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FULL PAPER

Long-term results of microcoil embolization for colonic haemorrhage: how common is rebleeding?

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Objective: To determine the long-term results of patients undergoing transcatheter coil embolization for the treatment of acute colonic haemorrhage.

Methods: Patients undergoing angiography for suspected colonic bleeding between January 2002 and December 2012 were reviewed (average age, 60 years; 38.4% male). Baseline, procedural and outcome parameters were recorded following the Society of Interventional Radiology guidelines. Primary outcome measures included early (<30 days) and delayed (>30 days) rebleeding events and adverse procedure-related complication. Average follow-up time was 996 days (median, 232 days; range, 30–3663 days).

Results: One or multiple sites of bleeding were identified in 40 cases. Coil embolization was performed in 39 patients, 26 (66.7%, 26/39) of whom were treated successfully without technical/clinical failure ($n=12$) or loss to follow-up ($n=1$). Three patients (11.5%, 3/26) rebled in the early period within 30 days; one patient went on to hemicolectomy. Four patients (15.3%, 4/26)

experienced delayed rebleeding after 30 days; two of whom also underwent hemicolectomy. No major complication occurred. One minor complication of short segment arterial dissection was seen in the clinical failure group. One case of asymptomatic ischaemia was identified on a patient undergoing pre-operative colonoscopy for elective bowel resection. No instances of ischaemic stricture were seen. All-cause mortality of successfully treated and all patients at 1 year was 31% (8/26) and 30% (12/40), respectively.

Conclusion: Transcatheter coil embolization is a durable treatment option with a technical and clinical success rate of 67% in the setting of acute colonic haemorrhage. A modest level of rebleeding was seen among successfully treated patients in both the early and delayed periods; in the majority of patients, embolization proved to be definitive therapy.

Advances in knowledge: Transcatheter coil embolization is a durable and potentially definitive therapy in the management of acute colonic haemorrhage.

Acute lower gastrointestinal (GI) bleeding, defined by bleeding distal to the ligament of Treitz, is a potentially life-threatening condition that is often treated conservatively by medical management alone. Colonic haemorrhage constitutes the predominant subset of lower GI bleeding cases, occurring in up to 75–90% of patients and is commonly owing to bleeding diverticula, angiodysplasia, inflammatory bowel disease or neoplasm.¹ In up to 20% of these patients, haemorrhage is classified as massive, requiring blood transfusions greater than 3–5 units of packed red blood cells (RBCs) to maintain haemodynamic stability.² In these instances, more invasive management for haemostasis is necessary, with treatment options including endoscopic therapy (*i.e.* colonoscopy), transcatheter embolization and/or surgery.

In the past two decades, suboptimal performance of alternative endovascular techniques such as vasopressin infusion and continued developments in coaxial catheter technique

for transcatheter coil embolization have resulted in its increased usage by demonstrating an increased effectiveness at controlling life-threatening bleeding from a minimally invasive approach.^{3,4} Despite these advances, few studies to date have evaluated the long-term efficacy of superselective transcatheter microcoil embolization in the treatment of colonic haemorrhage. Given that embolization treats a symptom (*i.e.* bleeding in a patient with diverticulosis) of an underlying problem rather than the problem itself, recurrence is a concern. The purpose of this study is to retrospectively review all transcatheter microcoil embolizations undertaken at our institution for acute colonic bleeding to determine the short-term clinical outcome and long-term durability of this treatment.

METHODS AND MATERIALS

Study population

Following approval from our institutional review board, we retrospectively reviewed mesenteric angiograms performed

in all patients with suspected colonic bleeding between January 2002 and December 2012. Clinical selection criteria included a recent prior positive tagged ^{99m}Tc RBC scan or haemodynamic instability that failed conservative measures with blood transfusion. The query resulted in a total of 87 mesenteric angiograms performed in 79 patients (average age, 62 years; male, 38%). Among the 87 angiograms performed, 1 or multiple sites of bleeding were identified in 40 cases. Coil embolization was performed in 39 patients. One patient was not embolized owing to extensive multifocal bleeding. Data collected included patient demographics, comorbidities, clinical presentation, initial management and procedure technique.

