

Retrospective Assessment of Vascular Injuries: 23 Years of Experience

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Purpose: To analyze the operation methods, injury etiologies and localizations, post-operative complications and the reasons for mortality in patients who were admitted for peripheral vascular injuries to our clinics.

Methods: From January 1979 to February 2002, 410 patients were operated for peripheral vascular injuries. Three hundred and one of the patients were male (73.5%) and 109 of them were female (26.5%), and their ages ranged between 1-88 (mean 35.5 years).

Results: The most common etiological reason was firearm injuries in 163 patients (39.8%). The most common injured artery was the brachial artery (83 patients, 22.5%) among a total of 369 patients whereas the most commonly injured vein was the common femoral vein (60 patients, 23.4%) in a total of 256 patients. Isolated venous injuries were encountered in 41 patients whereas isolated arterial injuries were detected in 154 patients (37.5%). Hospital admission duration of the patients after trauma was approximately 3 hours.

Conclusion: The extremity-salvage rate in the group was 92.3%. The hospital stay period of the patients was 21.8 days. The mortality rate was 2.6% (11 patients). (*Ann Thorac Cardiovasc Surg* 2004; 10: 373–8)

Key words: vascular trauma, injury, peripheral artery and vein

Introduction

In vascular surgery mortality and morbidity of the vascular injury is highly related to the duration between the injury and surgical intervention. Since hypovolemia commonly exists in patients with vascular injury, this disorder should be urgently corrected with sufficient volume replacement and immediate intervention. For those patients with delayed late intervention and those whose operations extended and required massive of blood transfusion, patients may develop systemic coagulopathy prob-

lems and serious physical disorders, such as hypothermia, hypoxemia, acidosis, and hyperkalemia.¹⁾ For this reason, the purpose of our study was to analyze operation methods, injury etiologies and localizations, postoperative complications and reasons for mortality of the patients who were admitted for peripheral vascular injuries to our clinic.

Since non-invasive methods are mostly sufficient and many patients need urgent intervention, the use of advanced radiological screening methods are sometimes hard to reach and may result in lost time. But the patients who were operated immediately in such cases, should be followed-up with arteriography and / or duplex ultrasonography.¹⁾

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. The ligation method was initially used by Ambroise Pare during the XVIth century.²⁾ During the First and Second World Wars, important knowledge had

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been gained both in diagnosis and treatment of vascular injuries, but vascular reconstructive methods were mainly introduced during the Korean and Vietnamese wars with tremendous progress.^{2,3)} Consequently, a dramatic decrease in amputation rates was achieved.²⁻⁵⁾

Early diagnosis and immediate intervention is mandatory in vascular injuries in order to save the extremities and lives of the patients. The developments in clinical experience, an increase of centers employing staff experienced in vascular injury, the advance in antibiotic treatments, the usage of volume expanding solutions and blood transfusions provide great assistance in the treatment of such patients.

Materials and Methods

Various surgical interventions had been performed on 410 patients who were referred to our department with vascular injuries between January 1979 and February 2002. In this study, all data, including age, sex, etiology of the vascular injuries, injury regions, additional pathologies, injured vessels, physiopathology of the vascular injury, existing complications were assessed with applied treatment methods investigated retrospectively.

The patients with co-existing injuries trauma including fracture and soft tissue damage of an extremity, nerve, soft tissue and other systems were also assessed by related departments, and then referred to the theater for revascularization within about 50 minutes of reaching to the hospital.

Results

Diagnosis of vascular injury was done approximately 3 hours after the event in many cases in which the initial diagnosis of the injury was mostly assessed by peripheral circulation with the assistance of hand Doppler and physical examination. The number of the patients diagnosed with only hand Doppler (ankle-brachial index) and clinical inspection was 305 (74.3%). In other cases, duplex ultrasonography (64 patients - 15.6%) and peripheral arteriography (41 patients - 10.0%) 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 extremity is accepted as basis for the diagnosis.

Of the patients 301 were men (73.5%), and 109 were

Table 1. Vascular injury reasons

Ethiologic cause	Number	Ratio (%)
Firearm injury	163	39.8
Stab injury	120	29.3
Blunt injury	92	22.4
Iatrogenic injury	31	7.5
Electrical injury	4	0.9

women (26.5%). The mean age was 35.5 (1-88 years).

The most common etiology of vascular injuries was a penetrating trauma (283 patients, 69.1%). Firearm injury was the most common cause among penetrating trauma in all of our series, accounting for 163 patients (39.8%). Other etiological causes were stab injuries, blunt injuries, iatrogenic injuries and electrical injuries in 120 patients (29.3%), 92 patients (22.4%), 31 patients (7.5%), and 4 patients (0.9%), respectively (Table 1).

