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Traumatic fingers amputation

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A 46-year-old right-handed factory worker was brought to AED after finger amputation injury at workplace. The patient's limb was caught by machine and required extrication. All amputated parts were collected and rinsed with normal saline on ambulance. (Figure 1)

His vitals upon arrival were as follow:
- BP: 142/102mmHg, pulse: 95 beats per minute
- RR: 18 breaths/min, SpO2 100% on room air
- GCS: 15/15, pupils equal and reactive

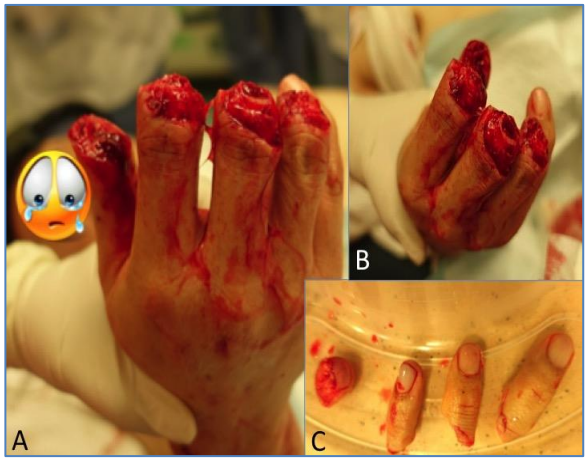

Fig 1: Clinical photo of patient's right hand (A and B) and the amputated parts (C)

In the pre-hospital phase, how shall we extricate the patient from entrapment?

Extrication from entrapment should be accomplished with preservation of the limb in mind. The entrapped anatomy must not be pulled with force, as this may cause avulsion injury.

Dismantling the machinery may be the best option for extrication, but this can take hours. If impossible, or for other reasons a 'field' amputation may be required.

What is the initial approach to the patient?

According to the Coordinating Committee (COC) A&E triage guidelines, patient with a near amputation or amputation of finger should be at least categorized as Cat 2 emergency.

Although the amputated part(s) are eye-catching, examination should not be limited to sites of obvious deformity. Priorities should always be based on overall patient assessment to identify life-threatening conditions first.

Following the Advanced Trauma Life Support (ATLS) protocol[1], primary survey should be performed quickly by assessing
- Airway with cervical motion restriction
- Breathing
- Circulation
- Disability (neurological status)
- Exposure/Environmental control.

After stabilizing ABCDEs, secondary survey which is a head-to-toe evaluation together with a complete history should be performed.

Apart from AMPLE history (Allergies, Medications, Past medical history, Last meal, Events surrounding injury), detailed history related to amputation injury also includes: [2,3]

- Time of injury and mechanism of injury
- Co-existing injuries
- Handedness
- Occupation and Hobbies
- Smoking history
- Tetanus immunization status

This information is essential when considering replantation. Besides, appropriate analgesics should be given.

Why is mechanism of injury important for patients with traumatic amputation?

The mechanism of injury is important to determine whether replantation is possible, successful or functional.

The mechanism of amputation injury is classified in the following table. (Table 1)

Clean cut	**Results from objects with narrow sharp edges e.g. knives or meat slicer Wound edge: Clean Minimal debridement is required**
Blunt cut	Results from objects with narrow blunt edges e.g. saws or fan blades Wound edge: jagged, crushing that extends a limited distance proximal and/or distal to the amputation Moderate debridement is required
Crush	Results from an object with a broad blunt edge e.g. punch press or wooden log Wound edge: irregular (torn rather than cut), significant tissue injury that extends proximal and/or distal to amputation Extensive debridement is required
Avulsion	Caused by traction e.g. anchor rope or the reins of horse Wound edge: tissue is torn rather than cut with separation of tissue (vessels, nerve tendon, bone and skin) occurs at different levels
Combined	Caused by a combination of crush, avulsion, or other mechanisms of injury e.g. initial incomplete crush amputation by a machine followed by an avulsion when the patient reflexively withdraws the hand

Table 1: Classification of mechanism of injury in amputation

How to handle the stump and amputated parts?

