

CLINICAL CASE

CURRENT PROCEDURES IN HAND REPLANTATIONS - PARTICULAR LEVEL OF TRAUMATIC UPPER LIMB AMPUTATION

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Abstract

Amputations in the upper extremity due to trauma are, by definition, devastating injuries that involve multiple critical structures of the fingers, hand, arm, or any combination of the three and nearly always lead to significant disabilities, both directly and through their psychosocial impact. Replantation is defined as the reattachment of a part that has been completely cut off and the reconnection of the damaged vascular structures. Chances of viability depend on the degree of vascular, bone, muscle and nerve lesions, the level of amputation, the trauma mechanism, the patient's age and comorbidities, the ischemia time while the functional recovery is assessed according to the following criteria: the active range of motion, the two-point discrimination sensibility ratings, the grip and pinch strength, the cold intolerance, and the return to previous employment. We report a case of a man D.V., aged 51, with a non-pathological personal history, admitted in April 2014 in the Emergency Hospital of Bucharest with the diagnostic “Severe injury by circular right upper limb. Hand amputation from radiocarpal joint, 3 hours old”. The patient was urgently transported in the operating room, where the right hand replantation was performed. He was first hospitalized in the Intensive Care Unit, then he was transferred in the Plastic Surgery and Reconstructive Microsurgery Clinic. Post-operatively, the results were favorable, our patient achieved at 6 months evaluation S3+ and M4 on British Medical Research Council's scale .

Keywords: *amputation, hand replantation, radiocarpal joint*

Introduction

Motto: “The hand is one of the most consistent bonds between the human being and the environment” (Juvara).

Amputation is an acquired condition that results in the loss of a limb, usually the result of an injury, disease or surgery. Nearly 70 percent of amputations due to traumata involve the upper limbs [1]. The traumatic amputations in

the upper extremity are, by definition, devastating lesions that involve multiple critical structures of the fingers, hand, arm, or any combination of the three and nearly always lead to significant disability, both directly and through their psychosocial impact. Replantation is defined as the reattachment of a part that has been completely cut off and the reconnection of the damaged vascular structures [2,3]. The replantation of the amputated segment is a

procedure that dates back to 1960 and in Romania it started being performed 30 years ago by Professor Doctor Ioan Lascăr. The first pursuit of the intervention is a functional one because 80% of the patients regained their sensibility and mobility of the limbs, but also an aesthetic one.

In order to perform this kind of intervention, a surgeon needs dozens of hours of experimental exercise. They start training in microsurgical techniques using the rubber membrane, then on slaughtered animal tissue (chicken) progressing onto the vessels and nerves of experimental animals to complex microsurgical experimental models. In the first place, the surgeons that are involved in microvascular replantations have to successfully perform 90% of the microvascular anastomosis on one-millimeter vessel in diameter of the laboratory animals. The interventions are time-consuming, very exhausting since the final result requires a lot of sophistication of the movements and a good control. For example, recovering a single finger by the specialist doctor requires about an hour. Complex interventions take place with the help of mixed teams, most often it involves the collaboration with the orthopedic surgeon. Also, many replantations are successfully completed due to the adequate postoperative care, some of the patients requiring secondary surgical reassessment for some check-ups. Yet, the immediate therapeutical attitude for the amputated part is one of the main factors that influence the decision for or against replantation. There are two methods to preserve the amputated part:

- After the recovery of the amputated part, it will be washed with lactated Ringer's or saline solution, wrapped in moistened gauze and placed in a airtight plastic bag, which is then placed in 2/3 water and 1/3 ice.

- The immersing in one of the above mentioned liquids and then placing it inside a plastic bag filled with ice [4].

The need to refrigerate the amputated segment is in line with the physiopathology of the tissues which suffers from acute ischemia; the degree of tissue degradation is proportional with the temperature of the environment and with the type of tissue: the muscle degrades faster than the skin. Usually the method of

immersion is preferable since the part is less likely to become frozen or be strangled by the wrapping and the instructions are easier to explain to the laymen. Also, maceration secondary to immersion is not a problem. In any case, the direct contact with ice is not advisable, because it will begin a process of formation of intracellular ice crystals that will lead to the rupture of membranes, which will impact on the cellular durability. Because it has no muscle, an amputated digit may be preserved at 4° C for 24 hours before replantation is performed. This usually applies only to digital amputations, although successful hand replantation has been reported after 54 hours of cold ischemia [4,5].

