

## Management of Extremity Vascular Injuries Associated with Soft Tissue Defects

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### ABSTRACT

*Background:* There are areas of greatest concern which are considered high-risk locations in the extremities. When vascular injury occurs in these areas, soft tissue defects are troublesome problem that mandates soft tissue coverage.

*Patients and Methods:* This study included 18 patients, 14 males and 4 females with extremity vascular injury associated with soft tissue loss, who presented to Kasr El-Aini Hospitals in the period from June 2001 to July 2003. Management were done by combined vascular repair and immediate soft tissue coverage by different types of fasciocutaneous, myocutaneous and free muscle flap.

*Results:* Clinical results were satisfactory except for one case that ended up by below knee amputation. Deep venous thrombosis occurred in two cases. Minimal sloughing and infection at the edge of the wound occurred in three cases. Lymph discharge occurred in one case that resolved in 3 weeks. There was a high rate of successful wound healing and limb salvage in 17 cases.

*Conclusion:* Combined teamwork of vascular, plastic, and orthopedic surgeons is necessary in complex extremity trauma. We conclude that immediate soft tissue coverage is mandatory to protect exposed repaired vascular injuries and exposed bone fracture allowing sound wound healing with high limb salvage.

### INTRODUCTION

Peripheral vascular injuries comprise approximately 3% of the major injuries. Most are caused by acts of violence or vehicular collisions [1]. They account for 80% of all vascular trauma and lower extremities are involved in 2/3 of patients [2].

There are areas of greatest concern, which are considered high-risk locations in the lower abdominal area (the inguinal area) and in the lower extremity, the medial aspect of the thigh, and popliteal

fossa are considered high risk zones [3]. Similarly in the upper extremity, the axilla, the antro-medial upper arm, and the anticubital fossa are considered high risk areas due to superficial location of the vessels in this region [4].

Infection is considered one of the disastrous complications especially after vascular repair of the injured vessels. Secondary hemorrhage, thrombosis, distal ischemia and eventual amputation will be the end results. Factors predisposing to infection include closure of contaminated wound and inadequate soft tissue coverage of an arterial repair. This complication is best avoided by vigorous cleansing of contaminated wounds, aggressive debridement of devitalized tissues and coverage of the repaired vessels with well vascularized soft tissue [5].

Most authors agree that early soft tissue coverage is associated with a lower complication rate. It was found that the overall complication rate of wounds closed within the first week of injury was 18% compared to 50% complication rate compared to those closed in subacute phase of 1-6 weeks. Others believe that closure within 72 hours is associated with lowest complication rate and highest success [6].

In this study, different types of soft tissue coverage of the repaired blood vessels in extremity trauma and their effects in minimizing the complication rate and success of vascular repair and limb salvage are studied.

### PATIENTS AND METHODS

This study included 18 cases received at Kasr El-Aini Hospitals in the period from June 2001 to July 2003. They were 14 males and 4 females with age range between 9 to 38 years.

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#### Abbreviations:

Polytetrafluoroethylene:PTFE

Deep vein thrombosis :DVT

Causes of trauma were motor car accident in 9 cases, fall from a height in 3, machinery injury in 5 and stab wound in the last case. In all patients, there was vascular injury of the upper and lower extremities associated with soft tissue loss of the overlying soft tissue. Associated venous injury was present in 9 cases, bone fractures in 6 cases, where fracture femur was present in 3 cases and fracture-leg bones in other 3 cases, rupture spleen in 2 cases and liver tear in one case.

Sites of vascular injury was lower extremity in 12 cases affecting the femoral artery alone in 2 cases, the femoral artery and vein in 5 cases, popliteal artery and vein in 2 cases, anterior and posterior tibial arteries in 3 cases. In the upper extremity, axillary artery and vein in 2 cases, brachial artery in 4 cases.

Resuscitation was done for correction of shock abdominal exploration and splenectomy was performed in 2 cases, repair of liver tear in one case,

fixation of fractures in 6 cases. Vascular repair was done within 3 to 6 hours after injury by interposition vein graft for the injured arteries except 2 cases required synthetic graft PTFE. Associated venous injury were managed by vein patch in 2 cases and interposition vein graft in 7 cases (Table 1).