Embolization technique

All cases were treated by a fellowship-trained attending interventional radiologist with or without assistance from a fellow. Patients with abnormal coagulation parameters were corrected with fresh frozen plasma or vitamin K to an international normalized ratio (INR) ≤ 1.7 prior to the initiation of the procedure.

Following informed consent, conscious sedation was administered with continuous haemodynamic monitoring. All operators performed

standard pre-procedural prep including hand washing, sterile gloves, gown, mask and cap. Standard procedural technique included placing the patient supine on the angiography table and prepping the groin in a sterile fashion. Using a 5-Fr micropuncture system (Cook®, Bloomington, IN), the right or left common femoral artery was accessed and a 5-Fr sheath was placed. Superior and/or inferior mesenteric angiograms were conducted in all patients with digital subtraction angiography (DSA). If active bleeding was not clearly identified in the initial catheterized artery, DSA of the alternate mesenteric artery was performed. In five cases, where bleeding was suspected to be in the distal colon, DSA runs of the middle and inferior rectal arteries from the internal iliac artery were also performed. Active bleeding was judged by extravasation that persisted throughout the venous phase on non-subtracted imaging. Superselective embolization was performed by catheterizing the most distal vessel possible—in most instances, the vasa rectae or marginal artery—using coaxial technique with a 2.4-Fr microcatheter (Renegade® STC; Boston Scientific, Marlborough, MA or Progreat®; Terumo Corporation, Shibuya, Japan) through the existing 5-Fr sheath and performing a hand injection. Microcoils (Interlock™ or pushable coils; Boston Scientific) were then deployed followed by repeat DSA to document treatment

Figure 1. (a) 74-year-old female who presented with bright red blood from the rectum from suspected diverticular haemorrhage. Digital subtraction angiography (DSA) image from an aortogram demonstrates a focal area of extravasation in the region of the ascending colon (arrow). (b) The DSA image from selective injection of the superior mesenteric artery demonstrates the haemorrhage (arrow) localized to a terminal branch of the right colic artery. This vessel was subsequently superselected and embolized with microcoils. (c) The DSA image following superselective deployment of two microcoils into a vasa recta branch of the right colic artery (arrow) demonstrates embolic arrest of the arterial bleeding source. The patient went on to recover without ischaemic complication or rebleeding.

Table 1. Patient demographics and comorbidities

Patient demographics and comorbidities	Successfully treated without rebleeding (<i>n</i> = 19)	Early rebleeding (<30 days, <i>n</i> = 3)	Delayed rebleeding (>30 days, <i>n</i> = 4)	All rebleeders (<i>n</i> = 7)	Total patients (<i>n</i> = 26)	<i>p</i> -value all rebleeders vs no rebleed
Total (<i>n</i>)	19	3	4	7	26	
Age (years) (range)	58.2 (18–91)	60.3 (42–72)	68.3 (57–76)	64.9 (42–76)	60 (18–91)	0.4694
Male	42.1% (8/19)	33.3% (1/3)	25% (1/4)	28.6% (2/7)	38.4% (10/26)	0.5292
Ethnicity						
African American	89.5% (17/19)	100% (3/3)	75% (3/4)	85.7% (6/7)	88.5% (23/26)	0.0629
Comorbidities						
Diabetes	42.1% (8/19)	66.7% (2/3)	25% (1/4)	42.9% (3/7)	42.3% (11/26)	0.9725
Hypertension	73.7% (14/19)	100% (3/3)	75% (3/4)	85.7% (6/7)	76.9% (20/26)	0.5184
Hyperlipidaemia	52.6% (10/19)	66.7% (2/3)	75% (3/4)	71.4% (5/7)	57.7% (15/26)	0.3895
Peripheral vascular disease	15.8% (3/19)	66.7% (2/3)	0% (0/4)	28.6% (2/7)	19.2% (5/26)	0.4632

success (Figure 1). We routinely did not perform provocative angiography (*i.e.* use of anticoagulants to promote GI bleeding) in the event of a negative angiogram.

