Ann R Coll Surg Engl 1994; **76**: 307–310

Penetrating injuries of the popliteal artery: the Baragwanath experience

Elias Degiannis MD FRCS
Senior Consultant and Senior Lecturer

George C Velmahos MD
Medical Officer and Lecturer

Marc G C Florizoone MD
Senior Registrar and Lecturer

Richard D Levy MD FCS(SA)
Consultant and Senior Lecturer

John Ross MB ChB
Medical Officer

Roger Saadia MD FRCS
Chief Surgeon and Professor of Surgery

Department of Surgery, Baragwanath Hospital, University of the Witwatersrand, Johannesburg, Republic of South Africa

Key words: Popliteal; Artery; Injury; Management

This study describes the management of 43 patients with penetrating injury of the popliteal artery. Of these patients, 33 (76.5%) had bullet wounds, four patients (9.5%) pellet wounds and 6 (14%) knife wounds. Patients with 'hard' signs of arterial injury underwent exploration without preoperative angiograms. There were no negative explorations. Patients with only 'soft' signs of arterial injury underwent preoperative angiograms. Of this group, 75% had positive angiograms and underwent exploration. There were no false-positive or false-negative preoperative angiograms in the group of patients with 'soft' signs in this study. Definitive orthopaedic management of associated fractures followed vascular reconstruction. There was no difference in the short-term patency of autologous saphenous vein graft as against PTFE grafts. Fasciotomy was performed on patients who had arterial and venous injury or presented late. Overall amputation rate was 14% and for bullet injuries 18%.

The Department of Surgery at Baragwanath Hospital has seen a vast increase in the number of patients presenting with gunshot injuries over the last 3 years. Many of these involved injury to the popliteal artery and, in addition, penetrating popliteal artery injuries caused by stabbing have become more common. The importance of managing these patients rapidly and efficiently in order to maintain distal tissue viability has been reported by our hospital in the past, although at that time, experience was limited.

Correspondence to: Mr E Degiannis MD FRCS, University of the Witwatersrand, Department of Surgery, Medical School, 7 York Road, Parktown, Johannesburg 2193, Republic of South Africa

The purpose of this study was to establish factors which favourably influenced the outcome of penetrating popliteal artery injuries in our hands.

Patients and methods

A retrospective study over a period of 3 years (1990–1992) is presented. In all, 43 patients with penetrating injuries of the popliteal artery were treated during this period at Baragwanath Hospital. All except two were males. The median age was 24 years (range 14–55 years). The mechanism of injury was stabbing in six patients (14%) while of the remaining 37 patients, 33 (76.5%) sustained bullet and 4 (9.5%) pellet injuries.

Response time

The mean time between the injury and arrival at the hospital was 1 h and 5 min. Of the patients, 70% arrived within less than 1 h 30 min. Of the total of nine patients referred from peripheral hospitals, five arrived between 4 and 7 h after the injury.

Initial management

The initial resuscitation and diagnostic work-up were conducted along Advanced Trauma Life Support principles.

Results

Clinical presentation

In all, 43 limbs had penetrating popliteal artery injury. Of 43 patients, seven had trauma to other anatomical regions;

five had bullet injuries of the abdomen, one of the neck and one had a stab wound of the chest. All of these patients were hypotensive on admission and one had an unrecordable blood pressure. Only 8/36 patients (22%) who had an injury localised only in the popliteal fossa, were hypotensive on admission.

The physical findings were classified as 'hard' signs and 'soft' signs, where 'hard' signs were cold ischaemic extremity, absent or decreased pulses, bruit or thrill, expanding or pulsatile haematoma and pulsatile bleeding and 'soft' signs were non-expanding haematoma, paraesthesias or paresis and proximity of wound to neurovascular bundle *(1,2)*.

The physical findings after the initial resuscitation are shown in Table I and Table II. The majority of the patients who sustained bullet trauma presented with 'hard' signs of arterial injury. In this group, 30 patients (91%) had absent or decreased peripheral pulses, 27 patients (82%) presented with a cold ischaemic extremity and 11 patients (33%) with an expanding or pulsatile haematoma, in contrast with the six patients who sustained knife injuries where only 3 (50%) presented with 'hard' physical signs, and in the pellet injury group the only patient who had been shot at extremely close range.

All patients with 'hard' signs were taken to theatre without preoperative arteriography; these consisted of 91% of the bullet injuries, 50% of knife injuries and only 25% of pellet injuries.

