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SUCCESSFUL REPLANTATION OF SEVERED ARM BY SHORTENING OF BONE

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Abstract

Although twelve years have passed since the first successful replantation of a traumatically amputated extremity was achieved by Malt in May 1962, the criterions for the indication of replantation and selection of the cases have not yet been clearly founded. Generally, cleanly severed limbs by sharp instruments with minimal contamination are more favorable for replantation than those with crushing and avulsion, especially if accompanied by gross contamination. On June 30, 1973, the authors had a opportunity to treat a 24-year-old man with his severed left arm which had been avulsed by a running train. The local conditions of the limb were so severe that we, initially, considered the case should be excluded from the indication. However, by performing a bold shortening of the humerus, we succeeded its replantation. The length of the shortened humerus was about 9 cm. This case illustrates a significance of bone shortening in replantation procedures. With a special emphasis to shortening of the bone, our policy for the management and replanation of severed limbs is summarized.

INTRODUCTION

Since the first successful replantation of a traumatically amputated extremity was achieved by Dr. Donald A. Malt in Boston in May 1962[1], the procedure has soon been distributed all over the world and reports of successful replantation of severed limbs have accumulated in the recent literature. However, most of these cases reported from China[2,3,4] and the United States[5,6,7] and few from other countries[8,9,10] including Japan[11].

In October 1963, one of the present authors (Inoue) accomplished the first successful replantation of a completely severed hand in Japan (12). Since then, no more than thirty cases of near or total severance of extremities have been successfully replanted and their reports have appeared in our country[13]. This total experience encourages us to perform

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replanatation more actively in the clinic, but criterions for the indication of replantation and selection of the cases have not yet been clearly founded.

Recently, the authors encountered a case of severed arm which had been avulsed by a running train. The local conditions of the limb were so severe that we, initially, considered the case should be excluded from the indication. However, by performing a bold shortening of the humerus, we succeeded its replantation. The length of the shortened humerus was about 9 cm.

CASE REPORT

On June 30, 1973, a 24-year-old male was brought to the emergency ward of Kawasaki Hospital along with his severed left arm which had been completely avulsed by a running train about 25 minutes prior to admission. He attempted suicide and plunged down from a platform.

On arrival, the patient was in clinical shock and fluids replacements and blood transfusions were immediately started. The level of amputation was about 10 cm. below the shoulder, and there was no active bleeding from the stump. There were no signs of damage to the central nervous system, chest or abdomen, but a slight contusion was seen in the left waist.

The distal stump of the severed arm was severely crushed exposing the fragments of the bone and muscles which were dirty and covered with sand and oil, and extensive losses of all the tissues were recognized (Plate Ia-1).

While the patient was being anesthetized, the severed arm was cleaned with 0.02% chlorhexidine solution (Hibitane) and immersed in a mixture of ice and normal saline solution to which sodium heparin and chloramphenicol had been added. To free the vessels of the severed arm, the brachial artery was cannulated with a No. 15 G. Teflon tube. Then, the artery was flushed with 10% sodium heparin in cooled Hartmann's solution until the returning fluid became clear. There was no appearant distension in the arm showing the vascular trees were patent (Plate Ia-2).

Débridement of the distal stump of the arm was began first removing the fragments of the humerus. The largest one of them was about 5 cm. in length. Then, all of the crushed muscles including the biceps were extensively removed. The brachial artery, the cephalic and basilic veins were identified and marked with sutures. The radial, ulnar, median and musculocutaneous nerves were also dissected and marking stiches were applied.

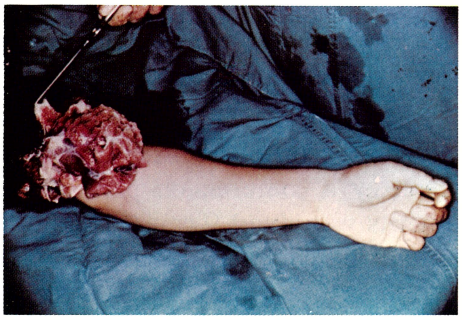

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Plate Ia-1 Photograph showing extensive injury on the severed arm.
Plate Ia-2 After flushing the brachial vessels, the arm was cooled by immersion in a mixture of ice cubes and normal saline solution.

