

Factors Influencing the Outcome of Arterial Injuries

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This is a retrospective study carried during January 1999 to December 1999 at North Surgical ward, Mayo Hospital, Lahore. Eighty-two patients were received during this period. Of these 70 were male and 12 were females. Age ranged from 6 to 60 years with mean age of 24 years. At the time of presentation 22 patients were in a stable condition and 60 in a state of shock. Sixty-eight patients had penetrating injuries, as compared to 14 with blunt trauma. The most common vessel injured was superficial femoral (18), followed by common femoral (17), popliteal (8) and brachial (8). The commonest repair performed was end-to-end anastomosis (19) followed by reverse vein graft (13) Thirty one patients had 58 different complications. Fifty percent patients had either single compartment or multiple compartment fasciotomies. Five patients required amputation. Mobility was 37.8% and mortality was 3.7%. The higher incidence of morbidity and mortality was due to shotgun injuries, late presentation, poor resuscitation at referral centers and poor patient selection for vascular repair.

Key words: Arterial injuries, reverse vein graft, fasciotomies.

The field of- vascular trauma is one of the youngest in surgery. This field is rapidly developing especially in the area of most common sites of vascular injury, the extremities¹. Considering the rising incidence of trauma following road traffic accidents and social crimes, it has become very important for the surgeon to be familiar with all the practical proceedings required to deal with these emergencies. The surgeon receiving this kind of emergency is mainly bearing the responsibility for the following.

Using all the ways of limb salvage.

Life Saving.

Rehabilitation of the patient.

The study is taken to determine the influence of prognostic factors on the outcome of management of peripheral vascular trauma.

Materials and Methods

During Jan 1996 to Dec 1999 every case with peripheral vascular injury presented in the emergency of North surgical unit of Mayo Hospital Lahore was included in the study. All injured extremities were evaluated for the presence of vascular trauma. Most significant extremity vascular trauma manifests "hard signs" or clear, unequivocal physical findings as shown in table (1).

Table No 1: Hard signs

- Absent or diminished distal pulses
- Active haemorrhage
- Large, expanding or pulsatile hematoma
- Bruit or thrill
- Distal ischaemia (pain, pallor, paralysis, paresthesia, poikilothermia)

Presence of these hard signs, mandate immediate surgery in the setting of limb trauma, without further time consuming evaluation. In the presence of "Soft signs" as shown in Table no 2, patients were monitored with

masterly inactivity till the investigations confirmed the diagnosis. On the other hand if the condition of patient deteriorated, surgical exploration was immediately performed.

Table 2: Soft signs

- Small stable haematoma
- Injury to anatomically related nerve
- Unexplained hypotension
- History of haemorrhage no longer present
- Proximity of injury to major vessel

Before taking the patient to emergency theatre, patients were resuscitated to maintain optimal tissue perfusion both prior to and during operation by the help of two or three large bore intravenous lines.

Doppler arterial pressure measurement was performed routinely in establishing the diagnosis and then in follow up period for monitoring.

Third generation cephalosporins were given as a routine in every case as prophylaxis. For rapid access and wide exposure the wound was explored by a long incision along the course of injured vessel. Once applying proximal slings controlled the bleeding, the extent of vascular injury was accessed, associated injuries noted and in case of bony injury the fracture was fixed prior to the repair of vascular injury. Other injuries were dealt according to merit after the vascular injury repaired.

The various treatment options employed to repair vascular injury were, ligation of vessel, arteriotomy with thromboembolectomy, lateral repair, end to end anastomosis, vein graft and finally prosthetic graft.

Renal failure was prevented by curtailing the length and depth of hypotension and by ensuring urinary flow throughout the operative procedure and beyond.

Coagulopathies were diagnosed by the presence of heavy drainage and ooze from the wounds and managed by correcting acidosis, hypothermia and platelet deficiency.

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Haemorrhage was identified by the presence of heavy drainage and signs and symptoms of shock. Re-exploring the wound and proceeding accordingly managed these patients.

Close monitoring was performed for any tension in the leg or forearm compartments. If the symptoms and signs were suggestive of compartment tension or syndrome, therapeutic as well as prophylactic fasciotomy was performed.

Results

Eighty two patients were included in the study. Seventy (85.4%) patients were male and 12 (14.6%) were females as shown in Table No. 3.

Table No. 3: Sex Distribution

Sex	N=	%age
Male	70	85.4
Female	12	14.6

Age of the patients ranged from 6 years to 60 years with a mean of 24 years.

