Management of The Lower Extremity Arterial Injuries

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Objective: **The incidence of vascular injuries has increased considerably during the past 40 years. However, although they represent less than 1% of all injuries, they deserve special attention because of their severe complications.**
Method: **From May 1999 to March 2003, 30 patients with lower limp vascular injury were surgically treated in our clinic. Diagnosis was made by physical examination alone, or in combination with angiography. Primer vascular repair was carried out where possible; if not possible the interposition graft was used. When an interposition graft was necessary either polytetrafluoroethylene (PTFE) or saphenous vein was used for vascular reconstruction.**
Results: **The study group consisted of 24 males and 6 females, ranging in age from 14 years to 39 years with a mean age of 26.2±8.1 years. Penetrating trauma was the cause of a high proportion of cases. There were 31 arterial injuries. Only one patient had bilateral arterial injuries (right and left tibial arteries). Arterial injuries were most common in the femoral artery area, followed by the tibial and popliteal arteries. Surgical procedures performed were primary repair in 12 arterial injuries, saphenous vein interposition graft in 15, and PTFE interposition graft in 4. There were 18 patients with associated venous injury, of which 11 cases had primary repair, and 7 had vein graft interposition. There were concomitant femur fracture in 3 patients, and fibula fracture in 1.**
Conclusion: **Patients who suffer lower extremity arterial injury should be transferred to vascular surgery centers as soon as possible. Anticoagulant treatment should be started as soon as possible to prevent the propagation of the thrombosis. Early fasciotomy is warranted if there is any suspicion of occurrence of compartment syndrome.**

Key words: *Arterial injuries, management*

Type of arterial injuries may comprise of contusion, intimal disruption, puncture, lateral disruption, arteriovenous fistula and transection (1). The successful management of patients with multiple injuries has two goals. The first is to treat the life-threatening problems by fluid resuscitation, controlling the bleeding and ensuring adequate oxygenation; the second is to repair the injured vessel and save the limb (2).

Modern methods of vascular surgery, fracture fixation, and soft tissue reconstruction have improved dramatically the potential for limp salvage (3).

The incidence of vascular injuries has increased considerably during the past 40 years. However, although they represent less than 1% of all injuries, they deserve special attention because of their severe complications (2).

Material and Method

From May 1999 to March 2003, 30 patients with lower limp vascular injury were surgically treated in our clinic.

Diagnosis was made by physical examination alone, or in combination with angiography. Limbs were accepted as ischemic if there were no palpable pulses.

Bleeding from the injured lower extremity arteries was sufficiently controlled in most patients by application of direct external pressure from arrival to operation. In the beginning of the operation, proximal control of the injured thigh vessel was achieved by femoral dissection. Common, superficial and profunda femoral arteries were clamped to prevent bleeding before opening the hematoma and dissection of the injured thigh arteries. In the patients with combined orthopedic and vascular injuries the vascular injury was repaired prior to bony fixation. Systemic heparinization was employed in the absence of a great deal of soft tissue and muscle destruction to arrest thrombus formation in the small distal vessels. Fogarty catheters were routinely passed distally to remove any thrombus and a diluted heparin solution was given to flush distal arterial bed. All patients were given a preoperative prophylactic antibiotic course of first generation cephalosporin which was administered over 72 hours.

Suturing of the femoral and popliteal vessels was done using running polypropylene suture of 6-0. However, repair of tibial vessels was usually done using running polypropylene suture of 7-0 because of the small diameter of the tibial vessels.

Primary vascular repair was carried out where possible; if not possible the interposition graft was used. When an interposition graft was necessary either polytetrafluoroethylene (PTFE) or saphenous vein was used for vascular reconstruction. Associated venous injuries were repaired whenever possible in an attempt to prevent postoperative venous hypertension and to minimize development of compartment syndrome.

