

Successful Revascularisation of Near Total Amputation of the Upper Limb after Ten Hours of Warm Ischaemia

A M Merican, MS Ortho, M K Kwan, MS Ortho, C Y Cheok, MS Ortho, E L W Wong, MBBS, T A Sara, FRCS

Department of Orthopaedic Surgery, University Malaya Medical Center, 50603 Kuala Lumpur

Summary

Near total amputation of the upper limb if unsalvageable would cause severe disability. However, delayed revascularisation can be life threatening. We report two cases of revascularisation of the upper limb following near total amputation that was successful and functional after a warm ischaemic time of ten hours. The first was a traction avulsion injury of the arm leaving major nerves contused but in continuity. The second was a sharp injury through the mid-forearm attached by only a bridge of skin. Attempting revascularisation of a proximal injury beyond 6 hours, in selected cases is worthwhile.

Key Words: Major Amputation, Replantation, Revascularisation, Warm Ischaemia

Introduction

Amputations and near total amputations at various levels of the upper limb are not uncommon in Malaysia. Currently, injury occurring at the workplace and the use of sharp weapons instead of firearms make these modes of injuries more common than in Western countries. More often these are distal injuries, but injuries at a proximal level pose a dilemma. On the one hand, if the limb is not revascularised, the patient would be left severely incapacitated and prosthesis would give a poor functional outcome. There are serious socio-economic implications of a definitive amputation especially since the patients who sustain these types of injuries tend not to be financially secure. On the other hand, the proximal injuries devascularise muscle bulk. When the injured limb is revascularised the patient may develop reperfusion syndrome. Therefore a special consideration to the timing of revascularisation is needed for these cases.

Conventional wisdom does not recommend major replantation or revascularisation after a warm ischaemic time of greater than 6 hours¹. The chances of a successful restoration of circulation are significantly diminished after that time. Furthermore, irreversible cellular changes within muscle and nerves will occur even if the circulation is restored. These patients may subsequently develop Volkmann's ischaemic contractures. The release of the build up of metabolites within the unperfused part of the limb into the systemic circulation may lead to reperfusion syndrome, which causes life threatening hyperkalaemia, acidosis, multiple organ failure and death. This condition may occur after revascularisation even with a warm ischemia of less than 6 hours².

Case 1

A 31-year-old industrial worker caught his left arm in a machine. He was right hand dominant. He sustained an avulsion type of amputation of his left lower arm. The

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Corresponding Author: Azhar M Merican, Department of Orthopaedic Surgery, University Malaya Medical Center, 50603 Kuala Lumpur

arm was held only by a bridge of skin posteriorly and the major nerves (median, ulnar and radial nerves) were in continuity but contused (Figure 1). There was a comminuted fracture of the lower third of the humerus. Pulses and peripheral circulation were absent.

Revascularisation was undertaken ten hours post injury due to the time taken for referral and transfer from a peripheral hospital. Shortening of 4 centimetres of the humerus was performed and fixed rapidly with a locked compression plate. The brachial artery repair required a saphenous vein graft and three veins were anastomosed. The veins were allowed to bleed to flush away the metabolites before the anastomosis were performed. The total estimated intra-operative blood loss was 4 litres and a total of 2.2 litres of blood was transfused. The transacted muscles were reattached and prophylactic fasciotomy of the forearm and hand was performed. The distal muscles viability was assessed and confirmed to be still viable. The surgery took approximately 6 hours. The fasciotomy wounds were covered with skin graft a week later.

After 6 months of follow-up, there was bony union of the humerus. The elbow had good active ranges of motion; flexion 0°-120°, supination 0°-30°, pronation 0°-60° (Figure 2). The sensation of the left hand recovered well and the function was excellent. The patient returned to his former occupation.

Case 2

A 20-year-old man was assaulted with a sharp weapon by a group of individuals. He was initially brought to a peripheral hospital. On arrival at our institution he was in severe hypovolemic shock. He sustained a near total amputation of the left mid forearm, severing all structures except for a bridge of skin measuring 8cm (Figure 3). He was resuscitated and stabilised for another hour before the operation commenced.

In view of the prolonged warm ischaemic time, the priority was to restore circulation. The radius was shortened 2 centimetres and provisionally fixed with a plate and only four screws. The radial artery was repaired first, followed by shortening and plating of the ulna and ulnar artery repair. Blood inflow into the limb was achieved at 10 hours post injury. The veins were allowed to bleed for 20 minutes to flush the limb of metabolites. During this time, the fixation of bone was completed with additional screws and the veins prepared for anastomosis. Three veins were reanastomosed. The median and ulnar nerves were repaired with group fascicular and epineurial repair. Muscle and tendon were repaired in the usual manner. Fasciotomy of the forearm was performed subcutaneously from within the wound but compartments of the hand were not released as there was no subsequent swelling. Primary skin graft was used to avoid tight closure. The surgery took approximately 10 hours.



Fig. 1: Near total amputation of the left lower arm, held by a posterior skin bridge and contused major nerves.

