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Case Report

Successful salvage of upper extremity following severe crush injury associated with vascular compromise using a supra thin free anterolateral thigh flap

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ABSTRACT

Traumatic injuries of the upper limbs can often result in serious and challenging wounds involving multiple compartments such as skin, bone, tendons and neurovascular structures. These type of injuries of the upper extremity pose several challenges to the plastic surgeon. The main difficulty is to provide a stable, long lasting and aesthetically acceptable coverage that enables joints excursion so that patient can return to work at the earliest. Here, we present a case of 45 years old gentlemen who sustained severe crush injury associated with avulsed radial and ulnar artery of left upper limb following road traffic accident. At presentation, there was no pin prick in his hand and hand was pale. At first surgery, hand was revascularized using a vein graft in radial artery and skin grafting was done over the forearm defect as a temporary cover. After 12 hours, when the viability of hand was reassured, the defect was covered with free supra thin anterolateral thigh (ALT) flap. Patient's hand and flap both survived and he was discharged in a satisfactory condition.

Keywords: Upper extremity trauma, Vascular injury, Flow-through flap, Free flap, ALT flap

INTRODUCTION

Composite defects of upper extremities may be seriously challenging especially in view of difficult reconstruction as these may involve different structures which can compromise limb functions. These complex injuries are usually caused by road traffic accidents, work-related trauma, firearm injuries, burns that includes thermal, chemical and electrical injuries. Salvage of limb is more aggressively pursued in the upper extremities as compared with the lower extremities. It can be attempted in most patients even if the patient has a mangled extremity. However, sometimes the nature of injury is so severe that primary amputation may be required to save the patient's life. The severity of associated injuries may preclude prolonged procedures for attempted limb salvage for some patients involving multisystem injuries. However, as hand is functionally a complex structure, it is often difficult to obtain a complete functional recovery.

Complex upper limb injury with vascular compromise can be managed either with two stage surgery which involve initial vascular repair followed by soft tissue cover or simultaneous soft tissue and vascular repair. An ideal option of hand reconstruction should give tendons and joints a gliding movement and be effective enough to allow heavy work and at the same time should maintain the sensitivity of the hand. The most common reconstructive options include advancement or rotation flaps, regional flaps and free flaps.[1]

Aim of this article is to have a clear knowledge of management of vascular injury associated with composite wounds of upper extremity.

CASE REPORT

A man in his mid-40s sustained severe crush injury to left forearm and hand, presented to us after five hours of accident. His blood pressure was 90/60 mm Hg, heart rate of 110 bpm with respiratory rate of 20 per minute. There was no associated major injury in terms of head injury, blunt trauma abdomen or chest injury. On local examination, his left hand was pale, cold, shrivelled with absent pin prick. A large muscle hematoma was present over volar aspect of distal forearm with a wound of size 18×11 cm which was extending over the extensor aspect on radial side (Figure 1). Some active bleeding present from the wound which was controlled using tourniquet and compression dressing. Splint was applied and hand elevation was given. The patient was resuscitated as according to advanced trauma life support (ATLS) protocol. Foleys urinary catheter was inserted for urinary drainage. Broad spectrum antibiotics were started and anti-tetanus prophylaxis was given. His haemoglobin was 7.5 gm % so, 2 units of packed red blood cells (PRBCs) were transfused. Liver and kidney functions test were with in normal limits along with the electrolytes. After resuscitation still there was no pin prick or capillary refill in hand. Ultrasonography (USG) doppler shows no flow in both radial and ulnar arteries. His X-rays showed distal radius fracture with wrist joint dislocation. Orthopedics consultation was sought and patient was immediately taken for emergency surgery after all necessary preparations as ischaemia time was increasing. Possibility of hand amputation was explained to patient and his care givers. Consent was taken for the same.

Figure 1 (a-c): Severe crush injury to left forearm and hand showing necrotic muscles and hematoma. Pin prick was absent and hand was shriveled, looking pale at presentation. X-rays shows fracture of distal end radius along with wrist joint dislocation.

