Eur J Vasc Endovasc Surg (2011) 42, 676–683

Embolisation for Vascular Injuries Complicating Elective Orthopaedic Surgery

A.F. Mavrogenis [a], G. Rossi [b], E. Rimondi [c], P. Ruggieri [a,*], M. Mercuri [a,d]

[a] Department of Orthopaedics, Orthopaedic Oncology Service, Istituto Ortopedico Rizzoli, University of Bologna, Via Di Barbiano 1/10, 40136 Bologna, Italy
[b] Department of Interventional Angiographic Radiology, Istituto Ortopedico Rizzoli, Bologna, Italy
[c] Department of Radiology, Istituto Ortopedico Rizzoli, Bologna, Italy

Submitted 28 February 2011; accepted 4 April 2011
Available online 8 May 2011

KEYWORDS
Vascular injuries;
Orthopaedic surgery;
Angiography;
Embolisation

Abstract *Objectives:* The study aims to present the indications and emphasise the role of embolisation for vascular injuries in orthopaedic surgery.
Methods: Thirty-one patients with vascular injuries complicating elective orthopaedic surgery had embolisation from 2003 to 2010. *N*-2-butyl cyano-acrylate (NBCA) was used as embolic agent in 28 patients, gelatin sponge in three and coil embolisation in addition to NBCA or gelatin sponge in two patients. The mean follow-up period was 37 months (range, 4–96 months).
Results: The most common orthopaedic operations associated with vascular injuries amenable to embolisation were hip-joint procedures; and the most common injuries were arterial tears of branch vessels or non-critical axial vessels, most commonly of the superior glutaeal artery. In all cases, angiography showed the bleeding point, and a single embolisation session effectively stopped bleeding. Embolisation-related complications were not observed.
Conclusions: Embolisation should be considered the treatment of choice for vascular injuries of branch vessels or non-critical axial vessels following elective orthopaedic surgery because of the advantages of minimally invasive therapy and the lack of complications.

The incidence of vascular complications in orthopaedic surgery is 0.005–0.5%.[1–3] They most commonly occur in the knee followed by hip arthroplasty, spinal surgery, knee arthroscopy and fixation of long-bone fractures,[1,2,4–10] and most commonly involve the poplitaeal, followed by the tibial, superficial femoral, iliac, common and profunda femoris arteries.[2] Vascular injuries usually include lacerations, pseudoaneurysms, thrombosis and arteriovenous fistulae secondary to inappropriately placed retractors or direct vascular injury, extreme joint positioning, previous or revision surgery, malpositioned implants and fixation devices, dislocations, prosthetic loosening and periarticular ossification.[2–4,11–16]

Traditional management of vascular iatrogenic injuries includes vascular surgical intervention.[1,2,17,18] However, open vascular surgery necessitates the availability of

* Corresponding author.
E-mail address: pietro.ruggieri@ior.it (P. Ruggieri).
[d] In memory of Professor Mario Mercuri who died from complications of cancer on the 7th may 2011, after treating cancer patients for many years.

1078-5884/$36
doi:10.1016/j.ejvs.2011.04.009

a vascular surgical team and a re-operation using the same or associated approaches;[19–21] re-operation may be difficult, it may fail because the source of bleeding is not always apparent,[1,16,18,19] and there is an increased risk of infection.[1,16,18,19] In this setting, previous studies reported on effective treatment of vascular injuries after orthopaedic procedures using endovascular treatments, such as cover stenting and embolisation.[3,8,11,12,18–27] Endovascular treatments are less invasive and morbid than open procedures, avoid the zone of soft-tissue injury, use local instead of general anaesthesia and allow for faster recovery.[3,8,11,12,18–29] Although several studies have already focussed on selective and superselective embolisation for the management of vascular injuries complicating orthopaedic surgery, the current literature on this method is predominantly composed of technical notes or reports and series reporting on combined embolisation and open vascular or endovascular treatments;[3,18–21,23–27] hence, the outcome of embolisation therapy is mainly documented from single cases. Moreover, although angiography and embolisation are now commonly performed by vascular surgeons and interventional radiologists, the awareness level of this kind of treatment among orthopaedic surgeons seems low. We previously reported the application of embolisation for the management of primary and metastatic bone tumours.[30–32] Herein, we present the largest series with embolisation for vascular injuries complicating elective orthopaedic surgical operations, with the rationale to provide the indications of embolisation, and to emphasise the role of embolisation for these injuries.

Materials and Methods

We retrospectively studied the files of 31 patients with vascular injuries complicating elective orthopaedic surgery treated with diagnostic angiography and embolisation from 2003 to 2010. There were 21 men and 10 women with a mean age of 48 years (range, 18–88 years). No patient had coagulopathy or anticoagulation therapy before the operation; all had anticoagulation for deep venous thromboprophylaxis begun the day after the operation that was discontinued when the vascular complication was diagnosed. The mean follow-up period was 37 months (range, 4–96 months); all patients were included in the postoperative evaluation performed by their treating orthopaedic surgeons (Table 1).

