Extremity Vascular Trauma-the Continuing Challenge.

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A retrospective study of 36 consecutive patients with extremity vascular trauma managed by the South Surgical Ward trauma team between February 1998 to January 2000. All our patients were men with a mean age of 27 years. The commonest clinical presentation was with haemorrhage (75%) or ischemia (58.4%). The mode of injury was gunshot wounds (75%), blunt trauma (20%) and iatrogenic injuries (5%). The most commonly injured arteries were the superficial femoral (27.5%), the popliteal (24%) and the brachial (24%). The techniques utilized for repair of the arterial injuries were autogenous reverse vein grafting (51.7%), end-to-end anastomosis (27.6%) and lateral repair (3.4%). 17.2 % of the arterial injuries were ligated. 43 % of the venous injuries underwent lateral venorrhaphy while 57 % were ligated. Tri-compartment leg fasciotomies were carried out in 14 patients. The commonest complication was vein graft thrombosis (16.7%). Our amputation rate and mortality were both at 6.9%. Early transport of the patient to a good surgical facility, good surgical judgement and the liberal use of vein grafts improves the outcome in vascular injuries of the extremities.

Key Words: Vascular injuries, Extremity vascular trauma, Peripheral vascular injuries.

Wounds that involve the extremity vessels are a significant cause of mortality and morbidity and may be associated with serious acute and chronic sequelae[1]. The magnitude of the problem can be seen in a classic study in which Oller et al compared vascular with non-vascular trauma in 1148 vascular injuries suffered by 978 patients reported from 8 trauma centers to a trauma registry (North Carolina Trauma Registry, NCTR, 1992) data base containing 26,617 patients entered over a 39 month time interval[25]. Vascular trauma was associated with a longer hospital stay (13 vs. 10 days), a longer ICU stay (5 vs. 4 days), greater hospital costs ($ 22,500 vs. $12,300) and a higher post-admission mortality (13.1% vs. 6.2 %).

Mayo Hospital, Lahore is the biggest and busiest trauma center in Pakistan and receives lots of patients with all kinds of trauma[3]. Extremity vascular injuries are frequently encountered[10]. The limited facilities and scarce resources available to us make the management of these injuries even more challenging.

The purpose of this study was to review our management of vascular injuries of the extremities with the objective of bringing about improvements.

Patients and Methods.

This is retrospective study of 36 patients with extremity vascular trauma managed by our trauma team at South Surgical Ward, Mayo Hospital, Lahore, between February 1998 to January 2000.

All patients were resuscitated according to ATLS recommendations. Patients received in shock were shifted directly to the operating room and resuscitated on table.

All patients were operated on the basis of clinical findings suggesting a vascular injury ("hard" and "soft" signs). The entire injured extremity was prepared, draped and included in the operative field. A contralateral uninjured lower or upper extremity was also prepared and included in the operative field if it was anticipated that an autogenous vein graft would be required. In all patients, incisions on the extremities were placed longitudinally over the injured vessel and extended proximally and/or distally when required. Proximal and distal vascular control was first obtained prior to directly exposing a vascular injury. With control established, the injured artery was inspected and debrided ("circumcised!") to macroscopically normal intima. When required, an appropriate sized Fogarty catheter was carefully passed both proximal and distal to the arterial injury in order to remove intraluminal thrombus. The arterial lumen was then flushed with heparinized normal saline solution. Systemic post-operative heparin was used very selectively. Repair of an injured artery was accomplished by either an autogenous interposition vein graft, an end-to-end anastomosis or a lateral repair. We used autogenous vein grafts, usually the proximal great saphenous vein harvested from an uninjured leg in all our cases that required a graft. In cases of isolated venous injury or venous injury associated with an arterial injury, either lateral repair/venorrhaphy or ligation was carried out depending on circumstances. Prolene 5-0 or 6-0 sutures was used in all our vascular repairs. It was desired that all completed vascular repairs would be free of excessive tension and well covered with available viable soft tissue in all cases. Tri-compartment lower leg fasciotomoies were done in all cases of combined arterial and venous injuries and delayed ischemia.

Results

The total number of patients in this study was 36. They were all male. The mean age was 27 years (range 18-50 years).

The mode of injury in 75% of our patients was firearm / penetrating trauma while in 20% it was blunt trauma. Iatrogenic injuries were a cause in a very small percentage of patients.(Table 1a.).

Table 1a. Mode of injury. n = 36

Mechanism	%age
Firearm	75
Blunt trauma	20
Iatrogenic	5

The average time between injury and presenting to us was 4.5 hours (range 30 min.-13 hours).

The commonest mode of clinical presentation was with hemorrhage (table 1b) while more than half of the patients presented in shock and/or with clinical signs of ischemia of the extremity.

Table 1b. Clinical presentation.

