Extremity vascular trauma

A 7-year experience in Lahore, Pakistan

Muhammad I. Hussain, FCPS (Pak), MRCS (England), *Muhammad Zahid,* MBBS, MS, *Abdul-Waheed Khan,* MBBS, FRCSI, *Hasan Askri,* MBBS, FRCS (Ed), *AbulFazal A. Khan,* FRCS Ed, FRCS (Glas).

ABSTRACT

الأهداف: تحديد النتائج والطرق المختلفة في إصلاح الإصابات الوعائية، وما يتعلق بالمضاعفات، ونسبة إنقاذ الطرف المصاب.

الطريقة: أجريت هذه الدراسة على المرضى اللذين تم قبولهم في قسم الجراحة العامة، خلال الفترة مابين 1999م وحتى 2005م، بمستشفى لاهور العام (LGH) – لاهور– باكستان، واللذين أجري لهم إصلاح للأوعية بسب إصابات الرف الوعائية. وقد تم استبعاد المرضى الذين أجريت لهم عملية بتر الطرف منذ البداية لعدم إمكانية إنقاذ الطرف المصاب، أو المرضى الذين حضروا بعد حدوث مضاعفات نتيجة الإصابة الوعائية.

النتائج: خضع 93 مريضاً لعمليات مختلفة للإصابات الوعائية، وكان معظمهم من الذكور الشباب (متوسط العمر 29.4 عاماً) (91.3%). شكلت الرضوض النافذة النسبة الكبرى (77.4%). كان متوسط الزمن بين وقت حدوث الإصابة والإصلاح 4.5 ساعات. وقد كان الشريان الفخذي المتوسط هو الأكثر عرضة للإصابة (26.8%). تم إصلاح باستخدام الوصلة لـ41 مريضاً (46.6%)، بينما تم الإصلاح مباشرة من دون وصلات بطريقة المفاغرة لـ(34.1%). كانت التهابات الجروح هي الأكثر حدوثاً (18.2%). أجريت عملية البتر الثانوية لسبع مرضى (7.5%)، وكان هناك 3 وفيات (3.2%) بسبب إصابات أخرى. كانت نسبة نجاح الإصلاح الوعائي في (89.3%) من المرضى.

خاتمة: يؤدي الإصلاح المبكر للإصابات الوعائية باستخدام الإصلاح المباشر أو وضع وصلة وريدية إلى نسبة نجاح عالية في إنقاذ الأطراف المصابة، مع نسبة معقولة من المضاعفات.

Objectives: To determine the outcome of various techniques of vascular repair in terms of repair related complications and limb salavagibility.

Methods: From January 1999 to December 2005, this retrospective study was conducted in the Department of General Surgery, Lahore General Hospital, Lahore, Pakistan. The patients, who underwent various surgical interventions for extremity vascular trauma, were included in this study. Those, who underwent primary amputation due to non-salvageable injuries or who presented with late complications of vascular injuries were excluded.

Results: Ninety-three patients underwent different surgical procedures for extremity vascular trauma. Majority of the patients were young, (mean, 29.4 years) male (91.3%). Penetrating trauma was the most common mode of injury (77.4%). The median time interval between injury and repair was 4.5 hours. Superficial femoral artery was the most frequently injured artery (26.8%). Graft repair was carried out in 41 patients (46.6%), while 34.1% of the patients had end-to-end anastomosis. Wound infection was the most common complication (18.2%). Seven patients (7.5%) had secondary amputations and 3 (3.2%) died from other injuries. Vascular reconstruction was successful in 89.3% of the patients.

Conclusions: Early revascularization by employing simple repair or interposition autogenous vein graft repair results in successful limb salvage with acceptable complication rate.