In addition, a large number of replantations are successfully finalized because of the post-surgical care; however some patients need a second surgical evaluation for increased examination or correction.

Full recovery lasts a year, but the surgeries provide outstanding results. There are cases where a driver could continue working without difficulties or where a young piano singer had the opportunity to reach a successful career.

Presentation of the case

D.V., aged 51, with a non-pathological personal history, was admitted by transfer from the Târgoviște County Hospital to The Emergency Hospital of Bucharest with the diagnostic "Severe injury by circular right upper limb. Hand amputation from radio-carpal joint, 3 hours old". He was preliminary stabilized in ER and he was given a venous catheter for the healthy upper limb. The homeostasis of the proximal stump was performed by applying a compressive bandage (clamping the vessel is not advisable because it causes injuries which require their shortening and then require the use of vascular grafts). He was given an antitetanic serum, analgesics and large spectrum antibiotics. He was not given anything per os, since he was considered to be a candidate for replantation. The patient is admitted in the Plastic Surgery and Reconstructive Microsurgery Department. He was urgently transported in the operating room, where the right hand replantation was being performed under general anesthesia with EI (endotracheal intubation).

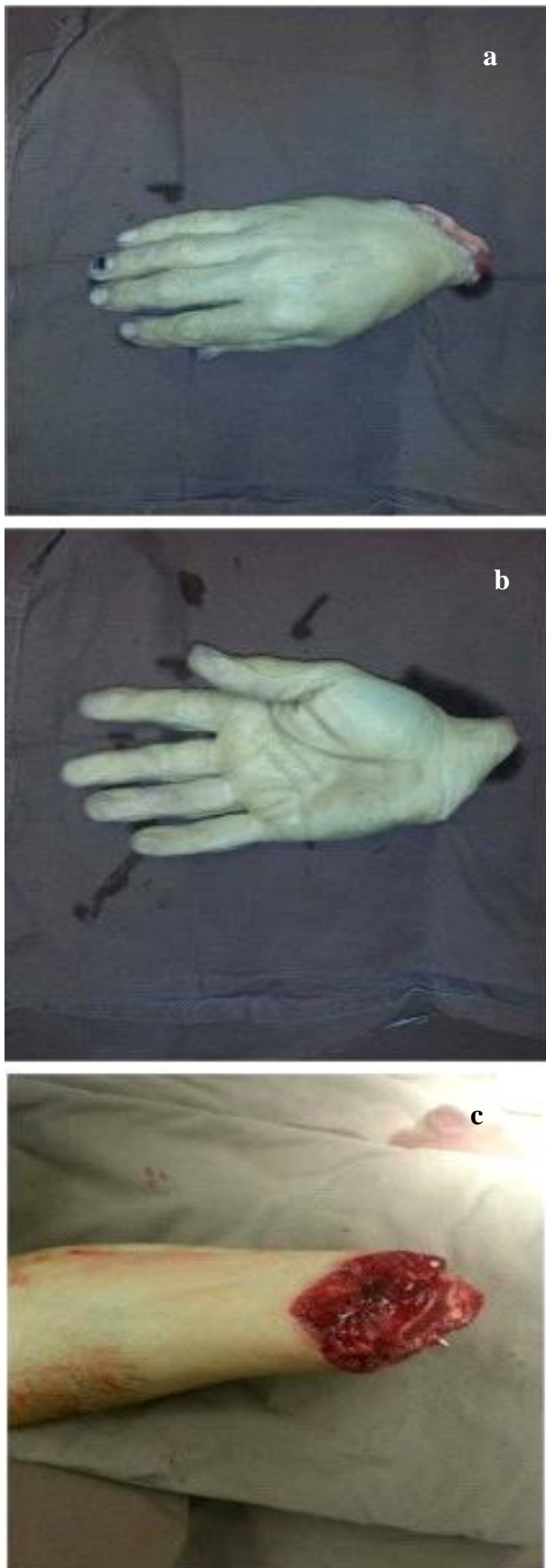


Figure 1 - Amputated part and proximal stump (a,b,c) (authors' personal collection)

At the start of this operative stage, the team of surgeon was split in two parts: the first was

assigned with the preparation of the amputated segment and the second one with preparing of the proximal stump. The primary surgical wound toilet was performed after the mandatory irrigation with normal saline solution and iodine solution. The devitalized tissue is carefully debrided, and the vessels are dissected. Once a vessel is identified, it is marked with a tag. Arteries are closely inspected for signs of stretching or avulsion, which are suggested by a corkscrew-like appearance termed the "ribbon" sign. Nerves and tendons are identified and tagged [6]. Being an amputation performed through cut, the vascular injuries are minimally debrided so that the section trances of the two stumps are regularized.

