



Research article

Characteristics of patients treated for active lower gastrointestinal bleeding detected by CT angiography: Interventional radiology versus surgery



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ABSTRACT

Purpose: To determine radiological or clinical criteria guiding treatment decisions in active lower gastrointestinal bleeding (LGIB).

Materials and methods: We consecutively and retrospectively included all patients admitted to our emergency department for acute LGIB proven by CT angiography (CTA) from 2004 to 2017. Patients were divided into two groups depending on whether they first underwent interventional radiological (IR) or surgical treatment. Two radiologists reviewed CTA and angiographic images. Patients' hemodynamic and clinical parameters, delay between imaging and treatment, procedure characteristics, and outcomes were investigated to detect differences between the two groups.

Results: Initial management consisted of IR in 62 cases (70.5%) and surgery in 26 (29.5%). IR cases were older than surgical cases (74.3 vs 64.3y, $p = 0.014$). Baseline hemodynamic parameters were similar between the two groups. For colonic bleeding sources, the delay between CTA and IR was shorter than between CTA and surgery ($p = 0.027$), while there was a trend towards a shorter delay for all LGIB taken together ($p = 0.061$). In cases with hematochezia or melena, IR was more frequently performed than surgery ($p = 0.001$). Surgical cases showed higher base excesses ($p = 0.039$) and lactate levels ($p = 0.042$) after treatment compared with IR cases. Length of hospital stay was similar between the two groups ($p = 0.728$).

During angiography, 41 (66%) cases were embolized. Complications occurred in three cases after IR (7%) and in five after surgery (19%).

Conclusion: Initial management of active LGIB revealed by CTA (i.e. IR versus surgery), may depend on age and clinical signs, rather than hemodynamic parameters.

1. Introduction

Lower gastrointestinal bleeding (LGIB) is defined as hemorrhage originating distally to the ligament of Treitz. LGIB is less common than upper gastrointestinal bleeding, but accounts for about 36 per 100'000 [1] cases presenting with lower intestinal diseases, and is associated with a mortality rate of approximately 5% [2]. The majority of LGIBs occur in elderly people. This population may have various comorbidities entailing the need for anticoagulation or antiplatelet drugs which increase bleeding risk. The most common sources of LGIB, in decreasing order are diverticular disease (40%), colitis and inflammatory bowel disease (21%), neoplasia (14%), coagulopathic hemorrhage (12%) and angiodysplasia [3–6].

Most patients with acute LGIB are managed conservatively, because

the condition resolves with supportive care in 75–85% of cases [4]. Colonoscopy is performed secondarily after colonic preparation and often enables localization of the bleeding and adequate treatment in a hemodynamically stable patient. However, in patients with massive LGIB defined by hemodynamic instability or a high amount of blood loss the situation is quite different. Here, the role of endoscopy is much more controversial, because it must be performed in an emergency context without prior colonic preparation. In these situations, the endoscopic view is often blurred by ongoing bleeding and residual faeces hampers the detection of the bleeding source. The diagnostic yield of emergency colonoscopy may therefore be poor, and technical failures are common [6]. Another drawback is that only the colon but not the small intestine is completely accessible endoscopically [7].

In most centres, CT angiography (CTA) is considered the diagnostic

Abbreviations: CTA, CT angiography; HU, Hounsfield units; IR, interventional radiology; LGIB, lower gastrointestinal bleeding; TAE, transarterial angioembolization

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modality of choice for any patient admitted to the emergency department with clinically relevant LGIB [8]. Extravasation of intravenously administered contrast medium (CM) into the bowel lumen is pathognomic for active gastrointestinal hemorrhage [8]. According to a recently published meta-analysis [6], CTA has proven to have excellent sensitivity (90%) and specificity (92%) in this context. CTA is reportedly sensitive enough to detect active bleeding that results in as little as 0.3 ml/min of blood loss, which makes it comparable to technetium-99m tagged red blood cell scintigraphy [9].

Aside from colonoscopy, the two treatment options for the management of active LGIB are interventional radiology (IR) with subsequent embolization, and surgery. Currently, there is no consensus in the medical literature about the initial treatment choice and few articles focus on this topic [4,10–16]. Up to now, no hemodynamic or clinical characteristics have been evaluated to guide the choice of management in these actively bleeding patients. However, it seems crucial to identify parameters, that may help stratify these patients to the appropriate therapy.

Therefore, the purpose of this study was to evaluate which criteria determine or influence the initial management of patients with active LGIB detected by CTA.

2. Material and methods

This single-centre retrospective study was approved by the institutional review board. The requirement to obtain informed consent was waived.

2.1. Patient population and cases

After entering the keywords “digestive bleeding”, “colic bleeding”, “colic hemorrhage”, “contrast medium extravasation”, “small intestine bleeding” and “small intestine hemorrhage” into our comprehensive electronic database of examination reports (search period from January 2004 to June 2017), we retrieved 131 patients in whom acute LGIB had been reported. Fig. 1 shows the flow chart with the exact numbers of in- and excluded cases. Only patients with active LGIB that were initially treated with IR or surgery, were considered. Patients with different emergency management of their LGIB, such as endoscopy or conservative treatment, were excluded because of the low number of cases (Fig. 1). The final statistical analysis included 75 patients. They accounted for 88 cases, because nine patients had been admitted more than once to our department for several consecutive treatments. Five patients had been admitted two times and four patients three times; these patients were investigated with CTA at each admission and then treated each time with either surgery or IR.

2.2. Technical parameters

2.2.1. CT angiography (CTA)

CTA performed using a 16-detector row CT machine (Light Speed 16 Advantage; GE Healthcare, Milwaukee, WI, USA) from January 2004 to November 2005, a 64-detector row CT machine (Light Speed VCT 64 Pro; GE Healthcare, Milwaukee, WI, USA) from November 2005 to November 2015, and a 256-detector row CT machine (Revolution, GE Healthcare, Milwaukee, WI, USA) from December 2015 to June 2017.