Clinical presentation.	n=36
Hemorrhage.	27 (75%)
Ischemia	21 (58.4%)
Shock	19 (52.7%)
A V Fistula	2 (5.5%)
Pulsating Hematoma.	1(2.75%)
Palpable Pulses	3 (10.34%)

Twenty nine patients had arterial injuries. 14 patients out of these 29 with arterial injuries also had an associated venous injury. 7 patients were found to have isolated venous injuries only. The most commonly injured artery in our series was the superficial femoral followed by the popliteal and brachial arteries which were the next most commonly injured arteries (Table 2.).

Table 2. Distribution of arterial injuries

Type of vessel.	No.	%age
Superficial Femoral.	8	27.5
Common Femoral.	2	7
Popliteal.	7	24
Posterior Tibial.	2	7
Subclavian.	1	3.5
Axillary.	1	3.5
Brachial.	7	24
Radial.	1	3.5
Total	29	100

As shown in Table 3, reverse vein grafting was the commonest method (51.7%) utilized to repair arterial injuries followed by end to end anastomosis (27.6%). A lateral repair was carried out in only 1 patient. 5 arterial ligations were also done. Associated venous injuries were dealt with either by ligation (57%) or lateral repair (43%). In case of isolated venous injuries, ligations was performed in 57% and lateral repairs in 43%, depending on the hemodynamic status of the patient.

Fasciotomies were added in 14 patients with injury to arteries and veins both (Table 3).

Table 3. Technique of repair.

Vessel	Type of repair	No.(%)
Arterial	End to end	8(27.6%)
n=29	Vein graft	15(51.7%)
	Ligation	5(17.2%)
	Lateral repair	1(3.4%)
Isolated	Ligation	4(57%)
Venous	Lateral repair	3(43%)
n=7		
Associated	Ligation	8(57%)
Venous	Lateral repair	6(43%)
n=14		***Fasciotomy Added***

Thrombosis of the vein graft and fasciotomy wound infection were the commonest complications (Table 4). 3 of the patients with vein graft thrombosis underwent prompt re-exploration with revision of the graft in 2 of them while 1 of these patients had the thrombus removed with the help of a Fogarty's balloon catheter. As shown in table 4, the amputation rate as well as the mortality in our series was 6.9%.

Table 4. Complications.

Type	n=	%age
Thrombosis	4*	16.7
Secondary haemorrhage	1	4.2
Fasciotomy wound infection	4	13.8
Amputation	2	6.9
Mortality	2	6.9

Discussion

In this time of increasing civilian violence and the "Klashnikov culture" prevalent in our society, firearms remain the commonest cause of extremity vascular trauma[26].

As investigations like doppler, colour duplex and arteriography are not freely available in our emergency department, we surgically explored all the patients in our series on clinical grounds only ("hard" and "soft" signs) and found this to be the safest and best approach[10,11,12,13]. It is interesting to note (Table 1b) that around 10 % of our patients presented with clinically palpable pulses although later on upon formal surgical exploration they were found to have significant arterial injuries. Erykberg et al have suggested that the overall predictive value of physical examination of penetrating extremity trauma for vascular injury approaches 100%[27].

Part of the reason for the successful outcomes of the majority of our patients is our aggressive protocol for prompt volume resuscitation in the emergency room as well as on the operating table. An inadequate initial resuscitation will result in a poor outcome and is doomed to failure regardless of the technical skill of the surgeon[9].

Venous ligation versus venous repair is an important

issue. In case of venous injuries, when the injury is limited and an end-to-end or lateral venorrhaphy is possible, repair should be performed unless the patient is hemodynamically unstable. When a more extensive venous injury is present which requires an interposition or panel graft for repair, the advisability of the repair is controversial[20]. This is especially true when the patient is hemodynamically unstable According to one study, 39% of the venous repairs thrombose[21]. According to the same author, if an interposition graft is used, the failure rate is close to 60%. In this series, limb salvage was 100% and unaffected by failure of the venous repair! In our own experience, repair of major venous injuries in the stable patient is reasonable but when venous repair is extremely complex or the patient is hemodynamically unstable, ligation is appropriate. Postoperative edema after venous ligation, which is usually transient, can be controlled by elastic crepe bandaging and limb elevation[14].

Tri-compartment leg fasciotomies were used liberally in our patients when a combined arterial and venous injury existed and when a prolonged period of shock and/or arterial occlusion had occurred[23]. Skin grafting, alone or in combination with delayed primary closure of the fasciotomy wounds was employed to close the fasciotomies later on in all our cases. Wound infection was commoner in patients undergoing fasciotomy closure utilizing delayed primary closure as compared to the patients who were grafted[24].