The surgical exploration begins by the distal and proximal extension of the incision for the dissection, identification and mobilization of the anatomic elements, as well as to insure a more rapid drain of the edema, which may appear within three days from the surgery. Any part of the skin with uncertain viability must be removed to avoid the risks of infection and thrombosis. The fasciotomy followed by fasciectomy must be performed for both segments.

The first part of the replantation intervention consists of reducing the fracture. Before performing the osteosynthesis, bone shortening is required. Its purpose is to ensure an alignment and a congruency of the distal and proximal bone segments. At the same time, it ensures a vascular non-tension anastomosis, the skeletal shortening being preferred in opposition to the vessel graft. The degree of the skeletal shortening depends on the traumatized mechanism. In the cases of avulsion or crush injury, a greater amount of bone must be resected until normal intimal coaptation is possible without tension. In our case, trauma was by cutting, so it was necessary the bone shortening of the carpals with 1,5-2cm. The osteosynthesis method in the replantation surgery must primarily allow early protected motion of the adjacent joints. The method chosen was performed with 5 Kirshner wires: 3 intramedullary wires on digital direction passed through carpal bones anterograde to radius and ulna and 2 wires for lateral stabilization of the radio-carpal joint.

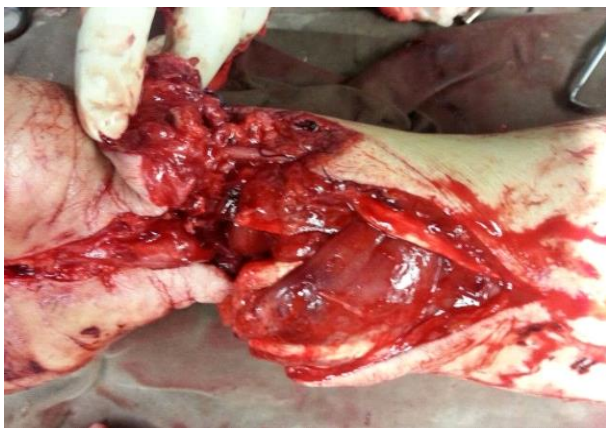


Figure 2 - After bone stabilization, before flexors tenorrhaphy (authors' personal collection)

After bone fixation, the flexor tendon was repaired for further stabilization. If possible, both flexor digitorum profundus and digitorum sublimis tendons are repaired. In this case of replantation, it is practiced just the restoration of deep flexor tendons (The flexor pollicis longus, the flexor digitorum profundus Dg. II-V). The tenorrhaphy was performed using modified Kessler suture of 3-0 and/or 4-0 braided nylon. The suture for flexor carpi radialis and ulnaris tendons which will be stabilized and protect future arteries and nerves anastomosis are passed. Then, the surgeon starts extensors tenorrhaphy using suture threads 4-0 polyester. Routinely, the flexor tendons are repaired after the bone is stabilized, before the microsurgical repair of the digital arteries and nerves contrary to extensors whose tenorrhaphy is the last step.

Vascular repair: is the most important step and it is indicated to be done as quickly as possible, because the amputated segment viability depends on it. The severed artery must be resected until normal intima is visualized under high-power magnification; only normal intima is reconnected, after the blood flow of the proximal stump is checked. Before initiating the first arterial anastomosis, a bolus of 3000 units intravenous heparin is administered to prevent clotting at the anastomosis site. A running infusion of 1000 units per hour is then initiated and adjusted according to the case depending on the patient's degree of bleeding. The method used, like in the majority of replantation cases is the end-to-end anastomosis because it ensures increased continuous blood flow which is imperative after the period of ischemia of the amputated tissue. In order to provide enough blood flow supply it was performed radial artery reparation. It required a

9-0 Prolene suture. Then the venorrhaphy of the vessels of superficial dorsal arch of the hand is performed. For each artery the surgeon must perform a two vein anastomosis. In our particular case 3 veins were repaired. In addition, for a full recovery and because the anesthesia allowed it, the ulnar artery was also repaired during this procedure by means of arteriorrhaphy. The most common error for the vascular anastomoses, especially the venous ones, is to put too much tension in the stump suture, this being avoided by skeletal shortening. In the amputated part, the collapsed veins were difficult to locate, their location being visible after arterial repair with engorgement.

