70.4 years) with positive contrast extravasation on multidetector computed tomography were treated with pharmaco-induced vasospasm embolization by semiselective catheterization technique. Distal rectal bleeding was excluded. The bleedings in three patients were considered to be tumor related. Eighteen underwent regular hemodialysis, and 22 showed unstable hemodynamic at intervention.

Results: Forty-two bleeders were found in superior mesenteric territory and eight in the inferior mesenteric territory. Successful, immediate hemostasis was achieved in 49 (98%) patients. Early recurrent bleeding (<30 days) was found in 13 (26.5%) patients with 6 local rebleeding (12.2%), 5 new-foci bleeding (10.2%), and 2 uncertain foci bleeding (4.1%). Repeated vasospasm embolization therapy was given to five patients, with successful hemostasis in four. All the three tumor-related bleeding patients undergoing vasospasm embolization had ceased bleeding and discharged. Patient-based primary and overall clinical successes were achieved in 73.5% and 83.7%, and lesion-based primary and overall clinical successes were 83.0% and 86.7%, respectively. The 30-day mortality rate was 21.3%, and the 1- and 2-year survival rates were 51.5% and 43.8%. No major procedure-related complications (eg, bowel ischemia) were encountered.

Conclusion: This study confirmed our prior preliminary conclusion that pharmaco-induced vasospasm embolization is easy, safe, and effective for LGIB. This treatment may be considered the first-line alternative approach for LGIB, especially for patients of advanced age with complex medical problems and/or when vasa rectal embolization isn't feasible.

Keywords: Hemostasis; Humans; Vasopressins

1. INTRODUCTION

Lower gastrointestinal bleeding (LGIB), defined as hemorrhage from the jejunum, ileum, colon, and/or rectum, is a common medical emergency associated with significant morbidity and mortality.[1] With the advancement of coaxial microcatheter systems and the use of various embolic agents, superselective embolization has now been adopted as the preferred method for the treatment of LGIB.[2–15] To reduce the possible associated risk of bowel ischemia in up to 33% of patients,[16] it is recommended to select an embolization point beyond the level of marginal artery (ie, vasa recta). However, as many as 27% to 35% of attempts to catheterize the vasa recta were reported to be technically difficult, due to issues such as the complexity of the extravasating mesenteric artery and vascular spasms during superselective catherization.[1,4,9,12]

Cynamon et al introduced catheter-induced vasospasm as a less technically demanding alternative by using semiselective catheterization with high success rate for immediate clinical hemostasis.[17] However, this technique has not seen wide adoption. In our own early experience of catheter-induced vasospasm, we found that some vessels had difficulty inducing vasospasm and that even slightly vigorous guidewire/catheter manipulation risks vascular perforation. In addition, the spastic duration of the bleeding mesenteric artery could not be controlled (much less made constant) by Cynamon's technique.

We have modified this technique with the use of vasoconstrictors in a semiselective catherization fashion to induce temporary vasospasm in extravasating arteries. We previously presented a preliminary report in a small patient group by using our modified technique with promising clinical outcomes.[18] Since then, we have continued to gather data. In this article, we present our expanded findings on this LGIB treatment with a larger data set. We report the technical success, early rebleeding rate, 30-day mortality and long-term survival of all these patients. Clinical outcomes of patients with small bowel (SB) and colon bleeding are compared. Finally, we emphasize the categorization of early rebleeding into local and new-foci rebleeding and the concept of patient-based and lesion-based clinical success in evaluating the therapeutic efficacy of a novel technique for LGIB.

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2. METHODS

2.1. Population

In our initial study,[18] 18 patients (11 men and 7 women) received pharmaco-induced vasospasm embolization therapy to treat acute LGI bleeding between 2009 and 2013. An additional 32 patients (21 men and 11 women) underwent the treatment through June 2020, bringing the total to 50. In our hospital, vasospasm therapy has become the first-line endovascular therapy for LGIB patients after 2015. The ages of our patients ranged from 21 to 94 years, with a mean age of 70.4 years. Patients were excluded from this study if they exhibited distal rectal or hemorrhoidal bleeding.

