Management Of Peripheral Vascular Trauma: Our Experience

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Abstract

Introduction: The incidence of vascular trauma has increased considerably during the past 40 years. However, although they represent less than 3% of all injuries, they deserve special attention because of their severe complications. The study is to analyses the causes of injury, presentations, surgical approaches, outcome and complication of vascular trauma of the upper and lower limbs.

Methods: A retrospective analyses of twelve years. From January 1992 to December 2004, 662 patients were operated for peripheral vascular injuries. Diagnosis was made by physical examination and hand Doppler alone or in combination with Doppler scan/angiography. Primer vascular repair was carried out where possible; if not possible the interposition vein graft was placed. Early liberal fasciotomy was considered as and when required. Patients with isolated venous trauma and patients with obviously unsalvageable lower extremity injury requiring primary amputation were excluded from the study.

Result: Five hundred and eighty of the patients were males (88%) and eighty two of them were females (12%), and their ages ranged from 4-65 years (mean 24 years). Mean duration of presentation was ten hours after the injury. The most common etiological reason was road traffic accidents i.e. 70% in penetrating trauma group and 52% amongst all blunt traumas. Incidence of concomitant orthopedic injuries was very high in our study (70.2%). The most common injured artery was brachial artery (32.6%), followed by popliteal artery (29.7%).Surgical procedures performed were primary repair in 55.5%, whereas interposition vein grafts were placed in 35.2% cases. The limb salvage rate was 94.2%.

Conclusion: Patients who suffer vascular injuries to the extremities should be transferred to vascular surgery centers as soon as possible. Decisive management of peripheral vascular trauma will maximize patient survival and limb salvage. Priorities must be established in the management of associated injuries, and delay must be avoided when ischemic changes are present. Early fasciotomy is warranted if there is any suspicion of occurrence of compartment syndrome.

INTRODUCTION

Trauma has become a public health problem in many parts of the world, and vascular trauma is an important component of this problem. The great majority of these injuries are due to penetrating trauma, with stab, gunshot wounds and road traffic accidents being the most common cause. ([1]) However, the mechanism of injury seems to differ between different parts of the world.([2], [3]) Since non-invasive methods are mostly sufficient and many patients need urgent intervention, the uses of advanced radiological screening methods are sometimes hard to reach and may result in lost time. But if required these patients should be followed up with ateriography and / or duplex ultrasonography.

In the past, attempts to control arterial bleeding were by means a cauterization method in addition to manual compression and pouring boiling liquid materials on the wounds. Ambroise Pare initially used the ligation method during XVIth century.([1]) During the first and second world wars, important knowledge had been gained both in diagnosis and treatment of vascular injuries, but vascular reconstructive methods were mainly introduced during the Korean and Vietnamese wars with the tremendous progress.([1],[3]). Consequently, a dramatic decrease in amputation rate was achieved.([2],[3],[4],[5]). While successful treatment of major arterial injuries may be life-saving as well as allowing limb salvage and restoration of function, ([4]) return of function is often related to the presence of concomitant injury to peripheral nerves.([5])

Vascular trauma associated with major morbidity and mortality, but little is known about its incidence or nature in our region. This is a retrospective study of 662 patients underwent operative intervention for vascular trauma under one vascular unit in a tertiary care center over a period of twelve years. In this report we are presenting the different mechanisms of trauma, arteries involved, associated orthopedic or nerve injuries and types of vascular repairs employed. To the best of our knowledge, this is the first report on vascular trauma from this region of India.

PATIENTS AND METHODS

During the twelve years period between January1992 and December 2004, 662 patients presented with extremity vascular injuries. All patients underwent full physical examination and resuscitation according to the principles of the Advanced Trauma and Life Support (ATLS) guidelines of trauma management. The patients were either first assessed by the chief medical officer or were referred from the orthopedic surgeon after finding absent distal pulses in a patient with fracture or fracture/dislocation of the extremity.

