REPEATED UPPER LIMB SALVAGE IN A CASE OF SEVERE TRAUMATIC SOFT-TISSUE AND BRACHIAL ARTERY DEFECT

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We present the case of a 9-year-old male patient who suffered a gunshot injury to the right arm. The patient arrived in shock, his right arm severely traumatized, with soft-tissue loss involving the anterior surface and both sides of the right arm. The humerus was exposed. There was brachial artery defect and damage to the lateral fibers of the median nerve. The mangled extremity severity score (MESS) was 8 points. The patient was treated with general resuscitation, blood transfusion, and debridement. A venous graft, 12 cm in length, to bridge the brachial artery defect, and tendon transfer, triceps to the biceps, was performed in one step. Postoperatively, there was a normal radial pulse, normal skin color, normal temperature, and normal movement of the fingers without pain. Unfortunately, the patient then sustained a second trauma to the right arm 3 weeks later, rupturing the graft. This time he lost 1,500 cc of blood. After another blood transfusion, we performed a second reverse saphenous vein graft. The patient stayed at the hospital for 3 weeks. At follow-up 12 months later, the limb has good function and, except for the presence of a scar and skin graft, is equal in appearance to the left side.

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Vascular injuries of the upper extremity represent approximately 30–50% of all peripheral vascular injuries.[1,2] The majority of injuries are to the brachial artery, with 90% of these injuries due to penetrating trauma. Stab wounds and gunshot wounds are the most common cause of injury.[1,2] Upper extremity revascularization is performed most commonly for repair of traumatic or iatrogenic disease.[3] The goals of revascularization of the upper extremity are prevention of digit or limb loss, and preservation of long-term function.

CASE REPORT

A 9-year-old male patient sustained a high-velocity gunshot wound to the right arm. There was tattooing, laceration, and extensive tissue damage to the skin, the underlying biceps, brachialis, and coracobrachialis muscles, the brachial artery, and the lateral fibers of the median nerve. The anterior surface and both sides of the humerus were exposed (Fig. 1). There was no radial pulse. The limb was paresthetic and bluish. The patient was in shock, with systolic blood pressure of < 90 mmHg, and Hgb of 6 mg %. The time from injury to surgery was 7 hr. The mangled extremity severity score (MESS) was 8 points.

General resuscitation was performed, and blood transfusion (a total of 2,000 cc of blood) and plasma expander fluids were administered. Studies included abdominal sonography and x-rays of the humerus, shoulder, elbow, chest, and skull. The x-ray of the right shoulder and the chest showed a huge number of shotgun pellets in the tissue, (Fig. 2) but the chest CT was normal.

OPERATIVE PROCEDURES

There was loss of skin and subcutaneous tissue to the front and both sides of the right arm. There was loss of the flexor muscles of the elbow. The humerus was exposed and the periosteum was damaged. There was a 12-cm defect to the brachial artery, extending from the surgical neck of the humerus to 5 cm proximal to the lateral humeral condyle (Fig. 3), the proximal stump was retracted and pulsating. The lateral fibers of the median nerve were damaged, most probably from the proximity of heat from the gunshot blast. There were a large number of gunshot pellets in the wound and the surrounding tissue.

We cleaned the wound, removed the accessible pellets, debrided the soft tissue from the skin downward,

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Figure 1. Photograph of right arm, showing extent of lesion and exposed humerus. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

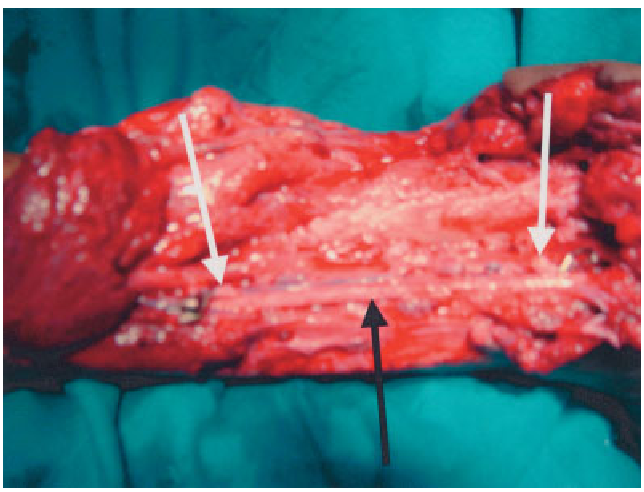

Figure 3. Intraoperative photograph. White arrows show both stumps of brachial artery occluded by microvascular clamps. Black arrow shows median nerve. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

and prepared the artery for the graft. We put a microvascular arterial clamp on both sides, excised the unhealthy damaged thrombotic tissue, and tested for patency on both stumps. The diameter of the great saphenous vein was about 1:6 that of the brachial artery, so we ligated both stumps and performed a reverse saphenous vein graft with end-to-side microvascular anastomosis. We removed the clamps, tested the patency of the graft, palpated the radial pulse, and examined the tissue perfusion. As the pulse was good, the insertion of the long head of the triceps brachii muscle was transferred with an intact nerve and vascular supply to the anterior brachial region and sutured above the radial tuberosity with the insertion tendon of the biceps brachii muscle. This was done in a single procedure to cover the venous graft and to restore elbow flexion. We performed