At the same time period of this study, other vascular complications also occurred in our institution during orthopaedic surgery; however, we are not aware of the exact number and type of these complications because acute haemorrhagic complications are often recognised and treated in the acute clinical situation by the orthopaedic surgeons themselves. In 10 cases, a vascular surgical consultation was requested intra-operatively; these patients had injuries of major and critical axial vessels. Nine of these were successfully treated by vascular surgeons using open vascular surgery; one patient with a perforated and ripped superficial femoral artery at the site of surgical infection following wide resection of a proximal thigh soft-tissue sarcoma was treated with hip disarticulation by orthopaedic surgeons.

The indications for angiography (Table 2) and technique of embolisation were the same in all patients during the period of this study. The indications for embolisation were vascular injuries of small branch and non-critical axial vessels. In all patients, diagnostic digital subtraction angiography and embolisation were performed in the sub-acute clinical situation, at a mean of 2 days (range, 1–4 days) postoperatively. Angiography and embolisation were performed under local anaesthesia using the Seldinger technique through the contralateral femoral artery. In patients with spinal and pelvic vascular injuries, aortography was performed using a 4-French Pigtail catheter; in patients with vascular injuries at the extremities, aortography was not performed. In 28 patients, the embolic agent used was the *N*-2-butyl cyano-acrylate (NBCA) in 33% lipiodol. One flacon (1 ml) of NBCA was mixed with 2 ml of 33% lipiodol. From the mixture, 1 ml was aspirated in an insulin syringe; depending on the type of vascular injury, 0.1–0.2 ml of the aspirate mixture was injected under fluoroscopic control 'sandwiched' with 2 + 2 ml of 5% glucosate solution to prevent polymerisation with blood. Then, angiography was repeated to evaluate occlusion of the vessel. If occlusion was not complete or more bleeding vessels were observed, the procedure was repeated in the same manner. In three patients (patients 2, 10 and 14) gelatin-sponge pledgets 1–2 mm in diameter, suspended in natural saline, were used as embolic agents. In two patients with arteriovenous fistula (patient 10) and pseudoaneurysm (patient 12), coils were used in addition to gelatin sponge or NBCA.

Post-embolisation angiography was performed to confirm cessation of bleeding; then, the catheters were removed and the puncture site was covered with compression dressing. Routine follow-up clinical evaluation of wound bleeding and healing was performed by the treating orthopaedic surgeons. Complications were recorded.

Results

Vascular injuries were most common in hip-joint procedures including total and resurfacing hip arthroplasty (12 patients) (Figs. 1 and 2), corrective hip osteotomy (seven patients) and tumour surgery around the hip (four patients), followed by knee-joint procedures including total knee arthroplasty (three patients) (Fig. 3), knee arthroscopy (two patients) and corrective knee osteotomy (one patient) and tumour surgery around the hip joint (four patients) and the spine (two patients) (Table 1).

In all cases, angiography showed the vascular injury and bleeding point. The most common vascular injuries were arterial tears (22 cases), followed by pseudoaneurysms (nine cases) and arteriovenous fistula (one case). The most common vascular injuries involved small branch vessels or non-critical axial vessels of the superior glutaeal (11 cases) followed by the profunda femoris (six cases), the genicular (six cases), the lateral circumflex femoral (four cases), the iliolumbar (two cases), the inferior glutaeal (one case), the medial circumflex femoral (one case) and the inferior epigastric artery (one case) (Figs. 4–6).

All patients had a single embolisation session that successfully stopped bleeding and recovered haemodynamic stability of the patients; a vascular surgical

Table 1 Details of the patients included in this series.