Our goals of care include control of haemorrhage, prevention of further injury and contamination.

In most cases of isolated finger amputations, haemorrhage is self-limiting when arteries are constricted and retracted, and it can be controlled by direct pressure.

If unsuccessful, temporary use of tourniquet can be considered as an adjunct. The time of tourniquet application should be clearly documented. The recommended maximum duration for use is 2 hours.[3]

<u>The Stump</u>

Remove all jewelry from the injured site and irrigate the stump with normal saline to remove gross contamination.

Do not scrub or apply antiseptic solution to the wound as it may damage viable tissue. It should then be covered with saline-moistened sterile dressing and splinted in a functional position to prevent further injury from concomitant fracture or compromise blood flow from a change in position. The stump should also be elevated to reduce swelling and control bleeding and [4-6]

<u>The amputated parts</u>

The amputated parts should be first irrigated with normal saline to remove gross contamination, then wrapped in saline-

moistened sterile gauze and sealed in a dry and closed waterproof plastic bag. (Figure 2)

The bag should be immersed in ice water or refrigerated at 4°C. The amputated part should **NOT** have direct contact with ice or saline or reach freezing temperature as it may cause cellular damage.[3-6]

The container should be well-labelled. Do not discard any tissue fragments as they may be used for grafting even replantation cannot be performed.

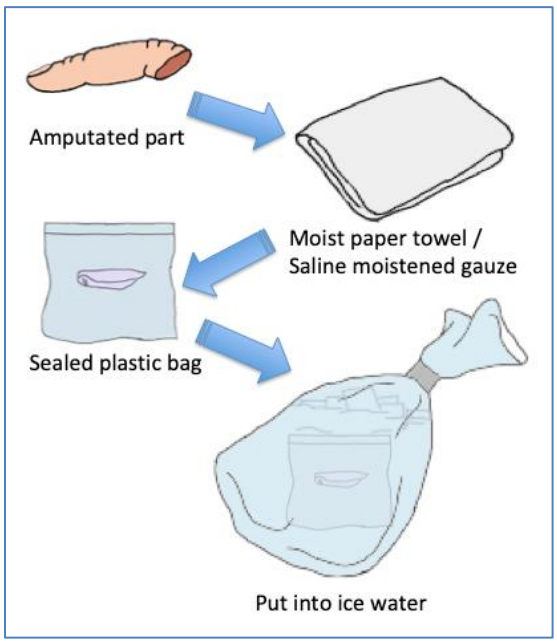

Fig 2: Preservation of the amputated part

Why is appropriate cooling of amputated part important?

Muscle has the highest metabolic demand among different tissues and it deteriorates most rapidly during ischaemia. Irreversible damage of digits may occur after 6 hours at 20-25°C.[7] Replantation of a digit is not recommended when warm ischaemia time exceeds 12 hours.

Appropriate cooling aim at preventing warm ischaemia and avoiding direct tissue contact with ice that can cause frostbite. It extends the acceptable ischaemia time up to 24 hours.[8]

Progress of patient

X-ray of the right hand was taken. (Figure 3) Combined with the physical examination findings, it showed that

- Thumb: Amputated pulp with exposure of distal phalanx tip
- Index finger, middle finger and ring finger: amputated at middle phalanx level, just distal to proximal interphalangeal joint

Fig 3: X-ray of the patient

Should replantation be performed?

- It depends on the characteristics of injury.
- The indication and contra-indication of replantation are shown (Table 2). [10,11]

Progress of our patient (1)

The patient was admitted to orthopedic ward. Two hours later, emergency operation for replantation (reattachment surgery) was arranged.

Table 2 Indication and contra-indication for replantation

	Indications	Contraindications
Patient factors	• All pediatrics amputation (superior neuroplasticity, regenerative capacity) • Patient desire (Aesthetic/social)	• High risk of surgery • Active psychiatric illness • Smoker • Drug abuse
Injury characteristics	• Thumb (important function) • Multiple fingers • Mid-palm/wrist/major amputation • Single finger zone I amputation	• Any life threatening injury that takes priority • Multiple level amputation • Extreme contamination • Severe avulsion or crush • Duration of warm ischaemia • Single finger zone II amputation

What is the difference between replantation and revascularization?