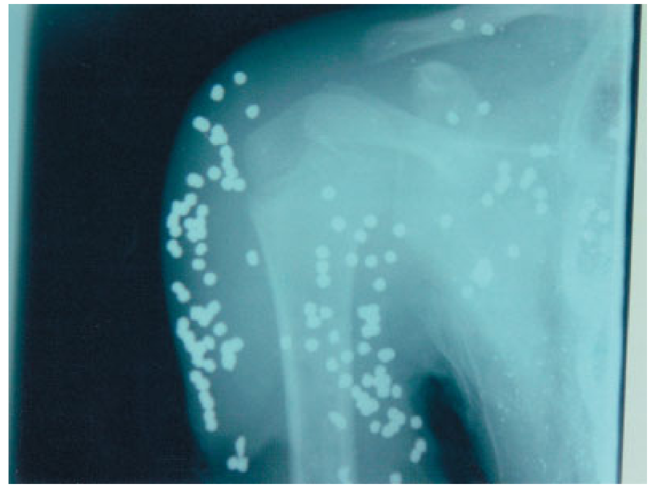

Figure 2. X-ray of shoulder and proximal humerus, showing huge number of shotgun pellets. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

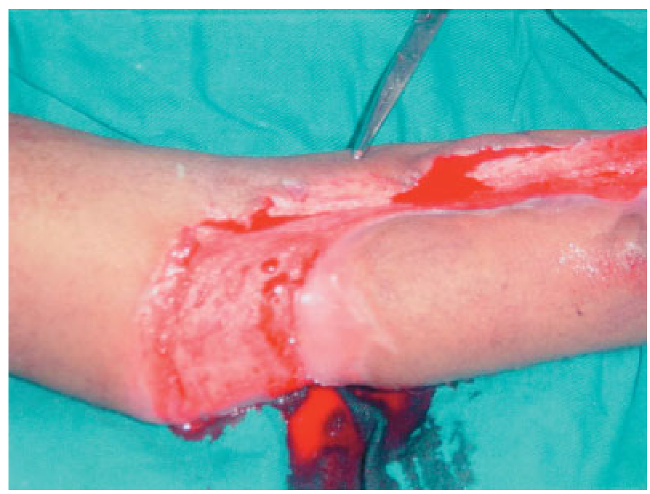

Figure 4. Intraoperative photograph, showing right arm and elbow before skin graft. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

an above-the-elbow slab, with special precautions regarding the graft site, and heparinized the patient for 5 days. Postoperatively, the right upper limb was good in regard to the radial pulse, skin perfusion, skin color, skin temperature, and movement of the fingers.

Three weeks later, the patient accidentally fell on the ground, again injuring his right upper limb. The graft ruptured, with severe bleeding, and the patient lost approximately 1,500 cc of blood. He was examined under general anesthesia. There was rupture at the proximal portion of the graft, with thrombus formation within the graft. We excised the graft and did another reverse saphenous vein graft. The patient was admitted to the hospital for 3 weeks, and a split-thickness skin graft was performed (Fig. 4).

Figure 5. Twelve months postoperative, with elbow flexion 110° and good hand function. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

Figure 7. Flexion of elbow, and lifting 2 kg. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

Figure 6. Elbow extension. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com]

After 12 months, flexion of the elbow was possible up to 110° (Fig. 5). Extension in the elbow joint was preserved (Fig. 6). The muscle strength (flexion of the elbow) according to the British Medical Council Scale was G4b (Fig. 7). The radial pulse was good, and the patient's hand remained well-perfused. The hand grip strength was 90% as compared to the left side. The 2-point discrimination of the right index finger was 8 mm. The patient returned to school 3 months after the operation.

DISCUSSION

The destruction of tissue in a penetrating gunshot injury depends on the effects of released energy, determined by mass, velocity, tumble, and angle of the bullet.[4] Velocity and missile weight are the two most significant determinants of tissue damage in gunshot wounds, with velocity the more important of the two properties. Low-velocity missile wounds usually leave a permanent wound track with minimal diameter, crushing, and soft-tissue laceration. There is no cavitation, and tissue necrosis around the bullet is not significant, i.e., the damage is essentially confined to the bullet track.[5] In our case, the injury was of the high-velocity type, with wide soft-tissue laceration, cavitation, and severe crushing.