Coverage of the soft tissue defects was done immediately after vascular repair which was preceded by bone fixation if needed. Fasciocutaneous flaps were used in 3 cases (Figs. 1A,1B,2A,2B) pedicled myocutaneous and muscle flaps in 14 cases (Figs. 3A,3B,4A,4B,5A,5B,6A,6B) and free muscle transfer in one case (Fig. 7A,7B) (Table 2).

Evaluation was done by the presence of good distal pulses, viability of flaps and limbs, presence or absence of infection, healing of wounds, and development of other complications as deep venous thrombosis or vascular graft thrombosis.

Table (1): Type and site of vascular repair.

Site of vascular injury	No. of cases	Type of repair & No. of cases
Femoral artery	2	Vein interposition (1), PTFE (1)
Femoral artery & vein	5	Artery → PTFE, vein → vein patch (1) Artery → vein interposition, vein → vein patch (1) Artery → vein interposition, vein → vein interposition (3)
Popliteal artery & vein	2	Artery → vein interposition, vein → vein interposition (2)
Ant. & post, tibial a.	3	Artery → vein interposition (3)
Axillary a. & v.	2	Artery → vein interposition, vein → vein interposition (2)
Brachial artery	4	Artery → vein interposition (4)

Table (2): Type and site of plastic reconstruction.

Type of flap	Site of flap	No. of cases
<i>Fasciocutaneous flaps:</i>		3
Parascapular fasciocutaneous flap	Axilla	2
Medial forearm flap	Cubital fossa	1
<i>Muscle flaps:</i>		14
Latissimus dorsi myocutaneous flap	Cubital fossa	3
Rectus abd. myocutaneous flap	Groin	3
Tensor fascia lata myocutaneous flap	Groin	4
Sartorius muscle flap	Popliteal fossa	2
Soleous muscle flap	Lower third leg	2
<i>Free muscle flap:</i>		1
Latissimus dorsi muscle flap	Lower third leg	1

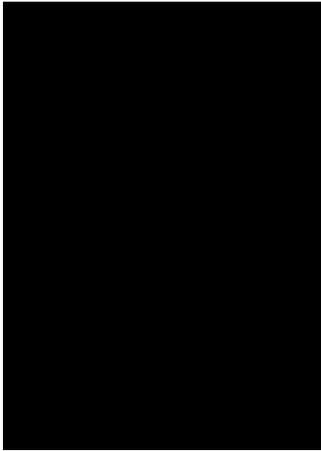


Fig. (1-A): Exposed repair of axillary artery by vein graft.

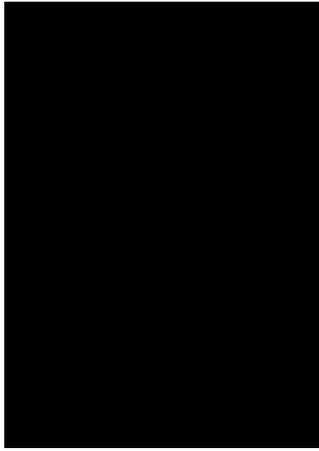


Fig. (1-B): Defect covered by parascapular fasciocutaneous flap (intraoperative and late postoperative).

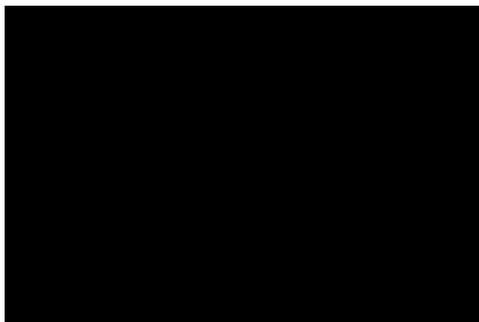


Fig. (2-A): Exposed repaired left brachial artery

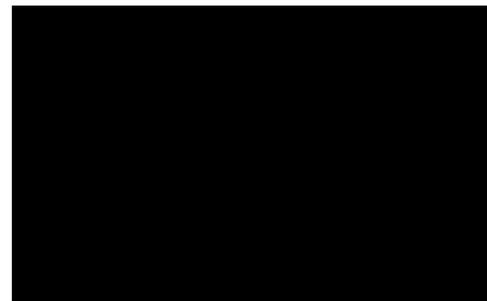


Fig. (2-B): Defect covered by medial forearm fasciocutaneous flap with skin graft to the donor site.