Table I. 'Hard' physical signs of arterial injury

	No (%) of patients			
Finding	*Knife (n=6)*	*Bullet (n=33)*	*Pellet (n=4)*	*Total (n=43)*
Cool ischaemic extremity	2 (33)	27 (82)	1 (25)	30 (70)
Absent or decreased pulses	3 (50)	30 (91)	1 (25)	34 (79)
Bruit or thrill	1 (17)	2 (6)	0 (0)	3 (7)
Expanding or pulsatile haematoma	1 (17)	11 (33)	0 (0)	12 (28)
Pulsatile bleeding	1 (17)	5 (15)	0 (0)	6 (14)

Table II. 'Soft' physical signs of arterial injury

	No (%) of patients			
Finding	*Knife (n=6)*	*Bullet (n=33)*	*Pellet (n=4)*	*Total (n=43)*
Non-expanding haematoma	3 (50)	6 (18)	3 (75)	12 (28)
Paraesthesias or paresis	2 (33)	9 (27)	1 (25)	12 (28)
Proximity of wound to neurovascular bundle	6 (100)	17 (52)	4 (100)	27 (64)

All patients who presented with 'soft' physical signs of arterial injury alone underwent angiography. In total, 12 patients, five with bullet, four with knife and three with pellet injuries underwent angiography with three, three and three respectively having positive angiograms (75% overall). There were no false-positive or false-negative angiograms. The mean time which elapsed from requesting to performing the angiograms was 1 h 35 min with a maximum time of 2 h 45 min.

Operative findings and management

The mean time between admission and operation was 1 h 40 min and the mean time between the accident and the operation was 2 h 45 min.

Intimal injury with thrombosis and/or complete or partial transection of the popliteal artery occurred in 83% of patients with knife injury, 82% of patients with bullet and 100% of patients with pellet injury (Table III). Pseudoaneurysm formation or arteriovenous fistulas were seen in one patient with knife and six with bullet injuries.

All patients underwent vascular repair via a medial approach. The types of repair in the different groups are listed in Table IV. Primary end-to-end anastomosis was carried out in all the knife injuries, but in only 7 (21%) of the bullet injuries. Of the bullet injury group, 76% had an interposition graft, 64% (16 patients) of which used saphenous vein and 36% (nine patients) PTFE.

Table III. Operative findings in penetrating popliteal artery injuries

	No (%) of patients			
Finding	*Knife (n=6)*	*Bullet (n=33)*	*Pellet (n=4)*	*Total (n=43)*
Artery thrombosed	1 (17)	6 (18)	1 (25)	8 (18)
Artery transected (partially/completely)	4 (66)	21 (64)	3 (75)	28 (65)
Pseudoaneurysm	1 (17)	4 (12)	0 (0)	5 (12)
Arteriovenous fistula	0 (0)	2 (6)	0 (0)	2 (5)
Trifurcation arteries also involved	0 (0)	7 (21)	1 (25)	8 (19)
Popliteal vein also involved	2 (33)	11 (33)	3 (75)	15 (35)

Table IV. Repair of penetrating popliteal artery injuries

	No (%) of patients			
Procedure	*Knife (n=6)*	*Bullet (n=33)*	*Pellet (n=4)*	*Total (n=43)*
Lateral arteriorrhaphy	0 (0)	0 (0)	2 (50)	2 (5)
Primary end-to-end	6 (100)	7 (21)	1 (25)	14 (32)
Vein interposition graft	0 (0)	16 (49)	1 (25)	17 (40)
PTFE interposition graft	0 (0)	9 (27)	0 (0)	9 (21)
Vein bypass graft	0 (0)	1 (3)	0 (0)	1 (2)

The popliteal vein was repaired in the two cases injured by stabbing and in two out of the three cases where it was injured by pellets. The repair preceded the arterial one. It was ligated in all 11 bullet injuries where it was damaged and also in one pellet injury.

Twelve patients with a combination of arterial and venous injury where the vein had to be ligated underwent intraoperative fasciotomies, as did three patients who arrived in hospital more than 4 h after the incident with ischaemic swollen legs. All fasciotomies were full-thickness (skin and fascia) and were aimed at decompressing the four muscular compartments of the leg.

The popliteal nerve was disrupted in 5 (11.5%) cases, all bullet injuries. None of these were repaired primarily, but the ends were brought near to each other and tacked to surrounding tissues for future repair.

Tibial/femoral fracture occurred in eight patients (18.5%), again all of them bullet injuries. All were sufficiently stable with no loss of length and definitive treatment was deferred until after the vascular repair.