Military and civilian experience has contributed to the way extremity vascular injuries are managed today[1,2,4,5,6]. During World War II, when ligation of injured arteries was routinely performed, the amputation rate for popliteal artery injuries was 73 %[1]. On account of continued improvements and refinements in the management of vascular injuries and formal vascular repairs being carried out through the Korean and Vietnam wars, the amputation rate for popliteal artery injuries declined to about 32%[5,2]. Considerably lower amputation rates for popliteal artery injuries have been reported by more recent authors including us and are about 0% and 7% for penetrating and blunt trauma respectively[7,8,18,19]. Thrombosis of the vein graft was our commonest complication . This was most commonly seen when reverse vein grafts were carried out to repair injuries of the popliteal artery. We believe that the cause of repair / graft failure in all cases was either a technical error or less than satisfactory surgical technique. The operative exposure, vascular control, and repair should be tailored to suit the injury. Reviewing this series some points of technical importance were noted.

In all our patients, after establishing vascular control, great care was taken to inspect and meticulously debride the injured vessels to macroscopically normal intima for a more secure and healthy repair or anastomosis[14]. This "circumcision" of the injured vessel, as we call it, also ensured that no tags or shreds of adventitia would achieve inversion into the vessel lumen after the repair or anastomosis was complete, and thus jeopardize the integrity and patency of our vascular repair/anastomosis.

Fogarty balloon catheters were always "test inflated" on the operating table just prior to actual use. When passing a Fogarty balloon catheter proximal and distil to an arterial injury in order to remove an intraluminal thrombus, great care was exercised not to over-inflate the balloon, thus damaging the endothelial lining and producing arterial spasm or thrombosis[14]. Care was also taken not to rupture the balloon within the lumen of the artery thereby sending a portion of the balloon as an embolus into the distil circulation.

We were careful not to pinch the arterial wall with forceps during dissection as this also may cause intimal damage and subsequent thrombosis / spasm, as would over-enthusiastic traction on a vascular sling by an excited assistant. We learnt that this same complication was also caused by the application of bulldog clips directly onto a vein graft or by "balloon angioplasty" of the vein graft in an attempt to increase it's diameter to overcome a lumen discrepancy. These maneuvers were carefully avoided. Bulldog clips were only applied to the arterial side when interposing a vein graft and the distil anastomosis was usually completed first. Autogenous vein grafts were preferentially harvested from the great saphenous vein high up in the thigh from the uninjured limb thus ensuring an adequate vascular lumen.

Based on our previous experiences and considering the wound infection rates of our high turnover emergency theatres[3], prosthetic grafts were not used in any of the patients in the present series. Autogenous vein, usually the great saphenous vein from an uninjured thigh, was the graft of choice[5,6,15,16].

In the present series systemic post-operative heparin was only used when either the popliteal vessels had been repaired or when any other venous repair had been performed and also when it was not contraindicated e.g. associated severe thoracoabdominal injuries or head injuries[18,19]. A copious flush of the arterial lumen with heparinized saline just prior to an anastomosis or repair was deemed to suffice in most of our cases where an arterial repair only had been carried out. In some cases, systemic heparinization can be a helpful adjunct to prevent thrombosis or thrombus propagation in patients devoid of contraindications to anticoagulation[11,12,14,18,19]. However, as previously discussed, we were very selective in it's use. Experimental evidence suggests that heparin may also limit reperfusion injury[17].

In most of our cases of combined vascular and orthopedic injuries, the arterial repair was performed first, with circulation of the limb established prior to orthopedic stabalization[22], with careful re-inspection of the repair prior to final wound closure.

In our series, the amputation rate and mortality were both at 6.9%. Factors affecting limb loss were delayed presentation, extensive associated tissue damage and improper or faulty surgical technique. Mortality was

affected by prolonged shock, associated major extra-vascular injuries, prolonged surgery (duration of surgery more than 5 hours), poor back up facilities and surgical judgement. A comparison of our amputation, mortality and repair failure rates can be made with the results of other workers[28,29,30,31] (Table 5).

Table 5.Comparative Data

Author	n=	Mortality	Amputation rate	Repair Failur.
Drapanas & Hewitt, 1970	226	6%	7.1%	9.3%
MO Perry, 1971	165	10.4%	2%	6%
L Lim,1980	204	NIL	1.2%	NIL
Cargile,1992	112	5%	ONE	4.7%
Trooskin 1993	51	9.6%	NIL	1.2%
Majid et al, 2000	36	6.9%	6.9%	8.3%

We conclude that good surgical judgement and the liberal use of vein grafts improve the outcome in gunshot vascular injuries of the extremities. Early transport of the patients to a good surgical facility remains the grey area of vascular trauma. Finally, it is important to document the clinical durability of the approach taken. Only in this way can future management of this difficult, and frequently encountered, problem improve.

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