Surgical Management of Vascular Trauma
Distal to the Popliteal Artery

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Experience with five patients requiring arterial reconstruction for injury distal to the popliteal trifurcation indicates that such operations are both feasible and valuable. Fractures and associated nerve and venous injury are common but do not preclude successful limb salvage. The importance of early diagnosis and prompt surgical repair is emphasized. Preservation of the ipsilateral saphenous vein and exclusion of vascular anastomoses from the wound are useful technical adjuncts.

Arterial reconstruction for chronic occlusive disease distal to the popliteal artery is now an accepted surgical procedure with a documented long-term patency rate of greater than 50%. To date very little experience with repair of vascular injuries distal to the popliteal trifurcation has been reported. Arterial trauma below the knee is usually associated with injury to the veins and nerves and often with fractures. Therefore, recovery of satisfactory limb function rather than simply limb salvage must be the goal of such procedures.

Patients requiring surgical reconstruction of the arterial system distal to the popliteal artery have been followed long enough to assess limb function. Experience with these patients forms the basis for this report.

Report of Cases

Case 1 (UH 42-95-50).—A 36-year-old man sustained a massive crush injury when several tons of steel fell across his left popliteal space and lower back. Initial treatment consisted of debridement of the popliteal wound and ligation of the left popliteal artery. His condition was evaluated at the University of Oklahoma Health Sciences Center eight hours after the injury. The patient's general condition was stable. The left leg was severely ischemic with paralysis and anesthesia of the foot. There was a large, open avulsion wound of the left popliteal space. X-ray films showed a comminuted fracture of the proximal left tibia, dislocation of the pubic symphysis, and a fracture through the right wing of the sacrum. At operation, ten hours after the injury, the ligated ends of the left popliteal artery were exposed. In addition there was a segmental fracture of the intima with distal occlusion near the division of the popliteal artery into the peroneal and posterior tibial arteries. A segment of the popliteal vein was missing and the ends were ligated. Care was taken to preserve the ipsilateral greater saphenous venous system. Arterial reconstruction was accomplished using a reversed greater saphenous vein graft from the opposite leg. The proximal anastomosis was made to the first portion of the popliteal artery, which was exposed by a medial incision above the popliteal wound. A distal incision paralleling the posterior border of the tibia was made below the contaminated wound and the proximal posterior tibial artery dissected. The distal anastomosis was made to the posterior tibial artery. Although the completed graft occupied the course of the popliteal artery and did span the open popliteal space, both anastomoses were placed out of the contaminated wound. The exposed vein graft was covered with the heads of the gastrocnemius muscles. No attempt was made to cover the skin deficit posteriorly and the fascia was not closed medially over the calf. In addition, fasciotomies were performed over the peroneal compartment. The common peroneal nerve had been avulsed but the sciatic nerve was traced distally to the intact posterior tibial nerve. Confinement of the posterior tibial nerve was evident but it was not interrupted. Stabilization of the proximal tibial fractre was achieved through Kirschner wire fixation and external traction. Despite prompt elevation the patient developed severe edema with bullae of the entire lower leg and foot. After the first week the edema began to subside, and by the third postoperative week a clearly palpable posterior tibial pulse was present. Split-thickness skin grafting to the popliteal fossa closed the wound. A long-leg cast was applied, and ambulation with crutches was begun. The patient developed an equinus deformity and subsequently required lengthening of...
skin grafts were placed over the open wounds. The skin grafts remained viable. By the third postoperative week a faint posterior tibial pulse was palpable, which was corroborated by ultrasound scanning. The patient was discharged with a viable extremity five weeks after the injury. An intrinsic minus deformity with cock-up toes and considerable pain ensued (Fig 3). The posterior tibial pulse remained intact. He was readmitted six months later and underwent planter fasciectomy with resection of the interphalangeal joint of the toes. Two through five. In addition he had extensor tenotomies and dorsal capsulotomies of the metatarsal phalangeal joints. He now is able to walk without pain, nine months after the injury.