Accepted for publication: 30 October 2003

More severe soft tissue and muscle injuries occurred with blunt trauma and gunshot wounds. All wounds were treated at the time of initial operation by debridement of all grossly nonviable tissue, removal of foreign bodies and copious irrigation with isotonic solution plus vascular repair. Fasciotomies were performed following vascular reconstruction in patients with clinically suspicious compartment syndrome. The wounds were inspected frequently during the postoperative period, and the case was taken back to the operating room for repeat debridement or fasciotomy as often as necessary. Repaired vessels especially at anastomotic suture lines and at graft localization were covered by soft tissue and rotated muscles if possible to prevent desiccation and disruption.

Patients with isolated venous trauma and patients with obviously unsalvageable lower extremity injury requiring primary amputation were excluded from the study.

Chi-square test was used for statistical analysis. A p value of less than or equal to 0.05 was accepted as being statistically significant.

Results

The study group consisted of 24 males and 6 females, ranging in age from 14 years to 39 years with a mean age of 26.2±8.1 years. Eighteen patients were hypotensive on arrival in the vascular surgery department. Three of these patients had unrecordable blood pressures, one of whom had a cardiac arrest and responded to resuscitation. Twenty five patients with obvious evidence of significant vascular injury following penetrating stab or gunshot trauma were taken directly to operation. Angiography was performed in 5 patients prior to surgery. Angiographic findings included flap in 1 patient, occlusion in 1, pseudoaneurysm in 1 and arteriovenous fistula in 2.

Penetrating trauma was the cause of a high proportion of cases (Table I). Only one patient had bilateral arterial injuries (right and left tibial arteries). There were 31 arterial injuries (Table II). Arterial injuries were most common in the femoral artery area, followed by the tibial and popliteal arteries. There were 18 patients with associated venous injury, of which 11 cases had primary repair, and 7 had vein graft interposition (Table III). There were concomitant femur fracture in 3 patients, and fibula fracture in 1.

The time interval between beginning of the trauma and arrival to hospital was changed 1 to 7 hours with a mean of 3 hours.

Table I. Distribution of patients by mechanism of injury.

Mechanism of injury		Number of patients
Penetrating injuries	Gunshot	17
	Stab	8
Blunt trauma		2
Iatrogenic		3

There were 18 femoral arteries injuries and all except 1 were the result of penetrating mechanisms. Of these 18 patients with femoral artery injuries, only 4 had common femoral artery injuries, 1 of whom had at the level of femoral bifurcation. The remaining 14 patients had superficial femoral artery injuries. Primary repair was performed in 7 patients. Saphenous vein graft was used in 8 patients. Polytetraflouroethylene (PTFE) graft was used in 3 patients. In one patient who had injury at the level of femoral bifurcation, injured profunda femoral artery was ligated owing to extensive injury, and a saphenous vein interposition graft was employed between common and superficial femoral artery. One patient with femoral artery pseudo-aneurysm and 2 patients with femoral arteriovenous fistula were repaired by primary repair. Eleven patients had simultaneous injuries of the femoral artery and femoral vein.

There were no saphenous vein graft related amputations. But there were two patients with PTFE interposition graft related amputations, 1 resulted from graft thrombosis and 1 from graft infection and subsequent hemorrhage.

There were 2 patients with neurological injury, one of which resolved within three months. However, the remaining had prolonged disability. Graft thrombosis occurred in 2 patients, one was within the first 24 hours following surgery. The remaining one was noted to be thrombosed on postoperative day 6. Former patient had a crush injury to the thigh; superficial femoral artery and vein were repaired with PTFE and saphenous vein interposition grafts, respectively. But both grafts were occluded within the first day. Despite revision of these grafts the patient eventually required a below knee amputation. The latter had a gunshot wound to the calf; anterior tibial artery was repaired with saphenous vein interposition graft. At control angiography, graft was found occluded. However extremity was felt to have adequate collateral flow in spite of thrombosis, and no attempt was made to reopen the graft.

There were 6 popliteal artery injuries, 5 from penetrating wounds and only 1 from blunt trauma. Primary repair was performed in 3, interposition saphenous vein graft in 1, and interposition PTFE graft in 1 case. All popliteal arterial injuries had popliteal venous injuries.