The imaging protocol included the whole abdomen and pelvis [diaphragm to pubic symphysis, 120 kV, 300–400 mA, table speed 55 m per rotation (0.8 s), pitch 1.375, except for the latest CT machine Revolution (rotation 0.5 s, pitch 0.998)]. A non-enhanced phase (2.5/2 mm or 5 mm/5 mm reconstructed axial slices) was performed in 78 cases (68.6%). Furthermore, from January 2010 to November 2015, the arterial phase of CTA was acquired at 100 kV, whenever the patient's body mass index (BMI) was ≤ 25 kg/m². Iodinated contrast medium (Accupaque®, Iohexol, 300 mgI/ml; GE Healthcare) was intravenously injected (volume in millilitres = body weight + 30 mL) in all patients at

a flow rate of 4 ml/s and an arterial phase and a venous phase were acquired (reconstructed in 1.25/1 mm and/or 2.5/2 mm axial slices). With the newer scanners, automatic tube current modulation in all 3 axes (SmartmA) was used, as well as the iterative reconstruction algorithm, either ASIR or ASIR-V according to the CT machine.

2.2.2. Angiography and transarterial embolization (TAE)

An 18-gauge single-wall needle was used to perform a retrograde puncture of the common femoral artery. Using the Seldinger technique, a 5-F vascular sheath was placed over a 0.035-inch guidewire. Depending on the bleeding site identified on CTA images, selective catheterization of the celiac axis, superior mesenteric and/or inferior mesenteric arteries was performed using 5 Fr catheters (Cobra C2 or Simmon-1; Cordis, Miami Lakes, FL, USA). Angiography was performed to confirm the bleeding and to localize the source (active contrast extravasation, contrast blush), a pseudoaneurysm or an abnormal vessel (truncated, irregular wall). Subsequently, whenever possible, a superselective catheterization using a microcatheter (1.7–2.1Fr Echelon, Medtronic, USA; 2Fr Stridesmooth+, Asahi Intecc co., Japan; 2.7Fr Progreat, Terumo, Japan) was coaxially advanced into the target artery.

TAE was performed using different coils depending on the operator's preference: 0.018 inch microcoils, such as Nester or Tornado (Cook Medical, Bloomington, USA, n = 25), Gelfoam (Pfizer, n = 6) or a combination of both (n = 9), or n-butyl cyanoacrylate mixed with iodized oil (Histoacryl/Lipiodol, n = 1).

2.3. Image analysis and patient records

Two experienced radiologists (S.S., R. D.) with 17 and 10 years of expertise in abdominal imaging, respectively, and 6 years of experience in IR for the latter, jointly reviewed all the CTA and the angiographic images on a picture archiving and communication systems (PACS) workstation (Carestream Vue, version 12.1.5, Carestream Health, Rochester, NY, USA). Radiologists only knew the presence of LGIB in each patient, without being aware of the clinical context or the outcome. They analysed each examination in view of the radiological findings listed in Table 1.

Active LGIB was defined as active extravasation of intravenously injected contrast medium into the bowel lumen measuring ≥ 90 HU detected on the CTA images during the porto-venous phase [17]. The two readers located the bleeding source (jejunum or ileum, cecum, ascending, transverse, descending and sigmoid colon; and rectum) and manually drew a region of interest (ROI) at the site of the contrast medium extravasation to register the maximal density (in Hounsfield units). They tried to encompass the maximal diameter of the extravasated contrast medium.

All angiographic procedures were reviewed. Presence/absence of active bleeding, level of embolization (if any) and embolic agent were recorded. A non-selective embolization directly involved the jejunal, ileal, ileocolic, colic, or rectal arteries, whereas a selective or super-selective embolization was defined as an embolization performed proximally or distally to its arterial arcade, respectively. Technical success was defined as the disappearance of contrast extravasation and lack of contrast filling of the pseudoaneurysm or abnormal vessel on the completion angiogram. Clinical success was defined as cessation of bleeding for 30 days [8,18].

Finally, one reader retrieved patients' historical, clinical, and biological data from electronic medical records, as described in Table 1. Laboratory values were recorded before and after the treatment performed first (i.e., IR or surgery). We also considered any prior medication, such as platelet antiaggregant therapy or anticoagulation, clinical signs of blood loss, such as hematochezia and/or melena, and the shock index of each patient. The shock index (heart rate / systolic blood pressure) is an indicator of hemodynamic instability. A shock index of > 0.9 is considered as sign of hypovolemic shock. Any red blood cells

