CardioVascular and Interventional Radiology

Cardiovasc Intervent Radiol (1999) 22:461–467

Massive Lower Gastrointestinal Hemorrhage from the Surgical Anastomosis in Patients with Multiorgan Trauma: Treatment by Subselective Embolization with Polyvinyl Alcohol Particles

Nail Bulakbaşi, Kemal Kurtaran, Bahri Üstünsöz, İbrahim Somuncu

Department of Radiology, Gülhane Military Medical Academy, Etlik, 06018 Ankara, Turkey

Abstract

Purpose: To evaluate the efficacy and safety of subselective arterial embolization with polyvinyl alcohol (PVA) particles with or without microcoil augmentation to control postoperative lower gastrointestinal (GI) bleeding.

Methods: Ten patients with clinical, scintigraphic, and angiographic evidence of postoperative lower GI bleeding were considered for subselective embolization. Subselective embolizations were performed through coaxial microcatheters with 355–500 μm PVA particles with or without additional coil embolization.

Results: Embolization was technically successful in 9 of 10 (90%) patients. In one patient, subselective embolization was not possible; consequently no embolization was performed. Clinical success was achieved after a single embolization in 6 of 10 (60%) patients and after a second embolization in an additional 3 of the 10 (30%) patients. While there was no rebleeding in patients with normal coagulation parameters, all three patients (100%) with coagulopathy rebled, two of them from another source. Although no acute ischemic effects developed, no long-term sequela such as ischemic stricture were specifically looked for. Seven patients developed abdominal discomfort and/or fever within 24–48 hr. Four of 10 patients died of complications other than hemorrhage or ischemia.

Conclusion: Subselective PVA embolization with or without a microcoil embolization is an effective and safe means of managing postoperative lower GI hemorrhage in patients with multiorgan trauma.

Key words: Arteries, therapeutic blockade—Blood, coagulation—Gastrointestinal hemorrhage—Coil—Polyvinyl alcohol particles

Correspondence to: N. Bulakbaşi, M.D.

Acute lower gastrointestinal (GI) hemorrhage is one of the most frequently encountered bleeding sources in postoperative patients with multiorgan trauma [1, 2]. Simultaneous injury to three major organs presents a mortality rate of 70%, half of this from hemorrhage [1]. The mortality rate of 14%–19% in patients with lower GI hemorrhage reaches 35% in the postoperative period [1–3]. Postoperative abdominal bleeding is possibly related to the operative anastomosis sites and to medium-to-small-sized arteries of the GI system that are not noticeable under emergent surgical conditions. Selective arterial embolization has been found to be effective in controlling such bleeding, which otherwise would not be controlled by medical treatment [4–11]. The major risk of embolization for control of lower GI bleeding is irreversible intestinal ischemia [4–13]. The aim of this study was to evaluate the efficacy and safety of selective arterial embolization with polyvinyl alcohol (PVA) particles with or without microcoil embolization in the control of postoperative lower GI bleeding.

Methods

Eight men and two women, with a mean age of 23.5 years (range 20–41 years) were admitted with lower GI bleeding following surgical treatment of multiorgan trauma at other hospitals during the past 4 years (Table 1). The causes of trauma included motor vehicle accident (n = 2) and gunshot injury (n = 8). Presenting symptoms were massive rectal bleeding, hypotension, shock, and change in conscience status. All patients had received 10 or more units of packed red blood cells over a 24-hr period. Three patients had coagulopathies with prothrombin times greater than 1.3 times normal, partial thromboplastin times greater than 40 sec and/or platelet counts less than 50,000/μL. The relationship between the total number of units of packed red blood cells received and the patient's coagulation status was compared and statistically analyzed by using the Wilcoxon rank sum test.