Depending on the mode of presentation, patients were either taken immediately to the operating room for vascular or orthopedic/vascular management or were assessed by preoperative duplex ultrasonography/angiography. In all patients with associated orthopedic injury, reduction of joint dislocation or bone fracture and immobilization by internal or external fixation. It always preceded vascular repair unless the extremity was threatened and required immediate revascularisation. Endoluminal shunts were not used in any of the patients. Patients with more severe soft tissue and muscle injuries were treated with thorough debridment of all grossly nonviable tissue, removal of foreign bodies and copious irrigation with isotonic saline. Suitable covers for the defect were given by Plastic surgeons with split skin grafting (SSG) or with the application of flap techniques. Repaired vessels especially at the anastomotic suture lines and at graft localization were compulsory covered with muscles and soft tissue to prevent desiccation and disruption. In all patients, management of vascular injuries was done in the operating room under general anesthesia using standard vascular techniques. Depending on the condition of the limb after revascularization, open full fasciotomy was used liberally to either relieve existing compression or to avoid one from occurring in the postoperative period. Few upper limbs fasciotomies were also performed. Fasciotomy wounds were usually covered later by a delayed primary, split-thickness skin graft. An intraoperative angiogram was done in few cases, wherein distal pulses were absent after the revascularisation, even after the repeated attempts.

Successful repair was assessed by the return of distal pulses at the end of the operation. Although associated nerve injuries were not usually repaired at the time of vascular repair, major associated venous injuries were repaired whenever possible, in an attempt to prevent postoperative venous hypertension and to minimize development of compartment syndrome. Patients with suspected nerve injuries were assessed late postoperatively by electric stimulation studies. Four weeks after discharge from the hospital, patients were routinely examined in the outpatient department (OPD) where segmental pressures were measured and functional status of the limb assessed. Thereafter, they were followed up at longer periods of time. The mean follow-up period for the whole group was 24.5±6 months (range 1-36 months). All patients received intravenous preoperative, prophylactic antibiotics, which were continued postoperatively for five to seven days unless prolonged use was dictated by the presence of contamination or infection, or else advised by the attending orthopedic/plastic surgeons. All patients also received intravenous heparin for a period of 5-7 days postoperatively and were discharged home on oral aspirin 150 mg tablet/day for a period of twelve weeks.

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

RESULTS

Successful outcome in vascular trauma depends on early diagnosis and early referral to the specialists. In our set up majority of the patients presented beyond what is considered as the “Golden Period”. The time interval between beginning of the trauma and arrival to our center was a mean of 10 hrs. However diagnosis of the vascular injury was done as soon as the patient reached to the emergency, mostly by assessing the peripheral circulation with the assistance of hand Doppler and physical examination. The numbers of patients diagnosed with only hand Doppler and clinical examinations were 476 (72%). In other cases, duplex ultrasonography (18%) and peripheral arteriography (10%) had been applied. During vascular injury, clinical findings and signs such as; presence of open arterial bleeding, presence of an increase intended or pulsated hematoma, presence of six ‘P' signs (pulselessness, poikilothermia, pallor, pain, paresthesia, paralysis) of the related extremities is accepted as basis for

the diagnosis. The patients consisted of 580 males (88%) and 82 females (12%) with a mean age of 24±12.6 years (range 4-65years). The lower limb vascular extremity trauma (58%) outnumbered the upper extremity trauma (42%).The left side was the more frequently affected side as it was involved in 332 patients (50.1%) the right side in 307 patients (46.3%) and bilateral in 23 patients (3.4%). The mechanism of trauma was penetrating in 391 patients (59%), blunt trauma in 169 patients (26%) and iatrogenic in the remaining 102 patients (16%).(Table1)

Figure 1

Table 1: Distribution of patients by mechanism of injury

Mechanism of injury		Number of patients
Penetrating injuries		391 (59.06%)
	Road traffic accidents	70%
	Industrial	10%
	Gun shot	6%
	Stab	4%
Blunt injuries		169 (25.5%)
	Road traffic accidents	52%
	Fall	40%
	Industrial	8%
Iatrogenic injuries		102 (15.4%)