Vascular injuries to the extremity are potentially devastating and can lead to limb loss and death if not appropriately managed.[1] Peripheral vascular trauma accounts for approximately 1-3% of total civilian trauma in various studies.[2] Worldwide increase in terrorist violence together with increase in high speed motor vehicle crash has resulted in the increase in vascular trauma.[3] Until World War II, arterial ligation was the main stay of treatment with an amputation rate of 49%.[4] On account of continuous improvements in trauma care system and formal vascular repair, amputation rate was declined to 13% in Korean and Vietnam conflict.[5] At present, these injuries are associated with amputation rate of less than 10% of the cases.[6-11] These improvements are secondary to the advent of organized trauma system, refinement in the technique of vascular repair, improvement in anesthesia, blood transfusion facilities, antibiotics and perhaps the greatest factor, the rapid evacuation of injured patients.[12] Vascular trauma is associated with longer hospital stay, greater hospital costs, and high post admission morbidity with serious acute and chronic sequelae. Vascular surgery has not yet established as a separate specialty in most of the teaching hospitals in Punjab, Pakistan. The management of such injuries is a challenging job for general surgeons, particular in developing countries, where limited resources make this task even more difficult. The objective of this study was to review the experience of general surgeons in the management of extremity vascular trauma and to determine the outcome of various techniques of vascular repair in terms of repair related complications, and limb salavagibility in a teaching hospital of Lahore, Pakistan.

Methods. This retrospective study was conducted in the Department of General Surgery, Lahore General Hospital, Lahore, Pakistan over a period of 7 years from January 1999 to December 2005. Lahore General Hospital is a teaching hospital, affiliated with the Post Graduate Medical Institute Lahore, Pakistan. After the approval from the hospital research and ethical committee, medical record of all patients, who were admitted with the diagnosis of vascular trauma, was retrieved. The patients, who underwent various surgical interventions for extremity vascular trauma, were included in this study. Those, who underwent primary amputation due to non-salvageable injuries, or who were observed for suspicion of vascular injury, or who presented with late complications of vascular injuries such as arteriovenous fistulae or pseudo aneurysms were excluded from the study. All patients were resuscitated and evaluated according to the guidelines of Advanced Trauma Life Support (ATLS)® protocol. Mostly, the diagnosis of vascular injury was made on the clinical grounds. The patients, having hard signs of vascular

trauma (namely reduced or absent distal pulses, arterial bleeding, expanding or pulsatile hematoma or presence of thrill, or bruit at the site of injury) were directly shifted to operation room for exploration of the wounds. Doppler ultrasound and radiographs of suspected bony fracture were taken selectively in suspicious cases. Arterial pressure index and repeated clinical examination was performed in patients with soft signs of arterial injury (unexplained or transient hypotension, stable hematoma, proximity of injury to major vessel, presence of neurological deficits). Patients with positive findings on Doppler examination or arterial pressure index studies were taken to operating room and the rest were admitted for observation for 72 hours in the ward. All patients received third generation cephalosporins, as prophylaxis before induction of general anesthesia. Longitudinal incision was made along the course of injured vessels. Proximal and distal control was achieved by using standard operating procedure. The injured vessels were identified along with associated injuries and the extent of injury was established. Bony fractures were fixed before repair by orthopedic surgeons. A thorough debridement of dead skin, soft tissue and muscle was carried out before repair. An appropriate size Forgarty's catheter was carefully passed through both proximal and distal ends to remove intra-luminal thrombus. The lumen of vessel was flushed with heparinized saline (10 unit/ml). Simple repair of injured vessels without tension was attempted as the first line procedure, but where multiple pallet injuries or segmental loss of more than 2 centimeter was noticed, interposition autogenous vein graft was employed. The conduit of choice was the great saphenous vein from uninjured limb. In cases of extensive soft tissue damage, where adequate soft tissue coverage was not available, repair was accomplished with extra anatomical interposition graft. Non-absorbable polypropylene suture 5/O or 6/O was used depending on the size of vessel. Venous repair was performed, wherever possible. Ligation was preferred in unstable patients, and in cases of extensive venous injuries, which required interposition graft. Associated nerve injury was repaired in clean wounds and tagged for delayed repair in contaminated cases. Adequate soft tissue coverage for repair was ensured at the end, either with primary closure of skin or with local rotational flaps. In grossly contaminated cases, skin was left opened for delayed primary or secondary closure. Prophylactic fasciotomy was liberally performed, once the ischemia time exceeded more than 6 hours, combined arterial and venous injuries, extensive musculoskeletal injuries or the clinical suspicious of compartment syndrome. Systemic postoperative heparin was started in cases of venous repair or interposition venous graft repair. All the patients were evaluated daily on the morning rounds. Doppler ultrasonography was performed