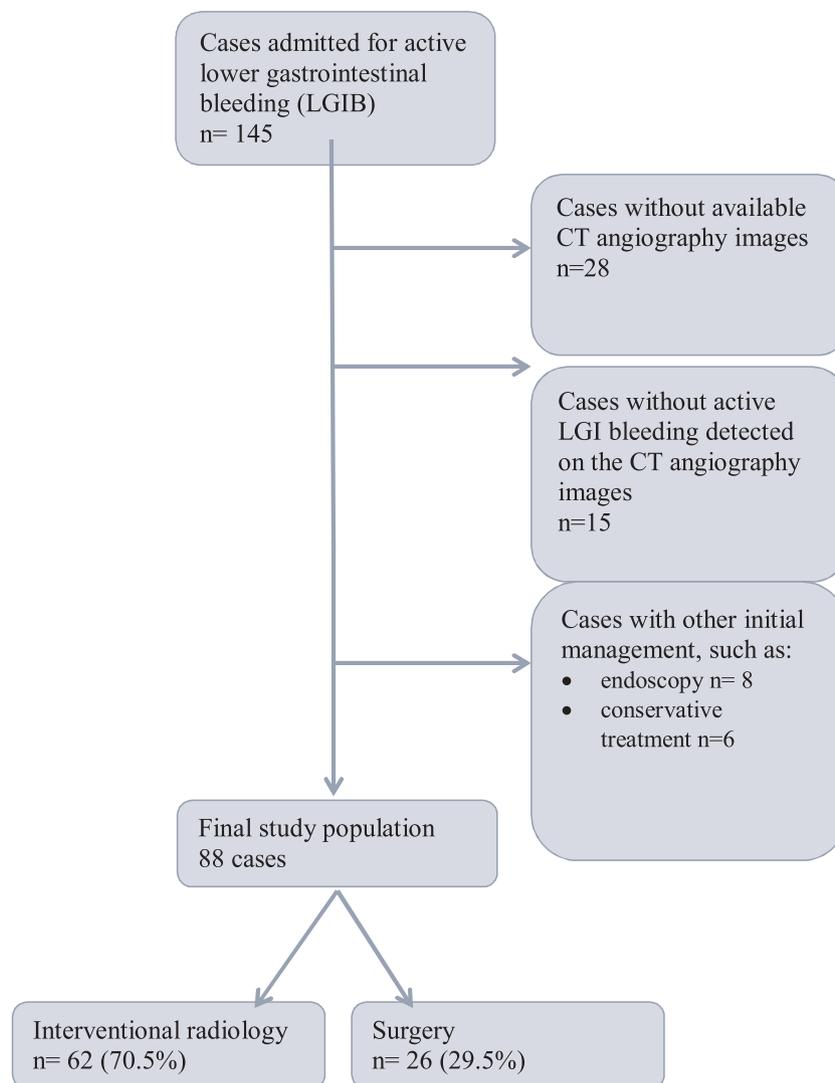


Fig. 1. Flow chart showing inclusion and exclusion criteria.

The initial study population included 131 patients (145 cases) and the final study population included 75 patients. The final study population ($n = 75$) accounted for 88 LGIB cases, because nine patients had been admitted more than once to our department (five patients had been admitted two times and four patients three times) investigated by CTA at each admission, and treated each time with either surgery or IR.

transfusion requirements during the intervention, recurrence of bleeding, each patient's outcome, and their final diagnosis were also registered. The latter was based on each patient's discharge letter.

The exact time of the first emergency treatment chosen after the CTA, either IR or surgery, was recorded and the delay between the acquisition of CT data and intervention was registered.

We also recorded any additional intervention after the initial treatment, provided it occurred during the same hospital stay, as well as complications following the chosen treatment (according to the Clavien-Dindo classification for the surgical cases) [19], and the length of the hospital stay for each group.

2.4. Statistical analysis

Statistical analysis was performed using the commercially available software JMP®, version 10, (SAS Institute Inc. Cary, North Carolina, USA). Data are presented as number and relative percentages. Quantitative variables are expressed as median (interquartile range) except for the age for which we used the mean value. We compared categorical variables with the Fisher or the Chi-square test, as appropriate. For continuous variables, we used the Moods median or the Mann-Whitney U test for non-parametric data distribution, Student's *t*-

test for parametric data distribution, or analysis of variance (ANOVA). P -value < 0.05 was considered statistically significant. The significance level was also corrected for multiple comparisons using the Bonferroni method when needed.

After the overall statistical evaluation of all LGIB cases, we grouped the cases into small bowel and colonic bleeds and performed a separate analysis for each bleeding location.

3. Results

3.1. Patients

The final study population included 88 cases corresponding to 75 patients ($n = 27$ women).

The causes of LGIB were described as diverticular disease ($n = 22$), trauma ($n = 9$), angiodysplasia ($n = 8$), postoperative/postendoscopic complications ($n = 8$), clotting disorders ($n = 6$), colitis ($n = 5$), tumour ($n = 4$), ulcer ($n = 1$) and undetermined causes ($n = 12$).

Table 1
Radiological and clinical findings, laboratory tests, anamnestic data, and final diagnoses assessed in the final study population (n = 88).

Radiological findings	Location of the LGIB (CT-angiography) Density of active bleeding (Hounsfield units) Technique of angiographic catheterization [(non-)selective, or superselective], if any Contrast medium leakage (angiography), if any Angioembolization (name/number of embolized arteries), if any Treatment success
Clinical signs of LGIB	Hematochezia Melena
Hemodynamic parameters	Blood pressure (mmHg) Heart rate (beats per minute) Shock Index (N > 0.9) Hemoglobin (g/dl) Red blood cell transfusion requirements (during intervention, in units) Serum lactate (mmol/L) Base excess (mmol/L)
Patient history	Anticoagulation Platelet anti-aggregant therapy
Final diagnosis	Neoplasia Vascular malformation Traumatic/iatrogenic origin Diverticulosis/diverticulitis Colitis/enteritis Other Unknown

3.2. Active LGIB: differences between interventional and surgical treatment groups (Table 2)

The two treatment groups were composed of 88 cases whose mean age was 71.6 ± 17.7 years (range 16–93). Active bleeding originated from the small bowel in 30 cases (34.1%) and from the colon in 58 cases (65.9%) (see separate analysis below).

In 62 (70.5%) of the 88 cases, the first chosen treatment was IR, and 26 (29.5%) cases underwent surgery (Fig. 1).

The cases managed with IR (mean age 74.3 ± 14.9) were

Table 2
LGIB: Differences between two groups initially treated with IR versus surgery.