Pts	Age/sex	Orthopaedic surgery	Arterial injury	Time from surgery	Embolic agent	Complications/ follow-up
1	47, M	THA (R)	Superior glutaeal artery (1 branch)	1 day	NBCA	None/4 months
2	71, F	THA (R)	Superior glutaeal artery (multiple branches) and lateral circumflex femoral artery (1 branch)	2 days	Gelatin sponge	None/3 months
3	32, M	Knee arthroscopy (ACLR, L)	Descending genicular artery (highest genicular artery)	2 days	NBCA	None/9 months
4	18, F	Osteosarcoma, L3-L5 resection	Iliolumbar artery (L)	1 day	NBCA	None/6 months
5	44, M	TKA (L)	Inferior lateral genicular artery	3 days	NBCA	None/16 months
6	44, M	Resurfacing THA (L)	Superior glutaeal artery (pseudoaneurysm)	2 days	NBCA	None/10 months
7	49, M	Resurfacing THA (R)	Superior glutaeal artery (1 branch)	3 days	NBCA	None/4 months
8	62, M	TKA (L)	Superior lateral genicular artery	2 days	NBCA	None/30 months
9	20, M	Soft tissue sarcoma resection (proximal femur, L)	Lateral circumflex femoral artery (pseudoaneurysm)	2 days	NBCA	None/24 months
10	45, M	Resurfacing THA (L)	Superior glutaeal artery and vein (arteriovenous fistula)	1 day	Coils and gelatin sponge	None/12 months
11	39, F	THA (R)	Inferior glutaeal artery (multiple branches)	3 days	NBCA	None/36 months
12	44, M	Corrective osteotomy (hip, R)	Profunda femoral artery (pseudoaneurysm)	4 days	Coils and NBCA	None/48 months
13	19, M	Corrective osteotomy (hip, L)	Profunda femoral artery (multiple branches)	3 days	NBCA	None/84 months
14	53, M	Soft tissue sarcoma resection (hip, L)	Superior glutaeal artery (1 branch)	2 days	Gelatin sponge	None/84 months
15	67, M	TKA (L)	Inferior lateral genicular artery	2 days	NBCA	None/72 months
16	55, M	Resurfacing THA (L)	Superior glutaeal artery (multiple branches)	2 days	NBCA	None/60 months
17	80, F	THA (R)	First perforator of profunda femoral artery (pseudoaneurysm)	2 days	NBCA	None/60 months
18	20, M	Knee arthroscopy (ACLR, L)	Inferior lateral genicular artery	2 days	NBCA	None/60 months
19	27, M	Corrective osteotomy (hip, R)	Profunda femoral artery (multiple branches)	2 days	NBCA	None/72 months
20	40, M	Resurfacing THA (R)	Medial circumflex femoral artery (pseudoaneurysm)	3 days	NBCA	None/96 months
21	19, M	Corrective osteotomy (hip, R)	Lateral circumflex femoral artery	2 days	NBCA	None/48 months
22	53, F	Corrective osteotomy (hip, R)	Profunda femoral artery (pseudoaneurysm)	2 days	NBCA	None/36 months
23	76, F	THA (L)	Superior glutaeal artery (pseudoaneurysm)	1 day	NBCA	None/36 months
24	88, F	Hemiarthroplasty (hip, L)	Superior glutaeal artery (1 branch)	2 days	NBCA	None/36 months
25	37, M	Corrective osteotomy (hip R)	Inferior epigastric artery	2 days	NBCA	None/36 months
26	75, F	THA dislocation (R)	Superior glutaeal artery (multiple branches, pseudoaneurysm)	2 days	NBCA	None/24 months
27	61, M	Corrective osteotomy (knee, R)	Inferior medial genicular artery	2 days	NBCA	None/48 months
28	45, M	Soft tissue sarcoma resection (proximal femur, L)	Lateral circumflex femoral artery	3 days	NBCA	None/24 months
29	43, F	RFA for osteoid osteoma (acetabulum, R)	Superior glutaeal artery (pseudoaneurysm)	2 days	NBCA	None/24 months
30	48, F	Corrective osteotomy (hip, L)	Profunda femoral artery	2 days	NBCA	None/24 months
31	58, M	Chondrosarcoma, L4—L5 resection	Iliolumbar artery (L)	1 day	NBCA	None/18 months

THA: total hip arthroplasty; TKA: total knee arthroplasty; NBCA: *N*-2-butyl-cyano-acrylate; ACLR: anterior cruciate ligament rupture; L: left; R: right.

Table 2 Indications for angiography in this series.

Indications	Patients ($n = 31$)
Excessive bleeding than expected following the orthopaedic operation	
Wound bleeding	31
Haematoma	12
Imaging showing a vascular injury such as extravasation, haematoma, pseudoaneurysm, or arteriovenous fistula	
Colour Doppler ultrasonography	31
Computed tomography	10
Acute decrease in haemoglobin (more than 3 g/dL) or haematocrit values (more than 9%)	28
Hypotension, tachycardia and haemodynamic instability	8

intervention was not necessary in any patient after embolisation of these types of vascular injuries. Complications related to the embolisation procedure or the embolic agent and the vascular injury, such as recurrence of bleeding or infection, were not observed. Twelve patients developed a wound haematoma; after the embolisation, two patients (patients 16 and 28) required surgical evacuation of the haematoma by their treating orthopaedic surgeons; in the remaining patients, the haematomas were treated successfully with sterile wound-dressing changes and cold-packing application. None of the patients with haematoma developed infection until the period of this study.

Discussion

Previous small series and case reports have shown that angiography and embolisation have a diagnostic and therapeutic role in the management of iatrogenic vascular complications.[3,8,9,11,16,18–21,23–27,33–36] In this study, we reported our experience with embolisation for vascular injuries complicating elective orthopaedic surgery aiming to provide the indications for embolisation, confirm the role of embolisation for vascular complications in the sub-acute clinical situation and increase the level of awareness for this kind of treatment among orthopaedic surgeons. Our results showed that embolisation was successful for tears, pseudoaneurysms and arteriovenous fistula of small branches and non-critical axial vessels without any complications, and support the role of embolisation as the first option in the treatment of these types of vascular injuries in the sub-acute clinical situation.