Surgery was conducted under general anaesthesia and tourniquet control. Whole of the hematoma was cleaned off. External fixator was applied by the orthopedic team. Massive contamination was present inside the wound. Thorough warm saline and betadine wash was given and all dirty foreign bodies were removed. Intraoperative findings showed both radial and ulnar arteries were avulsed in large segments (6 cm gap in radial and 7 cm gap in ulnar artery) along with the avulsion of median and ulnar nerves (8 cm nerve gap in each). Some of the flexor tendons were also torn off. Radical debridement was done. A vein graft of approximately 7 cm was used to anastomose radial artery under the loupe magnification (Figure 2). Immediately there was bright red pin prick was there in all hand fingers and turgor returned to normal. Ulnar artery was avulsed till the level of Guyon's canal and was thrombosed all along with its length. There was no soft tissue covering present over the anastomotic site as whole of the skin was avulsed off. So, a large sheet of split thickness skin graft was harvested from the left thigh posterior aspect and put over the forearm defect site as a temporary cover (Figure 3). Intraoperative urine output monitoring and arterial blood gas analysis along with the electrolytes was done to look for any reperfusion injury.

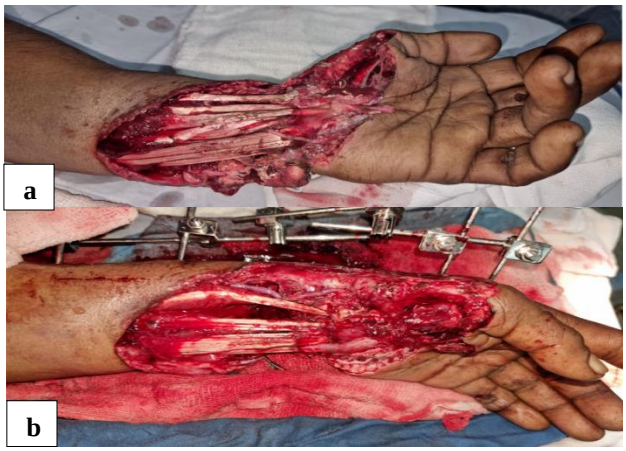

Figure 2 (a and b): After primary debridement, both radial and ulnar arteries were avulsed along with segmental gap. Hand was reperfused with radial artery anastomosis using vein graft. Median and ulnar nerves along with flexor tendons were also debrided.

Figure 3: Skin graft was put over the forearm defect to cover the vein graft at primary surgery as a temporary cover.

Post operatively, fluid hydration was given, hand kept elevated above the heart level for proper venous drainage.

Low molecular weight heparin was started. Vitals were stable throughout. 12 hours later, patient was again taken into operation theatre for relook debridement and to provide a permanent soft tissue covering over the defect site after ensuring of hand viability. The skin graft was removed and vein graft in the radial artery was found to be patent and pulsatile. Redo debridement was done of the devitalized materials which was not present at the time of primary surgery. All flexor digitorum sperficialis (FDS) tendons, flexor carpi radialis (FCR), flexor carpi ulnaris (FCU) along with FPL were removed (Figure 4). Then a free flap in the form of supra thin anterolateral thigh (ALT) was planned as he will further require secondary reconstruction of nerves and tendons. Flap of size 19×12 cm was marked on the right thigh. Two perforators were identified on doppler scanning. Flap was harvested and anastomosis was done with ulnar artery and its vena comitantes under microscope guidance with nylon 10-0 sutures (Figure 5).

Figure 4: At second surgery, skin graft was removed. Redo debridement was done. Vein graft was found to be patent.

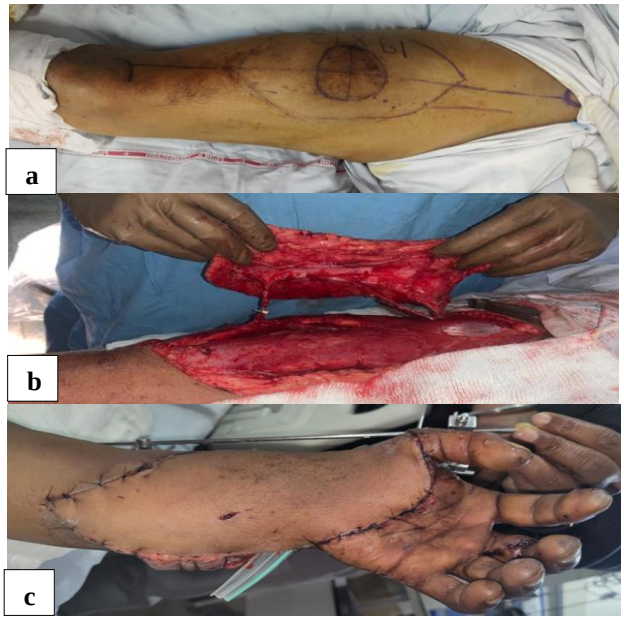

Figure 5 (a-c): Free supra thin ALT flap was marked and harvested from the right thigh. Anastomosis was done with ulnar artery and its comitantes. Flap inset was given.