There were 7 tibial artery injuries identified. All of them had penetrating trauma. Primary repair was performed in 1, interposition saphenous vein graft in 6. Two patients had simultaneous injuries of the tibial artery and tibial vein.

We performed prophylactic fasciotomies in 7 patients with combined vascular and large soft tissue injuries (2 blunt traumas and 5 penetrating gunshot injuries). Additionally, we performed fasciotomy in one patient with penetrating gunshot injury during the postoperative period for suspected compartment syndrome based on clinical findings.

Table II. The site of the injury and the type of performed arterial repairs.

	Number of surgical procedures			
Site of injury	Primary repair	Saphenous vein graft	PTFE	Total
Femoral artery	7	8	3	18
Popliteal artery	4	1	1	6
Tibial arteries	1	6	0	7
total	12	15	4	31

Table III. The site of associated venous injuries and the type of performed venous repair.

Site of injury	Primary repair	Saphenous graft	Total
Femoral vein	6	5	11
Popliteal vein	3	2	5
Tibial vein	2		2
Total	11	7	18

Clinical evidence of infection was noted in one patient with femoral artery and vein injuries. This patient had associated femur fracture, nerve and severe soft tissue injuries. We employed PTFE and saphenous vein interposition graft to femoral artery and vein, respectively. Infected PTFE graft ultimately disrupted at the site of anastomosis. Estimated blood loss from time of diagnosis to reoperation was 1500 cc. The time interval between initial operation and disruption was 5 days. Infected graft was removed. In this patient progressive muscle necrosis subsequently developed, and this led to above knee amputation.

One patient with simultaneous femoral artery and vein injuries and femur fracture had deep venous thrombosis in the right lower extremity after operation. He was free of symptoms 6 months after discharge.

There were no repair failures in 12 patients who had primary arterial repair. However, there were 2 failures in 19 patients who had interposition grafts, 1 involving vein and 2 involving PTFE grafts ($p<0.05$).

There were no deaths. On discharge, 24 patients had palpable pedal pulses. Follow-up evaluations ranged from 4 years to 6 months.

Discussion

Some authors (4) suggest that a detailed physical examination can replace arteriography in the majority of patients with proximity wounds. The patients with obvious signs of vascular injury should be taken directly to surgery. We believe that the time of preoperative evaluation should be as short as possible to prevent potential necrotic changes. Therefore we avoided arteriography in most cases.

Approximately 90% of arterial injuries are due to penetrating trauma. Blunt trauma accounts for the remaining 10% of vascular injuries (1).The cause of most injuries in our series was also penetrating trauma from gunshot wounds. We used PTFE graft only 4 patients without a suitable vein for interposition. We have not used prosthetic graft material in the venous system injuries of the extremity because of the prosthetic venous graft thrombosis in the extremity is high.

A major risk factor for limp loss is the development of compartment syndrome. A compartment syndrome occurs when the pressure of the one or more osteofascial compartments rises. Compartment syndrome has itself been linked to delay in restoration of blood flow; presence of associated venous injuries and lower extremity fractures (5). Performance of the fasciotomy prior to vascular repair has been recommended to improve collateral flow and reduce distal ischemia during arterial repair (6). Many extremity vascular injuries are associated with large soft-tissue defects (7). Combined arterial and venous injury associated with large soft tissue defect may cause compartment syndrome. Additionally, reperfusion of a prolonged ischemic extremity also may cause compartment syndrome. Selective prophylactic fasciotomies (ischemic time greater than 6 hours or combined arterial and venous injuries) effectively save limps (8). We performed prophylactic fasciotomy in seven patients with combined arterial and venous injury associated with large soft-tissue defect. Postoperatively, in one patient with tenseness and tenderness on palpation of the affected extremity, we performed fasciotomy to prevent necrotic changes.