The primary method of diagnosing LGI bleeding in our institute was multidetector computed tomography (MDCT). Angiography was performed only if a patient was positively diagnosed by MDCT. It was the clinician's decision to use entero- or colonoscopy for LGI bleeding detection and management before angiography. Thirty-two inpatients and 18 outpatients enrolled in the study with unstable hemodynamic status in 22 patients (SB, 14 patients; large bowel [LB], 8 patients) at the time of angiography. Eighteen patients had end-stage renal disease under regular hemodialysis. The patients' demographic data are listed in the Table 1. Informed consent was given by each patient/family prior to treatment. This retrospective review was approved by the Institutional Review Board of the Kaohsiung Veterans General Hospital. All experimental procedures were performed in accordance with the relevant guidelines and regulations.

Table 1

Demographic data and clinical outcomes of the vasospasm therapy

Patient Characteristic	Total (N=50)	Small Bowel (n=27)	Colon/Rectum (n=23)	*p*
Mean age, y	70.4	68.6	72.3	0.387
Sex (female/male)	16/34	5/22	11/12	0.017
Hemodialysis	18	12	6	0.147
In/outpatient	32/18	20/7	12/11	0.138
Hemodynamic instability	22 (44%)	14 (53.8%)	8 (34.8%)	0.183
Tumor bleeding	3 (5.9%)	0 (0%)	3 (1.3%)	0.058
Technical success	49 (98.0%)	26 (96.3%)	23 (100%)	0.332
Early rebleeding	13 (26.5%)	9 (34.6%)	4 (17.4%)	0.037
Local rebleeding	6 (12.2%)	5 (18.5%)	1 (4.2%)	0.112
New-foci bleeding	5 (10.2%)	3 (11.1%)	2 (8.3%)	0.739
Uncertain	2 (4.1%)			
Second treatment				0.66
Vasospastic therapy	5 (10.0%)	4 (14.8%)	1 (4.3%)	
op & others	5 (10.0%)	3 (11.1%)	1 (4.2%)	
Observation	4 (8.0%)	2 (7.4%)	2 (8.3%)	
Primary clinical success				
Patient based	36/49 (73.5%)	17/26 (65.4%)	19/23 (82.6%)	0.148
Lesion based	44/53 (83.0%)	21/27 (77.8%)	23/26 (88.5%)	0.267
Overall clinical success				
Patient based	41/49 (83.7%)	21/26 (80.8%)	20/23 (86.9%)	0.517
Lesion based	46/53 (86.7%)	23/27 (85.2%)	23/26 (88.5%)	0.443
30-d mortality	10/47 (21.3%)	6/25 (24.0%)	4/22 (18.2%)	0.464
Inpatient	8/31 (25.8%)	4/8	4/8	
Outpatient	2/16 (12.5%)	2/2	0/2	
1- and 2-y survival	51.5% and 43.8%			

2.2. Angiography technique: vasospasm and infusion

The routine puncture site chosen was the right common femoral artery. Based on the MDCT findings, either the superior mesenteric artery (SMA) or inferior mesenteric artery (IMA) was catheterized by 4-F RC1/RIM angiocatheters (Cordis, Miami Lakes, FL, USA), using Seldinger's technique. If the bleeding source was identified on the initial SMA/IMA angiograms, and then a microcatheter, either a 2.7-F Progreat (Terumo, Tokyo, Japan) or a 2.5-F Renegade (Boston Scientific, Cork, Ireland), was coaxially inserted through a Y adaptor for semiselective catheterization into the extravasating artery. We defined "semiselective" as placing the catheter at least distal to the second branch of the SMA/IMA but not to the level of the vasa recta.

A bolus dose of epinephrine (0.3–0.5 mg diluted to 5 mL with normal saline) was injected to induce vasospasm and was immediately followed by a continuous vasopressin (pitressin; Pfizer) infusion at a rate of 3 to 5 units/h. Dosages were chiefly decided by the patient's hemodynamic status and the microcatheter's location. Patients were then transferred to the ward for 3- to 5-hour vasopressin infusion (Fig. 1). Afterward, the catheter was left in place receiving a normal saline infusion (30–50 mL/h) for 12 to 24 hours prior to angiographic follow-up.

The above procedures were performed by four interventional radiologists, each with 3 to 28 years of vascular experience. Patients regularly received intravenous prophylactic antibiotics (cephacin, 1 g) prior to interventional procedures. Oxygen saturation, blood pressure, heart rate and rhythm, and other vital signs were routinely monitored during the procedure.