End point definition

Primary end points of the study included early and delayed rebleeding, defined as any lower GI rebleeding events before or

Table 2. Clinical presentation

Clinical presentation	Successfully treated without rebleeding (<i>n</i> = 19)	Early rebleeding (<30 days, <i>n</i> = 3)	Delayed rebleeding (>30 days, <i>n</i> = 4)	All rebleeders (<i>n</i> = 7)	Total patients (<i>n</i> = 26)	<i>p</i> -value all rebleeders vs no rebleed
Clinical symptoms						
BRBPR	73.7% (14/19)	33.3% (1/3)	75% (3/4)	57.1% (4/7)	69.2% (18/26)	0.0635
Haematochezia	10.5% (2/19)	33.3% (1/3)	0% (0/4)	14.3% (1/7)	11.5% (3/26)	0.7901
Melaena	0% (0/19)	33.3% (1/3)	25% (1/4)	28.6% (2/7)	7.7% (2/26)	0.4632
Melaena + BRBPR	15.8% (3/19)	0% (0/3)	0% (0/4)	0% (0/7)	11.5% (3/26)	
Clinical status						
Hypotension (systolic blood pressure < 90)	26.3% (5/19)	0% (0/3)	0% (0/4)	0% (0/7)	19.2% (5/26)	0.1310
Underlying disease						
Diverticulosis	47.4% (9/19)	66.7% (2/3)	75% (3/4)	71.4% (5/7)	53.8% (14/26)	0.1847
Rectal ulcer	21.1% (4/19)	0% (0/3)	0% (0/4)	0% (0/7)	15.4% (4/26)	0.1869
Unknown	10.5% (2/19)	0% (0/3)	0% (0/4)	0% (0/7)	7.7% (2/26)	0.3716
Post-polypectomy	10.5% (2/19)	0% (0/3)	0% (0/4)	0% (0/7)	7.7% (2/26)	0.3716
Angiodysplasia	5.3% (1/19)	0% (0/3)	25% (1/4)	14.3% (1/7)	7.7% (2/26)	0.4438
Sepsis/ multifactorial	5.3% (1/19)	33.3% (1/3)	0% (0/4)	14.3% (1/7)	7.7% (2/26)	0.4438

BRBPR, bright red blood per rectum.

