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Vascular Injuries of the Limbs: a Fifteen-year Georgian Experience

A. Razmadze

Central Railway Clinical Hospital, Tbilisi, Georgia

Objectives: to analyse the causes of injury, surgical approaches, outcome and complication of vascular trauma of the upper and lower limbs in patients with vascular injuries operated on over a period between 1981 and 1995.

Patients: in 157 patients, the injuries were penetrating in 136 cases and blunt in 21. Isolated vascular trauma was present in 92 (58.6%) patients, 65 cases (41.4%) were aggravated by concomitant bone fractures, severe nerve and soft tissue damage. The most frequently injured vessels were the superficial femoral (20.6%) and brachial (19.1%) arteries.

Results: saphenous vein interposition grafting was applied with good results in 34 patients, polytetrafluoroethylene grafts were used in three cases, end-to-end anastomoses in 42 cases, venous bypasses in five cases, and venous patches in seven cases. Seventeen patients underwent arterial repair and nine, venous repair. Fasciotomy was used in 18 cases, and vessels were ligated in 14 cases.

Blood flow was restored in 91 patients (58.0%), and collaterals compensated in 31 cases (19.7%). Fourteen primary and nine secondary amputations were performed. Twelve patients died. The limb salvage rate was 77.7% (84.1% among surviving patients).

Conclusions: most vascular injuries associated with limb trauma can be managed successfully unless associated by severe concomitant damage to bones, nerves and soft tissues.

Key Words: Vascular trauma; Extremities; Surgical management.

Introduction

The incidence of vascular injuries has increased worldwide during the last few years.^{1,2} Very often these injuries are associated with complex trauma to extremities, and the risk of fatalities is very high unless prompt diagnosis is made and appropriate surgical management is applied.^{3,4} Although vascular trauma is uncommon in some developed countries, being due to road traffic and other accidents,^{5,6} firearm-caused military vascular injuries as well as those related to civilian violence still constitute a serious problem^{7,8} in others. For the injuries resulting from the use of firearms, it is generally believed that fragment wounds frequently cause military vascular injuries, whereas gunshot wounds make up the majority of civilian injuries.⁹

In the present study, the author's fifteen-year experience in surgical management of vascular injuries of the upper and lower limbs has been reviewed retrospectively. Causes of injury, surgical approaches, outcome and complications of vascular trauma have

been analysed in terms of selection of the optimal management strategies.

Patients and Methods

The records of 157 patients who underwent surgical treatment for vascular trauma over the period between January 1981 and December 1995 were included. Most of the operations were performed at the Central Railway Hospital (Tbilisi) and Republican Centre of Emergency Medical Aid and Disaster Medicine of the Ministry of Health of the Republic of Georgia, which provides emergency services for the whole country. In 32 cases (20.5%) patients were transported into the Central Railway Hospital, but usually (in 125 cases) the author travelled by car or by helicopter to local hospitals, where urgent operations were performed. The distances varied between 80 and 350 km. Decisions on the transportation risks were made by initial telephone triage. Among the 157 patients, 145 (92.3%) were men and 12 (7.7%) were women. The median age was 24 years (range 5–51).

The main causes of the vascular injuries are shown

* Please address all correspondence to: Dr. A. Loktionov, Dunn Human Nutrition Unit, Hills Road, Cambridge CB2 2DH, UK.

Table 1. Causes of vascular injuries in the 157 patients.

Cause	Number of cases (%)
Stab wounds	39 (24.8%)
Gunshot wounds	42 (26.8%)
Road accidents	48 (30.6%)
Other accidents	28 (17.8%)
Total	157

Table 2. Types of vascular injury.

Associated with a bone fracture	65 (41.4%)
Penetrating	59 (37.6%)
Blunt	6 (3.8%)
Not associated with a bone fracture	92 (58.6%)
Penetrating	77 (49.0%)
Blunt	15 (9.6%)

in Table 1. In 136 cases (86.6%) the injuries were penetrating, and 21 patients (13.4%) had blunt vascular injuries (Table 2). In 92 cases (58.6%) patients suffered isolated vascular damage, and in 65 patients (41.4%) concomitant bone fractures, nerve injuries and/or massive soft tissue damage were observed. Head injuries were seen in nine patients (5.7%). Peripheral nerve injuries were documented in 39 cases (24.8%). Isolated arterial and venous injuries were found in 97 (61.8%) and 18 (11.5%) cases, respectively. Simultaneous damage to arteries and veins was diagnosed in 42 cases (26.7%). The most commonly injured vessels were superficial femoral (20.6%) and brachial (19.1%) arteries (Table 3).

The initial management of the patients was conducted according to the Advanced Trauma Life Support principles.¹⁰ Preoperative angiography was performed in three cases (1.9%), and intraoperative in five cases (3.2%). Duplex ultrasonography was not used in any patient, but preoperative pressure measurements using a hand-held Doppler flowmeter were carried out on 149 patients (94.9%).