2.3. End point definitions

We defined technical success as successful vasospasm achieved by semiselective catheterization of the extravasating artery, resulting in no immediate further extravasation of contrast medium or opacification of the pseudoaneurysm, in accordance to the guidelines set by the Society of Interventional Radiology.[19] We defined early recurrent bleeding as the need for blood transfusions requiring more than 2 units of packed red blood cells within 30 days of the procedure to stabilize hemoglobin levels, as patients often continued to pass dark stools for up to 48 hours after active bleeding ceased. As patients' rebleeding did not necessarily occur at the same focus lesion, recurrent bleeding was further categorized as local rebleeding and new-foci bleeding according to either later MDCT or angiographic study. If no definite bleeding could be identified, then it was classified as uncertain foci but calculated as local rebleeding in this study. Recurrent LGI bleeding that occurred after 30 days was considered delayed bleeding.

Primary clinical success was defined as successful hemostasis after initial vasospasm embolization therapy. Overall clinical success was defined as successful hemostasis including after repeated vasospasm embolization if necessary or observation follow-up without the need of further intervention. Clinical successes were further classified as either patient based or lesion based because one patient may have two or more bleeders. Ischemic complications were defined as either bowel ischemia or infarctions that required surgical intervention or focal bowel strictures or as late focal bowel strictures requiring surgery or endoscopic repair.

Medical charts were retrospectively reviewed. The clinical outcomes of SB and LB hemorrhage after vasospasm embolization were recorded. The 30-day mortality (inpatients and outpatients) and long-term (1 and 2 years) survival rates were also reported.

2.4. Statistics

Continuous data were expressed as mean ± SD.

The two-tailed Student t-test was used to compare the age between SB and colon/rectum. Chi-square was used to compare

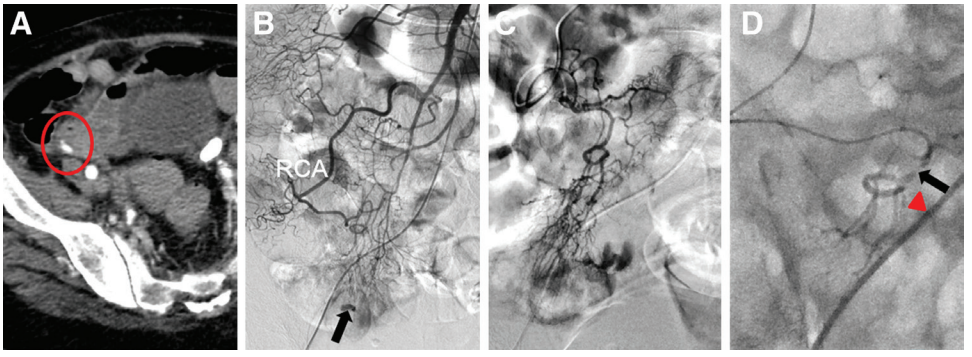

Fig. 1 An 82-y-old terminal stage breast cancer female patient who received surgical resection 3 weeks prior, due to small bowel strangulation. A, Multidetector computed tomography demonstrated contrast extravasation into the distal ileum (circle). B, Superior mesenteric artery angiogram showed active bleeding in the distal ileum (arrow). C, The bleeding artery was from one torturous branch of the right colic artery (RCA) with difficulty to reach the bleeding vasa rectum. D, The microcatheter tip (arrow) was left in the marginal artery for vasospasm therapy by bolus injection of 0.4 mg epinephrine and followed by 4 units/h vasopressin infusion for 5 h. Arrowhead: bleeding vasa rectum. No recurrent bleeding at 2-mo clinical follow-up.

two groups in sex, hemodialysis, in/outpatient, hemodynamic instability, tumor bleeding, technical success, early rebleeding, primary clinical success, overall clinical success, and 30-day mortality. The start date for follow-up tracking was the day of vasospasm embolization. The survival for over 30-days was estimated with the Kaplan-Meier survival analysis. A p value <0.05 was considered significant. Statistical analysis was performed by using SPSS software (SPSS 22.0; Chicago, IL, USA).