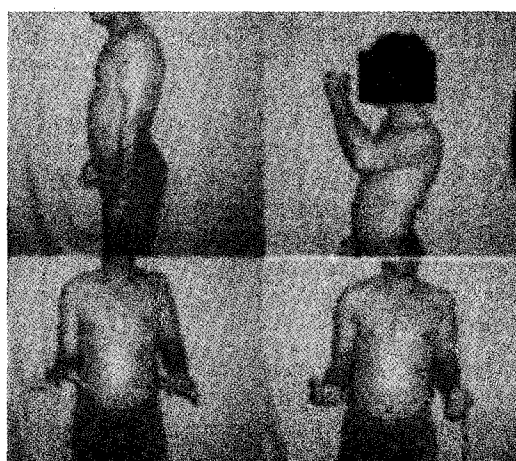


Fig. 2: Good active range of motion of the left elbow with an excellent functional recovery of the left hand 6 months post revascularisation.



Fig. 3: Near total amputation of the left mid-forearm. The forearm is folded over the intact bridge of skin. The radiograph is shown in the upper left corner.

An exploratory laparotomy was performed immediately following completion of the revascularisation as the abdomen was noted to be distending. A retroperitoneal haematoma was found and on retrospect the patient did remember being repeatedly kicked in the abdomen after his assailants severed his forearm. A total of 4 litres of blood and 4 litres of fluids were transfused. The patient's clotting profile was deranged and the platelet count was low (29×10^9). However, he made a good recovery postoperatively.

On follow-up with aggressive rehabilitation, 1 year later, he had fair function of his limb. He did not have ischaemic contractures. He had a useful grasp with functioning long flexors including the long flexor of the thumb and was able to key pinch. (Figure 4) The intrinsic muscles were still wasted; he was unable to oppose his thumb. Nerve recovery was progressing, though he was not expected to recover fine movements of the hand. Protective sensation was present.

Discussion

The first patient sustained a type II traction avulsion injury, where the site of the lesion was over the muscle bellies but distal to the neuromuscular junction with proximal muscles still innervated³. Most of these injuries are caused by trapping of the upper limb between two moving rollers with a small gap between

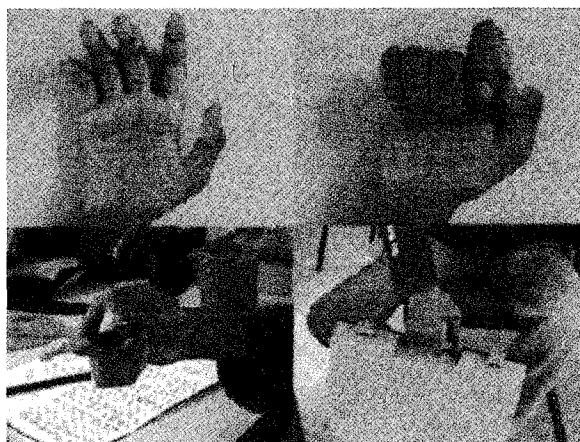


Fig. 4: Satisfactory function of the left hand 1 year post revascularization. The patient was able to perform key pinch and hold a bag.

them. When the limb is caught, it is squeezed between this rolling machine and pulled away from the body, resulting in shearing, traction and amputation. The prognosis is poor when there is a severe degree of soft tissue injury. Surprisingly, the first patient's nerves were in continuity after the injury and this is the reason for his remarkable recovery. Though not functioning at the time of the injury and appearing contused, some degree of nerve recovery was thought possible and this made it more of a justification in attempting revascularisation even though it had been delayed.

The second patient was a young patient with massive blood loss from the injuries and surgery. The injury was a clean sharp cut and this was a favourable prognostic factor. Though nerve recovery can never be complete, the result obtained in this patient is far superior to a prosthesis. Protective sensation gives him a prehensile limb that cannot be mimicked by a prosthesis. Blood component replacement and intensive care was an essential part of his management. Monitoring for reperfusion toxemia is crucial. If life threatening, it demands removal of the limb.

Near amputation as opposed to total amputation presents two additional problems. First, cooling and proper storage of the limb is not possible. Secondly, bleeding may be more of a problem as effective pressure by dressing cannot be applied to a stump as in a total amputation.

Amputations and near total amputations at a proximal level cause profound blood loss and hypovolemic shock. The time needed to stabilise the patient at the nearest hospital, the referral process before transfer to a specialised center, usually cause further delay. It is crucial that revascularisation is performed as early as possible to avoid the dangers of late reperfusion and continued blood loss. We feel that revascularisation should be attempted even after 6 hours if expertise, support and facilities are available for the surgery and anticipated complications. Of course many factors will modulate this decision. A patient who is physiologically

young and able to tolerate the systemic and coagulation effects of significant blood loss is a prerequisite. Favourable aspects of the injury will lend further justification for the attempted revascularisation. The upper limit for warm ischaemia is not known. There have been reported cases of successful major replantation with warm ischaemia of less than 8 hours or cold ischaemia of 10-14 hours⁴. Based on our experience, successful revascularisation at 10 hours warm ischaemia is possible and should be carefully considered.

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