We acknowledge three limitations in this study. First, the sample size is small; this should be attributed to the rarity of these complications. However, although with a small number of patients, to the best of our knowledge, the present series is the largest reported in the literature regarding embolisation for vascular complications. Second, the design of the study is retrospective. However, as prospective randomised trials are difficult, especially in life-threatening situations in patients with complicated surgical operations, well-designed retrospective studies are useful to draw conclusions regarding the effect of a treatment. Third, although we did not perform an analysis to compare the cost related to the embolisation and open vascular surgery, we believe that as anaesthesia and the operative suite are not necessary and specific post-embolisation rehabilitation is not required, embolisation does not result in a financial loss for the hospital compared with a re-operation, and can be applicable in a cost-restricted health-care system.

Total knee arthroplasty has been associated with arterial complications twice as commonly as total hip arthroplasty (0.17% vs. 0.08%).[1] In areas of multiple branches or bifurcations, such as the upper tibia, the risk of vascular injury is increased.[1] The risk after revision-knee arthroplasty is

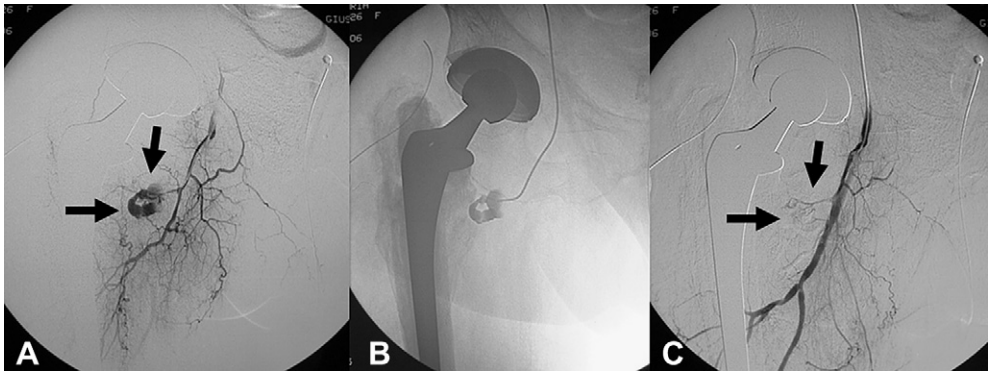

Figure 1 A–C. An 80-year-old woman with swelling and wound bleeding after right total hip arthroplasty (Patient 17). (A) Angiography at 2 days after the operation shows contrast leakage and a pseudoaneurysm of the first perforator of the profunda femoris artery (*arrows*). (B) Selective catheterization of the profunda femoris artery. (C) Completion angiography after NBCA embolisation shows occlusion of the bleeding vessel (*arrows*).

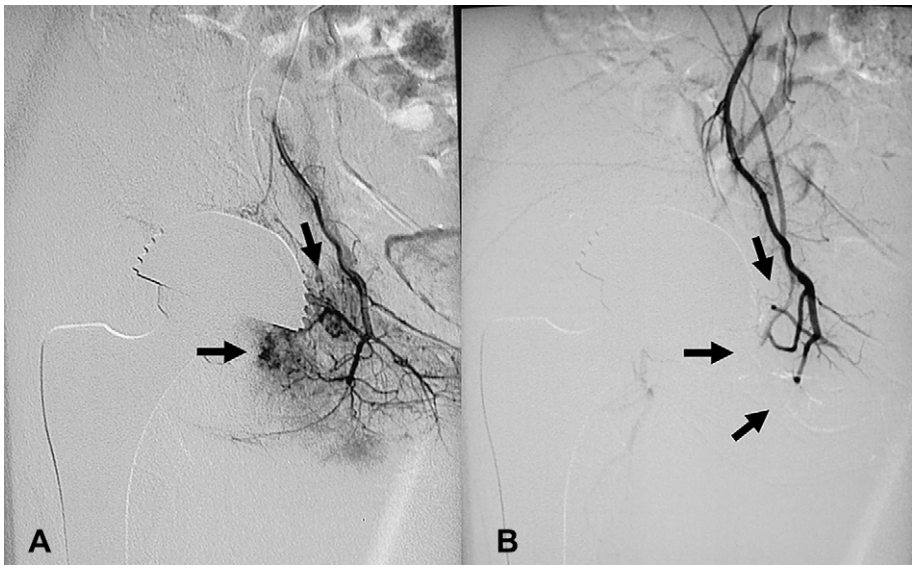

Figure 2 AB. A 39-year-old woman with swelling and wound bleeding after right total hip arthroplasty (Patient 11). (A) Selective angiography and catheterization of the inferior glutaeal artery at 2 days after the operation shows contrast leakage (*arrows*). (B) Completion angiography after NBCA embolisation shows occlusion of the bleeding vessels (*arrows*).

twice as high because of encasement of the poplitaeal vessels by dense scar tissue in the poplitaeal fossa.[2] The incidence of vascular injuries in spinal surgery has been <0.05%,[6,7,9] most commonly associated with L4–L5 lumbar discectomy.[6,9,37] In the present series, vascular injuries were more common in hip compared with knee arthroplasty. The most common injured vessel was the superior glutaeal artery, followed by the profunda femoris artery; in contrast to the literature,[8,10] iatrogenic vascular injuries of the genicular arteries were not rare.