Parameters	Evaluated cases	Cases treated with IR	Cases treated with surgery	p-value
Number of cases, n	88	62	26	
Mean age, years [SD]	71.6	74.3 [± 14.9]	64.3 [± 21.4]	0.014*
Drug-induced clotting disorders, n				0.671
• None	41	28/62	13/26	
• Anticoagulation	14	11/62	3/26	
• Platelet inhibitors	33	23/62	10/26	
Clinical signs of active LGIB, n (hematochezia, melena)	86/88	57/62	18/26	0.001*
Density of bleeding on CTA, Hounsfield units [IQR]	88/88	210 [153; 265.5]	211.5 [141.75; 276.25]	0.945
Delay between CTA and treatment, min [IQR]	88/88	161 [95.5; 305.8]	673 [63; 880.3]	0.061
Red blood cell transfusion (during intervention), n	88/88	40/62	13/26	0.124
Shock index before treatment [IQR]	50/88	0.86 [0.6; 1.1]	0.74 [0.59; 0.97]	0.436
Shock index after treatment [IQR]	63/88	0.7 [0.6; 0.82]	0.66 [0.56; 0.82]	0.506
Hemoglobin level before treatment, g/dL [IQR]	85/88	78 [67.8; 91]	88 [69; 97]	0.218
Hemoglobin level after treatment, g/dL [IQR]	82/88	93 [85; 98.8]	96 [84.8; 103.3]	0.345
Systolic blood pressure before treatment, mmHg [IQR]	63/88	108 [90; 125]	130 [103.8; 143.8]	0.104
Systolic blood pressure after treatment, mmHg [IQR]	66/88	119.5 [110; 138]	120 [107.5; 143.8]	0.275
Heart rate before treatment, bpm [IQR]	63/88	96 [76.8; 105]	95 [85; 115]	0.876
Heart rate after treatment, bpm [IQR]	65/88	86.5 [74.3; 93]	80 [75; 95]	0.876
Base excess before treatment, mmol/L [IQR]	56/88	-2.35 [-5; -0.8]	-4.85 [-7.6; -1.9]	0.278
Base excess after treatment, mmol/L [IQR]	53/88	-2 [-3.8; -0.3]	-3.8 [-6.7; -2]	0.039*
Lactate before treatment, mmol/L [IQR]	55/88	1.75 [1.1; 2.7]	1.7 [1.3; 3.2]	0.865
Lactate after treatment, mmol/L [IQR]	54/88	1.2 [0.8; 2]	2.3 [1.3; 3.5]	0.042*

SD = standard deviation, CTA = CT angiography, IQR = interquartile range [25% ; 75% percentiles].

LGIB = lower gastrointestinal bleeding.

Unfortunately, clinical, hemodynamic, and laboratory parameters were not always available for each included case.

significantly older than the surgical group (mean age 64.3 ± 21.4 y, $p = 0.014$).

Table 2 summarizes the overall differences between the two treatment groups regarding the parameters evaluated in cases of bleeding from the small bowel and colon.

In the presence of hematochezia or melena, IR was performed more frequently than surgery ($p = 0.001$).

The median delay between CTA and treatment with IR was 161 [95.5; 305.8] minutes, compared with 673 [63; 880.3] minutes for surgery; thus, there was a trend towards shorter delays with IR ($p = 0.061$).

None of the hemodynamic parameters measured before the intervention differed significantly between the two groups. After the intervention, the base excess ($p = 0.039$) and the lactate ($p = 0.042$) were significantly higher in patients undergoing surgery than in those managed with IR.

3.3. Active small bowel bleeding: differences between IR and surgical treatment groups (Table 3)

Among the 30 cases whose bleeding source was in the small bowel, 24 (80%) were treated with IR, and six (20%) underwent surgery.

The cases with small bowel bleeding managed with IR (mean age 73.9 ± 12.7 y) were significantly older than the surgical group (mean age 58.3 ± 21.5 y, $p = 0.028$).

In the presence of hematochezia or melena, IR was performed more frequently than surgery ($p = 0.001$).

When the bleeding originated from the jejunum ($n = 20$), we observed a trend favouring IR ($p = 0.053$) as first-line management, unlike for the ileal bleeding sources ($n = 10$). Indeed, 18 patients with jejunal bleeding were managed with IR, while only 2 underwent surgery. No other significant difference in hemodynamic or other clinical parameters were observed.

Table 3
Small bowel bleeding: Differences between two groups initially treated with IR versus surgery.

Parameters	Evaluated cases	Cases treated with IR	Cases treated with surgery	p-value
Number of cases, n	30	24	6	
Mean age, years [SD]	30/30	73.9 [± 12.7]	58.3 [± 21.5]	0.028*
Drug induced clotting disorders, n	30/30			0.157
• None	15	10/24	5/6	
• Anticoagulation	7	7/24	0/6	
• Platelet inhibitors	8	7/24	1/6	
Clinical signs of active LGIB, n (hematochezia, melena)	29/30	22/24	2/6	0.001*
Location of bleeding, n	30/30			0.053
• Proximal small bowel (jejunum)		18/24	2/6	
• Distal small bowel (ileum)		6/24	4/6	
Density of bleeding on CTA, Hounsfield units [IQR]	30/30	187 [151; 297]	145 [131; 207]	0.369
Delay between CTA and treatment, min [IQR]	30/30	191 [123; 669]	465 [50; 762]	0.57
Red blood cell transfusion (during intervention), n	30/30	18/24	6/6	0.171
Shock index before treatment [IQR]	22/30	1.05 [0.82; 1.17]	0.97 [0.83; 1.15]	0.624
Shock index after treatment [IQR]	24/30	0.8 [0.67; 0.95]	0.82 [0.64; 0.96]	1
Hemoglobin level before treatment, g/dL [IQR]	28/30	68 [61; 83]	75 [58; 135]	1
Hemoglobin level after treatment, g/dL [IQR]	27/30	93 [82; 96]	97 [85; 112]	0.92
Systolic blood pressure before treatment, mmHg [IQR]	24/30	95 [90; 117]	100 [98; 138]	0.328
Systolic blood pressure after treatment, mmHg [IQR]	26/30	120 [110; 123]	120 [95; 123]	0.54
Heart rate before treatment, bpm [IQR]	25/30	105 [95; 108]	110 [96; 119]	0.262
Heart rate after treatment, bpm [IQR]	26/30	90 [88; 106]	88 [78; 99]	1
Base excess before treatment, mmol/L [IQR]	18/30	-1.8 [-5; 0.15]	-3.5 [-11.5; 1-05]	0.609
Base excess after treatment, mmol/L [IQR]	15/30	-2 [-6.5; 1.1]	-3.2 [-5.3; -2.25]	0.157
Lactate before treatment, mmol/L [IQR]	18/30	2.7 [1.5; 3.1]	1.5 [1.5; 9.5]	0.125
Lactate after treatment, mmol/L [IQR]	16/30	2.2 [1.2; 3.5]	2 [1.65; 3.2]	0.602

SD = standard deviation, CTA = CT angiography, IQR = interquartile range [25% ; 75% percentiles].

