SALVAGE OF LIMBS WITH VASCULAR TRAUMA

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In an eight-year period we treated 51 cases of vascular injury associated with fractures and/or dislocations or soft-tissue injuries of the limbs. We relied on a clinical diagnosis and immediate exploration of blood vessels rather than the time-consuming procedure of arteriography. All patients were operated on by the orthopaedic residents on duty and not by vascular surgeons. Only 17 (33%) were repaired within six hours of injury. Limb viability with good function was obtained in 38. Complications included six deaths, four amputations, two renal failures and delayed occlusion in one case.

Vascular injuries are traditionally managed by vascular surgeons. However, when patients are admitted as orthopaedic emergencies, with major vascular damage complicating their musculoskeletal injuries, precious time may be lost in obtaining the services of a vascular surgeon. Orthopaedic senior residents trained in the management of vascular injuries can save time and limbs. This is very relevant in low-income countries like India where, for various reasons, many patients reach hospital only after a long delay.

MATERIALS AND METHODS

Patients with suspected vascular injury admitted to the orthopaedic emergency department, underwent exploration on clinical suspicion alone. Pre-operative arteriography was not used except in three cases, for whom it had been performed before they were referred from other centres.

Surgical management included exploration, appropriate stabilisation of bones and joints, reconstruction of injured vessels and management of associated injuries. Most vessels were repaired by end-to-end suture (Fig. 1). When this was not possible, a vein graft was used (Fig. 2). Lateral suture was used in two patients with false aneurysms and adventitial stripping was performed in two with true arterial spasm. Most patients were operated on under regional anaesthesia, continuous epidural or brachial block. Sympathetic blockade was continued for

48 hours postoperatively. We used an epidural cannula for lower-limb blockade; for the upper limb an intravenous cannula was left in place at the site of the brachial block and five-hourly injections of 0.5% bupivacaine were given. None of the patients was heparinised. Postoperatively, the limb was nursed at body level. Vasodilators and dextran (Lomodex; Rallis India Ltd, West Bengal) were used in all cases.

Peroperative and postoperative arteriography was performed to assess the patency of the repaired artery.

The patients were followed up regularly and surgical procedures for nerve injuries and nonunion of fractures were undertaken as necessary.

RESULTS

We treated 51 patients with vascular injury of the limbs in the orthopaedic emergency department in an eight-year period; there were 47 men and four women.

Table I gives the location of the vascular injuries; 32 had been caused by road accidents (Table II). The time interval between injury and vascular repair, the type of repair, and the final outcome in all 51 patients are shown in Table III.

There were associated limb fractures in 29 patients, dislocations with or without fractures in five, and soft-tissue injuries in the remaining 17. Table IV lists the various methods of stabilisation used.

There were six deaths and four amputations (Table V). Two of the amputations were in cases of popliteal artery injury and the other two in injury to the superficial femoral artery.

Septicaemia caused three deaths. One patient died from pulmonary embolism confirmed at post-mortem. In this patient both the popliteal artery and the vein had been repaired. One patient died from an associated head injury and another from hypostatic pneumonia (case 51). Acute renal failure developed in two patients. They were treated by haemodialysis and their kidney function

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Fig. 1a

Fig. 1b

Fig. 1c

Fig. 1d

Figure 1a – Open supracondylar fracture with an absent radial pulse in a ten-year-old child. Figure 1b – Brachial artery contusion found on exploration with no pulsation distal to the lesion. Figure 1c – Contused segment excised and bulldog clamps in position. Figure 1d – End-to-end anastomosis of brachial artery with the elbow in flexion.

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Figure 2a – A 20-cm-long defect of the femoral artery in the thigh of a 35-year-old man, bridged by a reversed saphenous vein graft. Figure 2b – Immediate postoperative photograph showing distal fasciotomy. The wound was closed after covering the vein graft with a vastus lateralis muscle-pedicle flap. Figure 2c – Postoperative arteriogram at three months. Fracture stabilised by a Küntscher intramedullary nail. Figure 2d – Clinical photograph after wound healing.

subsequently returned to normal. In one patient, in whom the popliteal artery had been anastomosed with the posterior tibial artery, the entire anterior compartment underwent necrosis. This patient, however, is ambulant with a below-knee caliper and has good sensation in the sole of his foot.

DISCUSSION

Experiences gained in World War II and the Korean and Vietnam wars have greatly influenced present-day vascular surgery. Some earlier reports of vascular injuries (DeBakey and Simeone 1946; Rich, Baugh and Hughes 1969) have dealt only with the injuries of war but with the increasing volume of road traffic there are now reports of civilian vascular trauma (Morris et al 1960; Drapanas et al 1970; Pasch et al 1986). Penetrating injuries are the usual cause of vascular injuries during combat and, even in civilian life, as many as 82% of such injuries have been caused by gunshot or stab wounds (Feliciano et al 1988). Recently, however, Chervu and Quinones-Baldrich (1988) found the aetiology of civilian vascular injuries to be more varied. Many result from motor-vehicle accidents and accidental falls. Bishara et al (1986) noted that 43% of such injuries were secondary to blunt trauma and that road accidents were the most common cause. The level of firearm ownership in India is low and in our series there was not a single case of firearm injury.