Both ulnar and median nerves were reconstructed using multiple cables of reversed sural nerve grafts. Flow through flap is ideal for these cases but in this case, ulnar vessels were too distal for anastomosis and their lumen was thrombosed and wall was not healthy. Flap was monitored as per protocol in terms of dermal bleeding, capillary refill, turgor and colour. Heparinisation was continued for five days. Post-surgical period was uneventful. Flap and hand both survived. The patient was discharged after 3 weeks in satisfactory condition. Vein graft was found patent on doppler USG at 1-month post operatively. Tablet aspirin 150 mg was given for 4 weeks. Neither donor nor recipient site morbidity was noted during the follow-up period (Figure 6).

Figure 6: 4-months post-operative pictures after removal of external fixator. Flap is well settled and patient recovered sensation. He is now planned for secondary tendon reconstruction

DISCUSSION

Optimal outcome in patients with severe crush injuries of upper extremity associated with vascular insufficiency requires a multidisciplinary approach. The primary goal of surgical management in these types of injuries is limb salvage, which is aggressively followed in upper extremities as compared to lower extremities. Limb salvage can even be attempted if there is mangled limb. However, importance must be given to patient's life over to limb salvage. Multisystem involvement may rule out longer procedures for salvage of extremities. These patients should undergo a damage control approach which includes splinting, or external fixation of fractures, ligation or shunting of vessels, identification and tagging of injured nerves, irrigation and debridement of soft tissues to remove gross contamination, devitalized soft tissues and foreign materials. Definitive treatment includes internal fixation, reconstruction of arteries, veins, nerves and coverage of soft tissues defects. Multidisciplinary approach for management of complex upper extremity trauma with associated vascular injury can be learned in following ways as given below.[2,3]

Examination

An adequate history regarding time since injury, mode of injury and comorbidities has to be taken. Any active bleeding should be controlled with direct pressure. If it is not possible, a tourniquet can be used. If that is not possible

due to the location of injury, a vascular clamp should be used. Only when all the above fails, the vessel should be ligated. Exposed muscles viability, distal vascularity, identification of cut structures, movements and sensation should be assessed. In situations where hard signs of vascular injury like active or pulsatile haemorrhage, pulsatile or expanding hematoma, clinical signs of limb ischemia, diminished or absent pulses, bruit or thrill suggesting arterio-venous-fistula are present and the location of vascular injury is known, there is no role for computed tomography (CT) angiography. In multi-level injury when the site of vascular injury cannot be discerned clinically, CT angiography may be indicated.[4]

Debridement

Adequate debridement of the wound is the most crucial step to ensure primary wound healing and bony union after any sort of reconstructive procedure. It should be performed under tourniquet control to minimize further blood loss and to clearly see the devitalized tissues. Inadequately debrided wounds can often result in infection, thrombosis of the grafted or repaired artery and also life-threatening blowouts of the vessels. Debridement of unquestionably dead and contaminated tissue should be followed by the application of wet dressings. At a second look within 48 hours, it may be possible to create a clean wound by further debridement on which reconstruction by an early flap can be done.[5]

Bone fixation

In high grade soft tissue injuries, contaminated wounds and unstable patients, it is better to do external fixation for bony stabilization. Definitive fixation can be done when the flap cover is settled which is generally achieved in 2-3 months duration. In relatively more stable patients and non-contaminated wounds with less soft tissue injury definitive fixation should be done. Bone fixation should be done prior to definitive arterial repair as there is the risk of the anastomosis being disrupted during bone fixation.[6,7]

Ischemia time

The critical time for reperfusion for the upper extremity is usually 8 to 10 hours, which is longer than the lower extremity which is typically up to 6 hours. So, if the revascularization cannot seem to be achieved expeditiously and the time since injury is 3 to 6 hours and direct repair of the artery is not possible, a temporary vascular shunt should be used to cut down the extremity ischemia duration. These shunts should not be kept for more than 6 hours as the chance of blockage is high. Shunting helps in assessing patient response to revascularization and can help in making a decision of limb salvage versus amputation. However, these shunts increase the length of vein graft needed and it can slip out of the vessel that may results in bleeding. Early revascularization within 6-8 hours of the injury prevents the nerve and muscle from further damage. Contraindications for revascularization includes concomitant life-threatening injuries, haemorrhagic shock and severe structural damage to the hand.[8-10]