Arterial puncture injuries may result from percutaneous vascular procedures. Many of these injuries heal uneventfully, but a few may persist and become expanding

pseudoaneurysms. Puncture injuries are seen as an eccentric irregularity or out pouching of the contrast column on arteriography. Early recognition and repair of iatrogenic arterial injuries were of paramount importance in minimizing subsequent morbidity and mortality. One apparently unavoidable subset of these arterial injuries is the false aneurysm that develops after transarterial diagnostic or therapeutic intervention (9,10). The chance of spontaneous cure of a false aneurysm was approximately 6% and of an arteriovenous fistula 2% (11). Any arterial injury may cause a serious complication months or even years later and therefore all arterial injuries must be repaired when recognized (12).

Severe soft tissue injury, concomitant venous injuries, fractures, shock and a crushed extremity were found to be associated significantly with amputation (13,14). Vascular repair has been shown to decrease amputation rates when performed before bony stabilization (15). Accordingly, we have performed vascular repair prior to bony fixation in all patients combined with fracture.

Simple repair, defined as either lateral arteriorrhaphy or end to end anastomosis, was associated with a 5% amputation rate. It should be performed whenever possible. More complex repairs had a significantly higher amputation rate of 25%. The higher amputation rate of complex repairs likely is a reflection of severity of injury. Simple repair, when performed without tension, offers the best chance of limp salvage (13). In our series, two patients with complex repair underwent amputation.

Venous repair improves limp salvage rates by decreasing venous hypertension and reducing compartment pressures (16).

Systemic anticoagulation with heparin can prevent propagation of distal small vessel thrombosis. Wagner et al (14) showed a significant impact on limp salvage with systemic heparin when compared to patients without heparin. Some have chosen to use local heparin instillation to reduce bleeding from extensive injuries (4). We used heparin solution to flush distal arterial bed.

In contrast to venous repair, direct suture or end to end anastomosis should be avoided in arterial reconstruction, as high blood pressure may cause tension in the anastomosis and damage of the endothelium (2). Most vascular injuries from gunshot wounds frequently necessitate an interposition graft to gain a tension-free repair (4). Some authors avoided a direct end-to-end anastomosis without graft and they preferred a vein graft whenever possible (2). In our series 10 arterial and 8 venous repairs were done with primary repair without tension.

Injuries to the common and profunda femoral arteries are uncommon because of their short length and proximal location. Superficial femoral artery injuries are very common, as was seen in our series. Femoral artery injuries present the opportunity to use either authologous vein or PTFE grafts depending on the choice of the surgeon (4). Lack of soft tissue coverage is a common reason for graft failure and infection (17). Accordingly, all of these grafts (authologous vein or PTFE) were covered by soft tissue and rotated muscles in our series.

One point of controversy does involve the management of one tibial artery injury with intact distal flow through the remaining vessels and a normal, non-ischemic extremity. Shah indicates that all injured tibial arteries should be repaired to prevent tissue loss and long-term morbidity even with an intact vessel to the foot (18). Some suggest that aggressive approach in repairing tibial vessels if one intact is unnecessary. If the crural arteries are injured, reconstruction requires repair of at least one vessel because there is a communication between anterior and posterior tibial arteries; in cases with anatomical abnormalities such as hypoplasia of the posterior tibial artery or absence of the dorsalis pedis, being verified on the angiography, at least two vessels must be repaired immediately (2). In our series all injured tibial vessels were repaired.

Synthetic grafts are less successful in below-the knee reconstructions for trauma, just as they are in atherosclerotic disease (4). Proponents of synthetic material feel that the saphenous vein grafts are not suitable for all wounds requiring an interposition graft because of: occasional inadequate lumen size, difference in diameter between the injured artery and the autogenous vein; possible nonavailability of a suitable vein; and the difficulty of leaving a vein graft exposed in a large, contaminated soft-tissue wound (7).

Patients who suffer lower extremity arterial injury should be transferred to vascular surgery centers as soon as possible (19). Anticoagulant treatment should be started as soon as possible to prevent the propagation of the thrombosis. Early fasciotomy is warranted if there is any suspicion of occurrence of compartment syndrome.

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