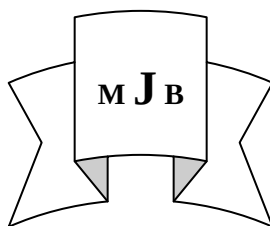


Replantation and Revascularization of Upper Limb Injuries, an Iraqi Experience

Jafer H.Zainy

Al-Wasity Teaching Hospital, Baghdad, Iraq.

E mail: jhzainy@yahoo.com



Abstract

Background: Revascularization/replantation is a complex but vital job that plays an important role in life improvement and functional recovery in devascularization /amputation injuries. The purpose is to estimate the survival rate of revascularization/replantation in different location of upper limb and different mechanisms of injury and to clarify the benefit/risk ratio of this complex job.

Patients and methods: 59 cases aged from 1 year to 56 years with 86 amputated parts of upper limbs of different levels and types were evaluated and managed by revascularization/ replantation.

Results The survival rate was 72% of cases and 81% for parts.

Conclusion: The revascularization /replantation is worth doing and vital process that plays an important role in improvement of shape and function of victims & can be considered as life improving procedure.

Key Words: Microvascular surgery, revascularization, replantation, arm replantation

الخلاصة

خلفية: عودة التوعي الدموي وإعادة الزرع هي وظيفة معقدة ولكنها حيوية وتلعب دورا هاما في تحسين الحياة واستعادة الوظيفة في حالات وقوع إصابات إزالة التوعية والبيتر . والغرض من ذلك هو تقدير معدل البقاء على قيد الحياة من عودة التوعي / إعادة الزرع في المواقع المختلفة من الطرف العلوي والآليات المختلفة للإصابات وتوضيح نسبة الفائدة والخطر من هذه المهمة المعقدة

المرض والطرق

جرى تقييم ٥٩ حالة تتراوح اعمارهم بين سنة واحدة الى ٥٦ سنة بلغ مجموع الاجزاء المبتوتة ٨٦ جزءا من الاطراف العلوية من مستويات وأنواع مختلفة عولجت باعادة التوعي او اعادة الزرع .

النتائج

كان معدل البقاء على قيد الحياة ٧٢% من الحالات ٨١% من الأجزاء المبتوتة .

اختتام

ان عملية إعادة التوعي / إعادة الزرع تستحق القيام بها ومهمة حيوية وهذه العملية التي تلعب دورا هاما في تحسين شكل ووظيفة الضحايا ويمكن اعتبارها عملية محسنة للحياة.

Introduction

Replantation/revascularization of upper limb at different levels is a complex job, begins from the decision to attempt replantation or not

,considering the potential risk of short and long term complications which may be life threatening, going through the technical challenges and ending in a surviving but non- functioning part.

In 1887, Halsted began experiments on limb replantation. [1] In 1906, Carrel and Guthrie described the first successful canine limb replantation, and Carrel outlined his technique for vascular repair the following year. [2] The 1st successful major limb replantation was performed by Malt and Mc Khann in 1962 and published in 1964 [3]. In a later report, this original patient was described to achieve some functional recovery of the replanted right arm after tendon transfers and wrist arthrodesis.[4] In China, Chen-Chung-Wei performed the 2nd upper limb replantation in 1963. [5] The 1st successful digital revascularization of incompletely severed thumb was performed by Klienert and Kasdan in 1963[6]. Komatsu and Tamai reported the first successful digital replant in 1965 and published in 1968[7].

The decision to proceed with replantation depends on many objective factors beside the surgeon subjective assessment, of these factors are the severity and type of the injury, the level of amputation, the duration of ischemia, the condition of the amputated part, the general condition of the patient, the motivation of the patient and the presence of any associated injuries.[8]

Extensive associated intracranial, thoracic or abdominal life threatening injuries are considered as contraindication for replantation, besides age above 50-60 years or major co morbid states. Scapulo-thoracic avulsion or brachial plexus avulsion injuries are considered as absolute contraindication for replantation.[4] Adequate preservation of the amputated part, contraction of muscles in the amputated part and smoking habits were fair indicators but serum potassium level higher than 6.5 mmol/L in the amputated

segment 30 minutes after perfusion is an indicator that replantation should be avoided.[8] The duration of ischemia is the major factor determining the decision for replantation. Irreversible necrotic damage begins after 6-8 hours of ischemia without cooling; cooling may extend the ischemia time to 10-12 hours. Irreversible cell damage and myonecrosis plus significant myoglobinuria and metabolic acidosis with renal failure may be life threatening. Twelve hours ischemic time may be considered as an absolute upper limit for major limb replantation in the upper extremity[4,8]. Temporary shunting may be used to shorten ischemic time. [9] For digital reimplantation, the warm ischemic time may extend to 12 hours while the cold ischemic time is about 24 hours [10]. Freeze cold injury also has detrimental effect on viability after replantation which may result in 72% failure rate due to bad hibernation of the amputated parts [11]. The outcome and digit viability have improved as surgeons have gained more experience with microvascular techniques, and have narrowed the operative indications for replantation. Currently, replantation is recommended for amputated thumbs, multiple digit amputations, and single digit amputations distal to the FDS insertion, as well as all amputations in children[12].