In our series 34 (66%) of the injuries were associated with fractures and/or joint dislocations. Orthopaedic residents handling road-traffic accidents should therefore be specially trained to look for vascular injuries. In warfare the average interval between injury and surgery decreased from 12 hours in World War II to less than one hour in Vietnam, but in civilian practice in India we find that this time interval continues to be high, at an average of 14.5 hours.

In our country the services of a vascular surgeon are available only in referral centres; procuring such services may therefore add further to the delay and to the risk of losing the limb. We achieved good limb function in 72% of cases without the help of specialised vascular surgeons; this may be important for other developing countries, where limbs may be amputated in the absence of a vascular specialist. Goodman (1978) also found, in his Vietnam war series, that young surgeons from several different backgrounds could achieve good results by applying the general principles of vascular surgery.

Eger et al (1972) reported that the shortest interval between injury and repair was five hours and the longest 30 hours. Bishara et al (1986) gave an average time interval of 13 hours. It is widely agreed that the operative outcome is related to the time between injury and the establishment of the circulation (Eger et al 1972; Goodman 1978). In view of this we attempted to make a clinical diagnosis and proceed with exploration. Despite our efforts a considerable delay occurred in diagnosing

Table I. Location of the vascular injury in 51 limbs

Lower limb	Number	Upper limb	Number
Popliteal artery	18	Brachial artery	15
Superficial femoral artery	7	Axillary artery	3
Bifurcation of popliteal arteries	1	Radial and/or ulnar arteries	7

Table II. Cause of injury

Cause	Number injured
Road-traffic accident	32
Broken glass	4
Knife	2
Industrial accident	3
Accidental fall	3
Iatrogenic	2*
Others	5

*case 7: exploration for chronic osteomyelitis; case 44: exploration of cubital fossa

two patients with false aneurysm of the superficial femoral artery in which distal pulses were palpable. One was diagnosed when there was profuse bleeding from the wound three days after the injury and the other when the distal pulses disappeared about three weeks after admission.

Eger et al (1972) reported that the immediate introduction of temporary arterial shunts enabled them successfully to overcome long delays. We did not use shunts in any of our patients.

Gorman (1968) found that a delay of up to 12 hours was compatible with limb survival, but if this was more than 12 hours the limb could not be saved. Our experience with civilian injuries has not entirely corroborated his findings in combat injuries of the popliteal arteries, probably because of the different extent of damage to the collateral circulation.

There have been many reports of the role of arteriography in vascular trauma (Doty et al 1967; Smith, Szilagyi and Elliott 1969; Snyder 1982; Feliciano et al 1988). Feliciano et al (1988) reported an arteriography rate as high as 64%. McCormick and Burch (1979) found an incidence of false-negative results of 20% when physical examination was compared with findings on exploration. We did not have any false-negative results and found that a thorough clinical examination was sufficient to diagnose vascular injury. Preoperative arteriography may help, however, when vascularity does not improve after repair, or in ipsilateral double lesions. In one patient with delayed occlusion, postoperative

Table III. Time interval between injury and vascular repair, type of repair and final outcome

