

# Immediate Revascularisation of Borderline Ischemic Limbs Followed by Replantation

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## ABSTRACT

**Introduction:** Salvage of complex limb injuries is not only dependent on the skill, experience and attitude of the surgeon but also on the ischemia time. If the revascularisation is not possible within the golden period then the outcome is unfavourable. There are very few reports of delayed replantation. We are presenting a case series of replantation beyond the golden hours i.e. 6 hours of warm ischemia by immediate revascularisation before undertaking definitive replantation. The definitive sequence of replantation is carried out after the limb gets revascularised and the vicious cycle of ischemia is broken. Study aimed to salvage amputated limbs in the borderline ischemia time by immediate revascularisation.

**Material and methods:** A study was conducted between April 2013 to March 2018 at SBM Plastic Surgery Hospital, Cuttack and included all patients with limb amputations of 6-10 hours duration. In this study the artery was anastomosed first to halt the sequence of prolonged ischaemia. Temporary stability to the repair was provided by taking deep bites to the proximal and distal muscle group with 2.0 vicryl sutures adjacent to the anastomosis. After the limb was adequately revascularised and proper hemostasis was achieved then the proper sequence of replantation was started.

**Result:** out of 31 patients presenting during this period, 9 patients were excluded for poor preservation of the limb and presenting after 10 hours of warm ischaemia. Total no of cases included in the study were 22 patients who presented between 4 to 9 hours of cold ischemia time. The break up according to the nature of injury was, 19 patients had avulsion injuries, two had assault with heavy sharp weapons and one had crush injury. Out of 22 cases of replantation 2 cases required amputation at a later date due to complications.

**Conclusion:** In our country majority of patient come to hospital after 6-8 hrs of warm ischemia which is the upper limit of ischaemia. If the ideal sequence of replantation will be followed these limbs will undergo irreversible ischaemic damage due to further delay. So the concept of immediate arterialisation gives the best opportunity for limb survival.

**Keywords:** Golden hour, Warm Ischemia, VIC, Reperfusion Syndrome, Avulsion Injury

## INTRODUCTION

The first successful limb replantation was reported by Ronald Malt in 1964 after which surgeons tried to salvage limbs before planning for amputation.<sup>1</sup> With advances in microsurgery and infrastructure in recent years and increased experience of surgeon the success of salvage of amputated limbs via replantation and revascularization was 80-90%.<sup>2-5</sup> To get better survival and improved function replantation within ischemia time is helpful. But in our country due to

multiple factors like limited centres, distance to cover, road conditions, poor awareness, and many patients reach hospitals after 6-8hrs of warm ischemia. Any further loss of time after the patient reaches the hospital can affect limb survival. In such cases where the patient has reached the upper limit of ischemia time, immediate revascularisation breaks the vicious sequence of ischemia and allows time for arranging logistics for proper sequence of replantation to maximise the outcome.

Bone, tendon, and skin can tolerate approximately 8-12 hours of warm ischemia and as long as 24 hours of cold ischemia. However, muscle necrosis after 6 hours of warm ischemia or 12 hours of cold ischemia. In general, amputated digits may tolerate 12 hours of warm ischemia and 24 hours of cold ischemia. Other major amputations tolerate 6 hours of warm ischemia and 12 hours of cold ischemia because of their larger muscle content. Excessive ischemia time reduces muscle function and can result in myoglobinuria on reperfusion, placing renal function at risk. More proximal amputations involving more muscles must, therefore, be treated quickly.<sup>6</sup>

Golder et al states not to perform replantation or revascularisation after warm ischemia time > 6hrs due to increased chances of VIC and reperfusion syndrome.<sup>7</sup> Study aimed to salvage amputated limbs in the borderline ischemia time by immediate revascularisation.

## MATERIAL AND METHODS

All patients reporting presenting to SBM Plastic surgery Hospital between April 2013 to March 2018, with major limb amputation between 6 to 10 hours of ischemia time were included in our study. The life of the patient was given first priority. Patients with polytrauma and lifethreatening injuries were excluded from the study. After the patient was properly evaluated and stabilised evaluation of amputated part was done to know the possibility of replantation. Injuries with mangled parts and multiple level of injuries in the limb

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were also excluded from this study. Identification of artery, vein, nerve and tendons were done in amputated stump after thorough cleaning. Patient was explained the merits and demerits of the procedure and other available options.

After patient's consent, the patient was shifted to the operation theatre. Preparation of patient for brachial block was done. In the meantime the amputated part was dissected and prepared. After the brachial block, cleaning of the amputated stump was done under tourniquet. Dissection of artery, vein, nerve and tendons were done in the amputated stump. Without skeletal fixation, the amputated part was kept closest to the stump so that end to end arterial anastomosis or a vein graft can be used to arterialise the limb. Two to three sutures were taken between proximal and distal muscles to protect the anastomosis by minimising shearing movement between the two parts (Fig- 1 and 2) Then artery was cannulated and flushed liberally with 1: 1,00,000 Heparin. Arterial anastomosis was carried out. Clamping of the bigger size veins to be anastomosed were done and rest were ligated to achieve haemostasis. Clamping of the artery intermittently at 10 min interval was done to prevent excessive bleeding. When the part was adequately reperfused and situation was congenial, the anastomosis was divided and the regular sequence of replantation carried out. The first was skeletal fixation followed by vascular repair, nerve repair, tendon and muscle repair. Then closer of skin or coverage of vital structures by flap cover was done followed by fasciotomy. Post up monitoring of the limb was done by pulse oxymetry. The patient was closely observed for signs and symptoms of ischemia reperfusion syndrome. A close watch was kept on urine colour, urine output, myoglobinuria, Serum Urea, Creatinine and electrolytes.

