

## Late presented vascular trauma should be considered for surgical vascular repair

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### Abstract

**Objective :** The aim of this study was to analyze the mode of injury of extremity injuries involving large vessels, to assess the success of the various surgical interventions performed and effect of time to revascularization on successful outcome. **Methods** This prospective study was conducted in the cardio thoracic vascular unit over a period of 3 years between Dec 2016 to Nov 2019. All the patients older than 16 years who were admitted with signs of vascular injury involving axillary and brachial artery in upper limb and femoral and popliteal artery in lower limb who underwent surgical vascular repair were included in this study. Patients with unsalvageable extremity injury and requiring primary amputation were excluded from the study. Clinical examination in combination with Color Doppler were used primarily for diagnosing vascular injuries. Surgical intervention either primary repair or interposition autologous vein graft was done as depends on the extent of vascular injury. **Results** A total of 50 patients were evaluated of whom 45 (90 %) were males. The mean age was 30 ±8.0 years (range 18-65 years). Penetrating trauma was present in 30 patients (60%) and blunt trauma in 20 patients (40%). Road Traffic Accidents was the single most common cause of extremity vascular injury in both penetrating and blunt trauma group (60%). In penetrating injury group, the commonest vessel injured was brachial artery in 18 out of 32 (56.25%). Popliteal artery was the most commonly involved vessel in 12 out of 26 (46.15%) cases who had non penetrating injuries. The median time to revascularisation was 10 hours. Interposition vein graft was the most common methods of repair in 31 out of 50 cases (62 %). Primary repair was done in 19 patients (38%). Associated venous injury was found in 08 patients. Limb was salvaged in 43 out of 50 patients (86%). Amputation of the limb was done in 2 patients (11.11%) in which revascularization was done within 6 hours while 5 (15.62%) in patients with time to revascularization more than 6 hours but it was not statistically significant. **Conclusion:** Early diagnosis and prompt surgical management is crucial in extremity vascular injuries. However, limb can be salvaged even if patient presented late with long trauma to revascularization time.

**Keywords:** Extremity Injuries, Revascularization, Autologous Vein Graft

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### Introduction

India, the second-most populous country in the world, is in rapid epidemiological transition, with an increasing burden of non-communicable diseases like injury. Injuries and trauma are rapidly increasing becoming the top causes mortality and morbidity in the country especially related to limbs. Injuries associated with arteries of upper and lower limb are most challenging as they are associated with risk of amputation of the limb if not addressed adequately at time. [1]. About 40-75 % of these injuries are related to peripheral vessels. [2]. The outcome of peripheral vascular injury depends on many factors but early diagnosis and repair definitely decreases the risk of amputation and other complications [3]. The most commonly involved artery in upper limb is brachial artery while in lower limb popliteal and femoral artery and its branches are most commonly injured after trauma. Prompt and early revascularisation or repair of these arteries not only decreases the chances of hemorrhage or ischemia related mortality but also salvage the limb and restores its function to lead a productive life. [4,5,6] Surgical management is the standard treatment modality for extremity vascular trauma, especially when major limb arteries are affected. But the analysis of the results

of vascular repair of these injuries are not analyzed in detail because of less number of patients operated at appropriate time, poor compliance of the patients in follow-up periods. We are analysing our experience with peripheral vascular repair during a time period of about 3 years. The aim of this study was to analyze the mode of injury of extremity injuries involving large vessels, to assess the success of the various surgical interventions performed and effect of time to revascularization on successful outcome.

#### Materials and methods

**Consent:** Written consent was obtained from the relatives of patients after explaining them the nature and purpose of the study. They were assured that confidentiality would be strictly maintained. The option to withdraw from the study was always open.

**Methodology** This prospective Study was conducted in the cardio thoracic vascular unit over a period of 3 years between Dec 2016 to Nov 2019. All the patients older than 16 years who were admitted with signs of vascular injury involving axillary and brachial artery in upper limb and femoral and popliteal artery in lower limb who underwent surgical vascular repair were included in this study. Patients with unsalvageable extremity injury and requiring primary amputation were excluded from the study. All the patients when admitted in emergency department were resuscitated and appropriate management was started.