Case	Age:sex	Artery	Time (hr)	Type of repair	Fasciotomy	Outcome
1	5:F	Superficial femoral	5	End-to-end	No	Died of head injury
2	30:M	Superficial femoral	7	End-to-end	Yes	Good
3	30:M	Superficial femoral	9	Vein graft	Yes	BK amputation
4	14:M	Superficial femoral	14	Lateral suture		Drop-foot
5	35:M	Superficial femoral	18	Vein graft	Yes	Good
6	25:M	Superficial femoral	20	End-to-end	Yes	Necrosis of anterior tibial muscles
7	14:M	Superficial femoral	72	Lateral suture	No	Drop-foot
8	12:M	Femoropopliteal	4 weeks	Lateral suture	No	Drop-foot
9	18:M	Popliteal	5	Embolectomy	Yes	BK amputation
10	60:M	Popliteal	5	End-to-end	Yes	Good
11	45:M	Popliteal	5	Thrombectomy	No	Good
12	28:M	Popliteal	6	End-to-end	Yes	Good
13	55:M	Popliteal	6	End-to-end	Yes	Good
14	14:M	Popliteal	6	Thrombectomy	No	Good
15	24:M	Popliteal	6	End-to-end	Yes	Good
16	28:M	Popliteal	6	Vein graft	Yes	Amputation
17	30:M	Popliteal	7	End-to-end	Yes	Died of septicaemia
18	30:M	Bifurcation popliteal	7	End-to-end	Yes	Necrosis of anterior compartment
19	33:M	Popliteal	8	End-to-end	Yes	Died of pulmonary embolism
20	26:M	Popliteal	8	End-to-end	Yes	Good
21	23:M	Popliteal	14	End-to-end	Yes	Died of septicaemia
22	25:M	Popliteal	18	End-to-end	Yes	Drop-foot
23	45:M	Popliteal	20	End-to-end	Yes	Good
24	10:M	Popliteal	24	End-to-end	No	Rethrombosis, anaesthetic foot
25	50:M	Popliteal	24	End-to-end	Yes	Good
26	35:M	Popliteal	4	Vein graft	Yes	Amputation
27	40:M	Axillary	2	End-to-end	Yes	Good
28	35:M	Axillary	7	End-to-end	Yes	Intrinsic foot contracture
29	30:M	Axillary	8	End-to-end	Yes	Good
30	9:M	Brachial	2	End-to-end	Yes	Case of reimplantation; good function; no intrinsic recovery
31	13:M	Brachial	3	Vein graft	Yes	Good
32	40:M	Brachial	4	End-to-end	Yes	Good
33	20:M	Brachial	5	Adventitial stripping	Yes	Good
34	68:M	Brachial	5	End-to-end	Yes	Died of pulmonary infection
35	25:M	Brachial	5	Ligation	Yes	Intrinsic foot contracture
36	26:M	Brachial	6	Vein graft	Yes	Associated median nerve lesion
37	18:M	Brachial	6	End-to-end	Yes	Good
38	10:M	Brachial	7	End-to-end	Yes	Good
39	26:M	Brachial	8	Vein graft	Yes	Associated radial nerve lesion
40	12:M	Brachial	8	End-to-end	Yes	Good
41	32:F	Brachial	8	End-to-end	Yes	Good
42	40:F	Brachial	9	End-to-end	Yes	Good
43	29:M	Brachial	14	Ligation	Yes	Good
44	15:M	Brachial	24	End-to-end	Yes	Gangrene of tip of index finger
45	30:M	Radial and ulnar	3	End-to-end	Yes	Good
46	23:M	Radial	4	Ligation	Yes	Good
47	24:M	Radial	4	Ligation	Yes	Good
48	22:M	Radial	5	End-to-end	Yes	Good
49	28:M	Radial and ulnar	5	End-to-end	Yes	Good
50	22:M	Radial and ulnar	5	End-to-end	Yes	Good
51	60:M	Radial and ulnar	6	End-to-end	Yes	Died of hypostatic pneumonia

Table IV. Method used for stabilising the 34 fractures and dislocations

Fixation device	Number
Plate and screws	5
Intramedullary nail	2
Kirschner wires or Rush pins	6
External fixator	7
Traction	1
Plaster of Paris	13

Table V. The time interval between injury and vascular repair related to the final outcome. The numbers include four ligations (two brachial and two radio-ulnar) and two false aneurysms

Time interval (hours)	Number	Deaths	Amputations
< 6	17	3	1
6 to 10	21	2	2
11 to 24	10	1	–
> 24	3	–	1

vascular continuity had been demonstrated arteriographically, but the vessel became obliterated later. We did not use the Doppler probe to measure arterial blood flow as our department does not have this instrument.

As regards fasciotomy Shah et al (1985) have given clinical guidelines for compartment pressure and the viability of the muscle at the time of surgery. We followed the criteria of Goodman (1978). Of the 26 lower-limb vascular injuries 19 (73%) required compartment decompression by fibulectomy but fasciotomy was performed in all upper-limb injuries. Infection of fasciotomy

30% in popliteal artery injuries. There was no failure in any of the upper-limb vascular repairs.

Recently, Howard and Makin (1990) proposed that external fixation should be the choice for stabilisation of skeletal injury in vascular cases. In our series, there were three deaths and two amputations in seven cases treated by external fixation, but this was used only for severe grade-III open fractures. The fear that internal fixation will compromise the collateral circulation, also expressed by these authors, is valid only if the vascular repair fails.

Abdul Razek, Mnaymneh and Yacoubian (1973)

Fig. 3a

Fig. 3b

Fig. 3c

Fig. 3d

Figure 3a – Proximal stump of the left arm of a nine-year-old boy after injury on a fodder cutting machine. Figure 3b – The amputated arm. Figure 3c – Six weeks after reimplantation. The fracture was stabilised with Rush pins. Figure 3d – Hand function after reimplantation.

wounds was not a major problem; they all healed well after skin grafting or secondary suturing.

There is always a risk of renal damage in delayed repairs, but we found acute renal failure in only two of our patients; both required haemodialysis. We ensured that there was adequate hydration in all patients after repair and gave diuretics when required as a prophylactic measure. We also gave mannitol and bicarbonate after repair and monitored the urinary output.

Nerve repair, when required, was done as a secondary procedure. Nerve lesions with neurotmesis were seen only in upper-limb injuries. There was no case of nerve injury in lower-limb injuries but in four patients drop-foot persisted after recovery of 'paralysis of ischaemia'. In case 30 in which the arm had been reimplanted all other functions returned to normal except for intrinsic function (Fig. 3).

Failed repair, leading to amputation, occurred only in cases of injury to the popliteal and superficial femoral arteries. Rich et al (1969) also reported a failure rate of

reported that unless the limb is obviously beyond salvage, arterial reconstruction should always be attempted, irrespective of the time elapsed since injury. Although we have not hesitated to do primary amputation whenever the limb was severely damaged, we have attempted to save limbs with vascular injury even after considerable delay unless there was obvious gangrene.

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