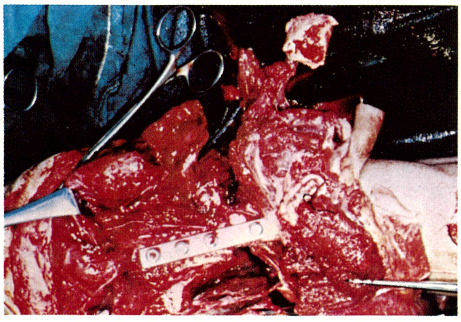

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Plate Ia-3 After shortening of the bone, the humerus was fixed with a plate.
Plate Ia-4 The length of the shortened humerus was about 9 cm.

The other team had worked on the proximal stump of the arm. Following cleaning and judicious débridement of the wound, the major versels and nerves were dissected proximally for about 5 cm. The end of the brachial artery was contused and sealed with a thrombus. After the excision of the thrombosed segment of the artery for about 2 cm., a vascular clump was applied. The three major veins and four nerves were marked with sutures.

By this time, the decision to attempt replantation had not yet been definitely made, because of the severe and extensive tissue damages recognized in the limb, albeit corresponding ends of each of the artery and veins and of the four major nerves were throughly identified.

However, there was a reasonable feeling of assurance that the arm could be successfully replanted if the humerus as well as all the tissues including the skin were shortened for about 10 cm. The replantation was attempted.

The humerus was shortened more by excision of about 2 cm. from each stump, and the fixation was done by a compression plate (Plate Ia-3). Total length of the excised humerus was about 9 cm. (Plate Ia-4). This shortening of the bone offered an ample room for the anastomoses of the vessels and nerves, and their segments conspicious of being damaged were excised from each end before the anastomoses were undertaken.

Vascular anastomoses were done first with to rejoin the cephalic and basilic veins and then the brachial artery. These anastomoses were carried out by end-to-end fashion with 6-0 Nylon sutures. When the vascular clumps were released, the forearm and hand became flushed and retrograde bleeding occurred. The elapsed time between injury and re-establishment of circulation was about 6 hours.

The radial, median, ulnar and musculocutaneous nerves were appeared to be traumatized over short segments, and resection of their damaged portions made it obvious that primary repair could be undertaken. This was done by means of interrupted epineural sutures (Plate Ib-5).

The multiple lacerations of the muscles were sutured with chromic cutgut sutures after devitalized segments of the muscles were resected. Penrose drains were placed in the wound and the skin was closed (Plate Ib-6). The entire upper extremity was placed in a plaster splint in a functional position. Total operation time was about 13 hours, and total amount of blood transfusions was 6,000 cc.

Postoperative course was uneventful. The forearm and had swelled moderately a day after the operation, but the swelling decreased by the 7th day. A wound infection became manifested within a week, but by intensive wound toilet and antibiotic therapy, the infection subsided gradually by the 4th week and the wound was completely closed.

Galvanic stimulation of the denervated muscle groups was begun on the 3rd week and was continued daily for more than a year. Physiotherapy with passive movement was started during the 4th week. Tinel's sign could be disclosed in the ulnar aspect of the forearm about five months after the operation. Eleven mouths later, the first active motion in the flexor muscles was observed above the elbow and he had good shoulder motion, but no elbow or wrist (Plate Ib-7).

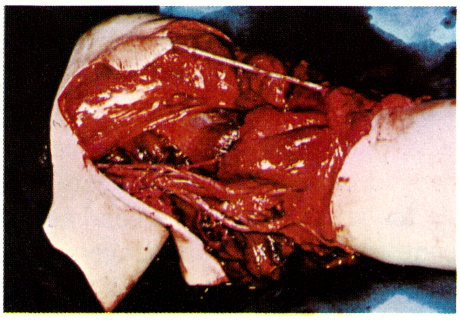

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Plate Ib-5 Shortening of the bone offered an ample room for the anastomoses of the vessels and nerves as well as the muscles.
Plate Ib-6 Completion of the operation before splinting.