3. RESULTS

Ten out of 50 patients underwent colonoscopy before angiography, but, in all cases, a bleeding source could not be identified or successful hemostasis could not be achieved. Every patient exhibited positive contrast extravasation on MDCT. Forty-two bleeders were found in the SMA territory (including 11 in the jejunum, 14 in the ileum, 16 in the ascending colon, and 1 in the transverse colon), and 8 bleeders were found in the IMA territory (including 4 in the descending colon, 2 in the sigmoid colon, and 2 in the proximal rectum). Of these patients, 3 bleedings were related to underlying malignancies (including descending colon CA in 2 and prostate CA with rectal invasion in 1) with abnormal tumor stain demonstrated on the angiograms. Usually 20 to 40 minutes were required to proceed from needle puncture to semiselective catheterization (including bleeding artery identification/localization) for further vasospasm embolization therapy.

3.1. Hemostasis

Technical success (vasospasm) was assessed from the 12- to 24-hour follow-up angiograms and achieved in 49 out of 50 patients (98%). Vasospasm embolization could not be successfully performed in one patient because easy back migration of the angiocatheter into the SMA main truck made the following with hours of vasopressin infusion into bleeding artery impossible; this patient was then treated by microcoil embolization with clinical success. Immediate hemostasis was obtained in all the other 49 patients. One patient showed contrast reopacification of a large pseudoaneurysm in the jejunum. He then received microcoil embolization but experienced recurrent bloody stool passage. Finally, he underwent surgical resection, and a big ulcer was found without any associated tumor growth pathologically. The other 48 patients' follow-up angiograms showed no more residual contrast extravasation with reopening of the spasmed vessels and normal opacification of the intestinal mucosal stain.

Of the 49 technical success patients, early rebleeding (within 30 days of the procedure) was found in 13 patients (26.5%), of whom 34.6% (9/26) were in the SB and 17.4% (4/23) were in the LB (p = 0.037). Six patients (12.2%) showed local rebleeding (18.5% in the SB and 4.2% in LB; p = 0.101), and five patients (10.2%) showed new-foci bleeding, with 11.1% bleeding in the SB and 8.3% in the LB (Fig. 2; p = 0.187). Rebleeding sites with uncertain foci were found in another two patients (4.1%). Of the 13 rebleeding patients, 7 had undergone hemodialysis (7/18, 38.9%), which was a higher percentage than those who had not (6/31, 19.4%) but not enough of a difference to reach significance (p = 0.119). Pharmaco-induced vasospasm embolization therapy was repeated in five early-rebleeding patients with clinical success in four cases.

Of the other nine patients who showed early rebleeding (including the one patient after second vasospasm embolization), one's was attributed to too proximal location of the angiocatheter placement. Afterward, this patient underwent colonoscopic hemostasis but failed. He then received superselective N-butyl-2-cyanoacrylate embolotherapy at the vasa recta with clinical success (Fig. 3). Surgical resection was performed in two patients and microcoil embolization and enteroscopic hemostasis with clips in one patient each. The other four patients (including one new-foci bleeding, two uncertain-foci bleeding, and one post-repeated-vasospasm-therapy bleeding) received clinical observation only. Of these four patients, three died on the 8th, 14th, and 37th day, and the other patient was discharged uneventfully.

As for the three tumor-related bleeding patients, one patient with sigmoid colon cancer received surgical resection under stable hemodynamic status 7 days after vasospasm embolization therapy. He survived for more than 5 months after intervention. The other two patients had either prostatic cancer with direct rectal invasion (Fig. 4) or advanced descending colon cancer. After vasospasm therapy, the clinical symptom of bloody stool ceased. They were both discharged and survived for 7 and 1 months without recurrent bleeding episodes.

Overall, a total of 55 vasospasm therapies were performed for the 53 different bleeding foci (the two uncertain foci were presumed to be local rebleeding) in the 49 technical success patients. Patient-based early rebleeding rate was 26.5% (13/49 patients) with primary clinical success of 73.5% (SB, 65.4%; LB, 82.6%; p = 0.148) and overall clinical success of 83.7% (SB, 80.8%; LB, 86.9%; p = 0.517). Lesion-based early rebleeding rate was 17.0% (9/53 treating foci) with the primary clinical success of 83.0% (SB, 77.8%; LB, 88.5%; p = 0.173) and overall clinical success of 86.7% (SB, 85.2%; LB, 88.5%; p = 0.473). No patients exhibited complications with bowel ischemia or any other procedure-related major complications, including cardiopulmonary distress.

