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ARM SALVAGE PROCEDURE WITH PEDICLED LATISSIMUS DORSI MUSCLE-SKIN FLAP IN HIGH-ENERGY FIREARM INJURIES

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ABSTRACT

High energy firearm injuries of the upper limb are usually associated with massive soft tissue necrosis, infection, and exposure of the vital structures. Management is fairly problematic, requiring multiple operations and prolonged hospitalization. The latissimus dorsi flap is an anatomically well-known flap that is elevated and transposed using a relatively straightforward surgical procedure. It can be used for large tissue defects and in a functional manner, as needed.

In 7 patients with such injuries, pedicled latissimus dorsi muscle-skin flap have been succesfully used. Mean follow up time was 13,7 months. All flaps survived completely. The donor sites were closed primarily, with acceptable linear scars in all cases.

Pedicled latissimus dorsi musculocutaneous flap provides an excellent cover for upper arm defects. This procedure is a simple, reliable, and extremity-saving method that can be used instead of tissue cover and functional muscle mass when high-energy firearm injuries involving the arm are associated with a vascular injury and repair.

Introduction

High-energy firearm injuries are almost always associated with significant tissue damage involving bone, nerve, muscle, and blood vessels. These injuries require multiple reconstructions and result in limb loss unless adequately treated. This type of injury does not involve only the upper extremity but also invariably presents with additional thoracic, cranial, and abdominal trauma. The presence of additional trauma hinders acute tissue reconstruction. [1]

The latissimus dorsi flap is an anatomically well-known flap that is elevated and transposed using a relatively straightforward surgical procedure. Additionally, the function of latissimus dorsi muscle is preserved since the thoracodorsal nerve is transferred intact in the pedicle. The pedicle makes its functional transfer possible especially when functional muscle groups are defective in the arm and forearm. [2] It can be used for large tissue defects and in a functional manner, as needed. It is a widely used, easy-to-learn, all-purpose flap with a wide rotation arch owing to a long pedicle [3]. In addition to defect reconstruction, it can also be transferred, for functional purposes, in the restoration of elbow flexion and forearm extension. [2,4] In smaller defects, thoracodorsal artery flaps can be used to reduce donor field morbidity. [5] As there are few studies in the literature that have used pedicled latissimus dorsi musculocutaneous flap for arm salvage, we presented our experience and outcomes in seven patients who underwent this type of arm salvage procedure.

Patients and methods

Seven patients (five males, two females; average age: 26 yrs; range: 12 to 47 yrs) who suffered a large defect in the arm after a high-energy firearm injury were included in this retrospective study. All operations were performed by the first author. Five of seven patients were treated against hypovolemic shock and additional trauma at our intensive care unit for an average period of 5.5 days before admission to our clinic. Thus, no reconstruction could be performed in the acute phase. Reconstruction was delayed until after the subacute phase in all patients. (Fig. 1 a-b-c)

Figure 1 a-b-c

All patients underwent vascular repair with a graft for major vascular injury. (Fig. 2 a-b) In five patients, the injury was accompanied by a humeral fracture. Five patients underwent bone fixation by our orthopedics clinic during the first operation. External fixation was used in three patients and compression plate was used two patients. Three full thickness median nerve and one ulnar nerve laceration was observed and repaired. The department of infectious diseases started cefazolin, metronidazole, and gentamicin antibiotic therapy against polymicrobial infections owing to the contaminated nature of the wounds. All patients underwent debridement at the operation room every other day.

A salvage operation was performed with pedicled latissimus dorsi musculocutaneous flap on the eighth day, on average, in all seven patients. (Fig. 3) The patients were discharged on the sixteenth day, on average. Each patient was begun on a physical therapy program before discharge. A psychiatry consultation for psychological support was obtained for all patients.

The average follow-up duration was 13.7 months. The patients were followed-up in outpatient clinic at 7, 14, 30, 60, and 90 days after discharge. The patient's data are summarized in Table 1 .

Table 1: Patients' Data

Case No	Age-Gender	Preoperative MESS	Time of Surgery Day	Humerus fracture level	Vascular injury	Defect Size	Defect localization	Hospitalization Time	Follow-up Time

1	12-F	7	3rd	Middle	BA	16*9	Middle 1/3 of the arm	10 day	12 month
2	18-M	7	8th	Distal	BA+BV	24*13	Middle and inferior (2/3) arm	22 day	18 month
3	22-M	7	5th	Distal	BA+BV	21*12	Middle and inferior (2/3) arm	18 day	15 month
4	26-M	7	5th	-	BA+BV	14*11	Distal 1/3 of the arm	18 day	24 month
5	26-M	8	7th	Middle	BV	15*13	Distal 1/3 of the arm	11 day	9 month
6	32-F	8	11th	-	AA	16*15	Proximal 1/3 of the arm	20 day	6 month
7	47-M	8	6th	Distal	BA	17*11	Distal 1/3 of the arm	21 day	12 month

AA: axillary artery, BA: Brachial artery, BV: Brachial vein, MESS: Mangled Extremity Severity Score

Figure 2 a-b

Figure 3

Results

No limb loss was observed in any of the patients undergoing salvage operation with a latissimus dorsi musculocutaneous flap. No partial or total flap loss was observed in any patient. Flaps fully adapted to the recipient field in all patients. No flap edema, congestion, infection, or hematoma was observed. The donor field was primarily closed. Infection was prevented by use of antibiotherapy and serial debridements. None of the patients developed osteomyelitis. Two patients developed a seroma that was reduced in size by local drainage and compression and vanished completely by the thirteenth day. None of the patients experienced any other donor field complications.