Table 3. Initial management

Initial management	Successfully treated without rebleeding (<i>n</i> = 19)	Early rebleeding (<30 days, <i>n</i> = 3)	Delayed rebleeding (>30 days, <i>n</i> = 4)	All rebleeders (<i>n</i> = 7)	Total patients (<i>n</i> = 26)
Pre-procedure haemoglobin					
≥10	52.6% (10/19)	33.3% (1/3)	25% (1/4)	28.6% (2/7)	46.2% (12/26)
<10	47.4% (9/19)	66.7% (2/3)	75% (3/4)	71.4% (5/7)	53.8% (14/26)
Pre-procedure international normalized ratio, average (range)	1.2 (1.0–1.7)	1.1 (0.9–1.2)	1.2 (1–1.6)	1.1 (0.9–1.6)	1.2 (0.9–1.7)
Pre-procedure thrombocytopenia (<50,000)	0% (0/19)	0% (0/3)	0% (0/4)	0% (0/7)	0% (0/26)
Transfusion requirements (number of PRBCs)					
Average	11.7	5	4	4.4	9.8
More than equal to five PRBCs	63.2% (12/19)	33.3% (1/3)	50% (2/4)	42.9% (3/7)	57.7% (15/26)
Less than five PRBCs	36.8% (7/19)	66.7% (2/3)	50% (2/4)	57.1% (4/7)	42.3% (11/26)
Prior imaging studies					
^{99m} Tc tagged RBC study only	42.1% (8/19)	66.7% (2/3)	25% (1/4)	42.9% (3/7)	42.3% (11/26)
Colonoscopy only	15.8% (3/19)	0% (0/3)	0% (0/4)	0% (0/7)	11.5% (3/26)
Tagged RBC study + colonoscopy	42.1% (8/19)	0% (0/3)	75% (3/4)	42.9% (3/7)	42.3% (11/26)
CT angiography	15.8% (3/19)	0% (0/3)	25% (1/4)	14.3% (1/7)	15.4% (4/26)
Oesophagogastrroduodenoscopy	15.8% (3/19)	0% (0/3)	0% (0/4)	0% (0/7)	11.5% (3/26)
No imaging	0% (0/19)	33.3% (1/3)	0% (0/4)	14.3% (1/3)	
Tagged RBC results					
Ascending colon	12.5% (2/16)	0% (0/2)	25% (1/4)	16.7% (1/6)	13.6% (3/22)
Hepatic flexure—mid transverse	18.8% (3/16)	0% (0/2)	25% (1/4)	16.7% (1/6)	18.2% (4/22)
Mid transverse—splenic flexure	0% (0/16)	0% (2/2)	25% (1/4)	50% (3/6)	13.6% (3/22)
Descending colon	6.3% (1/16)	0% (0/2)	25% (1/4)	16.7% (1/6)	9.1% (2/22)
Rectosigmoid	43.8% (7/16)	0% (0/2)	0% (0/4)	0% (0/6)	31.8% (7/22)
No active bleeding	18.8% (3/16)	0% (0/2)	0% (0/4)	0% (0/6)	13.6% (3/22)
Colonoscopy results					
No active bleeding	36.4% (4/11)	–	50% (2/4)	50% (2/4)	40% (6/15)
Blood obscuring field of vision	18.2% (2/11)	–	25% (1/4)	25% (1/4)	20% (3/15)
Polypectomy	18.2% (2/11)	–	0% (0/4)	0% (0/4)	13.3% (2/15)
Colitis	9.1% (1/11)	–	0% (0/4)	0% (0/4)	6.7% (1/15)
Failed treatment (thermal coagulation)	18.2% (2/11)	–	25% (1/4)	25% (1/4)	20% (3/15)
CT-angiography results					
Descending colon	33.3% (1/3)	–	0% (0/1)	0% (0/1)	25% (1/4)
Rectosigmoid	66.7% (2/3)	–	0% (0/1)	0% (0/1)	50% (2/4)
No active bleed	0% (0/3)	–	100% (1/1)	100% (1/1)	0% (0/4)

PRBCs, packed red blood cells; RBC, red blood cell.

after 30 days, respectively. Additional primary end points included any adverse events per the Society of Interventional Radiology standards of practice guidelines for transcatheter embolization.⁵ Technical success was defined by embolic arrest

of arterial extravasation at the conclusion of the procedure. Clinical success was defined by post-procedure haemostasis and haemodynamic stability. Any bleeding complication within 3 days of the initial procedure was considered a clinical failure.

Figure 2. Outcomes of all patients with positive bleeding identified on mesenteric angiography. CA, cancer; f/u, follow-up; IMA, inferior mesenteric artery; OR, operating room.

Complications investigated included both immediate post-procedural (*i.e.* haematoma) and delayed events such as infection, ischaemia and non-target embolization. Ischaemic complication was defined by symptomatic bowel ischaemia that resulted in stricture or necessitated bowel resection.

Statistical analysis

Baseline, procedural and outcome parameters were statistically analysed between patients who rebled and those who

did not. χ^2 and *t*-test analyses were performed for discrete and continuous variables, respectively. A $p < 0.05$ was considered statistically significant.

Follow-up

Follow-up was performed on all treated patients by internal chart review of the electronic medical record, a system that is integrated with both inpatient and outpatient records at our institution. All patients were encouraged routinely to schedule