The pathophysiology and pattern of arterial injuries were attributed to complete arterial cut in 245 (66.4%), partial arterial cut in 95 (25.7%) and blunt arterial injury without cut in 29 (7.9%).

The extremities were the most affected parts with a total of 380 patients (92.7%). Intrathoracic vessels, intraabdominal vessels, neck region vessels were injured in 11 patients (2.7%), 11 patients (2.7%) and 4 patients (1.0%), respectively. Lower extremity injuries account for 239 patients (%58.3), whereas upper-extremity injuries occur in 141 patients (%34.4). Intrathoracic and intraabdominal vessel injuries were found to be low because of two major factors. First, many injuries are minor traumas only sufficient to scare or alert the victim. These traumas are localized to the extremities. The other factor depends on the geographic conditions. Many patients die due to time loss after the event.

The most commonly encountered arterial injuries were those of the brachial artery, which occur in 83 patients (22.5%). Other injured arteries were as follows: Common femoral artery, popliteal artery, superficial femoral artery, radial artery, ulnar artery, axillary artery, anterior tibial artery, posterior tibial artery and other arteries in 78 patients (21.1%), 63 patients (17.1%), 44 patients (12.0%), 23 patients (6.2%), 18 patients (4.8%), 10 patients (2.7%), 10 patients (2.7%), 10 patients (2.7%) and 30 patients (8.1%), respectively. Distribution of vascular injuries and localization can be seen in Table 2.

The most common venous injuries were found to be in the common femoral vein in 60 patients (23.4%). Popliteal vein in 59 patients (23.0%), brachial vein in 53 patients

Table 2. Distribution of vascular injuries

Localization	Artery	Vein	Artery and vein	Total
Subclavian	1	-	3	4
Axillary	7	1	3	11
Brachial	32	2	51	85
Ulnar and radial	18	1	23	42
Common femoral	32	14	46	92
Superficial femoral	30	8	14	52
Popliteal	13	9	50	72
Anterior and posterior tibial	8	3	12	23
Thoracic aorta	7	2	4	13
Abdominal aorta	6	1	5	12
Others	-	-	4	4
Total	154	41	215	410

Table 3. Additional pathologies

Pathology	Number	Ratio (%)
Bone fracture	138	33.6
Nerve injuries	89	21.7
Traumatic pseudoaneurysm	29	7.0
A-V fistula	6	1.4

Table 5. Applied surgical interventions (venous)

Surgical intervention	Number	Ratio (%)
Saphenous vein graft interposition	98	38.2
Ligation	62	24.2
Lateral venoraphy	48	18.8
End-to-end anastomosis	48	18.8

(20.7%), ulnar and radial artery sideways veins in 24 patients (9.3%), superficial femoral veins in 22 patients (8.6%), anterior and posterior tibial veins in 15 patients (5.9%), subclavian veins and axillary veins in 7 patients (2.8%), and other veins in 16 patients (6.3%) respectively were injured. Isolated vein injuries were detected by physical examination, duplex USG, and surgical exploration.

Nerve injuries were seen commonly with popliteal, axillary and brachial vessel injuries. Compartment syndrome developed mainly in popliteal and distal parts of the popliteal artery region in the lower extremity. In the upper part, compartment syndrome was detected with wide tissue damage. Vascular injuries and additional pathologies are shown in Table 3.

Further, associated operations were performed to the additional pathologies encountered in our cases by the related disciplines. Surgical treatment methods are summarized in connection with artery and vein injuries in Table 4 and 5.

Table 4. Applied surgical interventions (arterial)

Surgical intervention	Number	Ratio (%)
Saphenous vein graft interposition	160	43.4
End-to-end anastomosis	83	22.5
Lateral arterioraphy	66	17.8
PTFE graft interposition	25	6.7
Ligation	24	6.5
Other (cephalic, basilic vein, embolectomy)	11	3.0

Table 6. Complications

Complication	Number	Ratio (%)
Infection	59	14.3
Compartment syndrome	26	6.3
Amputation	21	5.1
Death	11	2.6

Complications in post-operative patients can be seen in the following Table 6.

Eleven patients within our group died postoperatively. Six of the mortal injuries were with intrathoracic or intraabdominal large vascular injuries as a result of fire-arm shots. Some of these patients died during induction of anesthesia, while others survived intraoperatively but died in the intensive care unit due to systemic coagulopathy progression although successful vascular interventions were done. Systemic diseases caused the resulting deaths, and one occurred due to an arrhythmia problem which progressed post-operatively.

Although revascularization was maintained in an appropriate period, in 21 patients amputation was needed due to associated serious wounds such as wide soft tissue injury, or intractable fractures in addition to nerve injuries.