Table 1. Patients with postoperative abdominal bleeding

Patient no.	Sex/ Age	C	Cause	Surgical procedure	No. of embolizations	Bleeding arteries	Amount of occlusive agent	Results	Complications	Follow-up
1	M/20	+	GSI	Splenectomy, pelvic fracture, L hemicolectomy	2	SMA, ICA IMA, L-RA	<½ vial of PVA 1 vial of PVA	Rebleeding in 24 hr, successful	Pain and fever lasting 18 hr	Alive 3 years later
2	M/22	−	GSI	Primary repair of liver, splenectomy, ileal resection	1	SMA, ICA	<½ vial PVA	Successful	Pain lasting 12 hr	Alive 4 years later
3	M/22	−	GSI	Partial L colon and ileal resection, fractures	1	IMA, SRA	<½ vial of PVA + microcoil	Successful		Died 10 days later of HRF
4	M/21	+	MVA	R hemicolectomy, distal ileal resection, primary repair of liver	2	SMA, R-CA SMA, ICA	<½ vial of PVA 1 vial of PVA	Rebleeding in 36 hr, successful	Pain and fever lasting 48 hr	Alive 3 years later
5	F/41	+	GSI	Lumber fracture, L colon resection, L nephrectomy	2	IMA, SRA	1 vial of PVA 1 vial of PVA + microcoil	Rebleeding in 48 hr, successful	Pain and fever lasting 38 hr	Alive 2 years later
6	M/20	−	GSI	Splenectomy, L hemicolectomy, L nephrectomy	—	SMA, R-CA	—	Did not perform embolization	Reoperated on but died 7 days later of DIC	
7	M/23	−	GSI	Sigmoid resection, bladder repair, pelvic-lumbar spinal fractures	1	IMA, SRA	<½ vial of PVA	Successful	Pain lasting 8 hr	Died 4 months later of sepsis
8	F/24	−	GSI	L nephrectomy, ileal resection, splenectomy	1	SMA, IA	<½ vial of PVA	Successful	Pain and fever lasting 24 hr	Alive 3 years later
9	M/22	−	GSI	L hemicolectomy, splenectomy, L nephrectomy	1	IMA, SRA	<½ vial of PVA + microcoil	Successful	Pain and fever lasting 34 hr	Died 16 days later of HRF
10	M/20	−	MVA	Splenectomy, ileal resection, bladder repair	1	SMA, ICA	<½ vial of PVA	Successful		Alive 2 weeks later

C = coagulopathy, GSI = gunshot injury, MVA = motor vehicle accident, L = left, R = right, SMA = superior mesenteric artery, ICA = ileocolic artery, IMA = inferior mesenteric artery, RA = rectal artery, SRA = superior rectal artery, CA = colic artery, IA = ileal artery, PVA = polyvinyl alcohol particles, HRF = hepatorenal failure, DIC = disseminated intravascular coagulation

Patients with clinical evidence of postoperative hemorrhage in the lower GI tract were initially evaluated by scintigraphy with ^{99m}Tc-labeled red blood cells and then considered for embolization. Scintigraphy was also used for the detection of recurrent bleeding after embolization.

Diagnostic angiography and embolization procedures were performed with a digital angiography system (Digitron II, Siemens, Erlangen, Germany). Standard polyethylene tapered 5–6 Fr angiographic catheters (Mallinckrodt Medical, St Louis, MO, USA; Terumo, Tokyo, Japan) introduced through a 6 Fr sheath via the common femoral artery were used for diagnostic angiography. The aorta, celiac trunk, and superior and inferior mesenteric arteries were routinely examined. All patients underwent embolization immediately following angiographic demonstration of the bleeding site.

Twelve embolization procedures in nine patients were performed for control of postoperative lower GI bleeding. In one patient with active bleeding through the left colic artery we could not perform subselective catheterization and therefore did not embolize. For coaxial catheterization, 135–150-cm-long tapered microcatheters (Tracker-18 Unibody Hi-Flow, Target Therapeutics, San Jose, CA, USA) were used.

Embolization involved branches of the inferior (n = 6) and superior (n = 6) mesenteric arteries. Postoperative fresh anastomotic leakage was the source of bleeding in all patients. The occlusive agents were PVA particles (Contour Emboli, Interventional Therapeutics Corporation, South San Francisco, CA, USA) of 355–500 μm diameter with (n = 9) or without (n = 3) platinum microcoils (Target Therapeutics). After subselective catheterization, one vial content of 355–500 μm PVA particles was suspended in a solution of 10 ml low-osmolarity contrast material and 10 ml 0.9% saline solution. Aliquots of the mixture were slowly injected under fluoroscopic guidance. The amount of suspension totaled less than half a vial of PVA particles in cases with normal coagulation parameters, and not more than one vial of PVA particles in cases with coagulopathy. We flushed the microcatheter once with 0.34–0.60 ml saline to clear the catheter dead space, then removed the catheter. Repeat angiography was performed through the outer catheter. PVA embolization for the same bleeding site was never repeated in the same session in order to limit the risk of bowel ischemia. If particulate embolization was insufficient, an additional single microcoil was embolized. Patients were followed from 7 days to 4 years.