Fig. (3-A): Exposed repaired brachial artery and vein with saphenous vein grafts.

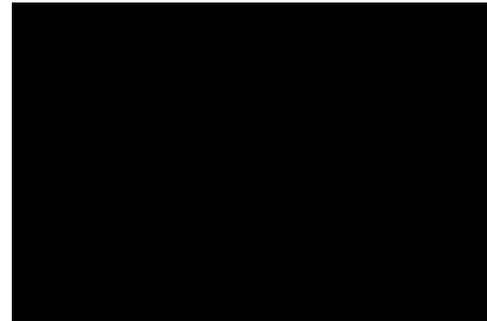


Fig. (3-B): Pedicled latissimus dorsi myocutaneous flap covering the exposed cubital fossa structures.

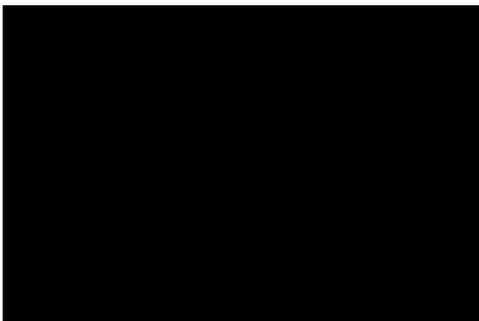


Fig. (3-C): Exposed repaired brachial artery and vein with saphenous vein grafts in midarm covered by pedicled latissimus dorsi myocutaneous flap + split-thickness skin graft.

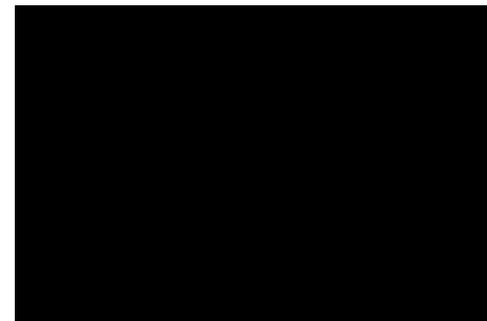


Fig. (3-D): Pedicled latissimus dorsi myocutaneous flap covering the exposed midarm structures 5 month postoperatively.

Fig. (4-A): Exposed repaired posterior tibial artery in lower leg with proximally based soleus muscle elevated.



Fig. (4-B): Early and late postoperative results after soleus muscle flap and fasciocutaneous closure with lateral skin grafting.

Fig. (5-A): Exposed repaired Lt. femoral & external iliac arteries using PTFE with soft tissue defect of the lower abdominal wall & Lt. groin.

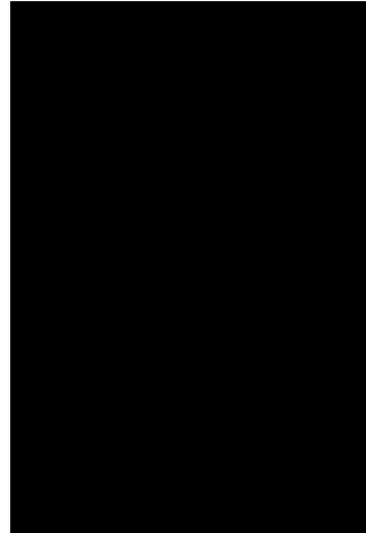
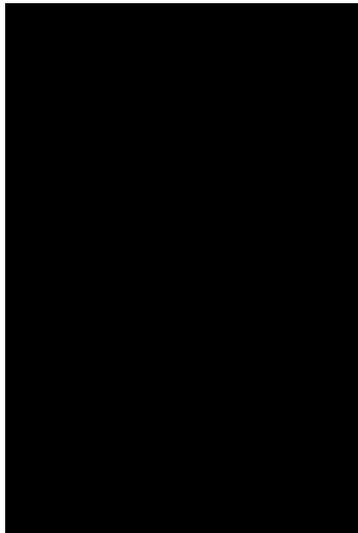


Fig. (5-B): Rt. Rectus abdominis myocutaneous flap with a sound healing of the defect in the left lower anterior abdominal wall & groin.