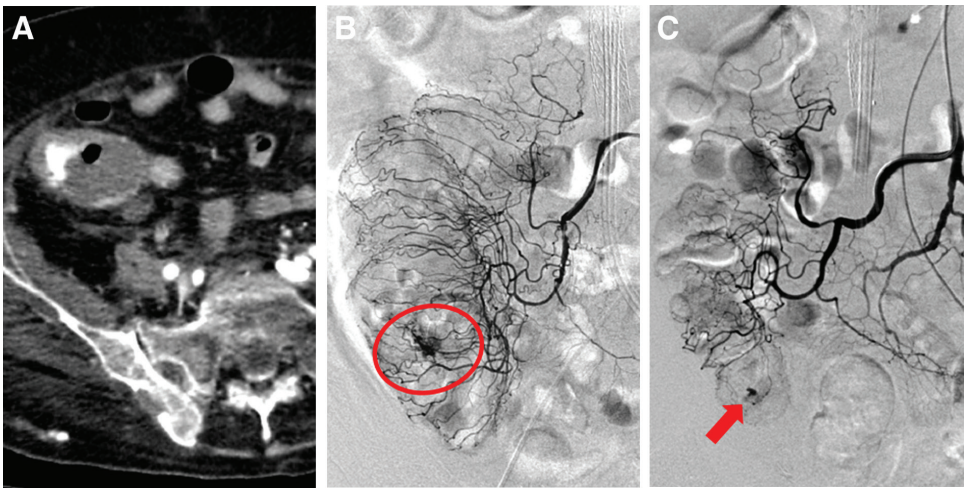

Fig. 2 A 74-y-old ESRD female patient with bloody stool for multiple days. A, Multidetector computed tomography showed contrast extravasation in the ascending colon. B, Superior mesenteric artery (SMA) angiogram confirmed active bleeding in the ascending colon (circle). Vasospasm therapy was performed. C, SMA angiograms showed recurrent bleeding at the cecum (arrow) 4 d after. No rebleeding after the second vasospasm therapy.

3.2. Early mortality and follow-up

We were unable to follow-up with two patients after discharge. Ten patients died within 1 month of intervention with a 30-day mortality rate of 21.3% (10/47), of whom 25.8% (8/31) were inpatients and 12.5% (2/16) were outpatients (p = 0.132). The therapeutic clinical outcomes are listed in the Table. No deaths were considered to be directly related to the interventional vasospasm procedure. Five patients expired from sepsis due to pneumonia (two patients), preexisting pancreatitis, infective endocarditis, or oxacillin-resistant staphylococcus aureus double lumen infection, the last in a hemodialysis patient. Three patients expired from hypovolemic shock–induced multiorgan failure, one patient expired from hepatic failure due to terminal-stage multiple myeloma with diffuse liver involvement, and one patient expired from bowel perforation after colonoscopic study. We were able to conduct 30-day clinical follow-ups on 37 patients. The mean follow-up period was 27.9 months (range, 1.1–94 months). By the time of the follow-up, no patients had developed clinical evidence of bowel stricture, obstruction, or other conditions requiring later surgical resection. The overall survival rates of the 37 patients at 1 and 2 years were 51.5% and 43.8%, respectively.

4. DISCUSSION

Conservative management is sufficient for the vast majority of LGI bleeding episodes, with only 10% to 15% of patients requiring intervention.[13] Commonalities among such patients include advanced age, prior or concurrent medical problems, and drug regimens that include anticoagulants and antiplatelet agents, the last presenting further complications for management.[10] In such cases, the recommended definite therapy is surgical resection, which unfortunately carries high mortality rates: 10% for semiselective cases and 36% for emergency cases.

Although more technically challenging, advances in microcatheter technology have made superselective embolization of small distal mesenteric arteries possible with technical success rates of 69% to 100% reported in the literature.[4–12] However, these success rates include embolizations performed in or proximal to marginal arteries. In a 2013 study, we reported successful