Major soft tissue débridement had to be performed in seven cases of bullet injuries and one case of pellet injury (a total of 18.5%). In two of these cases, the plastic surgeons had to be called to theatre to cover the defect with muscle flaps.

Morbidity and mortality

There was no mortality.

Out of 43 patients, 34 (79%) with penetrating injuries of the popliteal artery had a successful initial operation. Nine (21%) reconstructions had to be re-explored and a successful outcome was achieved in three. Out of these 9 patients, eight were treated initially with an interposition graft, five with saphenous vein and three with PTFE.

Six patients had an unsuccessful reoperation and underwent amputation after 48 h. There was an overall success rate of 86% and a 14% failure rate that led to amputation. All six amputees were from the bullet wound patients and thus the amputation rate of that group was 18%. All six patients had presented with 'hard' clinical signs of arterial injury and in five the time between injury and operation was more than 5 h, due to their transfer from peripheral hospitals.

Out of the 12 patients, 4 (33%) who had the popliteal vein ligated developed early post-phlebitic syndrome.

There was a 20% incidence of postoperative infection in those with bullet injuries.

Discussion

The management of penetrating popliteal injuries was initially the experience of military surgeons. In World War II most popliteal injuries were treated with ligation and there was an amputation rate of 73% *(3)*. Experience with arterial repair and reconstruction gained in the Korean conflict lowered this rate to 32% *(4)* and the Vietnam conflict to 29% *(5)*. Recent civilian experience has shown a decline in amputation rates to 15% *(6)*. In the last decade the experience at Baragwanath Hospital of penetrating popliteal artery injuries was limited. Pantanowitz *et al. (7)*, in a study covering the 3 years 1985 to 1987 inclusive, reported only seven cases, all bullet injuries, one of which was of high-velocity aetiology.

The Department of Surgery at Baragwanath Hospital has seen a dramatic increase in the number of gunshot injuries over the last 3 years. In 1992 alone, some 3000 patients presented with gunshot injuries, bearing witness to the widespread use of firearms in civilian violence. There has been a resultant large increase in the number and severity of penetrating popliteal artery injuries and our study has shown a sixfold increase in the incidence of popliteal artery injuries in our hospital over the past 5 years.

The role of preoperative angiography in the diagnosis of arterial injury is controversial. In our study all patients with 'hard' signs of popliteal artery injuries were explored without preoperative arteriograms. There were no negative explorations.

Patients with 'soft' physical signs of arterial injury underwent arteriography before exploration was decided upon. Of these, 75% were positive and the damage confirmed on exploration. There were no false-negative arteriograms on the evidence of a short period of clinical observation.

The only instance in which we advocate preoperative arteriography in penetrating popliteal vascular injuries with 'hard' signs is after shotgun injuries where the location of the arterial injury may be difficult to ascertain.

In the presence of 'soft' signs of arterial injury where, by definition, the extremity is not ischaemic and there is more time for evaluation, we find arteriography useful. Some authors recommend that in these cases arteriography should be performed by surgeons in the emergency centre *(1,8)* by means of direct arterial injection and a single exposure. This takes less than 10 min, is inexpensive and does not delay operative repair of injuries. In 515 patients with suspected vascular injury of the extremity, there were no complications with this technique *(1)*. We do not have experience with this method of fast and cost-effective arteriography, but it seems an excellent alternative to radiology room arteriography and must be considered in the future.

Intra-arterial digital subtraction angiography has not proved efficient in excluding injuries from high-velocity missile wounds or shotgun injuries *(9,10)*. When they are perfected, duplex scanning *(11)* and angioscopy *(12)* may play a greater role.

All injuries were approached medially. We do not have any experience with the posterior approach, but Hamsa *et al*'s experience from the Iran–Iraq war suggests that it may be an easier approach *(13)*.

Repair of the vein, where possible, preceded the repair of the artery, thus providing better venous outflow which may increase the success of the arterial reconstruction *(14)*. In our study, 12 patients had the popliteal vein ligated. Of these, 33% developed early post-phlebitic syndrome.

Venous repair should be attempted whenever possible but, in a number of patients, venous repair is technically impossible owing to extensive disruption of a small-calibre vein. Venous ligation becomes inevitable under these circumstances and the use of fasciotomy, elevation of the limb, and compression stockings leads to results similar to those seen with venous repair *(15–17)*. Early swelling after venous ligation improves with time as collaterals develop. In reconstructing the arterial injury, autologous saphenous vein from the contralateral side was our first choice. PTFE graft was only used if the saphenous vein was unavailable, insufficient in diameter (less than 6 mm) or if the time needed to harvest it might have compromised results. There was no difference in the short-term complications in the two groups of patients regarding patency and infection, as previously reported by Feliciano *et al. (18)*. The criteria for early fasciotomy were distal swelling, severe distal musculoskeletal injury, prolonged shock, delayed restoration of blood flow (4–6 h), combined arterial venous injuries and ligation of popliteal vein.