One hundred and sixty-three primary operations

were performed in the 157 patients (Table 4). Thirty-four (20.9%) were treated by saphenous vein interposition grafting and three cases (1.8%) were managed by polytetrafluoroethylene interposition graft. End-to-end anastomosis was applied in 42 cases (25.8%), five patients (3.1%) had autologous vein bypass, and venous patch was used in seven patients (4.3%). Arterial and venous repairs were performed in 17 (10.4%) and nine (5.5%) patients respectively. The vessels were ligated in 14 cases (8.6%), and fasciotomy was performed in 18 patients (11.0%). Primary amputations were carried out in 14 patients (8.6%) when the limbs were unsalvageable. In all those 14 cases the time elapsed between the injury and the beginning of the operation was over 18 hours.

Results

Outcomes of treatment are shown in Tables 5, 6 and 7. The overall mortality was 7.6% (12 cases). Seven patients died of exsanguination or secondary coagulopathy in the operating theatre. The remaining five patients died within the next three days (four of severe head injuries) in the intensive care unit from irreversible shock due to disseminated intravascular coagulopathy. It should be noted that eight deaths as well as 11 primary amputations occurred in the group of patients with simultaneous injuries of arteries and veins (Table 7), which were usually associated with severe concomitant trauma of bones, nerves and soft tissues. One hundred and forty-five patients (92.3%) survived primary operations. Excluding 14 primary amputations, there were 131 patients, in whom the treatment results and complications could be assessed comprehensively. In this group thrombosis of the repaired vessels was a common complication after end-to-end anastomoses, which were frequently used at the initial stages of this series. It occurred in 16 cases (12.2% of the 131 patients), and thrombectomies were

Table 3. Location of vascular injury.

Location	Artery	Vein	Artery and vein	Total
Subclavian	3 (3.1%)	1 (5.6%)	1 (2.4%)	5 (3.2%)
Axillary	7 (7.2%)	—	2 (4.8%)	9 (5.7%)
Brachial	26 (26.8%)	1 (5.6%)	4 (9.5%)	31 (19.7%)
Ulnar and radial	9 (9.3%)	4 (22.2%)	4 (9.5%)	17 (10.8%)
External iliac	3 (3.1%)	1 (5.6%)	—	4 (2.5%)
Common femoral	7 (7.2%)	1 (5.6%)	3 (7.1%)	11 (7.0%)
Superficial and deep femoral	28 (28.9%)	3 (16.7%)	8 (19.0%)	39 (24.8%)
Popliteal	6 (6.2%)	2 (11.1%)	4 (9.5%)	12 (7.6%)
Anterior and posterior tibial	8 (8.2%)	5 (27.8%)	16 (38.1%)	29 (18.5%)
Total	97 (100%)	18 (100%)	42 (100%)	157 (100%)

Table 4. Surgical approaches applied in 163 primary operations on the 157 patients.

End-to-end anastomoses	42 (25.8%)
Interpositions	
vein	34 (20.9%)
PTFE*	3 (1.8%)
Venous bypass procedures	5 (3.1%)
femoropopliteal	3 (1.8%)
axillobrachial	1 (0.6%)
femorofemoral	1 (0.6%)
Venous patch	7 (4.3%)
Arterial repair	17 (10.4%)
Ligation	14 (8.6%)
Fasciotomy	18 (11.0%)
Venous repair	9 (5.5%)
Primary amputations	14 (8.6%)
arm	2 (1.2%)
below knee	9 (5.5%)
above knee	3 (1.8%)
Total	163 (100%)**

* PTFE = polytetrafluoroethylene. ** In a few cases multiple procedures were performed in the same patient.

performed after vessel resections. In five of these cases secondary end-to-end anastomoses of the repaired arteries were successfully performed and circulation was restored. In nine patients (6.9%) secondary lower limb amputations had to be done (five below-knee and four above-knee). In eight of them fasciotomies were attempted, but without success. All these patients

suffered severe soft-tissue damage and skeletal injuries.

At the later stages of this work venous grafts were preferred to end-to-end anastomoses, and no complications leading to amputations were observed. Results shown in Tables 5, 6 and 7 demonstrate that blood flow was restored in 91 patients (58.0%), and collaterals compensated in 31 cases (19.7%). Thus, outcome on discharge was good in 122 cases with limb-salvage rate of 77.7% (84.1% among surviving patients). There was no opportunity of long-term follow-up in most cases.

Discussion

Vascular injuries of the extremities remain the most important cause of limb amputations, despite application of modern approaches to blood flow restoration. According to some authors, amputation rate may reach 78%.^{2,3} In this study a limb salvage rate of 77.7% was reached, but it is obvious that the cause of vascular injury strongly affects outcome. In several studies, penetrating injuries predominantly, cause vascular damage.^{5,7,11} On the other hand, there are observations of blunt trauma being the cause of over

Table 5. Location of arterial injuries and management outcome (three primary amputations excluded).