selectively in edematous limb. Patients were closely monitored in the ward, regarding their hemodynamic stability, signs of secondary hemorrhage, compartment syndrome, presence of distal pulses, and urine output. Patients with open wounds were dressed daily in the operating room by surgical registrars with simple wet to dry dressing, after irrigation of the wound with copious amount of normal saline. This was continued until the wound was ready for delayed closure or grafting. All the patients were discharged after satisfactory management of the primary and fasciotomy wounds. The patients were advised to come after a month, and then after every 6 months for follow up in the clinic. On follow up, primary and fasciotomy wounds were examined and the vascularity of the limb was established on clinical grounds or by Doppler examination. Clinical data including demography, mechanism of injury, time interval between injury and repair, site of injuries, associated injuries, techniques of repair and their outcome in terms of repair related complications such as secondary hemorrhage, thrombosis, amputations and mortality was collected on a proforma. Statistical analysis was carried out by using the Student's t- test. A P-value less the 0.05 was considered statistically significant. We used the Statistical Package for Social Sciences Version 11 for data analysis.

Results. Ninety-three patients, with extremity vascular trauma, who underwent different surgical procedures, were included in this study. Age of these patients ranged from 8-67 years (mean, 29.4 years). Majority of the patients were male (91.3%). Penetrating trauma was the most common mode of injury (77.4%). Out of them, 33 (35.4%) had gunshot injuries, 28 (30.1%) had bullet injuries, while 11 (11.9%) patients had stab wounds. Blunt injuries comprised of 22.6% (21 patients). Forty-six (49.4%) patients were in the state of shock at the time of arrival in emergency room

(systolic blood pressure [BP] <90 and diastolic BP <60 mm Hg). Active bleeding from the wound was noticed in 57 (61%) patients. Sixteen of them had palpable distal pulses. Fifty-four (58%) patients had pulse deficit. Distal ischemia in 13 (13.9%) patients and pulsatile or expanding hematoma was noticed in 7 (7.5%) patients. Eighty-six (92.5%) patients, who had a combination of hard signs of vascular injury, were taken directly to operating room for wound exploration. Seven of 19 patients, who had the soft signs of vascular injury, underwent wound exploration. The rest of 12 patients were admitted for observation and discharge after 72 hours with follow-up advice. This group of patients was excluded from the study. Preoperative or operative angiography was not carried out in any case, as this facility is currently not available in emergency room of our hospital. The median time interval between injury and repair was 4.5 hours (range 2-19 hours). Sixty (64.5%) patients had lower limb arterial trauma, while upper limb trauma comprised of 30.1% of the patients. Twenty-three (26%) patients had concomitant

Table 2 - Techniques of vascular repair.

Vessels/techniques	n	(%)
Artery (n=88)	41	(46.6)
Interposition venous graft	30	(34.1)
End to End anastomosis	5	(5.7)
Lateral arteriorrhaphy	12	(13.6)
Ligation		
Isolated venous injuries (n=5)	2	(40)
Lateral venorrhaphy	2	(40)
Ligation	1	(20)
End to end anastomosis		
Concomitant venous injuries (n=23)	5	(21.8)
End to end anastomosis	6	(26.0)
Lateral repair	12	(52.2)
Ligation		

Table 1 - Distribution of vascular injuries.