Most of the patients presented soon after injury, average interval being 4 hours. However this varied from 30 minutes to 24 hours as shown in Table No4.

Table no 4: Time interval

Time interval	n=	%age
<6 hrs	48	58.5
6-12 hrs	26	31.7
>12 hrs	08	09.8

At the time of presentation at Mayo Hospital, Lahore, 22 (26.8%) patients were in a stable condition and 60 (73%) in a state of shock.

In this study penetrating injuries 68 (82.9%) were more common than blunt trauma 14 (17%) patients as shown in Table No. 5.

Table No. 5: Mode of Injury

Mode of injury	N=	%age
Blunt trauma	14	17.08
Penetrating injuries	68	82.92
A- Firearm	48	
B- Stabs	18	
C- Shrapnel	02	

The most common feature of arterial injury was exsanguination. The minimum number of blood bags required for resuscitation was 3 with a maximum of 10 bags.

In this series the most common artery injured was superficial femoral followed by common femoral, brachial and popliteal. This was due to the fact that vessels in the proximal extremities were more prone to injury by firearms and road traffic accidents as shown in the Table no 6.

Table no 6: Arteries injured.

Artery	N=	%age
Common femoral	17	20.7
Superficial femoral	18	21.96
Profunda femoris	03	03.7
Popliteal	08	09.8
Post tibial	06	07.3
Anterior tibial	04	04.9
Subclavian	04	04.9
Axillary	02	02.4
Brachial	08	09.8
Radial	07	08.5
Ulnar	05	06.1

The various surgical techniques, which were employed for the repair of injured vessels, were ligation, arteriotomy with thromboembolotomy, lateral repair, End-to-End anastomosis, vein graft and prosthetic graft. Detail of the various procedures carried out is given in Table No7 & 8.

Table no 7: Arterial injuries and their management in upper limb

Procedure	Sub-Clavian	Axillary	Brachial	Radial	Ulnar
Thrombo-embolotomy	-	-	1	-	-
Lat repair	1	1	2	2	0
End to end anastomosis	0	1	2	1	1
Vein Graft	1	0	2	0	0
Prosthetic graft	-	-	-	-	-
Ligation	2	0	1	4	4

Table no 8: Arterial injuries and their management in lower limb.

Procedure	Common Femoral	Superficial Femoral	Profunda Femoris	Poplitea	Post. Tibia	Ant. Tibia
Thromboembolotomy	1	0	0	1	0	0
Lat. Repair	2	3	1	2	2	0
End to end Anastomosis	5	7	0	2	0	0
Vein graft	4	4	0	2	0	0
Prosthetic Graft	2	0	0	0	0	0
Ligation	3	4	2	1	4	4

The details of associated injuries and their management are given in Table no 9.

Table no 9 : Associated injuries

Associated injuries	N=	%age	Management
Venous injury	24	29.3	18- Ligation 6- Repair
Fracture bones	long 16	19.5	5- External fixators 5- Back slabs 3- Pin plasters 3- Skeletal tractions
Intra abdominal injuries	04	04.9	Expolatory laparotomy
Nerve injuries	13	15.9	4- Primary repairs 9- Left for secondary closure
Soft tissue injuries	32	39	18- Debridement & primary closure. 10- Debridement & secondary closure. 4- Amputations

Fifty percent patients had either single compartment or multiple compartment fasciotomies as required. Details are shown in Table no 10.

Table no 10: Fasciotomies

Limb	Compartment	N=	%age
Upper Limb	Single	01	01.2
	Multiple	06	07.3
	None	19	23.1
Lower Limb	Single	06	7.3
	Multiple	28	34.1
	None	22	26.8

In 51(62%) patients recovery was smooth without any post-operative complications. In 31 (38%) patients 58 different complications were seen, as shown in Table no 11.

Table No11: Complications

Complication	n=	%age
Wound infection	21	25.6
Secondary hemorrhage	03	03.7
Thrombosis	04	04.9
Arteriovenous fistula	01	01.2
Sensory loss	11	13.4
Motor loss	10	12.2
Amputations	05	06.1
Deaths	03	03.7

Five patients required amputations for one of the following reasons, blow out of arterial repair two, delay in arterial repair and incomplete fasciotomy two and extensive soft tissue injury one patient.