Replantation is the reattachment of a **completely** amputated body part by re-establishing arterial inflow and venous outflow.

Revascularization is the reattachment of incompletely amputated parts. It should ideally be restricted to incomplete amputations that require restoration of both arterial inflow and venous outflow.

If the incomplete amputation needs only an arterial repair for restoring circulation, the correct term is critical arterial repair.

Revascularization may appear to be easier compared with replantation; however, in practice it is often more difficult.

The presence of intact bone in an incomplete amputation means the surgeon may not be able to shorten the bone significantly, which, in turn, may necessitate the use of vein grafts, nerve grafts, or skin flaps to bridge any defects. It is also not possible to examine the part on the back table to isolate the neurovascular structures.

What is the order of replantation?

Replantation surgery takes long time. For major limb replantation, 6-8hours are required, while a distal amputation take 2-5hours. In multiple digital amputations, each digit takes up to 3-4 hours.

The exact order of repair depends on surgeon preference and the level of amputation. The logical sequence is to progress from repair of the deeper structures (bone and tendon) to superficial structures (nerve and vessels).

An operating microscope is needed for fine precise repairs.

The procedure of replantation is briefly described

1. Preparation of the amputated part:
- The digital arteries are inspected carefully under loupe magnification or the microscope.
- Red line sign (Figure 4) is the ecchymosis due to haemorrhage from avulsed branches of the digital artery. Replantation may not be successful.
- 'Ribbon sign' (Figure 4) is the coiling of the artery resulted from disruption of the vessel wall layers from avulsion injury. Vessels should be trimmed until normal appearing vessel ends present.

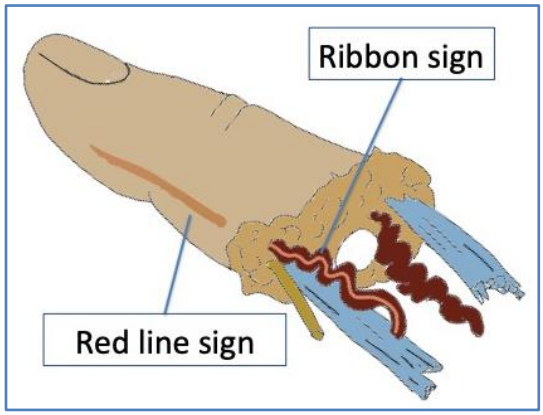

Fig 4: Clinical signs suggesting digital arteries injury include red line sign - Disruption of branches of digital artery and, ribbon sign - avulsion of digital artery and

2. Preparation of the stump
3. Bone fixation (usually K wire for finger)
4. Tendon repair
5. Vein repair
- Ideally, the number of vein repairs exceeds the number of arterial repairs by one e.g. at least 3 veins for 2 arteries
6. Artery repair
- May need vein graft) (Figure 5)
7. Nerve repair
8. Skin closure and dressing

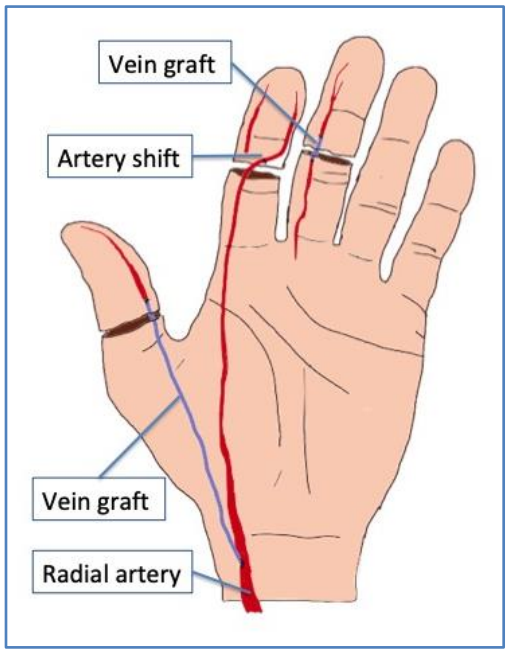

Fig 5: Technique for bridging segmental defects in the digital artery

The order of repair depends on surgeon preference and the level of amputation. There is no consensus on whether artery or vein should be repaired first. Repair the vein first minimizes blood loss. Repair the artery first allows selection of veins with good outflow for anastomosis; however, the field is bloody and dissection difficult.