Location	Restored blood flow	Collateral compensation	Amputation	Death	Total
Subclavian	2	—	1	—	3
Axillary	5	1	—	—	6
Brachial	22	1	1	—	24
Ulnar and radial	7	2	—	—	9
External iliac	1	—	—	2	3
Common femoral	5	—	1	1	7
Superficial and deep femoral	21	2	3	1	27
Popliteal	4	1	—	—	5
Anterior and posterior tibial	7	3	—	—	10
Total	74	10	6	4	94

Table 6. Location of venous injuries and management outcome.

Location	Restored blood flow	Collateral compensation	Amputation	Death	Total
Subclavian	—	1	—	—	1
Brachial	1	—	—	—	1
Ulnar and radial	—	4	—	—	4
External iliac	1	—	—	—	1
Common femoral	1	—	—	—	1
Superficial and deep femoral	2	1	—	—	3
Popliteal	—	2	—	—	2
Anterior and posterior tibial	—	5	—	—	5
Total	5	13	—	—	18

Table 7. Location of simultaneous arterial and venous injuries and management outcome (11 primary amputations excluded).

Location	Restored blood flow	Collateral compensation	Amputation	Death	Total
Subclavian	—	—	—	1	1
Axillary	—	—	—	2	2
Brachial	2	—	1	1	4
Ulnar and radial	1	3	—	—	4
Common femoral	2	—	—	1	3
Superficial and deep femoral	1	2	—	2	5
Popliteal	2	1	1	1	5
Anterior and posterior tibial	4	2	1	—	7
Total	12	8	3	8	31

50% of vascular injuries.^{3,4} In the present series of cases the vast majority of injuries resulted from penetrating trauma. Gunshot wounds and stabbings taken together accounted for 51.6% of all vascular injuries observed, and 35% of the accident injuries were penetrating as well. Consequently, the diagnostic and treatment approaches, while remaining as aggressive as possible, should have been appropriately adopted to the situation.

The role of angiography in patients with vascular trauma appears to be controversial. Its use is advocated by some authors^{3,9,12} and opposed by others, who quote impressive results obtained without arteriography.^{13,14} Of all patients of this series only five underwent intraoperative arteriography, whereas Doppler pressure measurements were extensively and successfully employed. These results support the concept of selective arteriography alongside careful clinical examination, duplex ultrasonography and Doppler pressure measurement.^{5,13,15,16}

In some cases peripheral vascular injuries are accompanied by other severe problems such as extensive brain damage, abdominal trauma, severe bone fractures etc. All these life-threatening injuries require immediate attention and should be managed by neurosurgeons or general surgeons, preferably simultaneously. In the present study all twelve perioperative deaths resulted from such severe concomitant injuries.

In 41.4% of the patients vascular injuries were associated with limb fractures. In general, external fixation appears to be preferable because of its technical simplicity and low infection risk. Most cases of uncomplicated fractures resulted in complete restoration of limb function. The presence of extensive soft tissue damage, especially in combination with bone fractures, was a major negative factor in determining limb salvage. This type of combined trauma (open bone fractures with massive damage to muscles and nerves) was observed in all 14 cases requiring primary amputation.

The experience accumulated during the first years of this work resulted in a gradual change in the author's attitude towards different surgical techniques employed. Early in this series the preferable methods were end-to-end anastomoses and direct sutures of injured arteries. However, thrombosis was a common complication, and secondary thrombectomies were successful in only five patients, and nine secondary amputations had to be done. With time, the author came to the conclusion that autologous vein should be considered the material of choice, and venous grafts were used whenever possible with improved results. Fasciotomy is recommended by many authors,^{14,17,18} but it is hardly necessary in all patients with lower limb vascular trauma,^{5,19} especially when early intervention was possible. Experience of the present series indicates that fasciotomy is helpful in situations when restoration of blood flow is delayed.

The results of the present study allow us to conclude that an aggressive approach, with early intervention, careful diagnostic investigation of damaged vessels and reconstructive techniques, allows successful management of most of the vascular injuries. Sometimes these urgent measures are delayed due to insufficient vascular surgical skills of local surgeons. Most of the patients in this study were treated in local hospitals to avoid transportation risks, which may be serious in a mountainous country like Georgia. Although general conditions, availability of equipment and skills of general surgeons involved in initial treatment of the patients varied from site to site, the author believes that in many cases urgent transportation of an experienced vascular surgeon to provide earlier specialised management of vascular trauma is preferable over hazardous transportation of patients. High rates of survival and limb salvage can be achieved, unless vascular trauma is complicated by severe concomitant damage to bones, nerves and soft tissues or appropriate reconstructive procedures are delayed.

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