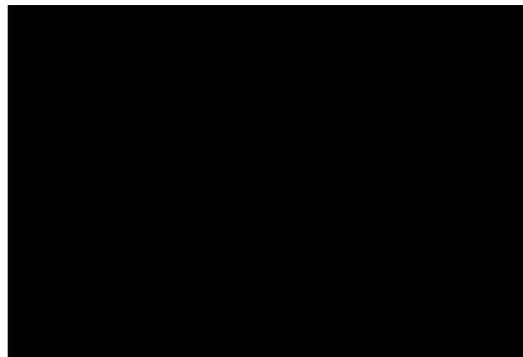




Fig. (6-A): Exposed repaired Rt. popliteal artery with vein interposition.



Fig. (6-B): Closure of defect by Rt. sartorius disinsertion to cover the exposed vessel & skin graft.

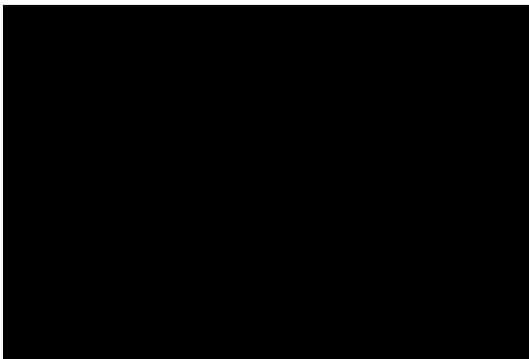


Fig. (6-C): Closure of defect by Rt. lateral head of gastrocnemius muscle to cover the exposed vessel then skin graft is applied.

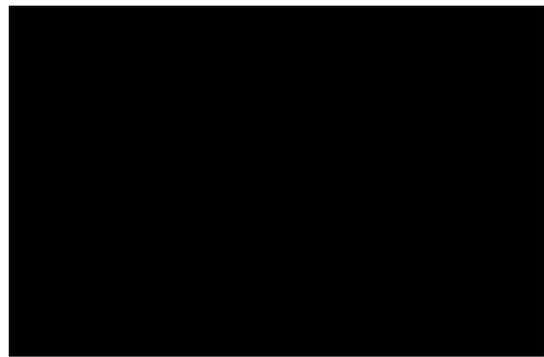


Fig. (7-A): Defect lower third leg, repair of anterior & posterior tibial aa. by vein interposition.

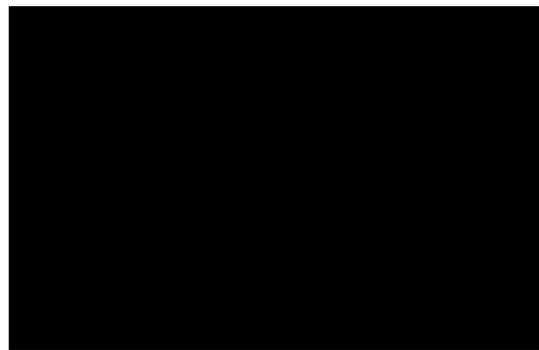


Fig. (7-B): Free latissimus dorsi ms. flap covering exposed bone & repaired a.

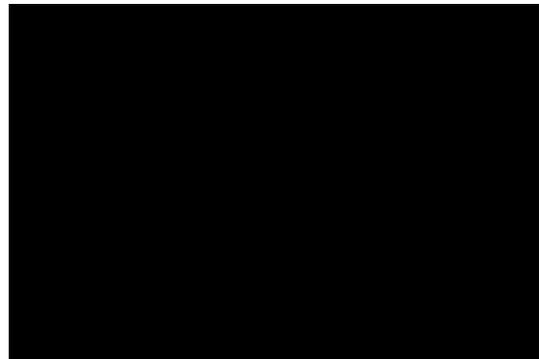


Fig. (7-C): Healed free latissimus dorsi ms. flap 2 months later.