The two situations when it is preferable to do the arterial repair first are a distal replant where the arterial inflow helps in identifying the veins and in major limb replantation to decrease the warm ischemia time.

Progress of our patient (2)

During the replantation, the bone fragments of middle finger, index finger and ring finger were fixed with K wire.

The flexor and extensor tendon were repaired followed by the digital arteries and veins and finally the digital nerves. Clinical photos were taken after the operation. (Figure 6)

What is the post-operation management?
Postoperative care is directed towards preventing external factors that may result in vessel spasm and thrombosis.[11]

The room is kept warm and the patient well hydrated. The replanted part is elevated slightly above heart level of the heart and kept warm with a lamp.

Analgesics are used to control pain because they can lead to adrenergic response and vasoconstriction, especially in children.

Smoking is prohibited to prevent hypoxia, reduction of peripheral blood flow, and risk of thrombosis.

Broad-spectrum antibiotics are given intravenously to prevent infections and maintained for 5 to 7 days. Dressing changes are minimized.

The highest risk of postoperative thrombosis is the first 72 hours (3 days) after surgery.

Early replantation failure (within 12 hours) is mostly due to wound infection and arterial thrombosis from persistent vasospasm and platelet aggregation. It presents with pallor and decreased/absent capillary refill over the replanted part. Urgent exploration and re-anastomosis are warranted.

Failure after 12 hours is typically secondary to venous congestion or thrombosis which manifests as cyanosis and swelling with a brisk capillary refill.

Is there any role for antiplatelet or anticoagulation?

Different protocols exist for perioperative anticoagulation. The commonly used anticoagulants can be divided into agents that

1. Decrease platelet function (e.g., aspirin)
2. Increase blood flow or decrease blood viscosity (e.g., dextran)
3. Counteract the effect of thrombin on platelets and fibrinogen (e.g., heparin).
4. Other anticoagulant agents include:

- Thrombolytics like streptokinase, urokinase, and tissue plasminogen activator
- Haemorrheologic agents like pentoxifylline, hirudin, and iloprost.

However, there are insufficient outcome data in humans regarding the choice of anticoagulants.[11]

Figure 6: A: Before the operation; B and D: Palmar side of the hand after the operation with K-wire fixation (Yellow arrow); C: Dorsal side of the hand after the operation

What is the outcome following replantation

With advancement in microsurgical techniques and instrumentation, the rate of successful replantation, especially for distal replantation, is as high as 86%.[12,13]

However, the viability of the replanted tissue is not the only concern. Replantation cannot be considered truly successful until function is restored. Various outcome measurements including functional recovery (in terms of range of motion, sensation recovery, grip strength, etc.), level of pain, cold intolerance, patient's satisfaction and ability to return work, health-related quality of life and cost-effectiveness should also be evaluated on individual basis.[14]

Progress of our patient (3)

Unfortunately, replantation of the right I/F, M/F and R/F was unsuccessful. The replanted fingers were complicated with wound infection and gangrene.

Wound swabs showed that there was heavy growth of mixed microorganisms despite the use of intravenous cefazolin (Table 3).

	Culture results
Right I/F	Citrobacter species + Acinetobacter calcoaceticus-acinetobacter baumannii complex + Enterococcus Gallinarum
Right M/F	Citrobacter species + Enterococcus Gallinarum
Right R/F	3 types Gram negative bacilli and 2 types Gram positive cocci

Table 3: Culture results from the superficial wound swabs after replantation

Removal of the gangrenous fingers and revision amputation were performed a week later. Also, Moberg flap was reconstructed to patient's right thumb. On post-op Day 14, all the wounds and the flap condition were well, and patient was discharged after removal of stitches.

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