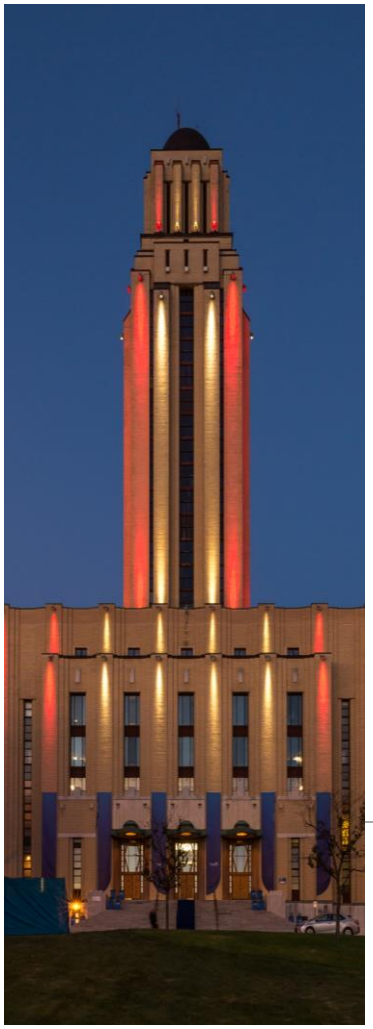


Pediatric Reimplantation: Therapeutic Considerations

Jenny C. Lin, MD PhD

Associate Professor Plastic Surgery Université de Montréal

Medical Director Quebec Provincial Replantation Program (CEVARMU)

Département de chirurgie
Faculté de médecine
Université de Montréal

Definitions

Replantation :

- reattachment of a part that has been completely amputated
- no connection exists between the severed part and the patient

Revascularization :

- repair of a part that has been incompletely amputated
- some of the soft tissue (e.g., skin, nerves, or tendons) is intact

Viability rates of revascularization are generally better than those of replantation - venous drainage often intact

Functional outcome possibly better in revascularization (more structures intact)

Indications for replantation

- Thumb
- Multiple digits
- Partial hand (amputation through the palm)
- **Almost any part in a child**
- Wrist or forearm
- Elbow and above elbow (depending on degree of crush injury)
- Individual digit distal to the FDS tendon

Département de chirurgie
Faculté de médecine
Université de Montréal

Contraindications

- **Severely crushed or mangled parts**
- **Amputations at multiple levels**
- Amputations in patients with other serious injuries/diseases
- Amputations in patients with severely arteriosclerotic vessels
- Amputations with prolonged warm ischemia
- Amputations in mentally unstable patients
- Individual finger amputations in an adult proximal to FDS insertion

Maximum ischemia time

Warm ischemia time < 12h or cold ischemia time <24h for digit

Warm ischemia time < 6h or cold ischemia time <12h for more proximal amputation

However, these are recommended maximum times – successful replantation can be achieved despite longer ischemia times also.

TABLE 82.2

CRITICAL ISCHEMIA TIME OF TISSUES

TYPE OF TISSUE	CRITICAL ISCHEMIA TIME AT NORMAL TEMPERATURE
Muscle	4 h
Nerve	8 h
Fat	13 h
Skin	24 h
Bone	4 d

Adapted from Gillani S, Cao J, Suzuki T, Hak DJ. The effect of ischemia reperfusion injury on skeletal muscle. *Injury.* 2012;43(6): 670-675 and Blaisdell FW. The pathophysiology of skeletal muscle ischemia and the reperfusion syndrome: a review. *Cardiovasc Surg.* December 2002;10(6):620-630.

Pre-operative recommendations

- ATLS protocol – patient must be stable prior to transfer (life over limb)
- need appropriate photos and radiographs to evaluate potential for replantation
- co-morbidities
- tetanus and antibiotic prophylaxis
- aspirin per os
- clean amputation site and part, wrap amputated digit/limb in saline-soaked gauze, keep cold (ice cold water, but not directly in the water or on ice)
- control bleeding, adequate fluid resuscitation prior to transport
- urgent transport with appropriate monitoring, transfusion if necessary

Surgical sequence - digits

- Locate and tag vessels and nerves
- Debride soft tissues after identification of vessels and nerves.
- Shorten and fix the bone
- Repair the extensor tendons
- Repair the flexor tendons
- Anastomose the arteries
- Repair the nerves
- Anastomose the veins
- Obtain skin coverage