Patients and Methods

59 cases (aged 1 to 56 years) with 86 amputated or devascularised body parts of different types and levels of upper limb injuries were received and managed by replantation or revascularization in Alwasity hospital for reconstructive surgery during the period from 2008 to 2012 and been evaluated according to

their type and level of injury and the resultant outcome. The epidemiological data, mechanism of injuries and results according to different ages and types of injuries were summarized in separate tables.

A. Major proximal arm replantation cases:

The 1st case, an 18 month old female baby presented to Al-Wasity Hospital from Al-Mahmoodia Hospital with total amputation of her right upper limb through proximal humerus. Her limb was caught by a motor belt of an electrical generator crushed and avulsed. The accident happened at 10 a.m and they reached our hospital at 1.00 pm. The limb was preserved in an ice container and was put directly in iced water. after preparation of the patient, she was transferred to the O.R .Two teams started the work, the 1st team began exploration of the amputated part preparing the artery the veins the nerves, the other team started wound excision and preparation of the proximal stump, after shortening of the bone, external fixation done, direct arterial repair and two veins sutured with 10-0 nylon, the nerves were coapted, 1000 i.u heparin were given s/c before removal of the clamps. The circulation was established at 4.00 pm. the veins were remained cross clamped for few minutes until the blood became bright where the clamps were removed, all devitalised tissue was excised, hemostasis done and skin closure. Distal fasciotomy done along the forearm and the palm. She was kept on s/c heparine for 5 days, i.v antibiotics for one week, analgesia and sedation. The post operative course was uneventful; she was discharged from hospital after ten days. we followed her for 10 months postoperatively until she immigrated with her family to another

country, after 10 months she was able to do shoulder abduction some wrist flexion and some finger flexion.

The 2nd case, a young man, 18 years old whose left upper limb was caught in a machine belt crushed and avulsed through the proximal humerus, there was avulsion of shoulder skin with the nerves dangled from the proximal stump with severe traction injury. the accident happened at 8.00 A.M, he reached the hospital at 11.00 A.M, the amputated arm was put directly In iced water, after full preparation, two teams approach started the replantation, after exploration and bone shortening and fixation was done by an external fixator, reperfusion established at 4.00 p.m [ischemic time, 8 hours], two veins were anastomosed, the nerves were left unrepaired as they was in need for long grafts, formal fasciotomy performed. on the 2nd postoperative day, he developed moderate fever, slightly dark urine, slight elevation of blood urea, he was treated conservatively by heparin 5000 iu four times daily S/c, antibiotics , good hydration, mannitol and sodium bicarbonate. The patient improved gradually over few days, locally there was necrosis of avulsed skin flap at the proximal arm which was managed by excision and skin grafting.

B. hand amputation:

The 3rd case, a young man presented to our hospital with a guillotine amputation of his right hand through distal radius and ulna by an electric saw, hibernation was incorrect by putting the amputated hand directly in iced water, the ischemic time was about 3 hours at the time of presentation that extended to 6 hours until the restoration of blood supply, both arteries were anastomosed with four veins, all tendons and median and ulnar nerves. The post operative

course was uneventful, 5000 IU of heparin was given for five days, he was discharged at the 7th day on aspirin 85 mg t.d.s. six months later tenolysis was done to improve finger movement, but at one year follow up there was still some stiffness of the fingers.

The 4th case, an 3 year old girl presented with amputation of her left hand through the bases of metacarpals caused by a fall of heavy glass table caused tangential amputation of the hand with local crush. the amputated hand was preserved in plastic bag which was put in an ice pot 8 hours after the injury, after taking the decision and the informed consent, we embarked on surgery, after preparation of the part, distal carpectomy performed, the ulnar artery anastomosed directly to its superficial counterpart and the radial artery anastomosed directly to the dorsal artery of the thumb, two dorsal veins were anastomosed, in all the anastomoses an 10 zero nylon was used, the circulation was established 6 hours after surgery (which means 8 hours of cold ischemia and 6 hours of warm ischemia, postoperatively she was put on Enoxaparine 2000 iu daily, the course went without significant events.