Results

Active bleeding was detected by scintigraphy with ^{99m}Tc-labeled red blood cells in all patients. Effective control of

bleeding with subselective arterial embolization was achieved in 6 of 10 (60%) patients with one procedure. Four of these patients were embolized with PVA particles (Fig. 1), and two with a combination of PVA particles and a microcoil. All patients were in severe hypotension or shock before and during the embolization procedure, but their clinical status improved within 24 hr following embolization. All six patients were closely observed and no further surgical treatment was necessary. Three of the six patients died between 10 days and 4 months after embolization from causes unrelated to bleeding or ischemia, one from secondary pulmonary infection and *E. Coli* sepsis and two from hepatorenal failure possibly related to massive blood transfusions. The other three patients are still alive without recurrent lower GI hemorrhage.

The three (30%) patients who did not improve immediately after the first embolization procedure had a coagulopathy. They were reevaluated by scintigraphy, and active bleeding was demonstrated 24–48 hr after their first embolization procedure. They underwent a second embolization procedure. In two, rebleeding was found to originate from a different source, but in one, recurrent bleeding came from the same artery previously embolized (Fig. 2). All three patients are still alive without recurrence of lower GI hemorrhage.

Embolization was technically successful in 9 of 10 (90%) patients. Clinical success was achieved after a single embolization in 6 of 10 (60%) patients and after a second embolization in an additional 3 of 10 (30%) patients. While there was no recurrent bleeding in patients with normal bleeding parameters, all three patients (100%) with coagulopathy rebled, though only one bled from the previously embolized vessel and was a true embolization failure.

In seven patients (70%), transient adverse effects were encountered, but none required surgical treatment or suffered from permanent sequelae; seven had cramp-like abdominal pain, five had fever. The pain resolved within 8–48 hr following embolization. Although no apparent ischemic effects developed, no long-term sequela such as ischemic stricture were specifically looked for. Four of 10 (40%) patients died of complications other than hemorrhage or ischemia.

There was no statistically significant relationship between the volume of transfusion and the existence of coagulopathy.

Discussion

Postoperative bleeding of multiorgan trauma patients is not uncommon and is a serious and life-threatening event with high mortality and morbidity [1–3]. Predisposing factors such as coagulopathy, shock, diabetes, cirrhosis, malignancy, and infection contribute to mortality [8, 14]. In the study of Encarnacion et al. [8] embolization was 2.9 times more likely to be unsuccessful and death from bleeding after embolization was 9.6 times more likely to occur in patients with a coagulopathy than in those without. Although our results showed that there was no effect of coagulopathy on the mortality rate, abnormal hemostasis directly affected the success of embolization. In all patients with coagulopathy, control of postoperative hemorrhage was achieved after the first embolization, but all had recurrent bleeding. In only one of them was there rebleeding from the previously embolized artery and the main cause of rebleeding was probably related to insufficient thrombosis around the occlusive agent. When abnormal hemostasis is detected, it must be corrected as early as possible.

The diagnosis of lower GI bleeding has some difficulties and controversies [15–18]. Since all of our patients were in poor condition we used scintigraphy first as a noninvasive technique to detect active bleeding. After a scan confirmed bleeding, angiography was performed as a roadmap for embolization therapy [5, 7, 12]. The role of selective mesenteric angiography in acute GI tract bleeding is less a diagnostic than a therapeutic one [4–13, 15].

After positive mesenteric angiography for GI hemorrhage, one is faced with the therapeutic options of observation, vasopressin infusion, embolization, or operation [4, 5, 19]. Although the surgery is still the main treatment option, perioperative mortality and morbidity rates are 30%–50% for hemicolectomy and 15%–20% for partial bowel resection [1–3, 10]. Transcatheter interventions are very effective for such hemorrhages with lower morbidity and mortality rates than surgery, as previously reported in the literature [4–19].