Département de chirurgie
Faculté de médecine
Université de Montréal

Surgical sequence – proximal limb

- irrigation/lavage , debridement of foreign material
- revascularize limb ASAP
- temporary vascular shunt BEFORE all else
- bony fixation
- definitive vascular repair – vein graft may be necessary (prep leg)
- fasciotomies, debridement of devitalized tissue
- nerve / soft tissue repair
- leave wounds open – 2nd look 24-48h later
- 3rd look and subsequent surgeries as needed

Département de chirurgie
Faculté de médecine
Université de Montréal

Proximal replantation or revascularisation

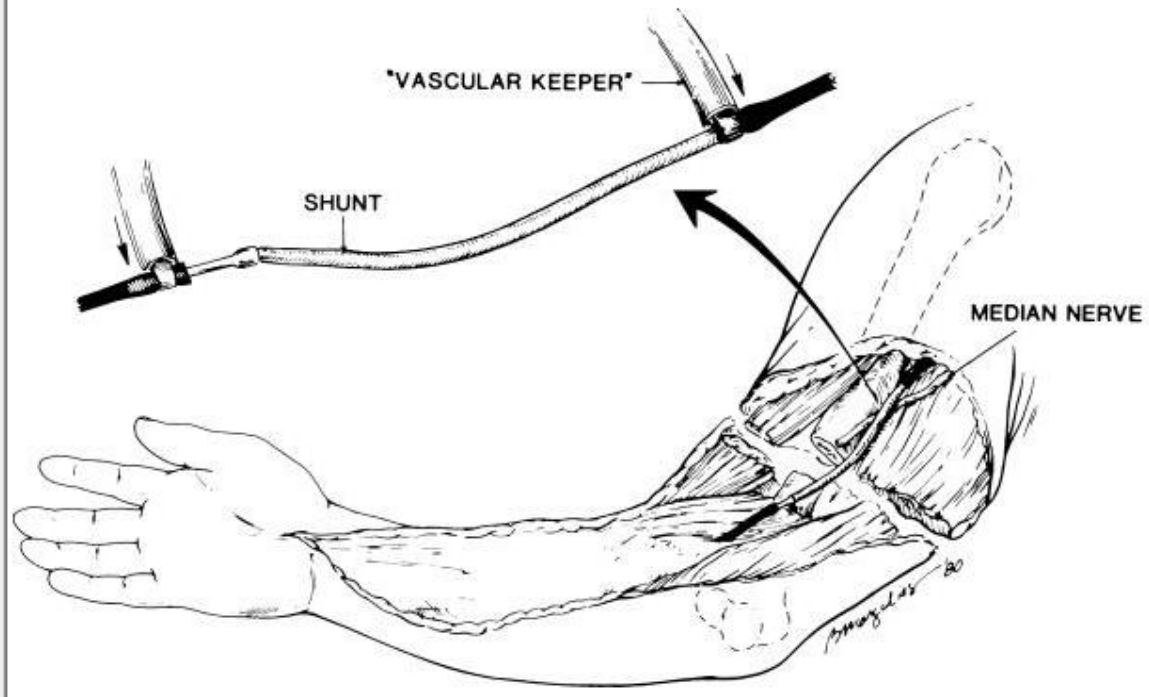


FIGURE 45-14 A Sundt shunt or a ventriculoperitoneal shunt is used to obtain rapid arterial inflow from the proximal vessel to the amputated part. [79]

Surgical sequence – proximal limb

- irrigation/lavage , debridement of foreign material
- revascularize limb ASAP
- temporary vascular shunt BEFORE all else
- bony fixation
- definitive vascular repair – vein graft may be necessary (prep leg)
- fasciotomies, debridement of devitalized tissue
- nerve / soft tissue repair
- leave wounds open – 2nd look 24-48h later
- 3rd look and subsequent surgeries as needed

Département de chirurgie
Faculté de médecine
Université de Montréal

Peri-operative management

- good perioperative hydration, especially in major replant/revasc
- blood transfusion as necessary
- regional block if possible (pain control and sympathetic block for vasodilatation)
- avoid vasopressors if possible (prioritize dobutamine or dopamine over levophed)
- antibiotics IV
- monitor for reperfusion syndrome (proximal injuries)