C. Fingers amputation and revascularization and other cases of revascularization at the forearm and hand level:

Fingers replantation and revascularization cases were accepted for replantation or revascularization after discussion with the patients or their families, the criteria for inclusion that are generally accepted were adhered to with regard to the status of the patient or parts, the level of injury and the warm ischemic time. the only exception was that we were not strict with regard to the type of injury where many cases of crush /avulsion injuries were attempted for

revascularization /replantation. Vein graft used liberally in this study .Bone fixation was usually done by K wires, single, crossed or parallel. in guillotine cases the sequence of repair was systematic started with bone fixation, extensor tendons, dorsal veins, flexor tendons, arteries ,nerves and skin.

Results

Successful replantation and revascularisation was achieved in about 72% and 81%of cases and parts respectively. The four cases of arm and hand replantation survived completely without major events postoperatively, the 1st case was followed for 10 months, she developed some shoulder abduction, elbow extension, wrist and finger flexion. The second case was followed for 9 months, he developed some shoulder abduction and elbow extension. The third case (hand replantation of young adult)was followed for one year, he developed finger stiffness, tenolysis done for him at 6 month post replantation that led to some improvement. The fourth case(hand replantation of 3 year old boy) had been survived completely but she developed some skin slough at dorsal and volar sides treated with skin graft and still under follow up. The two cases of forearm revascularization, one of them ended with failure and below elbow amputation, it was due to severe crush injury and widely devitalized muscles that led to thrombosis of the repaired artery. For digital amputation, the best survival and functional results were of thumb revascularization and replantation. For other digits, the results (table 1) were lower in terms of survival and function.

Discussion

The term successful replantation has changed from a surviving organ into a functioning organ, it should surpass available prosthesis. Major arm replantation carries many risks, they may be associated with missed associated traumas which had led to death of a young female after successful reimplantation because of hidden splenic rupture 10 years ago in Al-Wasity hospital .The other risk is the possibility of re-perfusion syndrome, in one study 25 cases of arm replantation were evaluated, 10 of them failed, the cause of failure was re-perfusion syndrome in 8 cases. [6]These cases are in need for secondary surgeries like nerve grafts for regaining sensation or some motor function, they may need wrist arthrodesis, tendon transfers or even free muscle transfer.

Survival rate of replantation of upper limb parts vary according to level of injury, mechanism, ischemic time and vary from center to center. in Yoshimora study,(13)there was an 100% survival rate of 85 cases with 107 amputated parts although in his discussion he quoted a survival rate of 60% to 94% in multi center studies which coincides with our results.

Tamai reviewed the results of 201 patients with 293 amputated parts of upper extremity amputation in the orthopedic clinic, Nara Medical University From 1965 to 1980 and found that success rate was 88%.[14] these are superior to our results as Tamai is the 1st who had done replantation of digit. The majority of our patients with surviving parts are satisfied with the results although the functional results are not optimum in many cases.

Conclusion

Upper limb amputation / devascularisation injuries' management with replantation/revascularization can lead to better cosmetic and functional results when carefully evaluated and done in qualified center and hands.

Acknowledgment

To all who have taught me, to all who have helped me, I dedicate this paper

References

1. Chai Y, Kang Q, Yang Q, Zeng B. Replantation of amputated finger composite tissues with microvascular anastomosis. *Microsurgery*. 2008; 28:314-320.
2. Halluksa-Handy M. Management of amputations. In: Roberts JR, Hedges JR, eds. *Clinical Procedures in Emergency Medicine*. 5th ed. Philadelphia, Pa: Saunders Elsevier; 2009:chap 47
3. The classic replantation of severed arms: Ronald A. Malt, M.D. and Charles F. McKhann, M.D. *Journal of the American Medical Association* 189:716, 1964.
4. Malt RA, Remensnyder JP, Harris WH. Long-term utility of replanted arms. *Ann Surg*. Sep 1972; 176(3):334-42.
5. Replantation of upper extremity: indications and outcomes: Kevin C Chung,MD. and Amy K. Alderman, MD.*Journal of the American Society of Surgery of the Hand* Vol.2,No.2,May 2002.
6. Kleinert HE, Kasdan ML. Anastomosis of digital vessels *J Kentucky Med Assoc* 1963; 63:106.
7. Komatsu S, Tamai S. Successful replantation of a completely cut-off thumb. *Plast Reconstr Surg* 1968;42:374
8. Replantation of the upper limb: Gulgonin A and Ozer K,,Edition

scientifique et Medicales Elsevier SAS (paris).Surgical Techniques in Orthopedics and Traumatology 55-330-D-10,6p.