Distribution	n	(%)
Arterial injuries		
Upper limb	28	(30.1)
Axillary	5	(5.4)
Brachial	16	(17.2)
Profunda brachii	4	(4.3)
Radial	3	(3.2)
Lower limb	60	(64.5)
Deep femoral	10	(10.7)
Superficial femoral	25	(26.8)
Profunda femoris	5	(5.4)
Popliteal	17	(18.3)
Posterior tibial	3	(3.3)
Isolated venous injuries	5	(5.4)

Table 3 - Associated injuries and management.

Associated injuries	n	(%)
Fracture or dislocation	23	(24.7)
External fixature (n=23)		
Nerve injuries	17	(18.2)
Primary repair (n=4)		
Tagging (n=13)		
Thoracic injuries	13	(13.9)
Chest tube (n=9)		
Conservative (n=4)		
Intra abdominal injuries	9	(9.6)
Laparotomy (n=9)		
Head injuries	7	(7.5)
Craniotomy (n=2)		
Conservative (n=5)		

venous injuries. Isolated lower limb venous injuries were noticed in 5 (5.4%) patients. Superficial femoral artery was the most frequently injured artery (26.8%), followed by the popliteal artery (**Table 1**). Interposition autogenous saphenous vein graft was used for repair in 41 (46.6%) patients. Six out 41 patients had extra anatomical graft repair (**Table 2**). Ligation of profunda femoris (n=5), profunda brachii (n=4), posterior tibial (n=2), and radial artery (n=1) was carried out. Two (one superficial femoral vein and one great saphenous vein) out of 5 isolated venous injuries and 12 (one common femoral, 5 superficial femoral, 4 popliteal, and 2 basalic vein) out of 23 concomitant venous injuries underwent ligation, resulting in limb swelling. This limb edema was transient and improved with time by limb elevation and elastic compression bandage. The detail of other techniques of vascular repair is outlined in **Table 2**. In 57 (61.2%) patient's wounds were left open due to gross contamination. Subsequently, they underwent delayed primary closure (18.2%), secondary closure (26.8%), and partial thickness skin grafting (16.2%). Thirty-six (38.8%) patients had primary wound closure with direct suture (24.8%) or local rotational flaps (14%). Fracture or dislocation was noticed in 23 (24.7%) patients. Other associated injuries and their management is described in **Table 3**. Prophylactic fasciotomy was performed in 49 (52.6%) patients. None of our patient required delayed fasciotomy. Nineteen (38.8%) of them underwent delayed suture closure while the rest (61.2%) had partial thickness skin graft. Wound infection of injured site was the most common complication (18.2%), followed by the neurological deficit (13.9%) of distal limb. Seven (7.5%) patients, who had contaminated open wounds, developed secondary hemorrhage. They all underwent ligation of bleeding vessels as life saving measure. Revascularization was not attempted in these cases. Three blowouts were noticed in popliteal artery repair (one simple repair and 2 graft repair), 3 in superficial femoral artery (one simple repair and 2 graft repair). One failure was observed in common femoral artery repair (simple repair). The ligation of common femoral and popliteal artery resulted into secondary amputations. Vascular thrombosis was noticed in 6 (6.4%) patients. Out of these 6 patients, 4 had interposition autogenous venous graft and 2 had end to end anastomosis. All these 6 patients were re-explored and revascularization was carried out accordingly. Finally, 3 out 6 patients ended up to the secondary amputation. Overall, 7 (7.5%) patients underwent secondary amputations. Three (3.2%) patients died. None of them was due to repair failure or by re-profusion injury. They all died due to associated abdominal visceral injuries, and major chest trauma. The mean hospital stay was 21.5 days (range 14-47 days). The Mangled Extremity Scoring System (MESS) was calculated retrospectively in all the patients. The mean MESS of salvaged limb was 5.4±1.6, while the amputated limbs had a mean of 7.6±1.3 (p=0.0006). All the discharged patients were seen, on the first follow up visit. Available follow up of 71 (76.3%) patients ranged from 6 months to 19 months with a mean of 10.5 months. Repair surveillance angiography was not carried out in any case. Long term follow up in our setup is difficult especially after trauma due to socioeconomic reasons.