Case 3 (UH 40-52-88).—A 39-year-old man was admitted to the hospital following a bumber injury to the left leg. On admission he had a markedly swollen left lower extremity from the mid thigh to the mid calf. There were absent popliteal, posterior tibial, and dorsal pedal pulses. He was unable to dorsiflex or plantarflex the foot and had loss of sensation of the entire dorsum of the foot. Complete sensation was present on the sole and posterior aspect of the calf. A large popliteal space hematoma did not appear pulsatile. X-ray films showed a severely comminuted fracture of the left proximal tibia with a fracture of the fibula (Fig 4). The left foot appeared viable with prompt capillary refill. Because of continued ischemia, left femoral angiography was performed. The superficial and profunda femoral arteries were normal. There was complete occlusion of the popliteal artery without distal filling. Surgical exploration five hours after the injury showed complete transection of the peroneal, anterior tibial, and posterior tibial arteries. It was obvious that the popliteal artery just beyond its trifurcation had been involved in the tibial fracture, and it appeared that the distal fragment had severed the three branches. Mild athereosclerotic disease was noted in the posterior tibial artery. The peroneal and anterior tibial arteries were ligated. The right greater saphenous vein was utilized to graft the left popliteal to the posterior tibial arteries. The popliteal vein was ligated, since repair was not judged feasible. A peroneal compartment fasciotomy was done and the fracture stabilized by external traction. Postoperatively the patient had a palpable pulse in the left posterior tibial artery with an obviously viable foot. Nevertheless, considerable swelling with bullae occurred. The edema began to subside six days postoperatively. He was discharged five weeks later, after placement in a long-leg cast. The cast was removed seven months after injury, and the patient has achieved a functional extremity.

Case 4 (UH 28-03-42).—A 59-year-old rancher was admitted to the University of Oklahoma Health Sciences Center 30 days after sustaining a .22 caliber bullet wound in the right leg. At the time of injury, bleeding was not excessive, although evidence of damage to the peroneal nerve was present. No operation was carried out, and the patient's convalescence was uneventful until three weeks after the injury when a pulsating mass in the anterior compartment at the mid leg level was noted. The mass had enlarged since it was first detected. On examination a bullet wound of entry was noted just behind the head of the right fibula and a wound of exit was present on the anterior surface of the leg 15 inches above the ankle. There was slight edema of the ankle. A visible pulsatile mass measuring approximately 5 x 10 inches in diameter was present just lateral to the anterior border of the tibia. The superficial veins were slightly dilated but not pulsatile. A continuous bruit was present over the mass. There was evidence of complete peroneal nerve palsy. At operation a false aneurysm of the anterior tibial artery was resected. The ends of the anterior tibial vein were ligated, and a 3-cm defect in the anterior tibial artery was bridged with a graft of reversed left greater saphenous vein. The neurora of the common peroneal nerve was resected and the nerve repaired. The patient's postoperative condition was quite uneventful. Good pulsation was immediately present in the dorsalis pedis vessel and this remained palpable. The patient regained excellent function of the leg, although some weakness of the foot flexors remained. He was able to resume his activities as a cattle rancher.

Case 5 (UH 37-18-09).—A 45-year-old}

Fig. 2.—Shotgun injury of left leg with interruption of peroneal, anterior tibial, and posterior tibial arteries (case 2).

Fig. 3.— showing in man was Oklahoma weeks aft right leg l no history. In was made by prob weeks aft pain radii ankle and the region time, an wound clo to the M there was healed 1- lateral to inches belt there was in diameter Overlying tion was p to poesis with sli A soft bru mass. At arterioven tibial arte short segr to the artery ioss. Th was resto metal frag to be pres but there postoper and the p
Comment