Subselective intraarterial injection of vasoconstrictor substances like vasopressin, prostaglandin F_2 alpha, and octreotide has been found to be 90% effective in controlling GI hemorrhage [20–22]. Ischemic heart disease and limb ischemia are the main contraindications for this method [4, 19, 23]. In addition, pressor infusion may not be effective and may be followed by recurrence of hemorrhage after discontinuation of the medication [4, 19]. The complication rate for pressor infusion has been reported to be as high as 43% [24]. The average overall success is about 52% but can reach up to 88% when combined with embolization [25]. Therefore we preferred embolization. Also pressor infusion was contraindicated in our patients because of a predisposing ischemic state due to surgery.

After the first description of Gelfoam embolization for control of GI hemorrhage by Goldberger and Bookstein [26], other large series have been published [4, 8, 10, 16, 25, 27–32]. The results of the largest series were compared with our results in Table 2. The clinical success in these series is about 55%–100% with an average rate of 70%–85%. Although Gelfoam was used most often in these studies, microcoil and PVA combinations were also reported [8, 25, 27–29, 31]. In the study of Guy et al. [10] in which mainly PVA was used as the embolic agent, the clinical success was 77%. Clinical success in our study was achieved after a single embolization procedure in 6 of 10 (60%) patients and after a second embolization in an additional 3 of 10 (30%) patients.