Discussion. The higher incidence of interpersonal and terrorist violence in Pakistan has given the general surgeons, a good exposure of extremity vascular trauma. There is no well established vascular surgical department in our hospital. General surgeons are routinely managing all kind of vascular trauma. This study substantiates the observation of Porter et al[9] that general surgeons with trauma experience can provide effective treatment of peripheral vascular injuries. Majority of our patients were young male (91.3%), as reported by worldwide trauma series.[7-10,13-16] Penetrating vascular trauma was more frequently encountered than the blunt trauma (78% versus 22%). The mechanism of vascular injury was similar to other studies in the same region.[7,8,13] This is because of easy availability of firearm weapons to common man and increasing incidence of terrorist violence. Penetrating injuries are also common in the United States of America,[1,9] and South Africa;[6,17] whereas blunt trauma due to road traffic accident accounts for majority of the injuries in the United Kingdom and Ireland.[15,18] The time interval between injury and revascularization of injured limb is an important factor in determining the outcome of repair. Rapid evacuation of the injured patients was the key factor in the successful management of vascular injuries in the Korean and Vietnam military inflict.[12] The median time interval of 4.5 hours between injury and repair is in the published range (4-9.3 hours) from Pakistan,[7,8,13] but is higher than the Western studies, where highly efficient rescue and transfer systems are well established.[6,19] Inadequate clinical assessment at primary hospitals, and ineffective transportation, frequently resulted in the late referral and subsequently delayed in the operative intervention in our setup. Active bleeding from the wound was the most common mode of presentation. Sixteen (17.6%) out of 57 patients had palpable distal pulses. Guraya[13] and Majid et al[7] reported 10% and 25% of their patients had palpable distal pulse respectively, in the presence of the vascular injuries. Presence of distal pulse does not exclude the existence of vascular trauma. Presence of hard signs of arterial injury are considered an indication of surgery without any investigation.[6,17] We observed the same protocol. These investigations delayed the revascularization and cause massive ischemia, which is the major risk factor for the failure of vascular repair.

Angiography has been advocated only in stable patients, to delineate the site, nature and extent of injury in cases of multiple pallet injury or multiple fractures.[20,21] We explored majority of the patients (92.5%) on the presence of hard signs and characteristics extensive wounding. In doubtful cases, we used Doppler ultrasonography and pressure studies, because of non availability of angiography in Emergency room of our hospital. Frykberg et al[22] stated that the accurate physical examination was found to be highly sensitive and specific with negative predictive value of 99%. It has also been described as the safest approach by others.[7,8,13] Recently duplex ultrasonography has emerged as a valuable diagnostic tool for the diagnosis of potential vascular injuries. Bynoe et al[23] demonstrated its sensitivity and specificity of 95% and 99% respectively in identifying the vascular injuries. It is operator dependant and has a limited role in extensive soft tissue injuries and large hematoma. Meissner et al[24] have recommended a combination of physical examination, Doppler arterial pressure measurement and duplex ultrasonography, as an optimum screening method for potential vascular injury. There are various scoring system used to determine the magnitude of injury and predicting the need of amputation. Currently, the most commonly used scoring system is the MESS. Value of ≥ 7 predict the eventual need for an amputation.[25] Menakuru et al[14] documented a low sensitivity (0.44) and specificity (0.7) of MESS index to accurately predict salavagibility. We found that it has limited clinical applicability with successful limb salvage achieved in 6 cases where MESS suggested that amputation would be required. However, it is also not very accurate in predicting the functional outcome. The limitation of this scoring system demands more accurate evaluation of every patient for rendering an appropriate treatment. Most frequently injured vessel was superficial femoral artery (26.8%), which is in accordance with majority of the studies.[6-8,11,26] Mattox et al[2] described that lower abdominal and groin vessels were more vulnerable to gunshot wounds than vessels in any other location. Popliteal artery injury accounted for 18.3%. Numerous authors have recognized that injury to popliteal artery carries a relatively poor outcome compared with other vascular injuries.[17,27-29] The management controversy in popliteal artery injury revolves around the priority of orthopedic stabilization versus revascularization and the use of temporary shunts.[21] Temporary arterial shunting has been advocated for complex wounds, for which fracture fixation and extensive debridement is required. It may reduce the total ischemic time, amputations and hospitalization.[27] However, it requires more dissection and longer operative time. Interposition graft repair was the most commonly performed procedure (46.6%), as simple repair could not be possible without tension