Unfortunately, clinical, hemodynamic, and laboratory parameters were not always available for each included case.

3.4. Active colonic bleeding: differences IR and surgical treatment groups (Table 4)

Among the 58 cases with active colonic bleeding, 38 (65.5%) were immediately managed with IR, while 20 (34.5%) underwent surgery. The bleeding originated from the proximal colon (cecum, ascending or transverse colon) in 36 cases and from the distal colon (descending colon, sigmoid colon or rectum) in 22 cases.

The cases with colonic bleeding managed with IR showed a trend toward being significantly older than the surgical group (mean age 74.6y vs 66y, $p = 0.095$).

In cases with hematochezia or melena originating from the colon, IR was performed more frequently than surgery ($p = 0.033$).

The delay between CTA and IR was significantly shorter than the delay between angio-CT and surgery ($p = 0.027$).

Finally, we observed a trend for a higher number of red cell blood transfusions in cases treated with IR, than in cases undergoing surgery ($p = 0.056$). No other significant difference in hemodynamic or other clinical parameters were observed.

3.5. Cases managed with IR (Fig. 3)

Of the 62 cases managed with IR, 29 (46.8%) were managed with superselective catheterization (Fig. 2), 26 (41.9%) were managed selectively, and seven (11.3%) were managed non-selectively.

During the IR procedure, 41 (66%) of the 62 cases were embolized; of these, 32 (78%) showed active intestinal bleeding on angiographic images. Eleven (26%) out of the 41 cases had a relapse of bleeding followed by a second IR ($n = 3$), surgery ($n = 5$), colonoscopy ($n = 1$), or conservative treatment ($n = 2$). Twelve of the 21 cases without embolization (57%) resolved spontaneously; of the nine cases that required additional treatment, two were treated with surgery, four with colonoscopy, and three with a second IR attempt.

Two cases (Fig. 3) with initial extravasation detected on the angiographic images were finally not embolized because the active bleeding stopped during the intervention, most likely because of sudden

occlusion of the bleeding vessels. In the first patient, it was due to local vasospasms caused by unsuccessful attempts to superselectively catheterise the very small and tortuous bleeding artery. In the second patient, who was already very hypovolemic before the intervention, a general vasoconstriction occurred during angiography which then most probably led to the bleeding stop. The first patient could then be treated conservatively, while in the second case recurrent bleeding occurred which was finally treated surgically.

We observed 3 complications after TAE: two cases with bowel wall necrosis required surgical segmental bowel resection during the same hospital stay, and one case with ischemic colitis detected endoscopically was treated conservatively.

3.6. Cases managed with surgery (Fig. 4)

Of the 26 surgically treated cases, five (19%) had post-operative complications that required further management. Two patients required reoperations for anastomotic leakage (Dindo-Clavien IIIb). Two other patients continued to bleed; one was treated with colonoscopy (Dindo-Clavien IIIa), and the other died without further intervention (Dindo-Clavien V). The fifth patient had a post-operative NSTEMI with further complications (Dindo-Clavien IV).

3.7. Patients' follow-up

Seven patients (9.3%) died during their hospital stay; of these, one patient was treated surgically, four patients were treated with IR, and two patients underwent an initial IR followed by surgery. Only one patient died directly from LGIB. After IR, he developed haemorrhagic shock due to bleeding recurrence. The other six deaths were unrelated to LGIB: three were due to septic shock, and one each was due to respiratory failure, cardiac failure and disseminated intravascular coagulation because of underlying lymphoma.

The length of hospital stay was not different between the two groups ($p = 0.136$). The median length of hospital stay was 18 days (range 6–45) for surgical cases and 11 days (range 6–102) for cases managed

Table 4
Colonic bleeding: Differences between two groups initially treated with IR versus surgery.

Parameters	Evaluated cases	Cases treated with IR	Cases treated with surgery	p-value
Number of cases, n	58	38	20	
Mean age, years [SD]	58/58	74.6 [± 16.4]	66 [± 21]	0.095
Drug-induced clotting disorders, n	58/58			0.921
• None	26	18/38	8/20	
• Anticoagulation	7	4/38	3/20	
• Platelet inhibitors	25	16/38	9/20	
Clinical signs of active bleeding, n (hematochezia, melena)	57/58	35/38	16/20	0.033*
Location of active bleeding, n	58/58			0.435
• Cecum		12/38	6/20	
• Ascending colon		9/38	2/20	
• Transverse colon		5/38	2/20	
• Descending colon		3/38	6/20	
• Sigmoid colon		8/38	4/20	
• Rectum		1/38	0/20	
Density of bleeding on CTA, Hounsfield units [IQR]	57/58	212 [153; 252]	232 [159; 287]	0.231
Delay between CTA and treatment, min [IQR]	56/58	142 [81; 278]	694 [138; 1013]	0.027*
Red blood cell transfusion (during intervention), n	58/58	22/38	7/20	0.056
Shock index before treatment [IQR]	38/58	0.68 [0.51; 0.88]	0.69 [0.56; 0.88]	0.749
Shock index after treatment [IQR]	39/58	0.63 [0.51; 0.73]	0.63 [0.55; 0.78]	0.87
Hemoglobin level before treatment, g/dL [IQR]	57/58	83 [76; 95]	88 [74; 97]	0.36
Hemoglobin level after treatment, g/dL [IQR]	55/58	93 [85; 101]	96 [85; 103]	0.341
Systolic blood pressure before treatment, mmHg [IQR]	39/58	120 [100; 134]	130 [111; 151]	0.153
Systolic blood pressure after treatment, mmHg [IQR]	40/58	119 [103; 142]	125 [111; 159]	0.626
Heart rate before treatment, bpm [IQR]	38/58	80 [65; 98]	90 [85; 115]	0.337
Heart rate after treatment, bpm [IQR]	39/58	78 [70; 85]	80 [75; 95]	0.364
Base excess (mmol/L) before treatment, mmol/L [IQR]	38/58	-2.5 [-5.2; -1]	-4.9 [-7.8; -2]	0.321
Base excess after treatment, mmol/L [IQR]	38/58	-2 [-3.6; -0.6]	-4.2 [-6.8; -1.9]	0.129
Lactate before treatment, mmol/L [IQR]	37/58	1.6 [0.9; 2]	1.9 [1.1; 3.2]	0.548
Lactate after treatment, mmol/L [IQR]	38/58	1 [0.8; 1.6]	2.4 [0.9; 3.5]	0.168