However, road traffic accident (RTA) was the single commonest cause of extremity vascular injury in both the penetrating and blunt trauma. Other forms of trauma in a descending order of frequency were fall from height, industrial or machinery like electric saw or hand drilling machines, gunshot and stab injuries. Incidences of iatrogenic injuries are increasing due to increase in the number of percutaneous procedures. 560 patients (85%) presented with ischemia, 24 patients with bleeding (4%) and 58 patients with a pseudo aneurysm (9%).Fourteen patients had post traumatic A-V Fistula. The brachial artery was the most frequently affected artery as it was injured in 216 patients (33%), followed by the popliteal artery in 197 patients (30%), and femoral artery in 148 (23%).(Table3) Other involved arteries were posterior and anterior tibials (26), radial and ulnar (21), axillary (16) and subclavian (8). The vascular injury was more often associated with orthopedic injuries as both occurred in 465 patients (70%).

Figure 2

Table 2: Additional pathologies

Pathology	Number of patients
Orthopedics injuries	465 (70.2%)
Major venous injuries	26 (3.9%)
Nerve injuries	18 (2.7%)
Traumatic pseudoaneurysm	58 (8.7%)
A-V fistula	14 (2.1%)

Figure 3

Table 3: Distribution of vascular injuries

Localization	Artery	Vein
Subclavian	08 (1.2%)	
Axillary	16 (2.4%)	
Brachial	216 (32.6%)	
Radial and ulnar	21 (3.1%)	
Femoral	148 (22.3%)	08 (1.2%)
Popliteal	197 (29.7%)	18 (2.7%)
Anterior and posterior	26 (3.9%)	

Orthopedic injuries were in the form of fracture in 437 patients (66%), fracture/dislocation in 66 patients (10%) and dislocation alone in 159 patients (24%). Concomitant vein or nerve injury also occurred in 44 patients (7%). Associated nerve injury occurred in 18 patients (3%), and vein injury in 26 patients (4%).(Table2) The most common venous injuries were found to be in the popliteal vein in 18 patients and femoral vein in 8 patients. Nerve injuries were seen commonly with brachial and popliteal vessels injuries. Brachial plexus injuries were seen with subclavian and axillary artery injuries. The patho-physiology and pattern of arterial injuries were attributed to complete arterial cut in 306 (52%), partial cut in 48 (8%) and blunt arterial injury without cut in 236 (40%) patients. Arterial repair was preferred over orthopedic fixatation in all the threatened limbs. While synthetic grafts were not used for any arterial repair, interposition vein graft was used in 208 patients (35%).End to end anastomosis after the resection of contused segment was the most frequently used single technique of arterial repair in 328 patients (56%). Other techniques used were patch angioplasty 24 patients (4%); lateral arteriorraphy in 14 patients (3%) and extra anatomical bypass using reverse saphaneous vein in 16 patients (3). In 58 patients with pseudoaneurysm, underwent excision of the pseudoaneurysm and repair of the vessel. A-V fistula was repaired in 14 patients.(Table4)

Figure 4

Table 4: Applied surgical interventions (arterial)

Surgical intervention	Number of patients
Saphenous vein graft interposition	208 (35.2%)
Extra anatomical bypass with saphenous vein	16 (2.7%)
End to end anastomosis	328 (55.5%)
Patch angioplasty	24 (4%)
Lateral arteriorraphy	14 (2.3%)
Excision of pseudoaneurysm and repair	58 (8.7%)
Repair of A-V fistula	14 (2.3%)