## RESULTS

Clinical results showed good function of the repaired arteries and veins with good distal pulses. There was also adequate healing of soft tissue coverage and evidence of healing of the associated bone fractures, gangrene occurred in one case with necrosis of soft tissue coverage, infection and graft thrombosis followed by below knee amputation. Deep venous thrombosis occurred in two cases due to vein graft thrombosis that was managed by intravenous anticoagulation. Minimal sloughing and infection at the edge of the wound occurred

in three cases that required repeated dressings for complete healing. Persistent lymph discharge from drain site at the groin in a case with sartorius muscle flap that resolved gradually within 3 weeks (Table 3).

Table (3): Complications.

Complication	No. of cases
Below knee amputation	1
DVT	2
Infection & minimal sloughing	3
Lymph discharge	1

## DISCUSSION AND CONCLUSION

Once diagnosis of arterial injury is made, the majority of patients will require surgical exploration and repair. In extensive trauma patients with multiple associated injuries, bleeding vessel ligation may be justified as a life saving procedure. When the patient's condition and hemodynamic status allow prolonged operative intervention, injured vessels are repaired and proper soft tissue coverage is necessary to obtain proper wound healing.

It is generally agreed that autologous vein grafts are the best due to durability, resistance to infection, and ability to draw nutrient flow from the surrounding viable tissues. Polytetrafluoroethylene (PTFE) grafts can be used in some situations but usually reserved for above knee and above elbow applications [7].

In our study, femoral artery alone was injured in 2 cases, femoral artery and vein in 5 cases, popliteal artery and vein in 2 cases, anterior and posterior tibial arteries in 3 cases. In the upper extremity, axillary artery and vein in 2 cases, brachial artery in 4 cases.

Management of vascular injuries is achieved to control life-threatening hemorrhage and prevent limb ischemia. Time of vascular repair is extremely important. It is generally accepted that more than 6-9 hours of warm ischemia time makes limb survival unlikely [8].

In a review of previous studies, it has been shown that closure of wounds within the first 72 hours after injury was associated with the lowest complication rate and highest success rate [9]. In this study, closure of defects with soft tissue coverage was done within 3-6 hours after trauma. Soft tissue coverage is mandatory when vascular repair is exposed. The commonly accepted reconstructive technique is chosen according to the so called reconstruction Ladder; starting by linear closure and ending by free muscle and myocutaneous free flaps. However, in cases with vascular repair, the preferred coverage should be a good muscle [10].

In severely traumatized extremity, wound closure is somewhat problematic. Knowing the fact that devitalized tissue act as culture medium for bacteria and impair the bactericidal effects of leukocytes, extensive debridement and irrigation is necessary. Moreover, exposed vascular repair will be at risk of desiccation, graft disruption and secondary hemorrhage [11].

In this study, a special group of patients were studied as they had combined vascular injury and

soft tissue defects. This situation mandates both vascular repair and immediate soft tissue coverage. Three main types of soft tissue coverage were used. Fasciocutaneous flaps, muscle flaps, and muscle free flaps.

In high-risk locations in the extremities, certain flaps are very important. Fasciocutaneous flaps provide coverage when a skin graft or random skin flap is insufficient for coverage. They are indicated when thinner flaps are required but they are not resistant to infection as muscle flaps [12,13]. They were used in 4 cases in this study to cover the repaired axillary and brachial arteries in the upper limb with good clinical results and effective wound healing. In the upper extremity, parascapular fasciocutaneous flap was used to cover defects in the axilla in 2 cases, medial forearm flap to cover the cubital defects in 2 cases, and latissimus dorsi myocutaneous flap was used to cover the cubital fossa in 2 cases. In the lower extremity, tensor fascia lata myocutaneous flaps were used in 3 cases, rectus abdominis myocutaneous flap was used in 3 cases, sartorius muscle flaps in 1 case, soleus muscle flap in 2 cases, and latissimus dorsi free muscle flap was used in the last one case to cover lower third of leg defect.