Since the ultimate goal of replanting is the amputated limb functional recovery, special attention should be paid to the injured nerves affected by the trauma - the median nerve and the ulnar nerve. Because bone shortening was performed, the neurorrhaphy is not difficult because there is no tension on the suture line. The excision of the damaged tissue was minimal, only for the fringed ends of epineurium. First the trances were aligned, thus it began with the isolation of the nerve ends, then continued with the cutting of the nerve ends perpendicular on the axis, the inspection of each end and the excision of the margins that cover the epineural tissues. The peripheral nerves are repaired with monofilament size 9-0 Prolene nonabsorbable suture.

Finally, the surgeon starts the tenorrhaphy of the extensors using 4-0 polyester suture threads.

The meticulous hemostasis was obtained after all the structures have been repaired and revascularization of the amputated part has been ensured. The skin is loosely approximated with a few interrupted nylon sutures and waiting threads to ensure drainage. The vessels should be covered without constriction from the overlying skin sutures. Tight closure is avoided because this will compress the venous outflow and lead to secondary venous thrombosis.

The wound dressing was made of gauze moistened in antiseptic solution, placed obliquely to prevent tourniquet effect then dry dressings and bandages were added. A big bandage moderately compressive is obtained. The superior limb is immobilized in a plaster-of-Paris splint, physiologically positioned, but constantly keeping the elevated position.



Figure 3 - After skin closure (a,b) (authors' personal collection)

Post-operative care and monitoring

This stage takes 7-14 days and is highly important in order to obtain a successful replantation. In our case, patient D.V stayed at the intensive care unit for 5 days and then he was transferred with the agreement of his plastic surgeon in the Plastic Surgery Department where he was supervised for 20 days and received pharmacological treatment such as heparin, antibiotics and painkillers (ketonal).

At first, in the intensive care unit the analgosedated patient with postoperative residual curarization (PORC) presented vesicular breath sounds across the surface of both lungs, no rales, the oxygen saturation =98-

100%, pale teguments and mucosae and also hemodynamic stability on minimal vasopresor support. The paraclinic exam reveals mild anemia (Hg-10 g/dl), hypokalemia, minor leukocytosis and rhabdomyolysis. The treatment of hydro electrolyte imbalance was followed by antibiotic therapy, proper painkillers, gastric protection, diuretics and heparin.

Over the 5 days period spent in the intensive care unit the general state of the patient had a favorable prognosis. The patient was conscious, cooperative and fully orientated and presented spontaneously breathing in the mask airway, diminished bilaterally vesicular murmur, no rales. He was hemodynamically stable, had slightly pale teguments and mucosae associated with warm limbs. The abdomen moved with respiration. Food was administered orally and the diuresis was furosemide stimulated. The syndrome of muscular cytolysis was in remission.

When he was transferred at the Surgical Plastic and Reconstruction Department he presented a mild anemia, the APTT was prolonged due to the administration of heparin and the creatine kinase was 396.00u/l. The treatment continues with Fragmine and in the 21 post-operative day a surgical re-exploration for bleeding is performed. The degranulation and covering of the tegumentary defect of the right distal-third forearm with skin graft from right medial forearm is done. Next comes the cleaning of the area, hemostasis, suture, bandage and immobilization. Post-operatively the evolution is favorable and the patient can be discharged with the following recommendation:

- Orthopedic reevaluation after 2 months postoperatively and proper treatment ;
- Removing the suture surgical material after 14 days
- Avoid cold exposure
- Maintaining an elevated position of the hand
- Treatment with aspirin 75 mg/day for 3 months



Figure 4 - Post-operative 5 weeks evaluation (authors' personal collection)

Discussions

The replanting surgery aims at two goals: survival and functional recovery of the replanted segment. Chances of viability depend on the degree of vascular, bone, muscle and nerve lesions, the level of amputation, the trauma mechanism, the patient's age and comorbidities, the ischemia time while the functional recovery is assessed according to the following criteria: the active range of motion, the two-point discrimination sensibility ratings, the grip and pinch strength, the cold intolerance, and the return to previous employment [2]. At the 6 months evaluation our patient achieved thumb opposition, flexion of fingers and distal sensibility was present. Restoration of tendons and joint function, shortening of warm ischemia for the amputated segment and protection for arterial anastomoses was aided by early and aggressive flexor tendon reconstruction. In our case there were multiple indications for replantation. Firstly, the patient's general condition was stable, he had no other external or internal injuries, medical history was non-pathological. Although patient age is not an absolute contraindication, most complete

recovery in the terms of replanting were performed in young patients up to 35- years old. The favorable factors were the absence of diabetes mellitus and atherosclerotic disease (BMI = 23kg / m; TGL = 89mg / dl; cholesterol = 190 mg / dl), non-smoker. In addition, the trauma was no longer than 3 hours and it was not contaminated. Most amputations require secondary reconstruction. For this patient, the relatively short time since the first intervention and methods which were used for bone and arterial reconstruction were favorable. The purpose of this second intervention is to improve functionality, sensitivity and durability. Auto graft could be attached to a well-vascularized tissue.