Colour Doppler ultrasonography and computed tomography (CT) scan, as in the present series, is usually the initial imaging method to evaluate vascular injuries.[9,18–20,22,28,34–36,38] The presence of a large haematoma is an indication to proceed with angiography. Angiography provides for superior image quality and detection of active bleeding even from small blood vessels,[1,3,9,18–20,28,35,36] and can be combined with endovascular procedures once bleeding is diagnosed.[9] Magnetic resonance angiography is usually not applicable in joint replacement operations because of the artefacts caused by the prostheses. Indications for embolisation are significant blood loss, coagulation defects, failure of surgical attempts by experienced personnel to control bleeding, recurrent bleeding, and bleeding sources at small branch vessels or non-critical axial vessels that are not immediately obvious and are amenable to embolisation.[2,3,11,16] In this series, after initial imaging evaluation with Doppler ultrasonography and CT scan, we performed diagnostic angiography that showed injuries of small branch vessels and non-critical axial vessels. These injuries were treated successfully with embolisation in all patients. Even if the majority

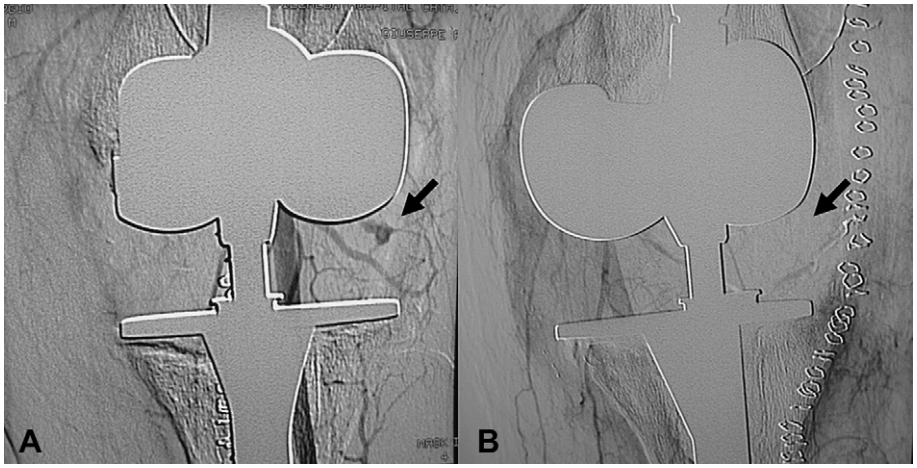

Figure 3 AB. A 67-year-old man with acute postoperative hemarthrosis and wound bleeding after left total knee arthroplasty (Patient 15). (A) Selective angiography and catheterization of the inferior lateral genicular artery at 2 days after the operation shows contrast leakage (*arrow*). (B) Completion angiography after NBCA embolisation shows occlusion of the bleeding vessel (*arrow*).

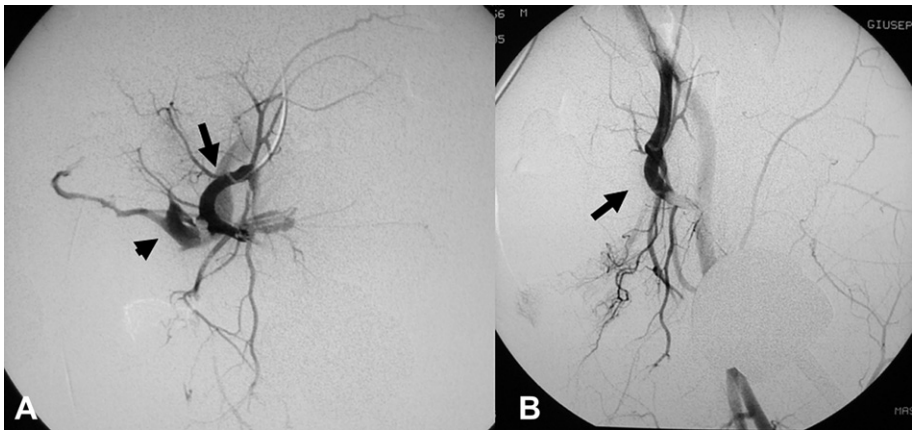

Figure 4 AB. A 45-year-old man with swelling and wound bleeding after left total hip resurfacing arthroplasty (Patient 10). (A) Selective angiography and catheterization of the superior glutaeal artery at one day after the operation shows an arteriovenous fistula between the superior artery (*arrow*) and vein (*arrowhead*). (B) Completion angiography after coils and gelatin-sponge embolisation shows occlusion of the fistula (*arrow*).

of small traumatic arteriovenous fistulae and pseudoaneurysms of branch arteries have been shown to thrombose over time, excessive, angiographically proven bleeding, haematoma formation and deterioration of haemodynamic status in the acute postoperative period in our patients necessitated other type of treatment than only observation. If angiography has shown complete tears, injuries of major branches and critical vessels, severely ripped, perforated, heated or occluded by plaque and thrombus vessels, embolisation would not have been performed, but rather vascular surgery would have been necessary to control haemorrhagic shock or acute ischaemia of the limb.