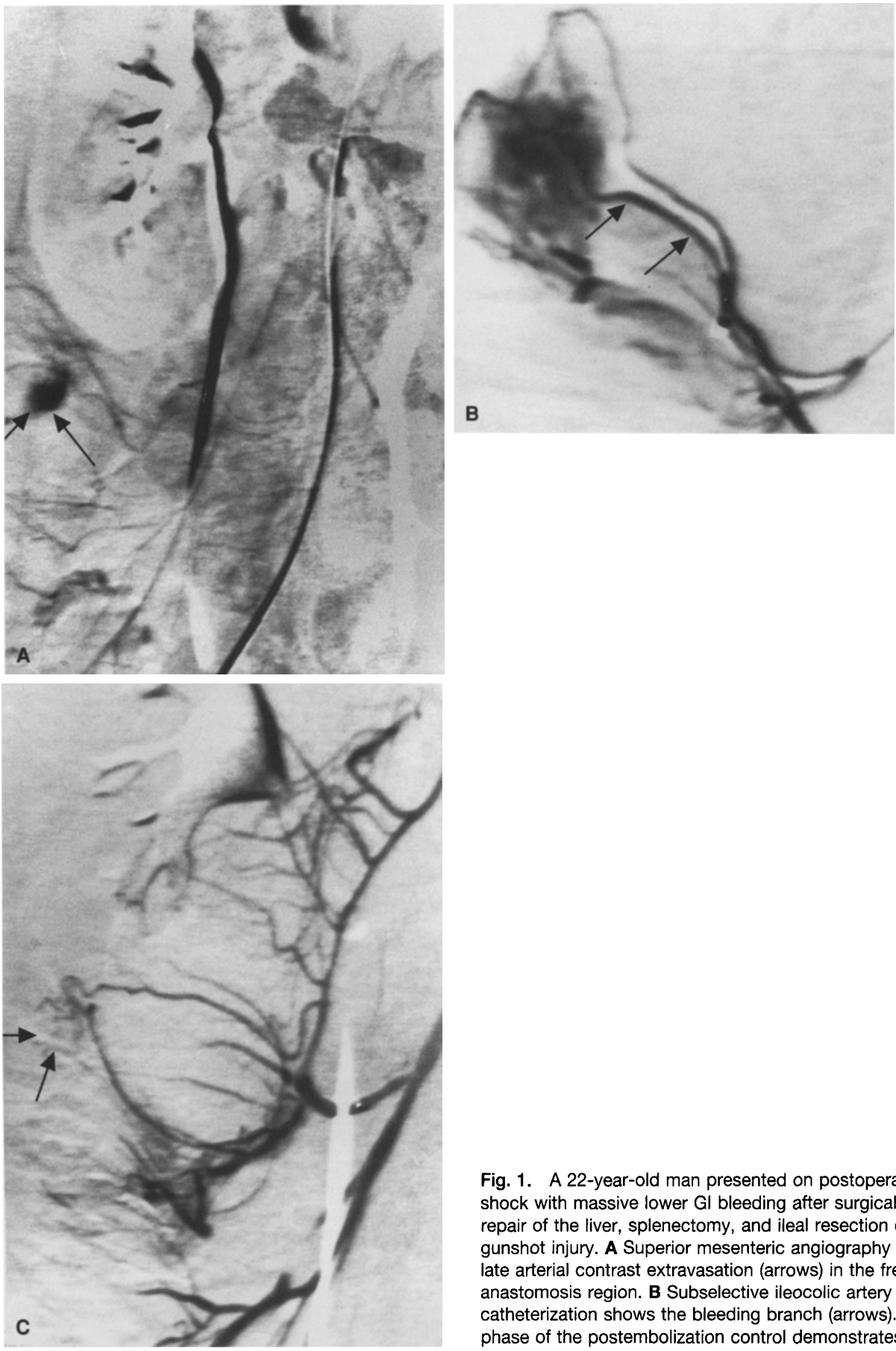

Fig. 1. A 22-year-old man presented on postoperative day 4 in shock with massive lower GI bleeding after surgical primary repair of the liver, splenectomy, and ileal resection due to gunshot injury. **A** Superior mesenteric angiography shows active late arterial contrast extravasation (arrows) in the fresh ileoileal anastomosis region. **B** Subselective ileocolic artery catheterization shows the bleeding branch (arrows). **C** Late phase of the postembolization control demonstrates occlusion of the ileocolic branch and control of bleeding (arrows).

