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Case Report
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Microsurgical Revascularization of Two Fingers after Prolonged (52 and 53 Hours) Warm Ischemia Time: Case Report and Literature Review

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Abstract

Multiple finger amputations in young individuals lead to severe hand deformities for the rest of their lives. Urgent microsurgical intervention with revascularization gives hope for hand function preservation as well as esthetics. However, circulation disturbances in incompletely amputated digits are sometimes overlooked, and prolonged warm ischemia time has a negative impact on the probability of tissue survival. Although revascularization of the hand at the wrist level should be achieved within 12 h of cold and 6 h of warm ischemia, fingers that do not contain muscle mass have been reported to be more flexible with these perfusion time limits. Here, we present a case report describing microsurgical finger revascularization after more than 50 h of warm ischemia, which belongs to the longest reported periods. Although surgeons face a risk of patient safety, in certain cases, late digit revascularization is possible and emphasizes the significance of a comprehensive evaluation of the patients' condition.

Keywords: Amputation; Finger; Revascularization; Warm ischemia

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Introduction

Different cases of finger amputations after traumatic injuries are encountered in clinical practice. Among them, total or subtotal (complete or incomplete) amputations are observed. Both types of injuries jeopardize digit vitality, although the prognosis of incomplete amputation is usually better [1,2]. However, total finger dissection allows for proper storage in cold ischemic conditions. Some specific conditions exist for incompletely amputated fingers. These types of injuries are intermediate-type injuries, but revascularization is necessary to rescue the finger. In such cases, surgeons face prolonged warm ischemia from the beginning of treatment. Warm ischemia is also encountered in cases in which the surgical procedure (operative bone fixation) was performed without vessel revision and without necessary repair. On the other hand, in cases of multiple finger amputations in young individuals, we should consider the possibility of severe hand deformities for the next 50 to 70 years of life. Not only functional but also social and psychological aspects of life-long disabilities in young people could explain attempts at revascularization even after prolonged periods of amputation. Although the critical ischemia time for hand is accepted to be 6 h to 12 h of warm ischemia, digits are able to sustain much longer times of separation when stored in cold ischemic conditions. The successful replantation of fingers after 94 h of cold ischemia was reported by Wei [3]. The limit of warm ischemia time for digits is poorly understood, but successful digit revascularization even after prolonged warm ischemia (33 h and 42 h) periods were described [4,5] (Table 1). We present a case report describing digit revascularization after more than 50 h of warm ischemia.

Case Presentation

An 18-year-old male patient suffered a severe crush injury to the left hand caused by a saw (February 12th, 2020, 13:00) with incomplete amputation of digits II-V at the level of the proximal phalanges. Fingers II-IV had a dorsal 1/3 circumference of skin preserved, and the fifth finger was attached with only a very tiny strip of skin (Figure 1). Bone stabilization with K wires, flexor tendon repair, and skin closure was performed by orthopedic staff. The damage to both digital arteries of the third, fourth and fifth fingers were initially unrecognized, and no vessel revision was performed. After the next two days, the ischemic changes in fingers III-V progressed, and an urgent plastic surgery consultation and aid were requested. The patient was referred to the Department of Plastic

Table 1: Literature review of cases with successful revasularization after prolonged warm ischemia time.

Digital ischemia periods reported in the literature.						
Authors	**publication date**	**quantity of cases**	**extremity**	**quantity of digits**	**the longest warm ischemia time**	**the longest cold ischemia time**
Chiu	1984	1	right hand	3	33 h	-
Inoue	1988	4	left & right hand	5	30 h	-
Horta	2014	1	left hand	1	>16 h	-
Seo	1987	1	left hand	1	26 h	-
Baek	1992	1	left hand	2	42 h	(+10, +12 h)*
Wei	1988	1	left & right hand	3	-	94 h
Woo	2015	17	left & right hand	24	>8 h	19 h

This table summarizes the data related to the successful finger revascularization cases ("-" means not applicable).
*added to warm ischemia time

Figure 1: The hand immediately after injury.

Figure 2: At admission, two days after bone stabilization without necessary vessels revision. Sings of ischemic changes of III-V fingers, A. volar view. B. dorsal view.

and Reconstructive Surgery on February 14th, 2020. On admission, all injured fingers (except finger II) were cold and did not bleed after needle puncture. Digits III, IV and V were pale without turgor and presented symptoms of deep ischemia. The epidermis of the dorsal skin from the third to fifth finger continued to show superficial necrosis (Figure 2). The second finger was properly supplied with

Figure 3: The hand after successful revascularization of III-IV fingers. A. Intensive bleeding from finger tips is observed three days after surgery. B. Bleeding is stopped with hemostatic sponge. Metacarpal area is closed temporary with plastic plate.