Relevant demographic characteristics, including age, gender, mode of trauma, timing of presentation and anatomical site of injury

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were recorded. History and clinical examination were recorded. Color Doppler of the injured limb was done in all the patients while CT angiography was advised in patients with inconclusive report on colour Doppler or CT angiography advised for management of other injuries. Surgical intervention either primary repair or interposition autologous vein graft was done as depends on the extent of vascular injury. Associated other injuries was addressed by specialist of respected field at the same time. As time to trauma is most important in successful peripheral vascular repair, the success of surgical intervention were categorised in two groups whether time to revascularisation is less than 6 hours or more than six hours. Limb

salvage after vascular repair was defined as successful outcome while patient who underwent amputation of the injured limb was categorised as failure.

#### Observations

A total of 50 patients were evaluated of whom 45 (90 %) were males. The mean age was  $30 \pm 8.0$  years (range 18-65 years). Penetrating trauma was present in 30 patients (60%) and blunt trauma in 20 patients (40%). Overall Road Traffic Accidents was the single most common cause of extremity vascular injury in both penetrating and blunt trauma(60%) [Table 1].

**Table 1: Mode of injury of cases with vascular trauma**

Mode of injury	Number of patients [n=50(%)]
Penetrating trauma	30 (60%)
Road Traffic Accidents	18
Stab injury	8
Injury at workplace	04
Blunt trauma	20 (40%)
Road Traffic Accident	12
Fall from height	6
Assault	2

All the patients with penetrating wound were presented with bleeding from the injured limb. Most of the patients were referred from remote areas with tight bandage applied over the injured limb to reduce the active bleed. All these patients had reduced or absent distal pulsations. In patients with blunt trauma vascular injuries, hematoma was found around the injured vessels in about 80 % of the cases. Signs of acute ischemia was present in 80 % of the patients. Associated orthopedic injuries were present in 70 % of the cases. In penetrating injury group, the commonest vessel injured was brachial artery in 18 out of 32 (56.25%).

Popliteal artery was the most commonly involved vessel in 12 out of 26 (46.15%) cases who had non penetrating injuries. Interposition vein graft was the most common methods of repair in

31 out of 50 cases (62 %) [Table-2]. Primary repair was done in 19 patients (38%). Associated venous injury was found in 08 patients (16%) who were managed by ligation (02 patients), primary repair (03 patients) or autologous graft (03 patients).

**Complications:** Wound infection was most common complication in these patients. Out of 10 patients who had wound infection 6 (60%) had penetrating injury and 4 (40%) were from non penetrating wounds.

All these patients were treated with appropriate antibiotic as per pus culture report, and appropriate dressings. Three patients required multiple debridement of the wound. Revision surgery for vascular repair was required in six patients (12%) due to secondary haemorrhage.

**Table 2: Vessel injured and Management of vascular trauma cases**

Vessel injured(Arteries)	Direct repair	Autologous Vein graft	Number (%)
Penetrating Injuries			30 (100%)
Brachial	4	8	12 (40)
Femoral	4	4	8 (26.66)
Popliteal	4	4	8(26.66)
Axillary		2	2 (6.66)
Blunt Trauma Injuries			20 (100%)
Popliteal	4	6	10 (46.15)
Brachial	3	5	8 (30.7)
Femoral		2	2 (7.6)
Total	19 (38%)	31 (62%)	50

**Table 3:Distribution of vascular injuries.**

Anatomical site of injury	Arterial injury	Arterial and venous injury	Total
Axillary	2	1	3
Brachial	20	4	24
Femoral	10	2	12
Popliteal	18	1	19
Total	50	08	58

**Outcome:** Limb was salvaged in 43 out of 50 patients (86%). Cause of limb loss was graft occlusion in three patients and infection related graft failure in four patients. The median time to revascularisation was 10 hours. It was less than six hours in 18 patients (36%) and

more than six hours in 32(64%) patients. Amputation of the limb was done in 2 patients (11.11%) in which revascularization was done within 6 hours while 5 (15.62%) in other group but it was not statistically significant [Table 4].