There are three deaths in this series. All three patients presented after more than 12 hours of injury. Two of these patients had multiple pallet injuries and one had crush injury due to road traffic accident. They developed acute renal failure and septicemia followed by multiple organ failure and death.

Discussion

Even today vascular trauma remains a formidable surgical challenge with considerable deaths from exsanguinations. The surgeon's prime objective in the management of vascular trauma is to prevent exsanguination. Once haemorrhage has been controlled, an organized decision must be reached about the best management of the vascular injury. The factors that influence this decision include the underlying condition of the patient, the severity of associated injuries, and the complexity of the proposed arterial repair.

Pre-operative arteriography to document the presence and location of an arterial injury in an asymptomatic patient or a patient with soft signs² is the approach favoured by trauma centers. Patients with normal arteriographic findings have less than 1-2 per cent incidence of missed injuries^{3,4}.

In the recent years the role of Duplex Ultrasonography is substantially increasing in the early diagnosis of blunt and especially penetrating trauma to decrease the morbidity and to lessen the expenses. Meissner, Paun & Johnson: in their study demonstrated a substantial reduction in the percentage of exclusion arteriograms (from 14 to 5.2%) performed for extremity trauma by initiation of a non invasive vascular diagnostic algorithm that reserves contrast arteriography for patients with abnormal physical examination or doplar arterial pressure index. The have recommended a combination of physical examination, Doppler arterial pressure measurement and duplex sonography be the optimal screening examination for trauma patients, potentially harboring an arterial injury^{5,6}.

As we have no facility for duplex USG and arteriography at present in our emergency department, we have gone for the physical findings and Doppler arterial pressure measurement in suspicious cases^{7,8}.

In our setting where the patients coming in the emergency are mostly belonging to low socio-economic class. Also the hospital resources are meager, the approach of direct exploration in the case of overt clinical signs is best. This is the strategy we have adopted with no mortality, but with significant morbidity.

Most of our patients reported in the emergency room after the injury with a mean interval of about 4 hours, range varied from 30 minutes to 24 hours which is more than the foreign studies^{7,9,10,11}. This is one of the reasons for high morbidity and mortality in this series.

The various operative techniques were used according to the situation. Clean-cut partial tears were repaired laterally with 100% success. Lacerated arteries were resected, ends mobilized taking care of the collaterals and end-to-end anastomosis done in 19 patients. Most of the end to end anastomosis were done in the superficial femoral (7) followed by common femoral (5) and Brachial Artery (2) with failure of two with a success rate of 89.5% which is comparable to the foreign studies^{12,13,14,15}. Where a large segment of the artery was lost and ends cannot be mobilized, and autogenous reverse vein graft was placed in 13 cases with a failure of one resulting in a success rate of 92.3%, which is very encouraging and comparable. Only in one case of common femoral a PTFE graft was placed with good results.

Jospeh Mayer et al; in their study reached a conclusion that early thrombosis rate of venous repair is substantial (39%), local venous repair had a significantly lower thrombosis rate (21%) than those requiring extended repairs (59%), limb salvage was not affected by whether venous repair was patent or thrombosed¹⁶.

In our study there were twenty-four associated venous injuries, only 6 (25%) were repaired and 18 (75%) were ligated, those repaired were three popliteal veins, two common femoral veins and one axillary vein. There was no difference in the clinical features of which were repaired, and those ligated, except slight oedema of the lower limb in one of the patient with popliteal vein ligation.

On the other hand in patients with injury to both deep and superficial venous compartment, the morbidity was high.

A variety of techniques are available for performing fasciotomies. Although limited skin incisions (subcutaneous) fasciotomies were performed previously in the lower extremities, concern about failure to divide the skin as another limiting envelope and failure to decompress all four compartments below the knee has prompted the use of other techniques in recent years¹⁷. We have done parafibular four-compartment fasciotomy and double incision four-compartment fasciotomy. The later technique allows excellent visualization of all four compartments and prevent injuries to neuronal structure when properly performed was used in 25 out of 41 fasciotomies.

The combination of extensive injuries to, the peripheral arteries and overlying soft tissues is seen far frequently in high velocity missile injuries and short gun injuries. We have adopted following options when dealing with combined injuries, leave the debrided wounds containing the arterial conduit open, attempt primary closure of the soft tissue wound over arterial conduit after debridement, rotate a myocutaneous flap at the first operation if the patient is stable or at later operation if the patient is unstable and to restore arterial continuity with the insertion of an extra anatomic bypass and treat the open wound by packing.