The patients with nerve injury had partial lesion in the EMG at 180 days after injury. Elbow flexion of all patients was improved due to the fact that the new insertion of the latissimus dorsi flap was placed near the bicipital aponeurosis. Follow-up for patients with nerve injury was extended until the 12th month after discharge. No patient had any complication at follow-up.

Discussion

Although rare, isolated high-energy firearm injuries cause complex defects containing extensive muscle necrosis, infection, and exposure of vital structures in the upper extremity. [5] Since they also involve vascular injuries, high-energy firearm injuries eventually result in limb loss or a non-functional extremity unless they undergo an intensive treatment process. Therefore, these injuries should be evaluated by an experienced reconstructive microsurgery team, and defects should be repaired at once. [6]

Extensive tissue necrosis resulting from high-energy injury and the associated circulatory failure almost always results in infection. [5] If untreated, osteomyelitis will result. Serial debridements and intensive antibiotic therapy should be applied to prevent this devastating complication. Our patients underwent debridement every other day in the operating room of our clinic and were begun on antibiotic therapy in collaboration with our infectious disease department to prevent infection. This group of patients is also exposed to multiple operations, prolonged hospital stay, and a multitude of associated morbidities. [6]

An upper extremity salvage algorithm, like lower extremity salvage algorithms, primarily include resuscitation of patients followed by stabilization of extremity, revascularization, and debridement of devitalized tissues. These procedures are typically followed by nerve and muscle-tendon repair, where feasible, and simultaneous or delayed defect reconstruction steps. [1,2,7] To obtain a functional hand after high-energy injuries might require multiple operations. Muscle and nerve transfer procedures generally are inevitable.

High-energy firearm injuries almost always involve vascular injuries at multiple levels in the upper extremity. A positive history of a previous vascular injury and repair was present in all patients in our series. Although reconstruction with a free flap may offer an option that can be used for particularly large defects, involvement of recipient vessels in the injury zone and the presence of a line of vascular repair with the graft limits the safety of this option. [1,6] No reconstruction was performed at the acute phase as most of our patients were treated for hypovolemic shock and additional trauma before being admitted to our clinic. For this reason, pedicled latissimus dorsi muscle flap was chosen owing to its anatomical proximity to the region of injury and its ease of use.

The latissimus dorsi muscle has long been used as a safe flap with a well-known anatomy. [4] At our clinic, it is the preferred flap for reconstruction of large arm defects in patients injured by high-energy firearm injuries, both in pedicled and free forms, as it allows functional reconstruction by virtue of its muscle properties. [2] Thanks to its muscle structure, it provides abundant blood flow to the region of use, alters oxygen balance in a favorable manner, and fills up the dead spaces. It covers large defects and the underlying major structures well owing to its large muscular structure. It improves the peripheral blood supply at the site of injury.[3] When elevated as a large tissue island, it can serve as a flap that covers the arm to the distal part of the elbow.

As the thoracodorsal nerve is transferred intact in the pedicled use of the latissimus dorsi flap, the muscle functions of the flap are largely preserved. This feature allows functional transfer of the muscle in the case where functional muscle groups of arm and forearm are defective. [2,8,9] It is the most extensively used muscle transfer for biceps or triceps necrosis after replantations or revascularizations, for elbow flexion and extension, and for combined restoration of elbow flexion and finger extension in brachial plexus surgery. [2,9,10]

It is not possible to apply primary closure and secondary healing, which are the first steps of reconstruction, in large tissue defects caused by firearm injuries. Similarly, grafted reconstruction is out of question for these defects due to exposure of bony and vascular structures. Vacuum-assisted closure and grafted reconstruction techniques, which have recently been popularized, are not suitable due to exposure of vascular pedicle and the repair line. Since an extensive damage ensues in the surrounding tissues in firearm-induced upper extremity injuries, defect reconstruction with local flaps elevated from the extremity is generally not feasible. Lateral thoracic artery flap can be used for reconstruction of similar defects; however, it fails to boost regional blood flow, as it is a fasciocutaneous flap. Rectus abdominis muscle flap has also been

used for the same purpose. Nevertheless, we do not prefer it since its procedure requires two sessions and patient adaptation to a stable position is difficult. [7] Reconstruction with pectoral muscle flap is another alternative option for upper extremity defects but it is only suitable for reconstruction of the proximal one-third of the arm. [7] We did not choose pectoral muscle flap for our patients in the current study since their defects were too large.

Conclusion

Pedicled latissimus dorsi musculocutaneous flap provides an excellent cover for upper arm defects. This procedure is a simple, reliable, and extremity-saving method that can be used instead of tissue cover and functional muscle mass when high-energy firearm injuries involving the arm are associated with a vascular injury and repair.

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