in these cases. This technique was also observed as the most common used technique by others.[6,7,10,13,15,17,30] In cases of extensive soft tissue damage, repair was accomplished with extra anatomical interposition graft (6/41patients), covering the proximal and distal anastomosis with healthy tissue. We did not use the synthetic graft due to financial constraints, and presence of badly contaminated wounds in majority of our patients. However, some authors have reported that, the patency and infection rates of autogenous vein graft repair and polytetrafluoroethylene graft repair are comparable.[6,31] Ligation of injured profunda brachii or femoris, single forearm and leg artery was well tolerated in 12 patients without any complication. Although venous repair or ligation is a controversial, but the experienced vascular surgeons always prefer to repair the concomitant venous injury.[10] It improves the outcome of arterial repair and minimized potential long-term complications.[20] Ligation of vein is advocated, in unstable patients, or in the presence of extensive disruption of vein, requiring graft repair. In this study, 12 out of 23 patients with combined injuries underwent ligation of vein, resulting in limb swelling. Mostly, early swelling improves with time as collateral vessels develop. The limb edema in our patients was transient and improved by limb elevation and elastic compression bandage. The reported long term results of repair and ligation of vein are comparable.[32,33] Moreover, Nair et al[17] described that there was no significant effect of venous ligation on the outcome of arterial repair. Adequate fasciotomy has been considered a useful adjunct to repair the extremity vascular injuries by several authors.[1,6-8,10,13,14,17] We have a relatively high rate of early fasciotomy (52.6%). The morbidity of unnecessary fasciotomies (wound problems, iatrogenic neurovascular injuries) is low, when compared with grave consequences of untreated compartment syndrome. Adequate liberal fasciotomy is therefore strongly recommended. Seven (7.5%) patients developed secondary hemorrhage. These blowouts were noticed in patients, who had wound infection of injured site, resulting in sloughing off the soft tissue coverage. Gunshot wounds and high speed motor vehicle accidents produce a large soft tissue defects with gross wound contamination. Both these factors interfere with reconstructive procedures and increase the risk of infection. More aggressive debridement of injured site and use of extra anatomical graft repair during the initial surgery might reduce the incidence secondary hemorrhage and subsequently the amputation rate. We suggest frequent wound toilet, intravenous antibiotics, early thorough debridement with local rotational flap to cover the repair, in case of wound infection. Early arterial thrombosis rate was 6.4%, which is in the reported range.[8,9,14,34] Anastomotic narrowing, poor arterial coaptation, adventitial

inversion, extensive soft tissue injury and delayed revascularization of traumatized limb are the probable factors, causing early thrombosis in these patients. By avoiding these risk factors, we can reduce the thrombosis of arterial reconstruction. Vascular repair was successful in 89.3% of the patients, which is comparable with various international series.[7-10,13-16,35] There are certain limitations to this study. It is a retrospective study, lacking data, about the detailed morbidity of associated injuries, adequate follow up and surveillance imaging. We are unable to comment on the long-term patency rate of repair and the functional outcome of salvaged limb. However, we can conclude from our study, that extremity vascular trauma is a complex entity, which needs a multidisciplinary approach by vascular, orthopedic and plastic surgeon for better outcome. Prompt resuscitation and early revascularization by employing simple repair or interposition autogenous vein graft with reliable soft tissue cover results in successful limb salvage with acceptable complication rate.

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