## RESULT

31 patients presented to us between April 2013 to March 2018. Out of this 9 patients were excluded for poor preservation of the limb and presenting after 10 hours of amputation, polytrauma or mangled limbs. Total no of cases included in the study were 22 patients who presented between 4 to 9 hours of ischemia time. 19 patients had involvement of Right upper extremity, one had left upper extremity and one patient had right leg.

### Sex

Out of 22 patients, 21 were male and one was female.

### Type of injury

19 patients had avulsion injuries, two had assault with heavy sharp weapons and one had crush injury. (Fig 3, 4, 5 and 6)

### Level of injury-

Most of the injuries occurred at proximal and middle third level of forearm. The leg amputation was at middle third level.

In our series had 2 patients required amputation due to complications. One forearm was lost due to infective thrombosis on 7th day and another due to blow out of brachial artery on 5th day. Failure rate in our series was 9%. In all the cases we shortened the bones by about 2 inches to

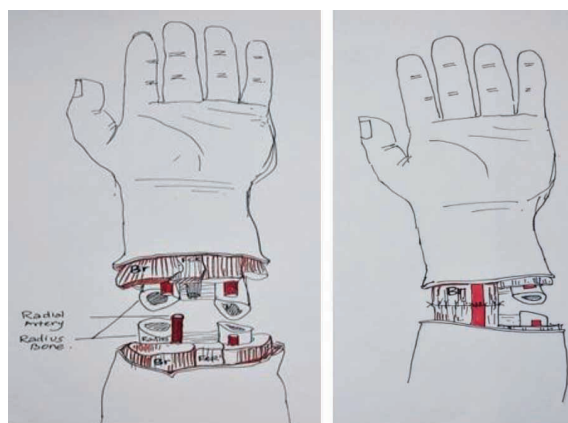


Figure-1 & 2:



Figure-3 & 4:



Figure-5 & 6:

allow proper debridement and avoid or minimise vein grafts. Most of the cases required vein grafts to repair the arteries and veins. We repaired at least one artery and two veins. However more vessels were repaired whenever it was feasible.

One patient in addition to forearm amputation had global brachial plexus injury. As most of the cases were avulsion injuries we used one nerve and coapted with other nerve. Out of 22 cases we coapted one nerve in 16 cases of which 11 were median nerve and 5 were ulnar nerve. In 4 cases two nerves were repaired and in two cases three nerves were repaired. Nerve grafts were used whenever required.

All cases of avulsion injury had necrosis of skin of different dimensions. The necrosed tissues were debrided and VAC was applied. When the wound was ready skin grafting was done.

## DISCUSSION

Many centres in India receive such patients after the golden hours. The formalities and preparations take a couple of hours which jeopardise the chances of limb survival. To overcome this delay we started the concept of doing immediate revascularisation before skeletal fixation. The limb was allowed to reperfuse adequately until preparations for replantation like implants and blood were available. Temporary stenting with silicone tube is another option

but with a higher rate of thrombosis.<sup>8</sup> Sabhapati et al have highlighted the concept of golden hours.<sup>9</sup> The revascularised artery can be intermittently clamped to reduce and control blood loss without fear of thrombosis. After the patient is stable with availability of adequate blood and orthopaedic and plastic surgery team the proper sequence of replantation is carried out after clamping or dividing the artery. There is scope of repairing a major vein so that the limb is perfused and the sequence of replantation can be performed at a more suitable time.

When the tissues have reached the highest limit of ischemia, immediate arterialisation reperfuses the tissues and stalls the process of tissue necrosis. This process is given adequate time so that the tissues are adequately reperfused. When the sequences of events are started the ischemia time is redefined from this point of time, thus giving a better chance for tissue survival and function. Long term studies have found that replanted limb is better than best available prosthesis.<sup>10</sup>

Replantation of a limb is complex is a complex procedure which require technically demanding surgery and proper decision making. Each step is very very crucial. Ischemia of the main muscle mass of the amputated part can produce severe complications during and after surgery. Inadequate management may lead to failure of surgery, severe bleeding even immediate death from the reperfusion syndrome. There may be poor function in the long term but most patients are pleased to retain their limb. There is no clear objective measurement which can help the surgeon to make a proper decision and to predict the immediate and late results. Most of the articles simply describe the author's experience.<sup>11-13</sup> Some have tried to use an algorithm for the treatment of traumatic amputation<sup>14</sup>, but the measurements and assessment have been subjective and the numbers of patients small. Various studies like Nanda et al, Jagdish Krishnan et al mentioned successful revascularisation after prolonged ischemia time.<sup>15,16</sup>

## CONCLUSION

In India majority of patient come to hospital after 6-8 hrs of warm ischemia which is the upper limit of ischaemia. There is a delay of couple of hours due to various reasons during which the limb is lost due to irreversible ischaemia. So immediate arterialisation gives the best opportunity of major limb survival.

With better understanding of pathophysiology of injury, well equipped and multi-speciality centre, improved skill of surgeon, advanced technology, close post op monitoring and rigorous follow up with secondary procedures salvage of limb in the upper limit of critical ischaemia time is possible.

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