Conclusions

- The desired result in terms of this type of injury is difficult to quantify because even two lesions are not identical in terms of the structures involved, the severity and traumatic mechanism

- In general, the expected outcomes after successful replantation are motor recovery, muscle strength, sensitivity, but the most important is the degree to which the patient may use the reconstructed hand in daily activities and how they will be able to continue their life. Last but not least, the aesthetic aspect is important because of the psycho-social impact. Our patient achieved S3+ sensibility: 7-15mm two-point discrimination and M4: mobility against gravity on British Medical Research Council's scale.

- The loss of a limb is a devastating yet relatively common injury with a vast panoply of effects. Beyond the obvious impairment of the quality of life there are profound social, psychological, and aesthetic consequences. Thus, despite the significant improvements in functional prostheses and rehabilitation for traumatic hand amputations, the option for replantation should always be carefully considered because of sensibility [7]. Since surgery is the initial step, it is essential to have a future perspective on patient functions as they say "look into block of marble" and give it proper treatment schemes for each step of healing, according to his injury.

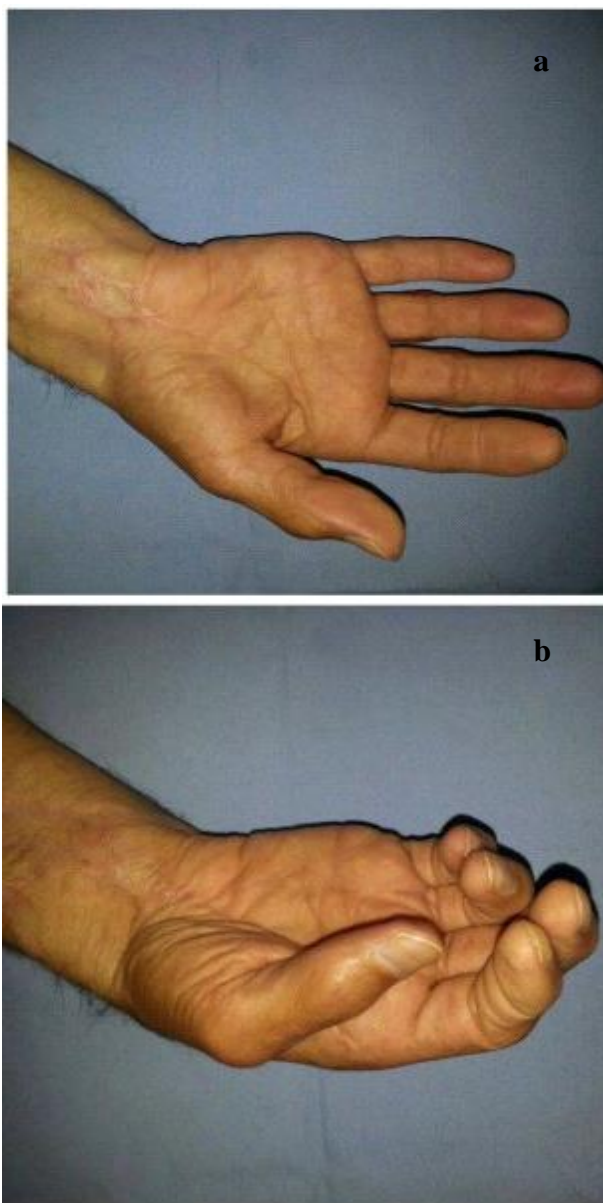


Figure 5 - Post-operative 6 months evaluation (a,b) (authors' personal collection)

The particular feature of the case

This comes from the rare level of amputation. Almost all forearm trauma occur in 1/3 distal

part, but in this case the traumatic agent directly affected the radio-carpal joint, that led to involvement of: the ulna and radius, but primarily the carpals. As a result, the healing process involved primary the wrist arthrodesis which accomplished the bony fixation [8].

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