Post-operative care

- non-compressive dressing, elevate replanted part
- keep patient and replanted limb/digit warm
- monitor volume status; maintain blood pressure and urine output
- heparine IV may be used (crush, graft, thrombosis in OR)
- largactil may be used for vasospasm
- monitor replanted part with close observation
- monitor for reperfusion syndrome in proximal injuries
- adequate pain control

Post-operative monitoring of replanted part

Q1h for 24h, q2h for 24h then q4h

Color, turgor, capillary refill, and warmth

O2 Saturation if possible

No smoking or caffeine

Fasting for 24h

Return to OR if venous or arterial thrombosis

Plan 2nd look, etc

Département de chirurgie
Faculté de médecine
Université de Montréal

Main peri- and post-op issues

Blood loss, coagulation problems

Vasospasm – common in children

Reperfusion syndrome (lactic acidosis, myoglobinuria)

Myonecrosis

Infection

Pain – physical and neuropathic

Wound management, coverage of vessels and nerves

Département de chirurgie
Faculté de médecine
Université de Montréal

Post reperfusion syndrome

- result from ischemia/reperfusion injury in skeletal muscle
- characterized by massive edema which increases fluid requirements and may cause shock
- washout of myoglobin, potassium, lactate, and microthrombi from the damaged skeletal muscle into the systemic circulation can cause renal failure, arrhythmias, and even death
- appropriate medical monitoring is essential – ICU admission post-op?

Long-term follow-up

- hospitalization following digit replantation (5-7 days if no complications)
- hospitalization after major limb replantation or revascularization can be several weeks or even months, with multiple returns to the OR
- patients require multi-disciplinary care, both in the hospital and once discharged home
- rehabilitation (PT, OT, psychologist) up to many years after initial trauma
- secondary surgeries may be needed to maximize function
- nerve recovery 1mm/day, expectations must be managed

Functional outcomes

The best results are obtained in replantation of the thumb, the hand at the wrist or distal forearm level, and the finger distal to the insertion of the FDS (zone 1).

Cold intolerance is present in most replanted digits and may or may not improve after 2 years.

Cold intolerance and a normal thermoregulatory response return as sensibility recovers.

Recovery is better in children and patients with distal amputations.

Proximal replantation can give better functional outcome than amputation and prosthesis, but recovery over many months and years.

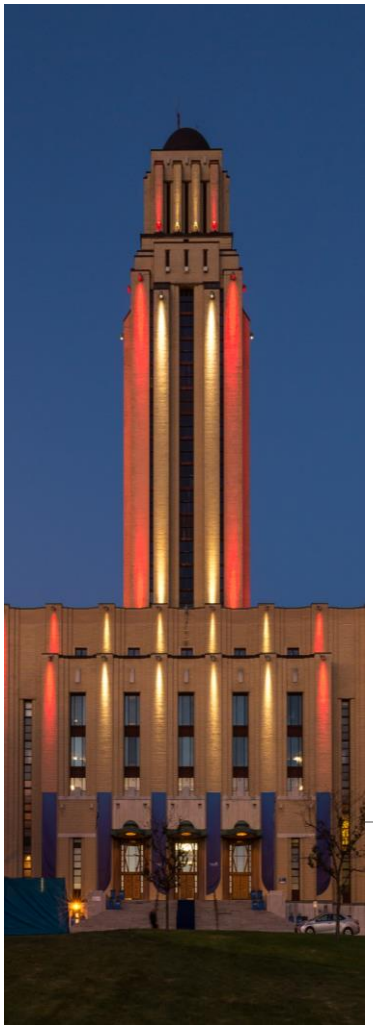
Département de chirurgie
Faculté de médecine
Université de Montréal

References

"Replantation and Revascularization", K. Cheung, editor, Hand Clinics, vol 35, issue 2 (2019)

"Pediatric upper extremity replantation", J.Y.S. Kim et al, Clin Plastic Surg 32 (2005) 1 – 10.

"Controlled reperfusion after acute and persistent limb ischemia", F. Beyersdorf et al, Semin Vasc Surg 22 (2009) 52-57.



Pediatric Reimplantation: Therapeutic Considerations

Jenny C. Lin, MD PhD

Associate Professor Plastic Surgery Université de Montréal

Medical Director Quebec Provincial Replantation Program (CEVARMU)

Département de chirurgie
Faculté de médecine
Université de Montréal