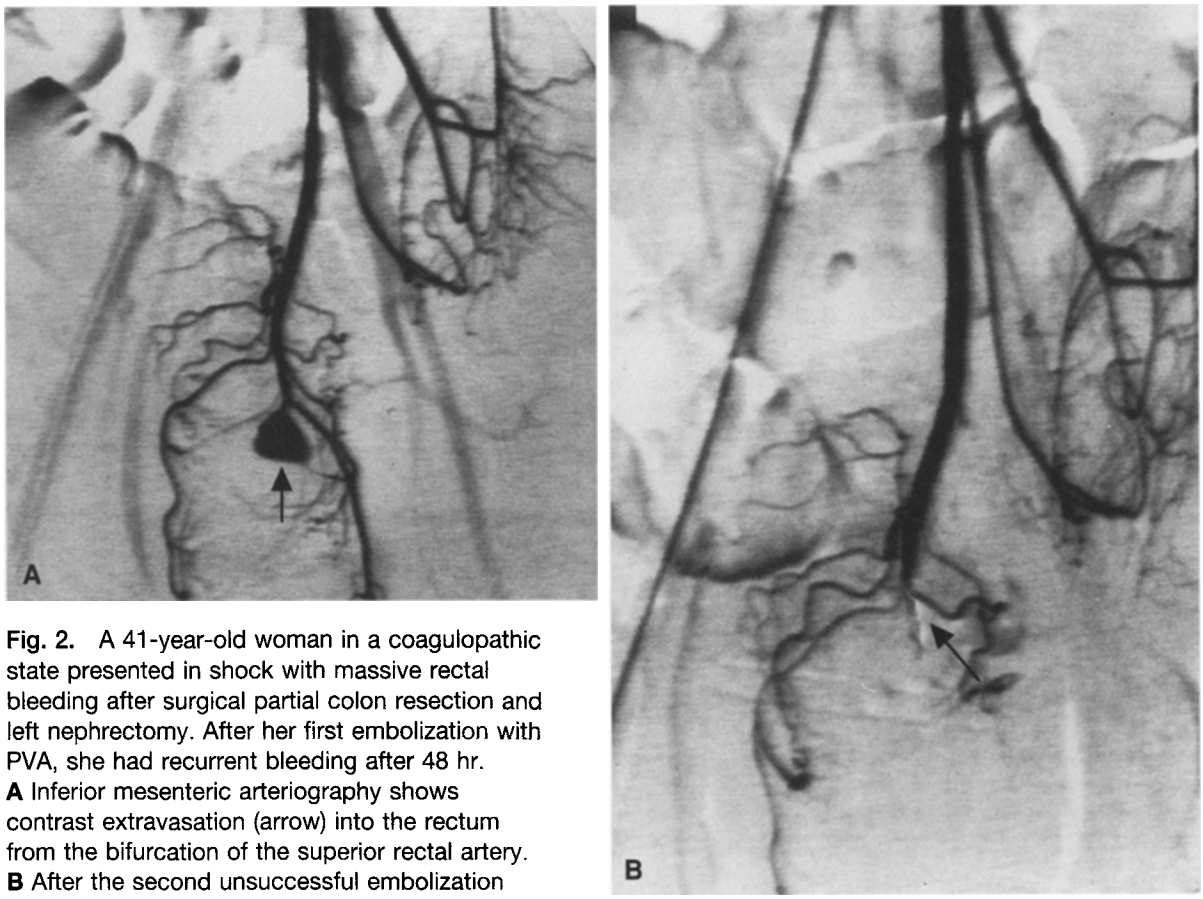

Fig. 2. A 41-year-old woman in a coagulopathic state presented in shock with massive rectal bleeding after surgical partial colon resection and left nephrectomy. After her first embolization with PVA, she had recurrent bleeding after 48 hr. **A** Inferior mesenteric arteriography shows contrast extravasation (arrow) into the rectum from the bifurcation of the superior rectal artery. **B** After the second unsuccessful embolization with PVA, GI bleeding was controlled with microcoil (arrow) embolization.

Table 2. Comparison of the studies

Study	Embolic material	Number of					
		Patients	Embolizations	Clinical successes	Rebleedings/ failures of control	Ischemic complications	Technical failures
Clarck et al. [27]	Vasopressin Embolization (G + C)	63	62/65 18/65	47 (75%) 10 (55%)	15 (25%) 8 (45%)	0	—
Gomes et al. [25]	Vasopressin Embolization (G, PVA, C)	47	23/47 24/47	12 (52%) 21 (88%)	4 (17%) 4 (16%)	2 (8.5%) 3 (12.5%)	—
Uflacker [4]	Vasopressin (n = 3) G (n = 12)	13	3 12	0 11 (85%)	3 2 (15%)	2 (15%)	1 (7.7%)
Guy et al. [10]	PVA (n = 10)	9	10	7 + 2/9 (77%–100%)	3/9 (33%)	2 (22%)	—
Encarnacion et al. [8]	G (n = 30), G + C (n = 2), C (n = 2), PVA (n = 2)	29	36	18/29 (62%)	11/29 (38%)	0	—
Gordon et al. [28]	C (n = 14), G (n = 3), PVA (n = 1)	17	14	13/17 (76.6%)	1/17 (5.8%)	0	3/17 (17.6%)
Ledermann et al. [31]	C (n = 5), PVA + C (n = 4), G + C (n = 1)	10	10	8/10 (80%)	—	0	2/10 (20%)
Nicholson et al. [30]	C (n = 14)	14/48	14	12/14 (86%)	2/14 (14%)	3/14 (21.4%)	—
Present study	PVA (n = 9) PVA + C (n = 3)	10	12	6 + 3/10 (60%–90%)	3/10 (30%)	0	1/10 (10%)

G = Gelfoam, C = coil, PVA = polyvinyl alcohol

The prevalence of recurrent hemorrhage or failure of embolization requiring surgery or second embolization was about 14%–45% in reported series [4, 8, 16, 25, 27–32] and 33% in the [10] study by Guy et al. Our rate was 30% (3 of 10); one of these was a real embolization failure i.e., recurrent bleeding from the same artery. The others were not true failures since they bled from different bleeding sites due to the coagulopathy rather than unsuccessful embolization of PVA.

The main complications of mesenteric embolization are postembolic intestinal infarction in the short term and ischemic bowel strictures in the long term. The prevalence of postembolic intestinal infarction in reported series had ranged from 0 to 20%, with the collective rate approximating 15% [8, 25, 27–29, 31]. We have no postembolic intestinal infarction in our clinical follow-up period. In their study, Guy et al. [10] reported a 22% rate of endoscopically proven ischemic changes in asymptomatic patients. We could not perform endoscopic or angiographic control in our patients because of their poor clinical status due to surgery and hemorrhage unless they rebled, but all were followed clinically from 7 days to 4 years. Although no long-term complications were specifically looked for, clinically all our patients were free of bowel stricture signs. If bowel stricture had occurred, it would be impossible to differentiate it from ones occurring secondary to surgery.

Significant ischemia may be avoided if the embolic agent can be delivered precisely to the arcade just proximal to the vasa recta supplying the bleeding segment [4, 29]. This will reduce the intraarterial pressure to the affected segment without completely occluding the vasa recta and causing ischemia and infarction [33]. As in our protocol, slower infusion of larger PVA particles provides more distal arterial occlusion and selective distal catheterization produces a very limited area of potential ischemia [34]. PVA embolization can be performed safely if a low dose of large (>300 μm) PVA particles is used [11]. Therefore we used 355–500 μm PVA particles and this may be the reason for success with regard to ischemia in this study.