blood from the preserved radial branch of the digital artery. Due to the patient's young age, absence of comorbidities and lack of smoking history, we decided to try an urgent revision. He received a regional blockade as well as intravenous anesthesia. After removing the stitches and debriding the wound, the hand was widely opened (midpalm to the carpal tunnel). Damage of the arteries and nerves to fingers III-V on both sides and to finger II on the ulnar side were diagnosed. Due to severe vessel injuries with vessel length insufficiency, only two arteries to fingers III and IV were anastomosed with 10-0 non-absorbable suture, using an operating microscope. The palmar artery of the fifth finger was used to make a cross-palm anastomosis to rescue the fourth finger. Finger V was not revascularized, no adequate vessels were found, and a prolonged revision time was considered. Revascularization of the third and fourth fingers was performed after 52 and 53 h of warm ischemia. After arterial revascularization, we observed spectacular improvement with decreasing signs of cyanosis. The pulp of the third digit filled up, and the previous shape of the fingertip was restored. During the next hour, the signs of necrosis in the dorsal skin disappeared, and the hematoma decreased. The results in the fourth finger were less obvious; however, there was bleeding from the top of both phalanges. There was no need for venous anastomosis, and the dorsal skin strips were patent and ensured venous blood outflow. Trying to avoid an increase in pressure due to suspected hand edema during following hours, flexible plastic plates were used to cover the wound and to reduce evaporation. A loose, dry dressing was placed, and the hand was immobilized in a splint. The patient was moved to the postoperative room in good general

condition, and no problems were reported during the next hours. Routine blood counts, creatinine kinase levels and urine tests were checked regularly and were normal. The patient was given fluids, dextran 40 (500 mL/d), low molecular weight heparin prophylactic dose, aspirin and antibiotics. Because of the significant increase in edema with venous insufficiency during the second postoperative day, we decided to dissect a small area of the epidermis on the finger pulps to support venous outflow (Figure 3A). The bleeding was maintained for the next 5 days. Then, the bleeding was stopped with some hemostatic sponge, which covered the fingertips (Figure 3B). When the edema of the whole hand decreased, the wound in the metacarpal and carpal areas was closed under local anesthesia. Gradual improvement of the digital circulation was observed. On the tenth day, the patient was discharged from our hospital with a proper blood supply and satisfactory appearance of fingers III and IV, without any sign of edema. Finger V was amputated. No follow-up was performed because the patient returned to his homeland.

Discussion

Although ischemia has become a major issue for tissue replantation and revascularization, there are only a few publications that discuss a time limit for finger preservation after unintended warm ischemia. Also, time limits of prolonged ischemia have not been yet clarified and different sensitivity of soft tissues, vessels and bones for ischemic changes should be notified. There are several case reports describing successful digit revascularization after prolonged warm ischemia periods. Chiu and Inoue described case reports of finger revascularization procedures after 30 h of warm ischemia [4,6]. Horta described a case of microsurgical finger revascularization after a long warm ischemia time following Dupuytren's contracture release [7]. It is believed that prolonged ischemia time negatively impacts the success of digit revascularization and is considered a contraindication for such operations. However, selected procedures such as thumb amputation, multidigit amputation, and replantation in children are acknowledged to have extended indications. Seo et al. [8] described a case of a seven-year-old boy who underwent replantation of a completely amputated digit after 26 h of warm ischemia, and this procedure resulted in good recovery of motor as well as sensory functions. There are no strictly defined rules concerning the ischemia periods related to incomplete amputations. Also the time limit, after which revascularization would be impossible stays unknown. Due to the descriptions in the literature of possible and successful finger replantation after prolonged ischemia time, we believe that the primary range for the time limit can be expanded. The longest reported warm ischemia period, prior to successful digit replantation, was 42 h (and 10 h of cold ischemia) [5]. Although we achieved revascularization of the digits after a longer warm ischemia time, we must emphasize that we did not reattach the completely detached fingers. If we take cold ischemia under consideration, the ischemic period prior to an effective procedure can be significantly prolonged even though 24 h was stated as the upper time limit [3].

Woo et al. findings indicate that outcomes of delayed and suspended hand or digit replantation are comparable to the results of an immediate procedure [9]. However, the mean time of cold and warm ischemia in this research was quite short, especially compared to that in the aforementioned cases. Moreover, the study group that underwent delayed or suspended replantation was considerably smaller than the group of patients treated immediately. On the other side, huge volume of metabolic factors with oxygen free radicals are released from ischemic fingers after revascularization, what can carry a risk of reperfusion syndrome with possible kidney injury. Fortunately, no cytotoxic reaction was observed in this case. One of the most important conditions to ensure success was incomplete wound closure after revascularization. Part of the wound was covered with plastic foil, which temporarily preserved the tissues. This kind of management is not applied routinely. However, this approach is crucial for any revascularization and replantation to enable tensionless conditions, especially for the first few days after treatment.

The loss of a finger can result in serious hand disabilities as well as psychological distress. The importance of salvaging the digit is undeniable; thus, surgeons must try to avoid amputation as much as possible. We suspect that the time that would still result in successful digit revascularization may be longer than previously thought, and we believe that this topic requires further reports and studies.

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