A balloon embolectomy catheter was routinely used in all the cases not only to clean the vessel but also to relieve the spasm. Repair of major venous injuries was performed in 26 patients (4%).Lateral venorraphy in 18 patients and end to end repair in 8 patients. Therapeutic or prophylactic fasciotomy was performed in 234 patients (61%) with lower

limb trauma and in 22 patients (8%) with upper limb trauma. 24 patients (4%) required revision procedures like embolectomies, revision of the anastomosis and revision of the graft. 86 patients (13%) developed infections mostly in lower limb trauma at the open fasciotomy sites. Infected wounds were treated with the appropriate antibiotics according to the cultural sensitivity along with frequent wound dressings. However in spite of this secondary hemorrhage resulted in 4 patients (2%). 37 patients (6%) underwent delayed amputation, 34 above knee and 3 above elbow.(Table5) A limb salvage rate of 94.2% was therefore achieved in 662 patients.

Figure 5

Table 5: Complications

Complication	Number of patients
Revision	24 (3.6%)
Infections	86 (12.9%)
Secondary hemorrhage	14 (2.1%)
Amputation	37 (5.5%)
Death	Nil

DISCUSSION

Despite modern surgical interventions, vascular injuries can still cause extremity loss and even death. According to some authors, amputation rates can even reach 78%.[6]The extremity salvage rate in our study was 94.2%.According to some authors, approximately 90% of the arterial injuries exist due to penetrating traumas.[7]Blunt traumas compose the remaining 10% ratio,[9]while others reported even over 50%.[6]In our study, blunt traumas are reported as 26%. Road traffic injuries among penetrating traumas were very common in our analysis (70%), exclusively in male patients. This is similar to what was reported from Sweden and to some extent from Thailand but totally different from that from the USA, where gun shot injury was the primary cause.[10] This may be due to the fact that existing roads seems to be much narrowed for the amount of people traveling on all sorts of vehicles. Also women usually do not prefer driving in our region. In reports, which were issued from war districts[11,12] and in some civil settlement regions,[3]firearm injuries are commonly reported. Fortunately, the frequency of firearm injury in our region is low.

Two factors seem to play a key role in such firearm injuries in our region. In many events such as weddings, national victories, the use of firearms is a very common issue that causes many accidental events. Secondary cause is the conflict, which occurs between families. Vascular injuries are frequent among young male population,[5,7]and male patients compose 87.5% of the cases. Vessels, nerves and bones may be injured together due to their close relation anatomically.[13,14]Bone fractures and nerve lesions were also accompanying 70.2% and 2.7% in our study, respectively.The patients with bone fracture, nerve injury, and severe soft tissue injuries are assessed by related disciplines and appropriate interventions were maintained. In our patients with fractures, external fixation is more preferred because of easier application and low infection risk. Peripheral angiography in vascular injuries is controversial. Some authors are suggesting angiography to every pre-operative patient,[6,8,16,17] while others don't.

Many clinicians report their successful vascular injury results without angiography.[5,7,18,19] Since the Doppler ultrasound is 95% sensitive and 97% specific in experienced hands, its use reduces the spent time with respect to angiography.[7,12, 20]Under this circumstance, careful clinical examination can give a reliable diagnosis with the combination of Doppler ultrasound, and measurement of peripheral circulation pressure differences with hand Doppler, if applicable. Our opinion is that, peripheral angiography should be applied in cases with multi level vascular and orthopedic injuries. This method is also a gold standard for the patients who cannot be diagnosed by basic diagnostic tools. Both time and expenses will decline with such basic tools. We follow the diagnostic step-by-step method and our results were found to be similar to those presented by many authors. It is essential to control the bleeding in vascular injuries, particularly, in the vessels, which have a greater diameter, hence the greater risk of hypovolemic shock. Under these circumstances, a severely injured patient should be taken to theatre as soon as possible with volume expanding solutions particularly blood. In all the patients with associated orthopedic injuries, the orthopedic surgeon performed reduction and fixation of fracture and / or dislocation prior to the vascular repair.