**Table 4: Effect of time to revascularization on successful outcome**

Time to revascularisation	No. of patients	Limb salvage	Amputation	p- value
<6 h	18	16	2	0.69
>6 h	32	25	5	

## Results

A total of 50 patients were evaluated of whom 45 (90 %) were males. The mean age was 30 ±8.0 years (range 18-65 years). Penetrating trauma was present in 30 patients (60%) and blunt trauma in 20 patients (40%). Road Traffic Accidents was the single most common cause of extremity vascular injury in both penetrating and blunt trauma group(60%). In penetrating injury group, the commonest vessel injured was brachial artery in 18 out of 32 (56.25%). Popliteal artery was the most commonly involved vessel in 12 out of 26 (46.15%) cases who had non penetrating injuries. The median time to revascularisation was 10 hours. Interposition vein graft was the most common methods of repair in 31 out of 50 cases (62 %). Primary repair was done in 19 patients (38%). Associated venous injury was found in 08 patients. Limb was salvaged in 43 out of 50 patients (86%).

Amputation of the limb was done in 2 patients (11.11%) in which revascularization was done within 6 hours while 5 (15.62%) in patients with time to revascularization more than 6 hours but it was not statistically significant.

**Statistical analysis:** Analysis was done with SPSS, IBM Corp, version 21. Fisher-exact test was used to compare limb salvage rate in two groups having trauma to revascularisation time more than six hours and less than six hours. Frequency and percentage were calculated & statistical test (Chi Square) was applied wherever applicable;  $p < 0.05$  was taken as statistically significant. Fisher-exact test was used to analyse limb salvage rate between two groups having median revascularisation time less than six hours and more than six hours.

## Discussion

As the economy of India is increasing, the incidence of trauma and associated vascular injuries are also increasing. Due to lack of health facilities required for diagnosis and management of these injuries, the incidence of mortality and amputation of limb is high in rural and sub urban areas in India. Other major factor associated with these injuries is that the majority of the patients of extremity vascular trauma are young adults and if not managed properly may lead to disability for the whole life.[4]

In this study most common age group involved were 25-40 years old. The time since injury ranged from 2-20 hrs as most of the patients included in this study was from sub urban population with lack of health facilities to manage these types of injuries. Thirty-one (62%) cases sustained vascular trauma by penetrating injuries over limb while 29 patient had blunt trauma related injuries. Most of these injuries are related to road traffic accidents. The mechanism of vascular injuries and their prevalence defer from region to region depends on the mode of transport and different cultural and social issues.

In the study done by Somshekhar et al blunt trauma accounted for about 84% of the injuries. The brachial artery was the most common artery injured with the femoral next most common.[4] Salman et al in Pakistan reported thirty-one (54.3%) cases had vascular trauma due to firearm, 10 (17.5%) by blunt trauma, 7

(12.2%) stabs, 6 (10.5%) machinery work and 3 (5.2%) by crush injury in their study.[6] In this study, the most commonly artery injured in upper limb was brachial artery while in lower limb popliteal artery was most commonly injured followed by femoral artery. Most of the studies also reported the same pattern of traumatic peripheral vascular injury leading to whole limb or a major part at risk.[4,6] The arterial involvement mainly depends on the mode of injury and may be associated with accompanying venous injury in significant number of cases which makes the limb even more critical.[6] Management of peripheral vascular injury depends on many factors such as extent of soft tissue damage, associated other organ injuries, the extent of vascular injury, the capacity of collaterals and pre-existing arterial disease, while time to injury is most critical among all these. Ischemia time more than eight hours are associated with increased rates of limb loss as muscles and nerves can tolerate only 6-8 hours.[7] Therefore, clinical suspicion of vascular injury, localization and characterisation of vascular injuries by appropriate imaging studies are essential for the effective management.[8] As these injuries always require urgent intervention to prevent loss of life or limb but sometimes serious vascular injury presents only with subtle or occult symptoms or signs. If the patients presents with pain, pallor, pulselessness, parasthesias, paralysis, pulsatile bleeding and large or expanding haematoma chances of vascular injury is more than 90% but sometimes cases may present with soft signs of vascular injuries like a relatively diminished but palpable pulse, a non expanding haematoma, and peripheral nerve injury.

30- 35% of these patients who presents with the soft signs will have vascular injury and should be subjected to investigation to confirm the vascular injury. CT-angiography is the gold standard for diagnosis of vascular injury. However Color Doppler is a non invasive and easily available investigation with sensitivity of 95%, 99% specificity, and 98% accuracy in assessment of peripheral vascular injuries.[8] Color Doppler is an easy to perform investigation. It has almost 100% sensitivity and specificity as compared with the conventional arteriography and operative exploration.[9] We have also used colour doppler as primary imaging modality in this study and CT angiogram was done in selected patients with diagnostic dilemma or if needed for other associated injuries.