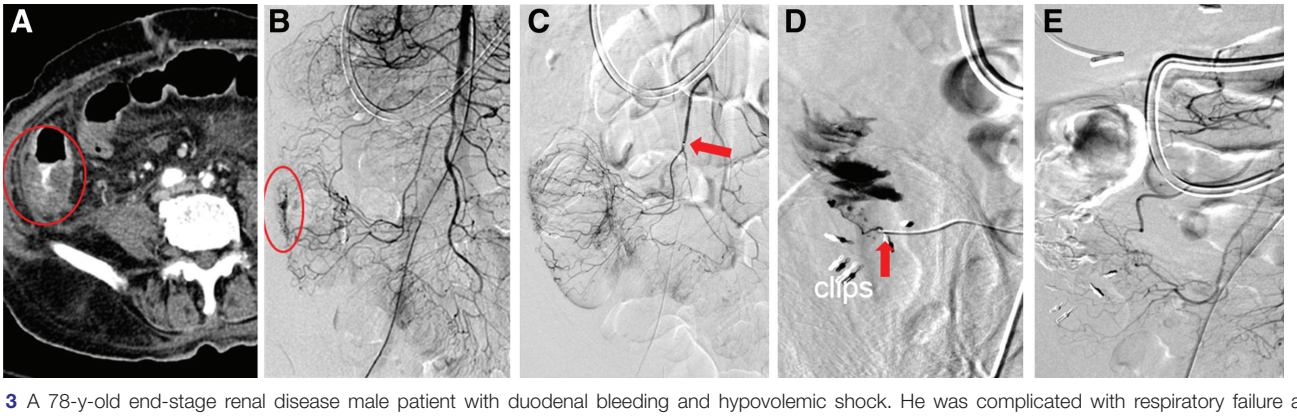

Fig. 3 A 78-y-old end-stage renal disease male patient with duodenal bleeding and hypovolemic shock. He was complicated with respiratory failure and transferred to our hospital. During the admission, bloody stool for days was noted. A, Multidetector computed tomography demonstrated contrast extravasation in the ascending colon (circle). B, Superior mesenteric artery angiogram showed active bleeding in the ascending colon (circle). C, The tip of a microcatheter (arrow) was at the distal first branch of the right colic artery, which was too proximal for effective vasospastic therapy under the recommended dosage. The patient then underwent colonoscopic hemostasis as bleeding continued. D, Superselective angiogram showed recurrent bleeding after clips hemostasis. Arrow: microcatheter tip in the vasa rectum. E, Embolization was performed with NBCA injection into the vasa rectum with successful hemostasis. Unfortunately, this patient expired 8 d after NBCA embolization due to pneumonia with respiratory failure.