Muscle flaps appear to work by increasing local tissue oxygenation and phagocytic activity, augmenting delivery of antibiotics to the site of defect, and eliminating dead space which prevents hematoma and/or seroma formation. The preference in the lower extremity defects is muscle flap and a skin graft as it provides a better result than the all-in-one myocutaneous tissue transfer [14].

In this study, muscle flaps were used in 14 cases to cover repaired brachial artery in 3 cases and repaired femoral, popliteal, and posterior tibial arteries in 11 cases. Latissimus dorsi, rectus abdominis, tensor fascia lata, gastrocnemius, and soleal muscle flaps were used effectively with only one case of failure in the lower extremity that ended with below knee amputation. The last muscle flap was free muscle flap used to cover exposed bone and arterial repair of injured tibial arteries and fractured lower end tibia. The clinical results were excellent with restoration of blood flow to the foot, good bone healing and limb salvage.

In the current study, the overall limb salvage was achieved in 16 out of 18 limbs treated (88.9%), and amputation (below knee amputation) was done in two patients (11.1%), following necrosis of soft tissue coverage, infection and graft thrombosis. This in comparison to the results of the study by

Lin et al. [15] who showed limb salvage rate of 75%, and overall secondary amputation rate of 25%. Another study for lower extremity injuries showed limb salvage in 56% of patients with amputation rate of 28% [16].

Complications that may occur after vascular repair and may lead to loss of the limb include hemorrhage either from the suture line of the vascular repair or due to missed arterial or major venous injury, thrombosis causing occlusion of the vascular repair, compartment syndrome due to trauma or reperfusion following severe prolonged ischemia causing swelling within a closed fascial space and necrosis of the muscles, and infection of an arterial suture line causing hemorrhage, thrombosis, distal ischemia and amputation [5,17].

Complications included deep venous thrombosis in 2 cases that improved by anticoagulation with evidence of recanalization. Sloughing of the edge of 2 fasciocutaneous flaps that healed by repeated wound dressings. Persistence lymphatic discharge in the groin in case with sartorius muscle flap that took 3 weeks to stop with sound wound healing. Only one case had below knee amputation after thrombosis of the arterial graft and gangrene of the foot.

*In conclusion*, management of vascular injuries is achieved to control life-threatening hemorrhage and prevent limb loss. Time of vascular repair is very important as more than 6-9 hours makes limb survival unlikely. The use of autogenous vein graft is better than synthetic grafts especially when the field is potentially infected or associated with soft tissue loss.

Use of different types of coverage of the exposed repaired blood vessels is very helpful in eradicating infection, filling the dead spaces and encouraging oxygenation and antibiotic delivery to the injured area.

There are high-risk areas in the extremities that mandate soft tissue coverage after vascular reconstruction; the axilla and antecubital fossa in the upper extremity and groin and popliteal fossa in the lower extremity. The vascular surgeon must be aware of the different types of flaps that could be used in these areas. Knowledge of the anatomical basis, blood supply, and donor sites are impotent in order to offer a chance for plastic reconstruction of associated soft tissue defects after vascular repair.

It is clear that soft tissue coverage is associated with a lower complication rate. It was found that over all complication rate of wounds closed within

the first week of injury was 18% compared to 50% complication rate of wounds closed in sub-acute phase of 1-6 weeks [13]. In this study minor complication rate was 27% and major complication rate was 11%. Others believe that closure of wound within the first 72 hours after injury was associated with the lowest complication rate and high success rate [9].

Finally, combined work of vascular, plastic, and orthopedic surgeons is necessary in complex extremity trauma. Soft tissue coverage protects both vascular repair and exposed bone fracture. This will prevent serious complications of infection, maintain graft patency, allow bone formation and with better outcome of sound wound healing and limb salvage rate.

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