In the cases which the period between revascularization and vascular injury exceeds 6 hours, various fasciotomies were applied to the extremity within the same time. In all cases, besides tetanus prophylaxis, 1st generation cephalosporine combination with aminoglycoside were administered pre-operatively as empiric therapy and continued up to 5 days in severely contaminated wounds or for 2 days for cleaner wounds. Infected wounds were treated with the appropriate antibiotics according to cultural sensitivity along with frequent wound dressings. The patients with minor vascular injuries received Dextrane 40 with pentoxifylline for 5 days.

The mortality ratio was found to be 2.6% with 11 patients, whereas extremity salvage rate was 92.3%.

A-V fistulae and pseudoaneurysm occurred in 6 (1.4%) and 29 (7.0%) patients, respectively. Those late complications were treated with appropriate methods.

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 92.3%.

According to some authors, approximately 90% of the arterial injuries exist due to penetrating traumas.^{7,8} Blunt traumas compose the remaining 10% ratio,⁹ while others reported even over 50%.⁶ In our study, blunt traumas are reported as 22.4%. Firearm injuries among penetrating traumas are very common in our analysis (39.8%). In reports, which were issued from war districts^{10,11} and in some civil settlement regions,³ firearm injuries are commonly reported. But in the series of some authors,^{5,7} frequency of firearm injuries also within civil regions is behind the other etiological reasons. Two factors play a role in the huge amount of firearm injuries in our region. Initially, having a gun in this local area has been a custom for many years particularly for men. 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. Unfortunately, the frequency of firearm injury in our hospital is high.

Vascular injuries are frequent among young male population,^{5,7} and male patients compose 73.5% of the cases.

Vessels, nerves and bones may be injured together due to their close relation anatomically.^{12,13} Bone fractures and nerve lesions were also accompanying 33.6% and 21.7% in our study, respectively. The patients with bone

fracture, nerve injury, head trauma and intra-abdominal trauma 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.¹⁴

Peripheral angiography in vascular injuries is controversial. Some authors are suggesting angiography to every pre-operative patient,^{6,8,15,16} while others don't. Many clinicians report their successful vascular injury results without angiography.^{5,7,17,18} Since the Doppler ultrasound is 95% sensitive and 97% specific in experienced hands, its use reduces the spent time with respect to angiography.^{7,11,19} 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 when vascular injury is expected. 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. Six of our patients died before operation because of great vessel injury and consequent hypovolemic shock. In arterial injuries, successful results were obtained in arterial reconstruction procedures, which were held 6-8 hours after the event.^{15,20} Almost all of the amputation performed in our patients was late cases that were revascularized after 8 hours following the injury. Blunt trauma, extremity without pulse, more than one tibial vascular damage and multiple fractures are the factors that increased the amputation rates.^{1,9,21} 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.²¹ In our retrospective study, 59 patients developed infection and a patient died due to systemic disease encountered with advanced age. Amputation was required for 4 patients because of infection. Other patients did well with appropriate treatment methods.

Fasciotomy is suggested especially in lower extremity



Fig. 1. Preoperative MR angiography imaging of anterior tibial artery pseudoaneurysm.²⁵⁾

injuries by lots of authors.^{17,22,23)} Compartment syndrome of the muscles can progress after late revascularization, which is ischemic for a long period. Under these conditions, immediately decompressing fasciotomies should be applied.^{9,21)} In our clinic, following lower extremity injuries, fasciotomies were performed to the 4 anatomic compartments within the related extremity.

Fewer thrombotic events occurred with respect to some publications.⁵⁾ We encountered few thrombotic events after end-to-end anastomosis method, applied to approximately 83 arterial injuries. 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. Using heparin with a prophylactic dose (500 IU/h), leads to greater patency rates only on the vessels with a medium and large diameter.

Although etiological factors of vascular injuries differ between publications, penetrating injuries are the most commonly encountered reasons.^{3,7)} Firearm injuries, compared to stab injuries, cause greater damage and more serious tissue loss directly proportional to its kinetic energy.³⁾ When cases within our series are inspected, one can see that the first rank of the etiological factors belongs to firearm injuries, and this effects the treatment



Fig. 2. Postoperative peripheral angiography (saphenous vein interposition to anterior tibial artery).²⁵⁾

method applied, and thus saphenous vein graft interposition is used more frequently during both artery or vein injuries encountered. Actually the most popular conduits; PTFE or Dacron grafts for arteries with a diameter larger than 6-8 mm and autogenous saphenous vein for venous reconstruction or arteries with a diameter of less than 5 mm, are strongly recommended.¹⁾

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,^{3,24)} 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. One anterior tibial artery pseudoaneurysm case, presented with pain and peripheral circulation complaints 18 months after firearm injury, was one of the best examples (Fig. 1 and 2).²⁵⁾ We believe that advanced imaging methods should be applied to all patients especially with firearm injury, stab injury and particularly to patients with blunt trauma in

whom pathological findings with physical inspection and hand Doppler were undetermined.

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, in case 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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