9. Arterial Shunting as an Adjunct to Major Limb Revascularization: james a. Nunley, m.d., l. Andrew koman, m.d., james r. Urbaniak, m.d. Ann. Surg. * March 1981.

10. Replantation of multiple digits and hand amputation:Four case reports:Mohammed M. Salah, Khalid N. Khali, cases journal,Biomed central.

11. Cold injury of amputated digits: Uros Ahcan et al, Prevention of cold

injuries (10-1_10-4), 2005.http://www.rtonato.int/abstract.asp.

12. Kaplan FD, Raskin KB, Indications and surgical techniques for digit replantation. Bull Hosp Jt Dis. 2001-2002; 60(3-4):179-88.a}

13. Limits of digital replantation: Mitsuo Yoshimura, JMAJ 64(10): 460-467, 2003.

14. Susumu Tami, Kashihara Nara, twenty years experienceof limb replantation,review of 293 upper extremity implants:The journal of hand surgery.Vol.7 No.6 November 1982(549-556).

Table 1 site type and no. of injuries

site of injury	incomplete	complete	total cases	survival	%	total parts	survival	%
arm	0	2	2	2	100%	2	2	100%
fore arm	2	0	2	1	50%	2	1	50%
hand (through wrist)	0	1	1	1	100%	1	1	100%
hand (through palm)	4	1	5	5	100%	5	5	100%
single thumb	6	8	14	11	78%	14	11	78%
thumb with other digits	2	4	6	5	83%	12	11	91%
multiple digits	6	9	15	10	66%	36	31	86%
excluding thumb								
single digit other than thumb	8	6	14	8	57%	14	8	57%
total no.of cases	28	31	59	43	72%			
total no. of parts	42	44				86	70	81%

Table 2 Mechanism of injury versus extent of injury

Type of injury	Guillotine	Local crush	Wide crush plus/minus avulsion	Avulsion
Incomplete	8	10	6	4
Complete	22	5	2	2

Table 4 Complication

complication	case	management	time	Outcome
No reflow phenomenon	4	Revision anastomosis	of immediate	100% failure
Arterial thrombosis	12	Revision	1 st 24 hrs	50% failure rate
Venous thrombosis	5	Revision &/or leech	2 nd p.o. day	80% failure
bleeding	1	Exploration &cauterization of bleeders	2 nd p.o day	Uneventful
Skin necrosis	2	Skin grafting	7 th day	Successful
infection	2	antibiotics Change,debridement	3 rd p.o.day	100%Arterial thrombosis &failure
Reperfusion injury	0			
Malunion nonunion	0			
Joint stiffness	30	physiotherapy	After week	3 rd Improvement



a



b



c

Fig 1 Case no. one, a. the amputated arm.b. the fasciotomy wound is prepared for skin graft.c. few months after replantation



Fig. 2/Case No. 2: photos show the amputated part, the stump, the early post operative results & result 9 months after replantation.



Fig 3 /case 3 hand replantation in an adult that led to partial recovery of function



Fig 4 Total avulsion of right thumb of a 12 year old boy replanted with direct vascular anastomosis.





Fig 5 Total amputation of the left hand of a three year old girl after dragging of large LCD screen on her hand, replantation done after proxproximal raw carpectomy & direct vascular repair of ulnar artery &anastomosis of radial artery to the dorsal artery of the thumb.She developed immediate spasm of the arteries which was relieved by warming of the patient &the hand.7 days later she developed sloughing of volar &dorsal skin which was managed with skin grafting.



Fig 6 total amputation of the right thumb with devascularisation of the right index , managed with replantation of the thumb & revascularization of the index.

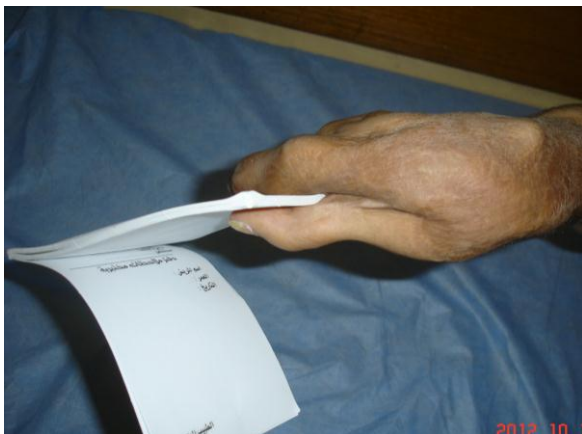


Fig 7 severely crushed hand after heavy press injury, revascularization of three digits by direct anastomosis of radial artery to the thumb, ulnar artery to the little finger, plus vein graft to the middle finger.