SD = standard deviation, CTA = CT angiography, IQR = interquartile range [25% ; 75% percentiles].

Unfortunately, clinical, hemodynamic, and laboratory parameters were not always available for each included case.

with IR.

4. Discussion

In our study, we compared patients with active LGIB that was detected by angio-CT and treated with either IR or surgery. To our knowledge, we are the first working group to investigate this clinical setting (i.e. the further management of these actively bleeding patients). According to our results, no hemodynamic parameter assessed before the intervention enabled us to distinguish the two groups. Only the patient age and the presence of clinical signs (hematochezia and melena) differed significantly. The cases managed with IR were older ($p = 0.014$) than those that underwent surgery. This probably reflects a selection bias, because emergency surgery for LGIB is associated with significant morbidity and mortality, especially in elderly patients [20]. Among the 26 surgically treated cases, nearly one-fifth ($n = 5$) had post-operative complications, of whom four were severe according to Dindo-Clavien. Moreover, the higher post-intervention lactate ($p = 0.042$) and base excess ($p = 0.039$) levels in the surgical group suggest that surgical patients suffer from greater stress than those treated minimally invasively with IR. Surgery might therefore be reserved for patients who do not respond to initial TAE [4,13,18,21]. According to Raphaeli et al. [4], and Koehler et al. [18], 18–25% of patients with active LGIB will finally require surgery. This rate is higher than the seven cases (11.2%) in this study that were secondarily treated with surgery after initial IR with failed TAE. Köhler et al. [18] stressed the still important role of surgery after failed localization of the bleeding site by initial IR, because IR failure was predictive of recurrent hemorrhage ($p = 0.009$). Furthermore, the authors highly recommended surgery as second-line intervention instead of repeating IR, because complications and haemorrhagic recurrence increased significantly when more than one embolization was performed [18].

Several authors advocate primary colonoscopy for locating and treating active LGIB [13,14,18,21]. However, considering the technical difficulty of performing emergency colonoscopy without prior bowel cleansing, this examination remains very operator-dependent, especially in severely bleeding patients. Thus, it requires experienced gastroenterologists who may not always be available in an emergency situation. Other authors recommend therapeutic colonoscopy as a primary intervention immediately after CTA [6,22,23]. According to Nakatsu et al., the rate of detecting the bleeding source on colonoscopy is significantly higher in patients with extravasation on contrast-enhanced CT than in those without extravasation on CT [6]. However, emergency colonoscopic haemostasis can only be applied in a minority of patients, with one large retrospective study reporting therapeutic interventions in < 5% of patients [7]. At our hospital, diagnostic or therapeutic emergency colonoscopy are very rarely performed in patients with active LGIB because our standard of care is CTA followed by either IR or surgery. With the recent scanners, we took advantage of the benefits inherent in “low kV imaging” (i. e. arterial phase acquisition at 100 kV, when the patient’s BMI was $\leq 25 \text{ kg/m}^2$) and, thus, could increase the sensibility of our CTA examinations to detect active bleedings.

After reviewing 200 original and review articles published between 1966 and 2004 that focused on the management of LGIB, Farrell et al. highlighted the paucity of high-quality evidence to guide the LGIB management [16]. Accordingly, each author tended to recommend the approach towards his own discipline. Hence, the choice of the treatment method was mainly based on the locally available resources, the experience of the physicians and the preferences of the individual hospital [16]. This may explain why in our study population with active LGIB therapeutic colonoscopy was only rarely chosen as the primary treatment method. Indeed, only eight cases were managed endoscopically after active LGIB was visualized on angio-CT. Because we