Table 4. Procedural data

Procedural data	Successfully treated without rebleeding (<i>n</i> = 19)	Early rebleeding (<30 days, <i>n</i> = 3)	Delayed rebleeding (>30 days, <i>n</i> = 4)	All rebleeders (<i>n</i> = 7)	Total patients (<i>n</i> = 26)
Time to angiography from admission					
<24 h	47.4% (9/19)	66.7% (2/3)	75% (3/4)	71.4% (5/7)	53.8% (14/26)
<48 h	15.8% (3/19)	0% (0/3)	0% (0/4)	0% (0/7)	11.5% (3/26)
>48 h	36.8% (7/19)	33.3% (1/3)	25% (1/4)	28.6% (2/7)	34.6% (9/26)
After-hour emergent embolization (5 pm–7 am)	21.1% (4/19)	0% (0/3)	25% (1/4)	14.3% (1/7)	19.2% (5/26)
Angiography immediately following tagged red blood cell study (within an hour)	43.8% (7/16)	50% (1/2)	25% (1/4)	33.3% (2/6)	34.6% (9/26)
Vessel embolized					
Superior mesenteric artery	42.1% (8/19)	100% (3/3)	50% (2/4)	71.4% (5/7)	50% (13/26)
Inferior mesenteric artery	57.9% (11/19)	0% (0/3)	50% (2/4)	28.6% (2/7)	50% (13/26)
Level of subselection					
Vasa recta	57.9% (11/19)	66.7% (2/3)	75% (3/4)	71.4% (5/7)	61.5% (16/26)
Marginal artery	26.3% (5/19)	33.6% (1/3)	25% (1/4)	28.6% (2/7)	26.9% (7/26)
Third order or greater branch	15.8% (3/19)	0% (0/3)	0% (0/4)	0% (0/7)	11.5% (3/26)
Number of coils					
Average	4.3	3.7	4	4.1	4.3
≥Five coils	26.3% (5/19)	33.3% (1/3)	50% (2/4)	42.9% (3/7)	30.8% (8/26)
Four coils	21.1% (4/19)	0% (0/3)	0% (0/4)	0% (0/7)	15.4% (4/26)
Three coils	26.3% (5/19)	33.3% (1/3)	25% (1/4)	28.6% (2/7)	26.9% (7/26)
Two coils	26.3% (5/19)	33.3% (1/3)	25% (1/4)	28.6% (2/7)	26.9% (7/26)
Coil size (mm)					
6	5.3% (1/19)	0% (0/3)	0% (0/4)	0% (0/7)	3.8% (1/26)
4	10.5% (2/19)	0% (0/3)	0% (0/4)	0% (0/7)	7.7% (2/26)
3	15.8% (3/19)	0% (0/3)	0% (0/4)	0% (0/7)	11.5% (3/26)
2	68.4% (13/19)	100% (3/3)	100% (4/4)	100% (7/7)	76.9% (20/26)

follow-up appointments with their primary care physician or gastroenterologist. Any patients with a follow-up of less than 30 days (*n* = 1) were excluded. Average time of follow-up was 996 days with a median of 232 days and range of 30–3663 days.

RESULTS

26 patients (66.7%, 26/39) were treated successfully without technical failure (*n* = 6), clinical failure (*n* = 6) or loss to follow-up (*n* = 1). Technical failure occurred from inability to subselect the bleeding vessel (*n* = 3), mechanical vasospasm

(*n* = 2) or severe atherosclerosis (*n* = 1). Demographic information and comorbidities between groups are highlighted in Table 1. Additional comorbidities including end-stage renal disease, coronary artery disease, liver failure and malignancy were not found to be statistically different between groups.

Among successfully treated patients (*n* = 26), 3 (11.5%, 3/26) patients rebled in the “early” period within 30 days. Two of these patients died of severe comorbidity, while one patient was ultimately managed by hemicolectomy alone. An additional

Table 5. Follow-up and mortality data

Follow-up and mortality data	Successfully treated without rebleeding (<i>n</i> = 19)	Early rebleeding (<30 days, <i>n</i> = 3)	Delayed rebleeding (>30 days, <i>n</i> = 4)	All rebleeders (<i>n</i> = 7)	Total patients (<i>n</i> = 26)	<i>p</i> -value all rebleeders vs no rebleed
Follow-up colonoscopy	47.4% (9/19)	100% (3/3)	75% (3/4)	85.7% (6/7)	57.7% (15/26)	0.0792
Clinical follow-up (days)						
Average (range)	805.9 (30–3184)	96 (30–228)	2570.5 (132–3663)	1510 (30–3663)	995.5 (30–3663)	0.2138
Median	236	30	3243.5	228	232	
1 year all-cause mortality	21.1% (4/19)	100% (3/3)	25% (1/4)	57.1% (4/7)	30.8% (8/26)	0.0770