Repair of extremity arterial injuries is traditionally accomplished either by direct repair or patch plasty, and interposition grafts is used in extensive injuries. The choice of surgical repair of arterial injury by direct repair, end-to-end anastomoses, patch plasty, or graft interposition depends primarily on the extent of the arterial injury and adjacent soft tissue trauma.[10]

As long segment arterial injuries are more frequently seen in blunt extremity injuries [11,12] interposition of vein or prosthetic grafts represents the treatment of choice. In our study, interposition vein grafts were the most common methods of repair in 31 out of 50 cases (62 %) while primary repair was done in 19 patients (38%). Interposition vein graft was done in 13 patients with blunt trauma

injuries (65%) and 18 patients with penetrating injuries (60%). Amputation was done in 7 patients (14%).

Associated venous injury was found in 08 patients (16%) who were managed by ligation (02 patients), primary repair (03 patients) or autologous graft (03 patients). Regarding graft selection for repair of arterial injuries in limbs, autogenous veins were traditionally preferred to synthetic grafts because of high patency rates and low incidence of secondary graft infection. [13,14] However, Martin and coworkers reported equivalent patency rates when expanded polytetrafluoroethylene and vein grafts were used to repair the iliac, femoral, and superficial femoral arteries but there was significant difference in immediate patency rate when anastomosis was at or below the popliteal artery with higher failure with expanded polytetrafluoroethylene grafts.[15]

Klocker J. et al also advocated that prosthetic grafts should be used only when autogenous vein was unavailable or when a large size discrepancy between a vein graft and the native artery.[10] Autogenous vein grafts for the reconstruction of acute extremity arterial injuries provide excellent initial and long-term patency and durability as well as resistance to infection. All 73 autologous vein grafts were found to be patent on follow-up and the primary patency rate was 98% and a cumulative secondary patency rate was 99%. No late amputations were required.[16]

Dorweiler and coworkers published their retrospective experience with 23 interposition vein grafts used for arterial repair in 12 upper and 11 lower limbs: In their series, four patients (17%) had early graft occlusions within 30 days after surgery, and two of them were followed by major amputations in the lower limb. They advocated that interposition vein grafts provide durable long-term results and should be attempted even in single-vessel injuries of forearm and lower leg.[17]

When comparing graft performance, Martin and coworkers reported that failure was more frequent in blunt trauma injuries (eight of 23 patients; 35%) than in penetrating injuries (two of 165; 1.2%). Interestingly, in Martin's series, all eight graft failures after blunt trauma resulted in amputation. [15] Nathan et al in their study over combined arterial and venous extremity injuries found that ligation of vein did not impact success of arterial repair in patients with combined venous and arterial trauma in the lower extremities. Vein ligation did not produce a higher incidence of muscle debridement, necessity for secondary intervention or amputation. [18] Lauren Haney et al in their study performed 48 arterial repairs in the upper extremities consisting of 43 vein grafts and occlusion was found only in one case.

Similarly 73 vein graft were performed in the lower extremities out of which 73 were patent on follow up. Concomitant vein injuries occurred in 28% of the arterial injured in lower extremities and 44% were treated by ligation. Out of 10 lower extremity venous injuries, 4 were repaired using vein grafts and primary repair was done in 2 cases.

All 10 venous repairs were patent with median follow-up of 3 months.[19] In our study associated venous injury was present in 8 cases (16%). Ligation of the vein was done in 4 patients while vein graft and primary repair was done in 2 cases each.

#### Conclusion

Road traffic accidents were the most common mode of injury leads to vascular injuries in extremity and commonly involved the young adults. Brachial artery was the most common vessel injured followed by Popliteal artery and active bleeding was the commonest presentation.

#### What this study add to existing knowledge?

Autogenous vein grafts for the reconstruction of acute extremity arterial injuries provide excellent initial and long-term patency and durability as well as resistance to infection. Surgical intervention should be considered in those patients with delayed presentation as

result of delayed vascular repair was lower but not statically significant.