Another problem of embolization is technical failure in placing the coaxial catheter distally enough to allow safe embolization of bleeding arteries. This occurs more often in postoperative patients because of anatomical changes from the surgery. Technical failure has been reported to be 8%–21% [4, 28, 31, 32]. Our rate was 10%, within the limits in the literature. The development of newer small caliber angiographic catheters, like the Tracker-18 catheter, have enabled more coaxial peripheral superselective catheterization of distal vessels, permitting more selective vascular interventions [10]. As previously reported [11, 35], using larger PVA particles through Tracker microcatheters did not cause an inadvertent catheter occlusion during the embolization.

The control of postoperative lower GI hemorrhages in patients with multiorgan trauma is a life-saving procedure. Although the result of the present study suggests that PVA particles are safe and effective in the control of lower GI hemorrhage, results from long-term studies are still needed.

References

1. Carmona RH, Lim RC Jr, Clark GC (1982) Morbidity and mortality in hepatic trauma: A five-year study. Am J Surg 144(1):88–94
2. Dertinger SH, Vestner H, Muller K, Merz M, Hahn EG, Altendorf-Hofmann A, Ell C (1996) Prospective study of diagnosis, therapy and follow-up of acute gastrointestinal hemorrhage in 397 patients. Wien Klin Wochenschr 108(22):717–721
3. Kouraklis G, Misiakos E, Karatzas G, Gogas J, Skalkeas G (1995) Diagnostic approach and management of active lower gastrointestinal hemorrhage. Int Surg 80(2):138–140
4. Uflacker R (1987) Transcatheter embolization for treatment of acute lower gastrointestinal bleeding. Acta Radiol 28:425–430
5. Pennoyer WP, Vignati PV, Cohen JL (1996) Management of angiogram-positive lower gastrointestinal hemorrhage: Long-term follow-up of non-operative treatments. Int J Colorectal Dis 11(6):279–282
6. Barth KH (1995) Radiological intervention in upper and lower gastrointestinal bleeding. Baillieres Clin Gastroenterol 9(1):53–69
7. Richter JM, Christensen MR, Kaplan LM, Nishioka NS (1995) Effectiveness of current technology in the diagnosis and management of lower gastrointestinal hemorrhage. Gastrointest Endosc 41:93–98
8. Encarnacion CE, Kadir S, Beam CA, Payne CS (1992) Gastrointestinal bleeding: Treatment with gastrointestinal arterial embolization. Radiology 183:505–508
9. Seppänen SK, Leppänen MJ, Pimenoff G, Seppänen JM (1997) Microcatheter embolization of hemorrhages. Cardiovasc Intervent Radiol 20(3):174–179
10. Guy GE, Shetty PC, Sharma RP, Burke MW, Burke TH (1992) Acute lower gastrointestinal hemorrhage: Treatment by superselective embolization with polyvinyl alcohol particles. AJR 159(3):521–526
11. Kusano S, Murata K, Ohuchi H, Motohashi O, Atari H (1987) Low-dose particulate polyvinyl alcohol embolization in massive small artery intestinal hemorrhage: Experimental and clinical results. Invest Radiol 22(5):388–392
12. Heider J, Layer G, Textor HJ, Schild HH (1998) Does angiographic localization of bleeding affect the management and mortality in gastrointestinal hemorrhage of unknown origin? Aktuelle Radiol 8(2):71–75
13. Selby JB Jr (1992) Interventional radiology of trauma. Radiol Clin North Am 30(2):427–440
14. Wilson RF, Dulchausky SA, Soulier G, Beckman B (1987) Problems with 20 units or more blood transfusions in 24 hours. Am Surg 53: 410–417
15. Pennoyer WP, Vignati PV, Cohen JL (1997) Mesenteric angiography for lower gastrointestinal hemorrhage: Are there predictors for a positive study? Dis Colon Rectum 40:1014–1018
16. Suzman MS, Talmor M, Jennis R, Binkert B, Barie PS (1996) Accurate localization and surgical management of active lower gastrointestinal hemorrhage with technetium-labelled erythrocyte scintigraphy. Ann Surg 224(1):29–36
17. Lewis DH, Jacobson AF (1998) BUN/creatinine ratios: Aid to decision making about delayed imaging in Tc-99m red blood cell scans for gastrointestinal hemorrhage. Clin Nucl Med 23(4):201–204
18. Ng DA, Opelka FG, Beck DE, Milburn JM, Witherspoon LR, Hicks TC, Timmcke AE, Gathright JB Jr (1997) Predictive value of technetium Tc99m-labeled red blood cell scintigraphy for positive angiogram in massive lower gastrointestinal hemorrhage. Dis Colon Rectum 40(4):471–477
19. Chen HM, Jan YY, Chen MF (1998) Intra-arterial infusion of octreotide to stop gastrointestinal tract bleeding that is difficult to manage surgically: A case report. Hepatogastroenterology 45(19):128–132
20. Athanasoulis CA, Baum S, Rösch J, Waltman AC, Ring EJ, Smith JC Jr, Sugarbaker E, Wood W (1975) Mesenteric arterial infusions of vasopressin for hemorrhage from colonic diverticulosis. Am J Surg 129(2):212–216
21. Waltman AC (1980) Transcatheter embolization versus vasopressin infusion for the control of arteriocapillary gastrointestinal bleeding. Cardiovasc Intervent Radiol 3(4):289–295
22. Fara JW, Barth KH, White RI Jr, Bynum TE (1979) Mesenteric vascular effects of prostaglandins F_2 alpha and B_2: Possible advantages over vasopressin in control of gastrointestinal bleeding. Radiology 133(2):317–320
23. Eckstein MR, Kelemouridis V, Athanasoulis CA, Waltman AC, Feldman L, van Breda A (1984) Gastric bleeding: Therapy with intraarterial vasopressin and transcatheter embolization. Radiology 152(3):643–646
24. Conn HO, Ramsby GR, Storer EH, Mutchnick MG, Joshi PH, Phillips MM, Cohen GA, Fields GN, Petroski D (1975) Intraarterial vasopressin