We believe, as previously suggested by other authors, that a well stabilized skeleton is essential before definitive arterial and soft tissue repair can be performed [15], unless the limb is immediately threatened requiring urgent arterial repair. However this is contrary to the view of Hunt et.al, who suggested that arterial revasculaization should be followed by skeleton stabilization and nerve and tendon repair.[21]In arterial injuries, successful results were obtained in arterial reconstruction procedures, which were held 6-8 hours after the event.[16,22]Almost all of the amputation performed in our patients was late cases that were revascularized after 8hours

following the injury. Infection is also a major factor, increasing amputation rate after a successful vascular surgery intervention. For this reason, vigorous and appropriate tissue debridement is a very important intervention before and after the revascularization procedure.([23]) In our retrospective study,86 patients developed infection. Amputation was required for the failed procedure in spite of repeated revisions.

Early fasciotomy is should be considered in most cases of combined extremity trauma. The devastating nature of these injuries, largely due to violent forces, the associated muscle and integument trauma, and the often considerable pre-operative and operative warm ischemia time, all favors the development of tissue edema that may progress to cause a compartment syndrome that may seriously jeopardize a successful arterial reconstruction. Under these conditions, immediately decompressing fasciotomies should be applied.([9,23,24,25,26]) Although our reported fasciotomy rate of 61% in lower extremities and 8% in upper extremities, is much higher than that reported by most authors at 7-10% ([11,17]), there was no significant morbidity observed due to this procedure. Therefore, we recommend its liberal use especially in cases of established ischemia, as previously pointed out by Fletcher and Little.([15]) Fewer thrombotic events occurred with respect to some publications.([5]) We encountered few thrombotic events after arterial reconstructions in 24 patients. We think that several factors are effective in this result. The first is that we particularly take care to free anastomotic ends from neighboring tissues in order to achieve a good anastomotic line and this feature leads to a loose anastomosis. Another factor is that we perform longitudinal incisions on vessel walls on anastomotic line to maintain a wider diameter on anastomosis. Systemic anticoagulation with heparin can prevent propagation of distal small vessel thrombosis. Wagner et.al([27]) showed a significant impact on limb salvage with systemic heparin when compared to patients without heparin. Some have chosen to use local heparin instillation instead of systemic administration. We use both depending upon the nature of the injury. In patients with extensive raw area, we prefer local instillation. Return of good volume distal pulses indicate successful arterial repair, whereas its absence necessitates immediate corrections. We recommend the role of intra operative angiograms in such cases. Although etiological factors of vascular injuries differ between publications, penetrating injuries are the most commonly encountered reasons.([3,7]) When cases within our series are inspected, one can see that the first rank of the etiological factors belongs to high velocity trauma in road traffic accidents, and this effects the treatment method applied, and thus saphenous vein graft interposition is used more frequently during both artery or vein injuries encountered. We usually do not prefer synthetic grafts for arterial reconstructions in trauma patients; however we recommend its use when the size of venous graft does not match to the injured vessel. The most interesting point within our series is the excessive frequency of pseudoaneurysms. The first factor causing this increase is iatrogenic reasons. These pseudoaneurysms, progressing after diagnostic or treatment aimed angiographies,([3,28])were among the most important reason within our study. Besides, there is another patient group, in whom vascular injury diagnosis is not performed with simple investigation methods in surrounding hospitals. These patients, in whom even a Doppler ultrasound is not carried out, with suspected penetrative and non-penetrative vascular injuries, came to our hospital with a pseudoaneurysm at late period. Early recognition and repair of iatrogenic arterial injuries were of paramount importance in minimizing subsequent morbidity and mortality.

In conclusion, early diagnosis and treatment during vascular injuries has an importance for saving the extremity and life of the patient. Vascular injuries require immediate surgical intervention, regardless of and localization. We think that mortality and morbidity rates of patients will highly decrease with suitable surgical technique, incase of requirement, liberal application of fasciotomy, aggressive debridement of necrotic tissues and suitable cure of other accompanying pathologies as well as post-operative suitable wound care and medical support.

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