The value of immediate repair of severed major vessels was firmly established during the Korean conflict. The amputation rate for arterial injuries was dramatically reduced to 13% following suture repair from the previously reported rate of 51% after ligation. The frequency of popliteal artery involvement was 20% of the major arterial injuries reported in the battlefield series from both World War II and, more recently, from the Vietnam conflict. Injury to one or a combination of the three branches of the popliteal artery occurred in 20% of 2,472 World War II vascular injuries. The popliteal artery and its branches are less commonly injured in civilian trauma. A combination of three large, recently reported series revealed involvement of the popliteal artery in only 5.5% of civilian trauma cases and injury to the distal branches in 3.75%. Popliteal artery trauma is associated with an amputation rate of approximately 30%. Nearly one half of injuries to the distal popliteal artery and its divisions require amputation. Although immediate ligation of any one of the trifurcation vessels or tibial peroneal trunk has been advocated, an amputation rate of 13.5% was reported after posterior tibial ligation, 8.5% after anterior tibial ligation, and 69.3% after ligation of both tibial branches in the World War II series. This approaches the 70% amputation rate associated with popliteal artery ligation. Recent reports confirm the high incidence of amputation of severe ischemia from the loss of the posterior tibial artery or from injury to both tibial vessels.

Early diagnosis of arterial injury is critical. Adequate capillary refill and apparent viability of the extremity are often responsible for delay in arteriography and early exploration. The presence of palpable distal pulses does not rule out major arterial injury. Although preoperative arteriography correctly identified the arterial injuries in our cases, failure of arteriography to show significant arterial injury is well-documented clinically and experimentally. A high index of suspicion coupled with a liberal policy for early angiography and early exploration of penetrating injuries will reduce ischemic time. An aggressive approach toward fractures with associated ischemia and hematoma is also indicated.

Arterial reconstruction was accomplished utilizing a reversed autogenous saphenous vein in four of the five reported cases. Infection and subsequent hemorrhage from the venous anastomosis has lead to amputation when soft tissue injury prevents adequate coverage of the vein graft. This hazard can be reduced by placing an anastomosis above and below the site of injury through separate incisions if necessary. The vein graft may traverse the defect and should be covered initially with viable muscle if possible. Shires and others have appropriately emphasized the importance of fasciotomy at the time of initial arterial reconstruction. The frequently associated venous injury and delay in repair herald postoperative edema and render adequate fasciotomies mandatory.

Associated injuries are common with popliteal artery trauma and are
important prognostically. Rich et al reported associated neural injuries in 47%, associated venous injury in 59%, and concomitant fractures in 49% of 150 examples of popliteal artery trauma from the Vietnam experience. The importance of venous interruption in reduction of arterial inflow and in edema postoperatively has been emphasized recently both clinically and experimentally. Concomitant venous injury should be repaired if possible. We have utilized the saphenous vein from the opposite extremity for arterial reconstruction, in an effort to preserve the ipsilateral superficial venous system. In two of our cases deep venous repair was not feasible but preservation of the ipsilateral saphenous vein was possible. Both patients have good long-term functional results without edema. Severe postoperative edema appears related both to venous injury and to ischemic time. Edema was a prominent feature in our patients with both deep venous interruption and an ischemic time of greater than five hours.

An extraordinarily high rate of amputation after popliteal artery injury with associated fracture is well-documented. This is a reflection of both the extent of injury and concomitant nerve and venous injury. Irreparable deep venous injury often accompanies such extensive tibial fractures even without arterial injury and interferes with venous return. In two of our reported cases preservation of the superficial venous system was possible in such injuries and may have been of critical value in the long-term recovery. Early immobilization of unstable fractures with elevation is also essential. External fixation has been preferred because of the lower risk of infection in the military experience and was selected for our patients. However, in our patients with extremity re plantation internal fixation has been satisfactory. Careful documentation of neural injury both preoperatively and at exploration is essential. Despite significant neural injury, a successful functional recovery is frequently possible and is evident from our case reports. In selected instances nerve repair at the time of vascular reconstruction is feasible.

In two patients the presence of arterial injury was not discovered at the time of injury, probably because the vessel was not completely divided and the degree of ischemia was less impressive. Similar cases of unrecognized or delayed repair have frequently led to amputation. In both of these patients the appearance of a pulsating mass and the diagnosis of arteriovenous fistula necessitated distal arterial reconstruction several weeks after injury. Obviously morbidity was prolonged and operative management made more difficult by the delay of surgical treatment.

References