Nerve elements are rarely injured by direct impact. Injury to nerves is most often attributable to shock waves and cavitation, causing compression and stretching. In our case, this was the cause of damage to the nerve structures outside the path of the projectile and to the longer nerve segments.[4] Furthermore, this was the cause of the anatomic and functional partial injury to the median nerve, which spontaneously recovered.

Although upper extremity injuries are usually not life-threatening, they can produce significant immediate and long-term morbidity, especially if there is an associated nerve injury.[6] Amputation in the shoulder region has to be considered for patients who have severe closed or open soft-tissue injuries with concomitant vascular and nerve injury.[7] The fact that the fitting of prostheses is less often successful in the upper limb, as compared to the lower limb, may also bias the surgeon towards an attempt to preserve a nonviable, nonfunctional upper extremity.[8–10]

Slaughterbeck et al.[11] used the MESS evaluation system in a retrospective review of 43 upper extremity injuries. They found that a score of at least 7 points was

Table 1. MESS Score (Slaughterbeck et al., 1994)[11]

Variable	Points
Skeletal soft-tissue injury	
Low energy (stab wound, simple fracture, low-velocity gunshot wound)	1
Medium energy (open or multiple fractures, dislocation)	2
High energy (shotgun, high-velocity gunshot wound, crush injury)	3
Very high energy (above + gross contamination, soft-tissue avulsion, massive crush injury)	4
Limb ischemia	
No ischemia	0
Pulse absent, perfusion normal	1[a]
Pulse absent, paresthetic limb	2[a]
Pulse absent, cool insensate	3[a]
Shock	
Systolic blood pressure of >90 mm	
Hypotensive transiently	1
Persistent hypotension of <90 mm	2
Age (years)	
<30	0
30–50	1
>50	2

[a]*Double score for warm ischemia of >6 h.*

highly predictive of amputation (Table 1). The decision to amputate a patient's limb, whether it be a child or an adult, is difficult.[12] In addition, limb salvage in borderline cases tends to make both the patient and surgeon reluctant to decide on a secondary amputation, even when it becomes badly needed.

There is also a strong humanitarian argument against early amputation. Surgical limb salvage does give the patient a chance for the most optimum physiologic outcome, i.e., the preservation of the patient's own limb. There is still the option for a later change of plan should that be necessary. However, once the limb has been amputated, there is no further option.[13]

Virtually all vascular repairs can achieve temporary success, as determined by immediate postoperative patency. However, immediate technical success predicts neither ultimate limb salvage nor a satisfactory outcome.[14]

Free-tissue transfer has revolutionized limb salvage surgery. Limbs that previously required amputation are now salvaged with durable soft-tissue coverage. Many different free flaps have been described, and expanded capabilities have been discovered with various flaps, including transfer of composite flaps containing bone, tendon, and nerve. More recently, there has been an increase in the use of flaps for both soft-tissue coverage and vascular conduits. Flaps that have been used in this capacity include radial forearm flaps, anteromedial and anterolateral thigh flaps, temperoparietal flaps, dorsalis pedis flaps, latissimus dorsi flaps, and fillet-of-amputated-part flaps. The potential remains for the development of other flaps.[15] In our case, we did a local transposition of the pedicled long head of the triceps brachii muscle to the biceps tendon above the radial tuberosity, because the general condition of the patient was critical, the defect was large, and there were no flexor muscles of the elbow.

Reconstruction of elbow flexion by transposition of the pedicled long head of a triceps brachii muscle is described as a new technique to restore flexion in the elbow joint in an inveterate injury of the brachial plexus. The insertion of the long head of the triceps brachii muscle was transferred with an intact nerve and vascular supply to the anterior brachial region and sutured above the radial tuberosity with the insertion tendon of the biceps brachii muscle. Anatomical investigation revealed that the mean length of the nerve of the long head of the triceps was 5.5 cm, the number of terminal branches was 3–4, 70% of the vascular supply was from the brachial artery, and the length of the bundle was 3.6 cm. In 33% of all investigated specimen, there was an additional neurovascular hilus which was 2–3 cm distal from the main hilus.[16]

In our case, we faced many difficulties: the MESS score was 8 points, the patient was in shock, and there was significant disparity between the diameter of the brachial artery and that of the great saphenous vein. We were then faced with the decision to do another graft after the patient's second accident, with all the previous difficulties and circumstances. However, we tried again to preserve the limb because we believed that there was no indication for posttraumatic primary amputation. We had successfully restored the limb once, after profound traumatic injury, and it was worthwhile again to preserve the limb with good function, especially because it was the upper, dominant limb of a child.

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