4 patients (15.3%, 4/26) experienced “delayed” rebleeding events after 30 days. Two of these patients rebled in the same area and were managed surgically. One patient was successfully managed conservatively as a follow-up mesenteric angiogram and colonoscopy did not reveal any active bleeding. The final patient bled from a colonic polyp from a different site than the initial embolization. This was successfully managed endoscopically by epinephrine injection. In cases of surgical resection, the decision to pursue surgery instead of repeat embolization was not made clear in the medical chart.

The clinical presentation of successfully treated patients (*n* = 26), including clinical symptoms, haemodynamic status, underlying aetiology of bleeding, anticoagulation, prior surgery or history of prior bleeding is listed in Table 2; none of which was found to be statistically significant as predictors of rebleeding. Additionally, further analysis of clinical variables including anticoagulation status upon admission as well as a history of prior GI surgery or bleeding were not found to be statistically significant among the groups. Initial work-up of these patients, including pre-procedure haemoglobin, INR, thrombocytopenia, number of packed RBCs transfused, prior imaging and intervention, as well as results of the studies is listed in Table 3. Finally, procedural data including time to angiography and embolization technique, including the artery embolized, level of subselection for embolization, number of coils used and size of coils used are shown in Table 4.

No major complications were seen in the immediate post-procedural period of all treated patients. No procedure-related mortality was reported. One minor complication of short segment arterial dissection was identified during the peri-procedure period that resulted in cessation of arterial bleeding on angiography. This patient, however, rebled clinically within 48 h (clinical failure category) and ultimately underwent surgical hemicolectomy.

No symptomatic cases of ischaemia, ischaemic stricture or death related to bowel ischaemia occurred. One case of ischaemic change was seen on follow-up colonoscopy in an asymptomatic

patient with diverticulosis, who electively chose to undergo bowel resection. The colonoscopy report described inflammatory changes in this region with nodular mucosa, green exudate and a minute quantity of pneumatosis. All-cause mortality of treated patients at 1 year was 31% (8/28), none of which was thought to be related to their lower GI bleeding. Specific follow-up and mortality data are shown in Table 5, Figure 2.

DISCUSSION

Interventional techniques in colonic embolization have continued to evolve over the past decade. At the turn of the century, embolotherapy for lower GI haemorrhage with microcoils was still relatively new and fraught with potentially serious complications such as bowel infarction.⁶ Given the lack of a dual blood supply in the lower GI tract, it was perceived that embolization could never effectively treat lower tract bleeding without compromising healthy enteric tissue.^{7–10} However, innovations in coaxial technique have allowed for a superselective approach to bleeding vessels, resulting in continued high rates of haemostasis with reduced instances of ischaemia. Numerous studies in recent years have demonstrated this benefit,^{11–17} contributing to the overall acceptance of embolization as a legitimate and even preferred treatment option in the management of acute massive colonic haemorrhage. Additionally, direct comparisons of embolotherapy with catheter-directed vasoconstrictive therapy (*i.e.* vasopressin) have concluded the superiority of coil embolization in the vast majority of indications, reserving vasoconstrictive therapy mainly for patients with multifocal bleeding or technically challenging cases that preclude superselective catheterization.^{18,19}