in the treatment of upper gastrointestinal hemorrhage: A prospective, controlled clinical trial. Gastroenterology 68(2):211–221
25. Gomes AS, Lois JF, McCoy RD (1986) Angiographic treatment of gastrointestinal hemorrhage: Comparison of vasopressin infusion and embolization. AJR 146(5):1031–1037
26. Goldberger LE, Bookstein JJ (1977) Transcatheter embolization for treatment of diverticular hemorrhage. Radiology 122(3):613–617
27. Clark RA, Colley DP, Eggers FM (1981) Acute arterial gastrointestinal hemorrhage: Efficacy of transcatheter control. AJR 136(6):1185–1189
28. Gordon RL, Ahl KL, Kerlan RK, Wilson MW, LaBerge JM, Sandhu JS, Ring EJ, Welton ML (1997) Selective arterial embolization for the control of lower gastrointestinal bleeding. Am J Surg 174(1):24–28
29. Okazaki M, Furui S, Higashihara H, Koganemaru F, Sato S, Fujimitsu R (1992) Emergent embolotherapy of small intestine hemorrhage. Gastrointest Radiol 17(3):223–228
30. Nicholson AA, Ettles DF, Hartley JE, Curzon I, Lee PW, Duthie GS, Monson JR (1998) Transcatheter coil embolotherapy: A safe and effective option for major colonic haemorrhage. Gut 43(1):79–84
31. Ledermann HP, Schoch E, Jost R, Decurtins M, Zollikofer CL (1998) Superselective coil embolization in acute gastrointestinal hemorrhage: Personal experience in 10 patients and review of the literature. J Vasc Interv Radiol 9(5):753–760
32. Peck DJ, McLoughlin RF, Hughson MN, Rankin RN (1998) Percutaneous embolotherapy of lower gastrointestinal hemorrhage. J Vasc Interv Radiol 9(5):747–751
33. Kerns SR (1994) How safe is the use of platinum microcoils for embolization of small mesenteric arteries in patients with gastrointestinal bleeding? AJR 162(6):1497
34. Choe DH, Han MH, Kang GH, Yeon KM, Han MC (1997) An experimental study of embolic effect according to infusion rate and concentration of suspension in transarterial particulate embolization. Invest Radiol 32(5):260–267
35. Barr JD, Lemley TJ, Petrochko CN (1998) Polyvinyl alcohol foam particle sizes and concentrations injectable through microcatheters. J Vasc Interv Radiol 9:113–118