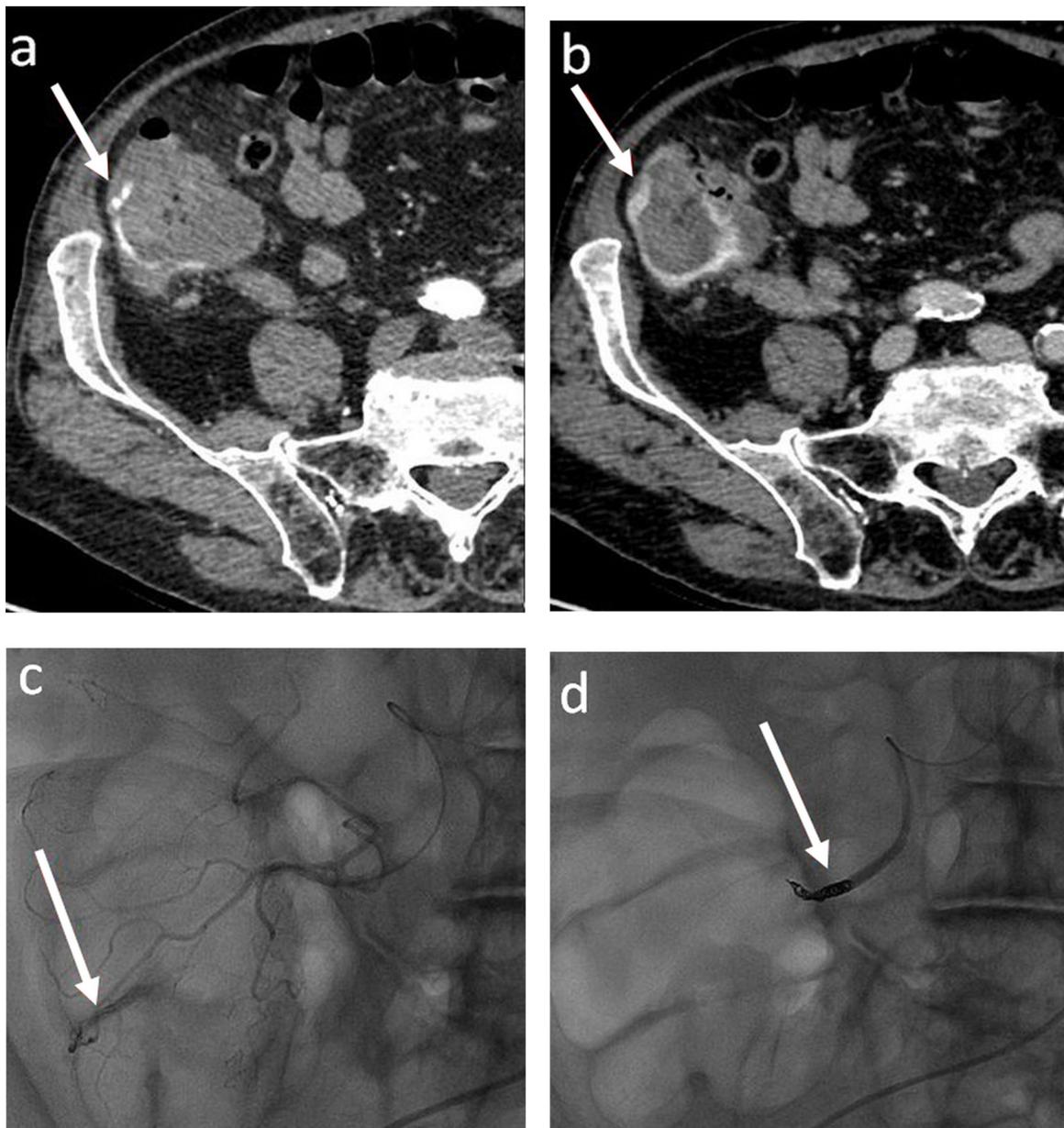


Fig. 2. Sudden onset of hematochezia in an 82-year-old patient known for rheumatoid polyarthritis (treated with non-steroidal anti-inflammatory drugs) and colonic diverticulosis. Intravenously contrast-enhanced axial CTA images clearly show active bleeding (arrows) originating from a caecal diverticulum during the arterial (a) and more so during the venous phase (b). The bleeding was immediately treated with selective catheterization and coil embolization (arrows) of the ileocecal artery (c,d). The interventional treatment was successful; no recurrence or complication of bleeding was observed.

considered this number too low for reliable statistical tests, we excluded them from the analysis.

Transarterial embolization (TAE) in the setting of active LGIB has been demonstrated to be safe and successful, especially when using superselective catheterization [4,8,11,13,18,20,24,25]. The latter approach was used in nearly one-half of our 62 cases ($n = 29$, 46.8%); nearly all the others ($n = 26$, 41.9%) were treated with selective catheterization. In the literature, the technical success (angiographic cessation of bleeding) ranges from 85 to 100% [8,11,13,14,18,24–26], which was confirmed by our study with 100%. Our clinical success rate (cessation of bleeding for 30 days) was 73%, and therefore was also in agreement with the literature describing rates of 63–91% [8,13,18,20,24–29]. The best treatment response to TAE is observed in patients with diverticular bleeding; bleeding due to other causes, such as coagulopathies, angiodysplasia, ulcers or malignancy, respond less well to embolization [13,17,29]. Accordingly, all our cases with

actively bleeding diverticula that were treated by TAE ($n = 7$) showed excellent results with neither complications nor haemorrhagic recurrence.

Because LGIB will cease spontaneously in about 75–85% of cases, some authors advocate a “wait and see” policy [13,14,30]. However, this may not be the right approach in severely bleeding patients. By including only cases with active LGIB proven by contrast medium extravasation on angio-CT, we focused on hemodynamically unstable patients. Foley et al have shown that angio-CT is unlikely to demonstrate active LGIB in the absence of hemodynamic instability [15]. Nevertheless, in 45% of our cases managed with IR, no contrast medium extravasation was observed on the angiographic images and 12 of 21 cases without TAE resolved spontaneously. A partial explanation may be that these patients had received a pro-coagulant treatment between CTA and IR with consecutive improvement of their bleeding disorder, if any.