Flap coverage and reconstruction options

Wounds should be covered as soon as possible to get an ideal functional outcome. It can be performed as a secondary procedure if vessels have a viable skin or muscle cover. Free flaps are the flaps of choice for forearm defects reconstruction because they can be tailored as per the requirement of the wound, donor area is away from the injured recipient site, positioning of the limb is more comfortable and can be done as needed unlike the pedicled distant flaps. In situations of major vascular injuries, abdominal or groin flaps are performed as they do not sacrifice donor vessels from the injured limb. However, if the hand requires revascularisation, anterolateral thigh flap, a radial artery forearm flap, LD muscle flap and free fibula may be used a flow through flaps.[11-14]

The advantage of the flow-through free ALT flap transfer is that it provides vascular conduit and soft tissue coverage simultaneously. The long pedicle length provides vascular continuity by flow-through fashion in case of long vascular segmental loss.[15] If vessels are not exposed the wound can be closed using a sterile dressing and a flap cover may be planned electively within next 48 hours. If delayed, it can result in microbial colonisation and tissue desiccation. Early flap coverage provides immune mediators, improved oxygenation and enhanced delivery of antibiotics to the injury site, which decreases the risk of infection and accelerates healing.[16,17]

Vein graft with flap cover is the preferred method of reconstruction in soft tissue injury of upper extremity with vascular compromise because there is freedom to bridge any length of the arterial gap, multiple vein grafts can be used, appropriate size matched graft harvesting can be done, provides faster revascularization than a flow-through flap and has lesser blood loss and two teams are not required. In most cases, debridement of the wound followed by vein graft is done. It is best to do a definitive flap cover immediately. If that is not possible, the vein graft may be covered temporarily by a collagen sheet or split skin graft. Flap coverage should not be delayed in such cases for more than 12 hours. The use of acellular dermal matrix has also been described to provide temporary cover which prevent wound desiccation but their use is limited by the cost.[18] When using vein grafts wound bed should be healthy and it should be anastomosed in a mild stretch because this tends to dilate and expand once the flow is restored.[19] In upper extremity wounds, it is preferable to do fascio-cutaneous flap cover as it is easier for later re-elevation in cases where secondary surgeries are required. Muscle flaps like LD flap have the advantage of covering large area, obliterating dead space, having a long vascular pedicle, easier to harvest and can cope up with infection. They also lead to atrophy with time reducing the overall bulk. Muscle flaps have the

disadvantage of difficulty in re-elevation for secondary surgeries. However, there is little evidence to prove the superiority of muscle flaps compared with well-vascularized fascio-cutaneous flaps.[20]

Tendon and nerve reconstruction

In non-contaminated wounds, tendon and nerve reconstruction is best done in the same stage. If nerve or tendon grafts are to be used, immediate flap cover is needed. If that is not possible, then grafting should be done at the time of providing flap cover, which usually happens within 12 hours of vascular repair. In conditions where the wound is contaminated or there is extensive crushing, it is better to do the nerve and tendon reconstruction later on. Proximal and distal ends should be tagged with sutures and good documentation about the location of nerve ends and tendon ends need to be done to make secondary reconstruction easier.

Postoperative care and monitoring

Several different anticoagulants such as intravenous dextran 40, intravenous heparin, subcutaneous low-dose heparin, and oral low-dose aspirin are used prophylactically. There are no prospective controlled trials to confirm the efficacy of any of these anticoagulant regimens. Following revascularization, antiplatelet therapy (aspirin, 150 mg daily) should be given for 6 to 12 weeks until the intima heals at the anastomotic sites.

Present case was managed with vein graft followed by flap cover in the form of free supra thin ALT flap and his hand was saved successfully. The ALT flap, elevated in a supra-fascial or super thin plane, is a safe, effective option for extremity soft tissue reconstruction. The decreased flap volume and bulk provides the improved contour and pliability necessary for appropriate distal extremity function. The potential versatility of super-thin flaps reinforces the importance of continued innovation by reconstructive microsurgeons.

CONCLUSION

Management of complex upper extremity trauma with associated vascular insufficiency requires multidisciplinary approach with adequate planning and quicker decision making which will ultimately help to salvage the extremity and to achieve an optimal outcome. The decision to salvage or amputate has to be made on an individual case basis and importance should be given to early radical wound debridement. Flap cover in the form of flow-through flap or vein graft along with a pedicled or flee flap can be tailored individually and surgeon preferences. Immediate reconstruction of severe upper extremity injuries favours increased function, fewer complications, shorter hospital stays, lower costs, permits earlier mobilization which helps to maintain adequate joint excursion and prevents the tendon adhesions.