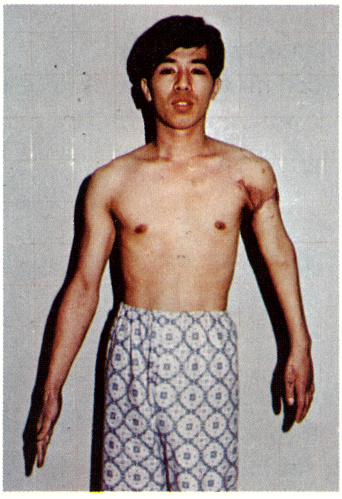

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Plate Ib-7 Replanted left arm four months after the operation.
Plate Ib-8 Tendontransfer of the greater pectoral muscle to the biceps of the arm was done a year later.

A year later, tendontransfer of the greater pectoral muscle to the biceps of the arm was performed. In the operation, the brachial artery and vein were accidentally teared off at their anastomoses. However, they were successfully repaired by using autogenous saphenous vein grafts from the thigh. After 14 months, there was 30 degree of flexion at the elbow and limited joint movement of all the fingers. There was an imperfect level of sensation down to the wrist over the medial aspect of the forearm. Sensation is still absent on the hand and fingers. He continues to have physiotherapy including the muscle stimulation (Plate Ib-8).

DISCUSSION

This case report demonstrates the principal factors necessary for the successful replantation of severed limbs. Our policy for the management and replantation of severed limbs is summerized as the following:

I. Preserving procedures of amputated extremities;

1. Cooling by immersion in a mixture of ice and normal saline solution containing heparin and antibiotics.
2. Flushing with heparin-Hartmann's solution through main arteries.

II. Operative techniques;

1. Débridement. (judicious, but adequate)
2. Fixation of bone and joint. Shortening of bone if necessary.
3. Blood vessel anastomosis from venous system to arterial system. Use autogenous vein as a graft material if needed.
4. Tendon suture.
5. Nerve suture. (primary repeir, as possible)
6. Fasciotomy and decompression incision with skin graft, if swelled markedly.
7. Plaster splint.

III. Postoperative procedures;

1. Prevention of shock and metabolic acidosis.
2. Prophylactic antibiotics.
3. Early passive movement of the limb.
4. Galvanic stimnlation of the muscles.
5. Secondary nerve repeir within 6 to 12 weeks.
6. Rehabilitation.

Although successful replantation of a severed limb with recovery of function is possible, all cases must be carefully evaluated before the decision to attempt replantation is made. The first priority in treatment

of patients with severed limbs is to save their lives and not endanger a poor risk patient by performing an indiscreet replantation procedures. Indication for replantation is elective and decision should be made from the aspects of both the local and systemic conditions of the amputee.

For the local conditions of the severed limbs, evaluation should be made of the following:

1. Degree of tissue damage, including crushed areas and actual loss of tissue.
2. Extent and type of contamination, whether by soil, dust, oil or other medium.
3. Time elapsed since severance.
4. The presence of nerve injuries proximal to the amputation such as a traction injury of the brachial plexus, should be looked for because they may seriouly jeopadize the final outcome.

For the systemic conditions of the amputee, there should be no detectable injury to vital internal organs and no urgent problem with respect to the other limbs. There are, also, both economic and psychological problems in performing replantation since the operation usually requires that the amptee be hospitalized for long periods of time and subjected to multiple surgical procedures. The age, occupation and economic status of the amptee should therefore be taken in consideration.

Generally, cleanly severed limbs by sharp instruments with minimal contamination are more favorable for replantation than those with crushing, avulsion and some fragmentation, especially if accompanied by gross contamination. However, the amputation of limbs occurs most usually in industrial accidents and are caused by the working appliances such as power press, centrifuge, screw geer, belt conveyer and so forth[13]. In such injuries, the amputated limbs are always contaminated by soil and oil, in addition to the extensive tissue damage.

To evaluate such cases for replantation, one must look for a possibility of anatomical reunion of the blood vessels, nerves, muscles as well as soft tissues of the severed limbs after an assamption of shortening of the bones. The late function of the replanted limbs is not determined by its length, but rather by the restoration of its muscle power and its nerve control. Our case report illustrates such a case. We shortened the humerus for about 9 cm. to make the replantation possible. Nonetheless, shortening of the bone may broaden the indication of replantation and selection of the cases.

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