Morbidity in this series was 37.8% and mortality 3.7%. The higher percentage of morbidity and mortality was due to, short gun injuries causing extensive soft tissue damage^{18,19}, late presentation, non availability of blood at times, poor resuscitation at referral centers and poor patient selection for vascular repair.

Conclusions

- Early exploration is mandatory in patients with obvious signs of vascular injury (within 6-8 hours in winter and 4-6 hours in summer).
- Pre-operative resuscitation without unnecessary delay reduces morbidity and mortality due to renal failure.
- Continuous sutures are good in larger vessels above the elbow and knee joint. Below these levels it is preferred to use interrupted sutures on oblique anastomotic lines.
- For larger defects or unsuitable conditions reverse saphenous vein grafts at extra-anatomical sites are preferable.
- If anastomosis is under slight tension, the limb should be splinted with a POP, last for 10-14 days.
- If good, quick and appropriate surgical technique is used, post-operative anti-coagulant is not mandatory.

- In case of soft tissue injuries thorough debridement is necessary to avoid septicemia.
- Arterial conduit should be covered by various methods to prevent infection and sloughing off.
- In patients with obvious signs of compartment tension, fasciotomy should be performed after taking control of bleeding vessel ends. If the muscles are dead or with equivocal signs one must defer vascular repair. In such situations ligation of vessel or amputation can be considered.

References

1. Rich NM, Spence FC: Vascular Trauma Philadelphia, WB Saunders, 1978.
2. Snyder WH III, That ER, Perry MO: Peripheral and Abdominal vascular injuries. In Rutherford RB (ed): Vascular surgery Edition 2. Philadelphia, WB Saunders, 1984, P460.
3. Turcotte JK, Town JB, Burnhard VN: Is arteriography necessary in the management of vascular trauma of the extremities? Surg.64:557,1978.
4. Jabara VA, Headed SN, Ghossain MA et al: Emergency arteriography in the assessment of penetrating trauma to the lower limbs. Angiology, 42:527,1991.
5. Meissner M, Pan Am, Johnson K. Duplex scanning for arterial trauma. Am J Surg. 161: 552,1991.
6. Flint LM, Richardson JD: Arterial injuries with lower extremity fractures. 93; 5-1983.
7. Frykberg ER, Dennis JW, Bishop et al: The reliability of physical examination in the evaluation of penetrating extremity trauma for vascular injury. Results at one year. J Trauma 31:502,1991.
8. Johnson K, Lynch K, Pan Am et al: Non invasive vascular tests reliably exclude occult arterial trauma in injured extremities. J Trauma 31:515,1991.
9. Debakey ME, Simeone FA: Battle injuries of the arteries in World war II: An analysis of 2471 cases. Ann Surg 123:534,1946.
10. Mattox KL, Feliciano DV, Burch JM et al: 5760 cardiovascular injuries in 4459 patients: Epidemiologic evolution 1958 to 1987. Ann Surg 209: 698,1989.
11. Feliciano DV: Vascular injuries . In Maull KI (ed): Advances in Trauma, vol 2. Chicago, Year Book . Medical Publishers, 1978, p179.
12. Feliciano DV, Hersowitz, O * Gorman RB,et al: Management of vascular injuries in the lower extremities. J Trauma 28:319,1988.
13. Lim LT, Michuda MS, Flanigan DP, et al: Popliteal artery trauma: 31 executive cases without amputation. Arch Surg 115:1307,1980.
14. Snyder WH, Watkins WL, Whiddon LL, et al : Civilian popliteal artery trauma: Aneleven year experience with 83 injuries. Surgery 85:101,1979.
15. Weimann S, San Nicolo M, Sandbichler P, et al:Civilian popliteal artery trama. J Cardiovasc Surg 28:145,1987.injuries. In Flanigan DP (ed): Civilian Vascular Trauma. Philadelphia, Lea & Febiger, 1992, p373.
16. Meyer JP, Schuler JJ, Flanigan DP: Management of peripheral venous
17. Shires GT, Patman RD: Vascular injuries. In Shires GT (ed): The care of trauma patient. New York, McGraw Hill,1966.
18. Roberts RM, String ST: Arterial injuries in extremity short gun wounds: requisit factors for successful management.Surg.96:902,1984.
19. AlexanderJJ, Pietro Wsky JJ, Graham D,et al: Outcome of complex vascular and Orthopaedic injury of the lower extremity. Am J Surg.162:111,1991.