#### References

1. Rich NM, Rhee P. An historical tour of vascular injury from inception to the new millennium. *Surg Clin North Am.* 2001;81:1199–1215.
2. Felicino DV, Moore FA, Moore EE, et al. Evaluation and management of peripheral vascular injury. Part 1. Western Trauma Association/Critical Decisions in Trauma. *J Trauma.* 2011;70:1551–1556.
3. Menakuru SR, Behera A, Jindal R, Kaman L, Doley R, Venkatesan R. Extremity vascular trauma in civilian population: a seven-year review from North India. *Injury.* 2005; 36:400–406.
4. Menakuru SR, Behera A, Jindal R, Kaman L, Doley R, Venkatesan R. Extremity vascular trauma in civilian population: a seven-year review from North India. *Injury.* 2005; 36(3):400-6.
5. Yu L, Deng L, Zhu S, Deng K, Yu G, Zhu C, Qi B, Pan Z. Limb-Salvage Outcomes of Arterial Repair Beyond Time Limit at Different Lower-Extremity Injury Sites. *Med Sci Monit.* 2021 ;27:e927652.
6. Guraya SY. Extremity vascular trauma in Pakistan. *Saudi Med J.* 2004;25(4):498-501.
7. Rush M.J., Kjorstad R., Starnes B.W. Application of the mangled extremity severity score in a combat setting. *Mil Med.* 2007;172:777–781.
8. Dueck AD, Kucey DS. The Management of Vascular Injuries in Extremity Trauma. *Current Orthopaedics.* 2003;17(4):287–291.
9. Fry WR, Smith RS, Sayers DV, Henderson VJ, Morabito DJ, Tsoi EK, et al. The success of duplex ultrasonographic scanning in diagnosis of extremity vascular proximity trauma. *Arch Surg.* 1993;128(12):1368–72
10. Klocker J, Bertoldi A, Benda B, Pellegrini L, Gorny O, Fraedrich G. Outcome after interposition of vein grafts for arterial repair of extremity injuries in civilians: *Journal of Vascular Surgery.* 2014;59(6): 1633- 1637
11. T. Huynh, M. Pham, L.W. Griffin, M.A. Villa, J.A. Przybyla, R. H. Torres, et al. Management of distal femoral and popliteal arterial injuries: an update *Am J Surg.* 2006;192: 773-778
12. M.J. Sise MJ, S.R. Shackford SR. Extremity vascular trauma In: N.M. Rich, K.L. Mattox, A. Hirshberg editors, *Textbook: Vascular Trauma* (2nd ed), Elsevier Saunders, Philadelphia (2004), pp. 353-420.
13. A. Vertrees, C.J. Fox, R.W. Quan, M.W. Cox, E.D. Adams, D. L. Gillespie The use of prosthetic grafts in complex military vascular trauma: a limb salvage strategy for patients with severely limited autologous conduit *J Trauma.* 2009;66:980-98
14. E.B. Woodward, W.D. Clouse, J.L. Eliason, M.A. Peck, A.N. B owser, M.W. Cox, et al. Penetrating femoropopliteal injury during modern warfare: experience of the Balad Vascular Registry *J Vasc Surg.* 2008;47:1259-12
15. L.C. Martin, M.G. McKenney, J.L. Sosa, E. Ginzburg, I. Puente , D. Sleeman, et al. Management of lower extremity arterial trauma *J Trauma.* 1994;37:591-598
16. R.R. Keen, J.P. Meyer, J.R. Durham, J. Eldrup-Jorgensen, D.P. Flanigan, T.H. Schwarcz, et al. Autogenous vein graft repair of injured extremity arteries: early and late results with 134 consecutive patients, *J Vasc Surg.* 1991; 13: 664-668
17. B. Dorweiler, A. Neufang, W. Schmiedt, M.H. Hessmann, L. R udig, P.M. Rommens, et al. Limb trauma with arterial injury: long-term performance of venous interpositions grafts, *Thorac Cardiovasc Surg.* 2003;51:67-72

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18. Manley N.R., Magnotti L.J., Fabian T.C. Factors Contributing to morbidity after combined arterial and venous lower extremity trauma. *Am Surg.* 2018;84:1217–1222
19. Haney LJ, Bae E, Pugh MJV, Copeland LA, Wang. Patency of arterial repairs from wartime extremity vascular injuries. *Trauma Surg Acute Care Open*, 2020;5(1) :e000616

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