When both orthopaedic and vascular damage has been caused by penetrating popliteal injuries the priority of stabilisation *versus* revascularisation must be judged on an individual basis. However, our experience is that tibial/femoral injuries caused by penetrating popliteal injuries are usually stable without foreshortening and thus definitive orthopaedic management can be delayed until after vascular repair *(1,2,6,9)*.

As a result of our experience, we advocate that patients with 'hard' signs of popliteal arterial injury should be explored immediately without preoperative arteriography, and that preoperative arteriography is performed on patients with 'soft' signs of arterial injury, that vascular reconstruction is generally performed before definitive orthopaedic management. Fasciotomy should be performed in injuries involving the vein and artery and in cases presenting late. In addition we note that saphenous vein and PTFE interposition grafts are equally effective in maintaining short-term patency and recommend that completion on-table angiogram should be performed, if possible.

References

1 Martin RR, Mattox KL, Burch JM, Richardson RJ. Advances in treatment of vascular injuries from blunt and penetrating limb trauma. *World J Surg* 1992; **16**: 930–7.

2 Snyder WH. Popliteal and shank arterial injury. *Surg Clin North Am* 1988; **68**: 787–807.

3 De Bakey WH, Simeone FA. Battle injuries of the arteries in World War II. *Ann Surg* 1946; **123**: 534–71.

4 Hughes CW. Arterial repair in Korean War. *Ann Surg* 1958; **147**: 555–61.

5 Rich NM, Baugh JH, Hughes CW. Popliteal artery injury in Vietnam. *Am J Surg* 1969; **118**: 531–4.

6 Peck JJ, Eastman AB, Bergan JJ, Sedwitz MM, Hoyt DB, McReynolds DG. Popliteal vascular trauma. A community experience. *Arch Surg* 1990; **125**: 1339–44.

7 Pantanowitz D, Franklin J, Hatzitheofilou C, Modiba MCM, Ritz M. Popliteal fossa injuries. *S Afr J Surg* 1988; **26**: 60–63.

8 MacFarlane G, Boffard KD, Saadia R, Wilkinson AE. Emergency room arteriography: a useful technique in the assessment of peripheral vascular injuries. *J R Coll Surg Edinb* 1989; **34**: 310–13.

9 Snyder WH, Thal ER, Percy MO. Vascular injuries of the extremities. In: Rugherford RB, ed. *Vascular Surgery*. Philadelphia: WB Saunders Co, 1989: 613–37.

10 Sibbitt RR, Palmasz JC, Carcia F, Reuter SR. Trauma of the extremities: preoperative comparison of digital and conventional angiography. *Radiology* 1986; **153**: 61.

11 Johansen K, Lynch K, Paun M, Copass M. Non-invasive vascular tests reliably exclude occult arterial trauma in injured extremities. *J Trauma* (in press).

12 Whitte GH. Angioscopy in vascular trauma. In: Bongard F, Wilson SE, Perry MO, eds. *Vascular Injuries in Surgical Practice*. Norwalk CT: Appleton and Lange, 1991: 87–94.

13 Hamsa N, Marath A, Al-Fakhry MR. The management of aneurysms and arteriovenous fistulae of the popliteal artery arising from war trauma. Emphasis on sigmoid operative approach. *J Cardiovasc Surg* 1990; **31**: 457–61.

14 Rich NM, Hobson RW II, Collins JD. The effect of acute popliteal venous interruption. *Ann Surg* 1976; **183**: 365–70.

15 Mullins RS, Lucas CE, Ledgerwood AM. The natural history following venous ligation for civilian injuries. *J Trauma* 1980; **20**: 737–41.

16 Harden WD, Adinolfi MF, O'Connel RC *et al.* Management of traumatic peripheral vein injuries. *Ann Surg* 1982; **144**: 235–40.

17 Yelon JA, Scalea TM. Venous injuries of the lower extremities and pelvis: repair versus ligation. *J Trauma* 1992; **33**: 532–8.

18 Feliciano DV, Mattox KL, Graham JM, Bitondo CG. Five-year experience with PTFE grafts in vascular wounds. *J Trauma* 1985; **25**: 71.

Received 26 January 1994