Considerations for choosing an embolic agent are speed and reliability of delivery, duration of occlusion and preservation of normal tissue.[8,20,28,35,36] Coils are highly radiopaque, and ideal for single and large vessel occlusion.[18–20,25] Coils can be deployed as a strut and combined with gelatin sponge or particles as occlusion agents.[28] The use of gelatin sponge alone has the disadvantage of temporary embolic effect; thus, recurrent bleeding may occur.[16,19,27] For multiple lesions and distal location, particles can be used. However, particles are not radiopaque and penetrate deeper into the vascular system due to lower viscosity, thereby increasing the risk of ischaemic complications.[27,28] NBCA, 'liquid glue' is a liquid embolic agent that spreads according to its polymerisation time and vascular flow. NBCA does not permeate all the way to the capillary level, and therefore does not cause tissue death. Another advantage of NBCA in lipiodol is its dense radiopacity. In addition, NBCA can be used in patients with clotting pathologies.[9,11] In our practice and the present study, NBCA was the preferred embolic agent because we consider it the most appropriate for controlled embolisation and permanent, complete occlusion of the bleeding vessels. If administered in low doses, sandwiched with glucosate under fluoroscopic control, post-embolisation complications are rare; if more volume of NBCA is administered at a time, it may reflux and occlude normal vessels. In three patients in this series (patients 2, 10 and 14) with injuries involving multiple small branches of the superior

Figure 5 AB. A 40-year-old man with swelling and wound bleeding after right total hip resurfacing arthroplasty (Patient 20). (A) Selective angiography at one day after the operation shows contrast leakage and a pseudoaneurysm of the medial circumflex femoral artery (*arrow*). (B) Completion angiography after NBCA embolisation shows occlusion of the bleeding vessel and the pseudoaneurysm (*arrow*).

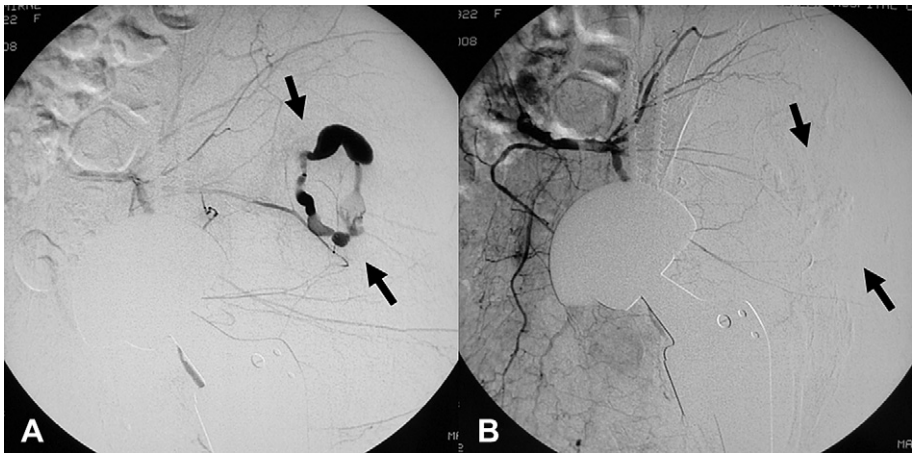

Figure 6 AB. A 76-year-old woman with swelling and wound bleeding after left total hip arthroplasty (Patient 23). (A) Selective angiography at one day after the operation shows contrast leakage and a pseudoaneurysm of the superior glutaeal artery (*arrows*). (B) Completion angiography after NBCA embolisation shows occlusion of the bleeding vessel and the pseudoaneurysm (*arrows*).

glutaeal and the lateral circumflex femoral artery, and an arteriovenous fistula, gelatin sponge was used as embolic agent to avoid possible ischaemic complications from embolisation of healthy tissue with NBCA. In one patient (patient 10), coil and gelatin-sponge embolisation was performed, using the coil as strut to occlude the fistula and the gelatin sponge as embolic agent to avoid pulmonary embolism with NBCA. In another patient (patient 12), coil embolisation was performed to control blood flow and protect collateral vessels before administration of NBCA.

Complications of embolisation are rare. These include the post-embolisation syndrome,[30–32] infection, haematoma at the puncture site and tissue necrosis from non-target embolisation of adjacent or distant vessels.[21,26–28,33] Death, pulmonary embolism, migration and backwash of coils have also been reported.[3] The post-embolisation syndrome with symptoms, such as fever, pain due to tissue necrosis and malaise, has been reported in 18–86% of cases.[30–32] Embolisation of non-targeted vessels can result in a large zone of tissue necrosis and may be associated with nerve palsy and long-term functional deficits, skin breakdown, muscle necrosis, infection or limb loss.[18–20,24,25] Care should be taken regarding the location and vascular supply of at-risk vital structures, such as the femoral region, to avoid embolising supply to the sciatic nerve.[30–32] The Adamkiewicz artery that originates between the T5 and L2 vertebrae should be recognised on the pre-embolisation angiography. In our practice, we have encountered the Adamkiewicz artery in the embolisation field during five embolisations for tumours of the spine; in these cases, the embolisation procedure was abandoned. In the present study, complications related to the embolisation procedure or the embolic agents and the vascular injury, such as recurrence of bleeding from the embolised site or infection, did not occur. This should be attributed to the experience of the interventional radiologists, and the use of the appropriate technique, microcatheters and embolic agents.