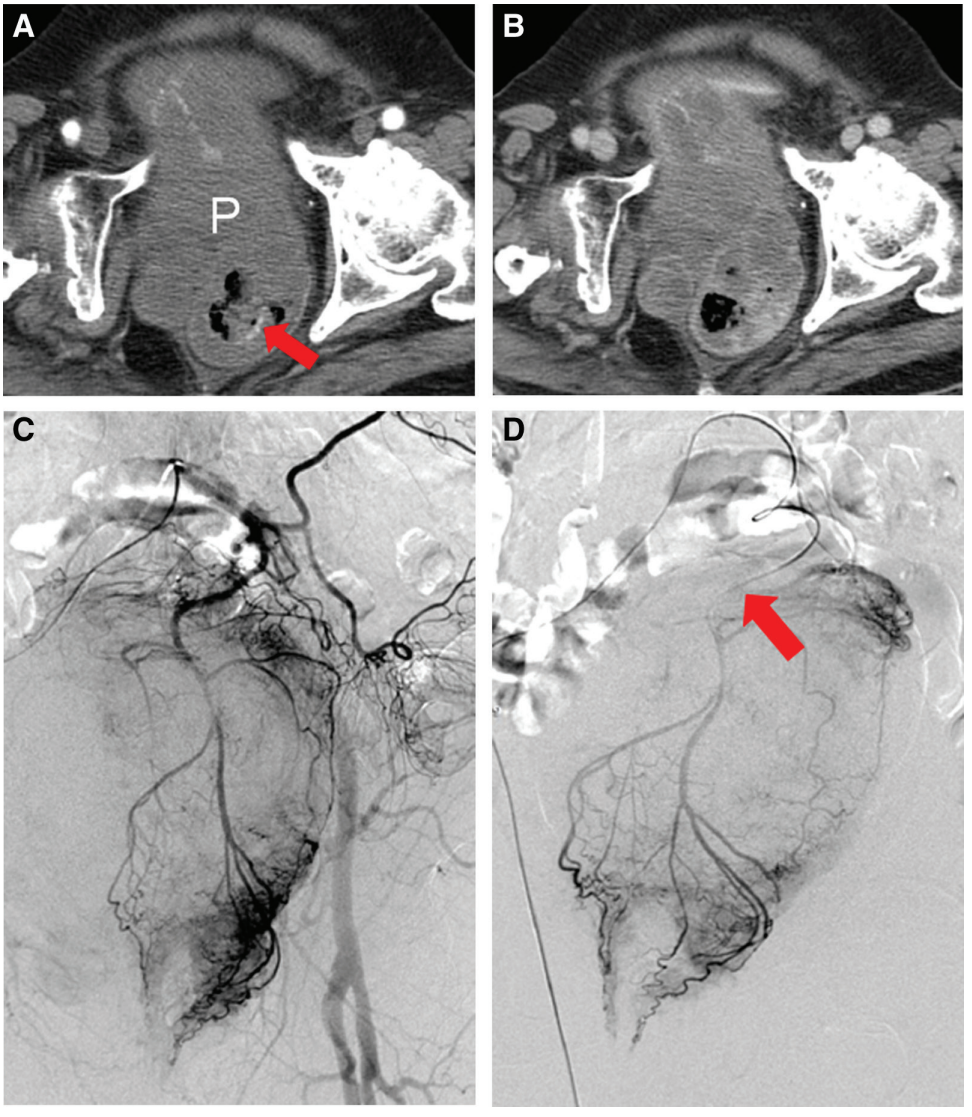

Fig. 4 A 69-y-old male patient suffering from massive bloody stool for multiple days due to his prostate (P) cancer with direct tumor invasion to the rectum. A, Multidetector computed tomography (MDCT; arterial phase) showed contrast extravasation (arrow) in the upper rectum. B, MDCT (venous phase) showed contrast spreading in the upper rectum. C, Inferior mesenteric artery angiography showed abnormal tumor stain in the rectum without active bleeding. D, Semiselective catheterization of the rectal branch with vasospastic therapy was performed. Arrow: catheter tip. Bleeding ceased and patient discharged uneventfully. This patient expired 7 mo after without any recurrent episodes of bloody stool.

vasa recta embolization rates in 65.4% (17/26 patients), while embolization could only be achieved at marginal arteries in another 19.2% (5/26), 40% of which (2/5) were accompanied with ischemic bowel complications.[12] We, therefore, recommended embolizing the vasa recta in every LGI bleeding patient. However, such embolizations require skillful superselective technique, limiting the availability of this therapy to institutes where such expert specialists are available. Other potential disadvantages of vasa rectum embolization include prolonged fluoroscopy times and increased amounts of contrast medium to determine and catheterize the actual bleeding site from several overlapping branches.

Cynamon et al introduced a catheter-induced vascular spasm technique to treat LGI bleeding with ease and high technical success.[17] However, the mechanical manipulation of the guidewire/catheter in small mesenteric branches is not in itself risk free. We, therefore, developed our own modified pharmaco-induced vasospasm embolization technique.[18] Our expanded data set continues to show that the intra-arterial injection of 0.3 to 0.5 mg epinephrine and the continuous infusion of vasopressin (3–5 units/h) for up to 5 hours in a small mesenteric artery are safe and effective for the treatment of LGI bleeding, without any accompanying systemic cardiopulmonary complications.

The risk of rebleeding in the short term after arterial embolization varies from 10% to 50%, as reported in the literature.[1–15,20–27] Hur et al reported a recurrent bleeding rate of 17.4% after excluding cases with technical failure and follow-up periods shorter than 30 days.[14] In our series, the overall rebleeding rate was 26.5% (13/49) or 20.0% (9/45) after the exclusion (as per Hur et al) of follow-up periods shorter than 30-day cases (four patients died within 30 days). As rebleeding does not necessarily occur at the initial bleeding site but could instead occur along the whole long GI tract, especially in patients with multiple comorbidities, we found that only 12.2% of the rebleeding sites stemmed from the original focus (local rebleeding rate) and that another 10.2% came from a new focus

(new-foci bleeding) of the LGI tract. Although we incorporated the uncertain foci bleeding (4.1%) into the local rebleeding, they were most likely to be new-foci bleeding because of spontaneous resolution by clinical observation only. Our present study confirmed the effectiveness of vasospasm therapy for the local or new-foci recurrent bleeding. However, special caution should be paid to large pseudoaneurysm bleeding, which may fail to respond to the vasospasm. As large ulcerations of intestinal lesions may be associated with underlying tumor growth, surgical resection may be an ideal treatment of choice.