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REFERENCES

1. Bashir MM, Sohail M, Shami HB. Traumatic wounds of the upper extremity. Hand Clin. 2018;34(1):61-74.
2. Mahajan RK, Srinivasan K, Jain A, Bhamre A, Narayan U, Sharma M. Management of Complex Upper Extremity Trauma with Associated Vascular Injury. Indian J Plast Surg. 2022;55(3):224-33.
3. Ng ZY, Askari M, Chim H. Approach to complex upper extremity injury: an algorithm. Semin Plast Surg. 2015;29(01):5-9.
4. Inaba K, Potzman J, Munera F, McKenney M, Munoz R, Rivas L, Dunham M, DuBose J. Multi-slice CT angiography for arterial evaluation in the injured lower extremity. J Trauma. 2006;60(3):502-6.
5. Scheker LR, Ahmed O. Radical debridement, free flap coverage, and immediate reconstruction of the upper extremity. Hand Clin. 2007;23(01):23-36.
6. Volpin G, Pfeifer R, Saveski J, Hasani I, Cohen M, Pape HC. Damage control orthopaedics in polytraumatized patients- current concepts. J Clin Orthop Trauma. 2021;12(01):72-82.
7. Herren DB, Nagy L, Campbell DA. Basel: Karger. Osteosynthesis in the Hand: Current Concepts. FESSH Instructional Course. 2008;89-98.
8. Polcz JE, White JM, Ronaldi AE. Temporary intravascular shunt use improves early limb salvage following extremity vascular injury. J Vasc Surg. 2021;73(04):1304-13.
9. Inaba K, Aksoy H, Seamon MJ, Marks JA, Duchesne J, Schroll R, et al. Multicenter evaluation of temporary intravascular shunt use in vascular trauma. J Trauma Acute Care Surg. 2016;80(3):359-64.
10. Wlodarczyk JR, Thomas AS, Schroll R, Campion EM, Croyle C, Menaker J, et al. To shunt or not to shunt in combined orthopedic and vascular extremity trauma. J Trauma Acute Care Surg. 2018;85(6):1038-42.
11. Qing L, Wu P, Liang J, Yu F, Wang C, Tang J. Use of flow-through anterolateral thigh perforator flaps in reconstruction of complex extremity defects. J Reconstr Microsurg. 2015;31:571-8.
12. Zhan Y, Fu G, Zhou X. Emergency repair of upper extremity large soft tissue and vascular injuries with flow-through anterolateral thigh free flaps. Int J Surg. 2017;48:53-8.
13. Hsu CC, Lin Y T, Lin C H, Lin C H, Wei F C. Immediate emergency free anterolateral thigh flap transfer for the mutilated upper extremity. Plast Reconstr Surg. 2009;123(06):1739-47.
14. Koshima I, Saisho H, Kawada S, Hamanaka T, Umeda N, Moriguchi T. Flow-through thin latissimus dorsi perforator flap for repair of soft-tissue defects in the legs. Plast Reconstr Surg. 1999;103(05):1483-90.

15. Yildirim S, Taylan G, Eker G, Aköz T. Free flap choice for soft tissue reconstruction of the severely damaged upper extremity. J Reconstr Microsurg. 2006;22(8):599-609.
16. Ninkovic M, Schoeller T, Wechselberger G, Otto A, Sperner G, Anderl H. Primary flap closure in complex limb injuries. J Reconstr Microsurg. 1997;13(8):575-83.
17. Ninkovic M, Deetjen H, Ohler K, Anderl H. Emergency free tissue transfer for severe upper extremity injuries. J Hand Surg Br. 1995;20:53.
18. Bastidas N, Ashjian PJ, Sharma S. Acellular dermal matrix for temporary coverage of exposed critical neurovascular structures in extremity wounds. Ann Plast Surg. 2009;62(04):410-3.
19. Shuck J, Masden DL. Options for revascularization: artery versus vein: technical considerations. Hand Clin. 2015;31(01):85-92.
20. Wang HD, Alonso-Escalante JC, Cho BH, DeJesus RA. Versatility of free cutaneous flaps for upper extremity soft tissue reconstruction. J Hand Microsurg. 2017;9(02):58-66.

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