In conclusion, embolisation for vascular injuries of branch vessels or non-critical axial vessels complicating elective orthopaedic surgery is a highly effective, successful and safe interventional technique in the acute postoperative period. It should be considered as the first option in the treatment of these injuries because of the advantages of minimally invasive therapy and the lack of complications.

Funding

None.

Conflict of Interest

None.

Institutional Review Board/Ethics Committee

This study was approved by the Institutional Review Board/Ethics Committee of the authors' institution.

References

1 Calligaro KD, Dougherty MJ, Ryan S, Booth RE. Acute arterial complications associated with total hip and knee arthroplasty. *J Vasc Surg* 2003;**38**(6):1170–7.
2 Wilson JS, Miranda A, Johnson B, Shames M. Vascular injuries associated with elective orthopedic procedures. *Ann Vasc Surg* 2003;**17**:641–4.
3 Kickuth R, Anderson S, Kocovic L, Ludwig K, Siebenrock K, Triller J. Endovascular treatment of arterial injury as an uncommon complication after orthopedic surgery. *J Vasc Interv Radiol* 2006;**17**(5):791–9.
4 Thaler M, Mayr E, Liebensteiner M, Bach CM. Injury of the right and left inferior epigastric artery during the implantation of a stand-alone ALIF cage through a left retroperitoneal approach: a case report. *Arch Orthop Trauma Surg*; 2009 [Epub ahead of print].
5 Small NC. Complications in arthroscopic surgery of the knee and shoulder. *Orthopedics* 1993;**16**:985–8.
6 Papadoulas S, Konstantinou D, Kourea HP, Kritikos N, Haftouras N, Tsolakis JA. Vascular injury complicating lumbar disc surgery. A systemic review. *Eur J Vasc Endovasc Surg* 2002; **24**:189–95.