When compared with colonoscopy and surgery, however, the optimal sequence for management of colonic haemorrhage remains controversial. Initial guidelines by the American College of Gastroenterology, published in 1998, advocated the usage of colonoscopy for initial work-up, reserving arteriography and surgery as salvage therapy in unsuccessful or refractory cases.²⁰ Additional data from this era also reinforced the efficacy of colonoscopy, highlighting its ability to control bleeding by epinephrine injections or bipolar coagulation.²¹ However,

initial treatment for lower GI bleeding by mesenteric angiography with transcatheter microcoil embolization continued, citing inadequate bowel prep or the presence of briskly bleeding vessels limiting visualization of the bowel as factors that prohibit colonoscopy for primary therapy.²² The choice for transcatheter microcoil embolization in this setting was also validated by increased data in literature supporting its high efficacy and decreased ischaemic risk, leading the American College of Radiology in 2006 to list transcatheter embolization as the preferred treatment for lower GI bleeding in acutely unstable patients.²³ The guidelines further re-assigned colonoscopy as the first line of therapy in acutely bleeding but haemodynamically stable patients or in those with chronic low-grade bleeding.

Likely owing in part to the high rates of clinical success obtained with both colonoscopy and microcoil embolization, many recent publications have continued to debate the theoretical advantages and disadvantages of both treatments.^{24–27} The decision to use coil embolization over colonoscopy, however, remains limited by the lack of long-term follow-up data that assesses the overall durability of this minimally invasive therapy. Additionally, prior published data on endovascular technique is limited by a majority of studies using a combination of different embolic agents to manage lower GI bleeding, consequently confounding the evaluation for efficacy of any one single agent.^{4,11–15,17–19,25,27,28} The present study sought to address this concern by examining both early and delayed rebleeding rates in patients managed specifically by superselective microcoil embolization, yielding rates of 11.5% and 15.3%, respectively. These findings take an initial step at showing the ability to achieve long-term haemostasis in most patients treated by endovascular coiling alone. It also demonstrates that symptomatic control of bleeding is often enough to maintain haemodynamic stability and prevent surgery in the majority of patients.

In addition to a moderately high rate of clinical success, we also demonstrated in our study a zero rate of significant ischaemic complication that necessitated surgery. We did, however, encounter one patient who had asymptomatic ischaemia noted on a follow-up colonoscopy prior to an elective bowel resection. Given that the rates of ischaemic events in past studies using endovascular technique with various embolic agents have been reported in the range of

3–21%,^{4,16,27,28} our experience provides validation to the idea that the risk of ischaemia is lower with coils than with the other agents used for treatment (*i.e.* particulates, gelatin sponge and n-BCA liquid embolic). Additionally, as most other published literature on transcatheter embolization is confounded by the usage of a variety of embolic agents, the results from this study show the overall low risk of ischaemia when microcoils are used in a superselective manner.^{4,11–15,17–19,25,27,28} The belief is that superselective coiling limits the area of embolization to the diseased or actively bleeding segment of large bowel in such a fashion that arrests bleeding but avoids end organ necrosis and ischaemia.³ This is in contrast to other embolic agents such as particles, gelatin sponge or liquid embolic (*i.e.* n-BCA glue) that may achieve higher rates of haemostasis with more distal embolization, however, at the risk of increasing tissue ischaemia and infarction. Given that the colon does not possess a dual blood supply such as that by the upper GI tract, it is the authors' preference to avoid the usage of such embolics if bleeding can be controlled with microcoils that allow collateral perfusion to non-diseased segments of the bowel.

The limitations of the study include its retrospective design, which inherently limits the ability to eliminate existing biases or to establish a specific protocol in terms of patient follow-up. An additional weakness is that a cohort of 26 successfully treated patients remains small for statistical analyses and also limits our ability to make definitive generalizations about ischaemic complication or other rare outcomes such as coil migration or haemolysis.²⁹ Furthermore, our cohort included a majority of patients with diverticular bleeding, a disease state that may represent a more challenging pathology to treat with a higher likelihood to rebleed given its multifocal nature. This finding may have falsely lowered the overall rate of clinical success of transcatheter embolization in treating colonic haemorrhage, specifically in diseases with more focal pathology (*i.e.* ulcer or angiodysplasia).

Overall, we conclude that transcatheter superselective microcoil embolization is a safe, effective and durable option for the treatment of acute colonic haemorrhage. Modest rates of rebleeding are seen in both the early and delayed periods; the majority of patients achieve long-term haemostasis and avoid the future need for more definitive surgical therapy.

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