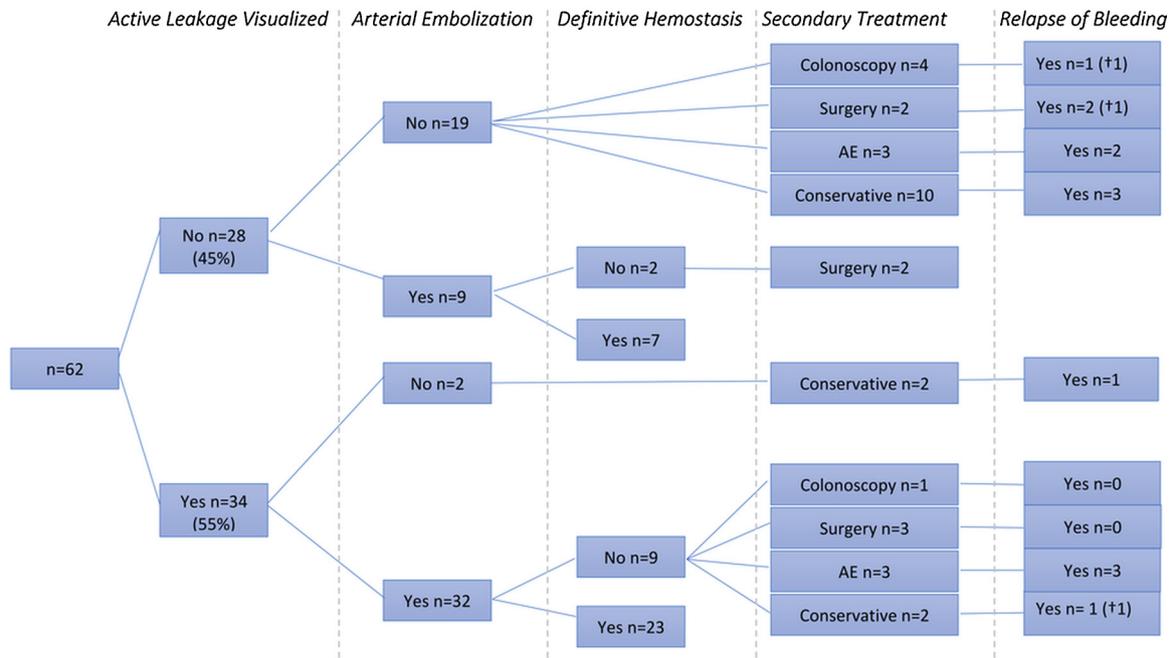


Fig. 3. Further management of the 62 cases with active LGIB who were initially managed with interventional radiology followed by possible angioembolization (AE). † = deceased patient.

In two of our cases, the bleeding stopped during angiography. In the first case, this was caused by arterial spasms which developed after several attempts to catheterize the very small and tortuous bleeding artery. In the second case, general vasoconstriction due to extreme hypovolemia most probably occurred during the intervention. In contrast, 11/41 cases (26%) treated with IR had a relapse of bleeding followed by a second IR (n = 3), surgery (n = 5), colonoscopy (n = 1) or conservative treatment (n = 2). This confirms the intermittent nature of gastrointestinal bleeding, the possibility of reducing the intravascular pressure through the catheter angiography and the need for a second intervention in the case of recurrence [15].

The median delay between the CTA and the IR treatment was

significantly shorter when the LGIB originated from the colon (p = 0.027) and tended to be shorter for any location of active LGIB (p = 0.061). This suggests that access to IR may be easier and faster than access to surgery despite the steady presence of surgeons at our hospital compared with the interventional radiologists.

The limitations of this study are mainly related to its retrospective study design. Additionally, because it was a single-centre study, the number of included patients was limited. Thus, prospective and, if possible, multi-centre studies based on a large population are necessary to further elucidate the best initial management in patients with active LGIB.

In conclusion, our study pointed out that patients with active LGIB

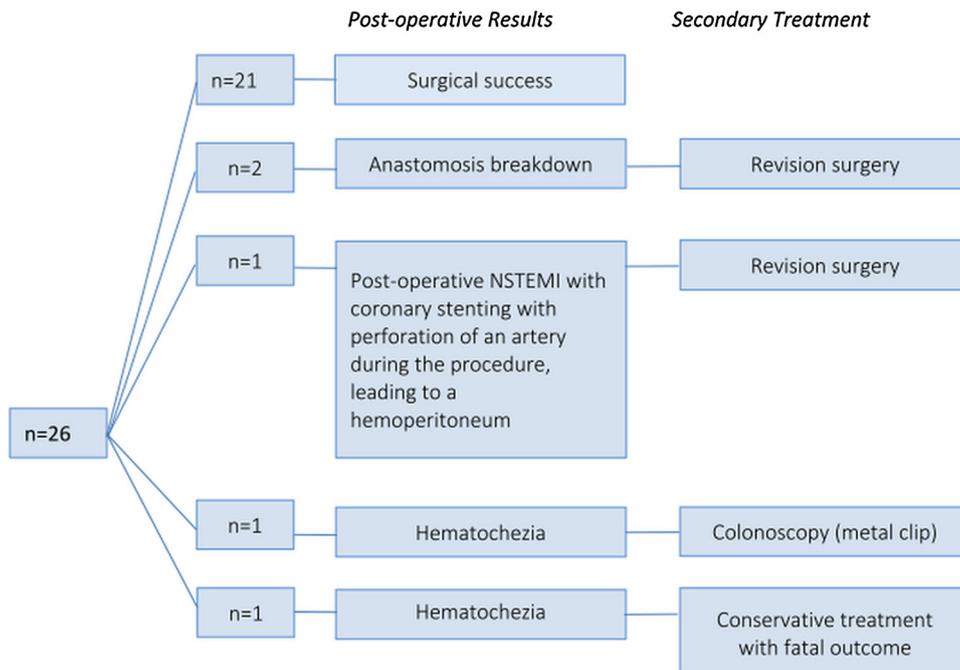


Fig. 4. Further management of the 26 cases with active LGIB who were initially treated with surgery.

selected for IR were significantly older than those treated by surgery. Furthermore, in the presence of hematochezia or melena, IR was the first treatment modality. None of the baseline hemodynamic parameters differed significantly between the cases treated with IR or surgery. IR should be considered the first-line treatment, because it is safe and less invasive than surgery. Surgical interventions should be considered as a second step, especially in cases with unsuccessful embolization and in patients with recurrent bleeding.

Declaration of Competing Interest

The authors declare that they have no potential conflicts of interest regarding this study.

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