7 Mendez JC, Gonzalez F. Endovascular treatment of a vertebral artery pseudoaneurysm. *Cardiovasc Intervent Radiol* 2005;**28**(1): 107—9.
8 Puig J, Perendreu J, Fortuño JR, Branera J, Falcó J. Transarterial embolization of an inferior genicular artery pseudoaneurysm with arteriovenous fistula after arthroscopy. *Korean J Radiol* 2007;**8**(2):173—5.
9 Kim HS, Chong HS, Nanda A, Park JO, Moon SH, Lee HM, et al. Vascular injury in thoracolumbar spinal surgeries and role of angiography in early diagnosis and management. *J Spinal Disord Tech* 2010;**23**(6):418—24.
10 Mullen DJ, Jabaji GJ. Popliteal pseudoaneurysm and arteriovenous fistula after arthroscopic meniscectomy. *Arthroscopy* 2001;**17**(1):E1.
11 Chun HJ, Osuga K, Sugihara E, Tsukaguchi I, Ohsawa S, Tsuda K. Transarterial embolization of large complex arteriovenous fistula associated with hip joint surgery. *Jpn J Radiol* 2010; **28**(6):489—92.
12 Hans SS, Shepard AD, Reddy P, Rama K, Romano W. Iatrogenic arterial injuries of spine and orthopedic operations. *J Vasc Surg* 2011;**53**(2):407—13.
13 Lopera JE, Restrepo CS, Gonzales A, Trimmer CK, Arko F. Aortoiliac vascular injuries after misplacement of fixation screws. *J Trauma* 2010;**69**(4):870—5.
14 Hussain WM, Hussain HM, Hussain MS, Manning DW. A late vascular complication due to component migration after revision total hip arthroplasty. *J Arthroplasty*; 2010 [Epub ahead of print].
15 Wera GD, Ting NT, Della Valle CJ, Sporer SM. External iliac artery injury complicating prosthetic hip resection for infection. *J Arthroplasty* 2010;**25**(4):660.e1—4.
16 Thomas CD, Asumu T, Chalmers N, Hirst P. Therapeutic embolization for sustained hemorrhage following total hip replacement in a patient with hemophilia A. *Orthopedics* 2000;**23**:849—50.
17 Calligaro KD, DeLaurentis DA, Booth RE, Rothman RH, Savarese RP, Dougherty MJ. Acute arterial thrombosis associated with total knee arthroplasty. *J Vasc Surg* 1994;**20**:927—32.
18 Carlin RE, Papenhausen M, Farber MA, Ronningen E, Mauro MA, Marston WA, et al. Sural artery pseudoaneurysms after knee arthroscopy: treatment with transcatheter embolization. *J Vasc Surg* 2001;**33**:170—3.
19 Lum DJ, Poon PC. Embolization as a treatment for bleeding post-total hip arthroplasty. *Aust N Z J Surg* 2000;**70**:469—70.
20 Katsimihas M, Robinson D, Thornton M, Langkamer VG. Therapeutic embolization of the genicular arteries for recurrent hemarthrosis after total knee arthroplasty. *J Arthroplasty* 2001; **16**(7):935—7.
21 Plagnol P, Diard N, Bruneteau P, Roncheau V. Pseudoaneurysm of popliteal artery complicating a total knee replacement: a successful percutaneous endovascular treatment. *Eur J Vasc Endovasc Surg* 2001;**21**:81—3.
22 Neo M, Matsushita M, Morita T, Nakamura T. Pseudoaneurysm of the deep circumflex iliac artery: a rare complication at an anterior iliac bone graft donor site. *Spine (Phila Pa 1976)* 2000; **25**(14):1848—51.
23 Noorpuri BSW, Maxwell-Armstrong CA, Lamerton AJ. Pseudoaneurysm of a geniculate collateral artery complicating total knee replacement. *Eur J Vasc Endovasc Surg* 1999;**18**:534—5.
24 Nozawa M, Irimoto M, Maezawa K, Shitoto K, Kurosawa H. False aneurysm of the profunda femoris artery after total hip arthroplasty. *J Arthroplasty* 2000;**15**:671—4.
25 Barriga A, Valenti Nin JR, Delgado C, Bilbao JJ. Therapeutic embolisation for postoperative hemorrhage after total arthroplasty of the hip and knee. *J Bone Jt Surg Br* 2001;**83**: 90—2.
26 Vaidhyanath R, Blanshard KS. Insertion of a covered stent for treatment of a popliteal artery pseudoaneurysm following total knee arthroplasty. *Br J Radiol* 2003;**76**:195—8.
27 Ulmar B, Aschoff AJ, Orend KH, Puhl W, Huch K. Minimally invasive intervention for acute bleeding from a pseudoaneurysm after revision hip arthroplasty. *Acta Orthop Belg* 2004;**70**: 361—4.
28 Dhondt E, Vanhoenacker FM, D'Archambeau O, Snoeckx A, Defreyne L. Angiographic findings and therapeutic embolization of late hemarthrosis after total joint arthroplasty. *Skeletal Radiol* 2009;**38**(1):31—6.
29 Minor ME, Morrissey NJ, Peress R, Carroccio A, Ellozy S, Agarwal G, et al. Endovascular treatment of an iatrogenic thoracic aortic injury after spinal instrumentation: case report. *J Vasc Surg* 2004;**39**:893—6.
30 Rossi G, Rimondi E, Bartalena T, Gerardi A, Alberghini M, Staals EL, et al. Selective arterial embolization of 36 aneurysmal bone cysts of the skeleton with N-2-butyl cyanoacrylate. *Skeletal Radiol* 2010;**39**(2):161—7.
31 Rossi G, Mavrogenis AF, Rimondi E, Ciccarese F, Tranfaglia C, Angelelli B, et al. Selective arterial embolization for bone tumors. Experience of 454 cases. *Radiol Med*; 2011. Mar 19 [Epub ahead of print].
32 Rossi G, Mavrogenis AF, Rimondi E, Braccaioli L, Calabrò T, Ruggieri P. Selective embolization with NBCA for metastatic bone disease. *J Vasc Int Radiol* 2011;**22**(4):462—70.
33 Velmahos GC, Toutouzas KG, Vassiliu P, Sarkisyan G, Chan LS, Hanks SH, et al. A prospective study on the safety and efficacy of angiographic embolization for pelvic and visceral injuries. *J Trauma* 2002;**53**:303—8.
34 Bingol H, Cingoz F, Yilmaz AT, Yasar M, Tatar H. Vascular complications related to lumbar disc surgery. *J Neurosurg* 2004; **100**:249—53.
35 Schneider JR, Alonzo MJ, Hahn D. Successful endovascular management of an acute iliac venous injury during lumbar discectomy and anterior spinal fusion. *J Vasc Surg* 2006;**44**: 1353—6.
36 Klein GE, Raith J, Passler J, Szolar DH, Sorantin E, Hausegger KA. Spontaneous recurrent hemarthrosis of the knee joint: endovascular treatment of a ruptured aneurysm with platinum microcoils. A case report. *J Bone Jt Surg Am* 1997; **79**(4):594—6.
37 Pham TT, Bouloudian S, Moreau PE, Mofid R, Garcier JM, Boyer L, et al. Recurrent hemarthrosis following total knee arthroplasty. Report of a case treated with arterial embolization. *Jt Bone Spine* 2003;**70**(1):58—60.
38 Masheshwari R, Kelley SP, Langkamer VG, Loveday E. Spontaneous recurrent haemarthrosis following unicompartimental knee arthroplasty and its successful treatment by coil embolisation. *Knee* 2004;**11**(5):413—5.