Nykänen et al reported a major complication rate of 17%, resulting in bowel resection for 13% of their LGI bleeding patients after embolization.[25] He concluded that ischemia remained a concern even with superselective transcatheter embolization. A meta-analysis published in 2017 concluded that the pooled clinical success and major complication rates in 175 patients with LGIB, in whom technical success was achieved with N-butyl cyanoacrylate embolization, were 86.1% (95% CI, 79.9%–90.6%; $p = 0.454$; $I^2 = 0.0\%$) and 6.1% (95% CI, 3.1%–11.6%; $p = 0.382$; $I^2 = 4.4\%$).[26] In the guidelines from the British Society of Gastroenterology, the reported major complication of bowel ischemia ranged from 7% to 24%.[20] In our present series, the overall clinical success rate was 83.7%, which was comparable to that of the meta-analysis but without being complicated with symptomatic ischemic bowels. Furthermore, since embolotherapy is a local treatment for a specific point-site bleeding, the evaluation of clinical therapeutic efficacy should be focused on the treated target lesion. From this perspective, the overall lesion-based clinical success could be considered as high as 86.7%. This high success rate confirmed that our modified technique could be a very effective treatment for LGI bleeding in both SB and colon bleeding.

The 30-day mortality rate was reported in the aforementioned meta-analysis as 19.4% among the patients in whom technical success had been achieved.[26] Hur et al reported the recurrent bleeding rates and in-hospital mortality for small-bowel, colon, and rectal sites were 17.9%, 3.6%, and 30.0% and 0.6%, 8.3%, and 35.0%, respectively,[14] implying small-bowel had high rates for recurrent bleeding but low rates for mortality. Our present data confirmed the SB did show a higher rebleeding rate when compared with that of the colon (34.6% vs 17.4%, $p = 0.037$) and a similarly 30-day mortality rate (24.0% vs 18.2%, $p = 0.464$). The higher rebleeding rate in the SB may be related to the low blood concentration of vasospasm medication in a more complex vessel territory (as compared with LB vascular anatomy), and the discrepancy of similar 30-day mortality may be because we excluded patients with lower rectum bleeding, and/or in our series, there were more SB bleeding patients (53.8%) with unstable hemodynamic at intervention. In the United Kingdom, it was reported that the in-hospital mortality rate was 3.4%, which rose to 18% in patients who developed LGIB while already hospitalized.[20] Our present data showed the overall 30-day mortality rate was 21.3% with a trend of higher mortality rate (25.8%) for inpatients than that of outpatients (12.5%) but was still not statistically significant. The long-term survival rate was 51.5% at 1 year and 43.8% at 2 years, which was much poorer than that of Maleux's series (1 year: 72.2%).[5] These facts imply that the underlying comorbidities of some of our patients were complex and severe, especially those of the outpatients. If the advanced age and complex medical problems of these patients are taken into account, the survival data may support the inference that minimally invasive endovascular therapy can be regarded as a first-line and potentially definitive therapy of life-threatening LGI bleeding.

This study contained a number of limitations. First, we are now more confident in our methods because of this expanded data set, this was still a single-center study and still a relatively small number of patients. Second, a lack of clear medical protocols meant that the decision to perform endovascular therapy instead of LGI surgery was based on radiological consultation and the selected drug dose and the duration of vasospasm therapy were based on the authors' experience, rather than any set guidelines. Fourth, we may have underestimated the full extent of mild-to-moderate ischemic complications because regular colonoscopic follow-ups were not performed. Finally, the patients' underlying medical comorbidities, not the endovascular therapy alone, determined the survival outcome of LGI bleeding, and so only limited further clinical inferences could be made from our expanded data set.

In conclusion, although superselective vasa rectal embolization with microcoils or N-butyl cyanoacrylate is currently the standard endovascular therapy for LGI bleeding, our study provides further evidence that pharmaco-induced vasospasm embolization is at least of equivalent effectiveness and safety. Being an easy technique with high rates of immediate clinical hemostasis and without the attendant labor issues of conventional vasoconstriction therapy, this may greatly benefit critical LGI bleeding patients when superselective vasa rectal embolization is unfeasible or in hospitals without expert interventional radiologists.

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