Leech Therapy in Digital Replantation

Leech therapy was first used in Egypt around 1500 BC to treat a range of ailments from nosebleeds to gout. In the Middle Ages, Anglo-Saxon physicians were called "leeches" because of their fondness for using these versatile creatures in their treatments.[1] After a long period of disuse, leeches became popular again in the 1960s because of the successes demonstrated by plastic and reconstructive surgeons in treating tissue compromise from venous congestion.[2] These successes have prompted surgeons to use leeches in microsurgical procedures involving digital replantations.[3]

LEECH ANATOMY AND PHYSIOLOGY

There are hundreds of varieties of leeches, but only four varieties are used for medicinal purposes. The type most commonly used in microsurgery is *Hirudo medicinalis* (Figure 1), which is native to southeast Asia and Europe.[4] This type of leech is dark brown or green in color and measures 12 cm to 20 cm when stretched out. Both ends of the leech have suckers that help it remain attached while feeding. The mouth on the anterior, narrower end has three sharp jaws that produce a Y-shaped bite. *Hirudo medicinalis* is a hermaphrodite that feeds infrequently; it can live up to 200 days between feedings.

Perioral glands in the leech's mouth secrete saliva containing the chemical hirudin, a potent natural anticoagulant that prevents or reverses blood coagulation in the leech's gut.[5] The therapeutic effect of a leech bite is not from the volume of blood ingested but from the continuous bleeding from the bite wound after detachment.[6] Continuous oozing from the bite site also may prevent infection from the bacteria *Aeromonas hydrophilia*, a normal flora present in the leech's gut. The routine use of prophylactic antibiotics during leech therapy also prevents infection that may be caused by the bacteria.[7] The leech's saliva contains two other notable components: a local anesthetic, which accounts for the painless attachment of the leech when it begins to feed, and a vasodilator, which promotes blood flow during the feeding period.

DIGITAL REPLANTATION CONSIDERATIONS

The primary treatment for traumatic multiple digit amputations is digital replantation.[8] Some patients, however, refuse digital replantation because of the long, technically involved microsurgical procedure and the lengthy rehabilitation and absence from the workplace.[9] The goal of digital replantation is to restore function to the patient's fingers, not simply to perform a technically successful surgery.

Ischemia. Patient access to a replantation center plays a vital role in a successful surgical outcome. Only one fifth of traumatic amputation victims reach a surgeon in time for digital replantation.[10] Ischemia time (ie, the amount of time the amputated

A B S T R A C T

This article presents a protocol for the perioperative care of patients undergoing digital replantation, which is the most common microsurgical procedure performed today. Venous congestion, a common complication of digital replantation, often has been treated through surgical exploration and creation of arteriovenous anastomosis. Leech therapy, however, is experiencing a resurgence among surgeons as an alternative method for treating venous congestion. This article discusses the anatomical, physiological, and clinical indications and methods of leech therapy in digital replantation. *AORN J* 62 (Sept 1995) 364-375.

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Figure 1 • Sketch of a *Hirudo medicinalis* leech. *(Figures 1, 2, and 3 courtesy of David Low, MD, Philadelphia)*

part is without a blood supply) is a critical factor in determining the likelihood of a successful digital replantation. Digits have survived cold ischemia times of 24 to 36 hours and warm ischemia times of eight to 10 hours.[11] Cooling slows down cellular metabolism by 50% for each 10° C drop in temperature, thus lengthening the time a body part can survive without its blood supply. An amputated digit, therefore, should be packed in ice until treatment is initiated.

Arteriovenous anastomosis. The availability of both an artery and a vein during replantation of an amputated digit is a favorable situation. Arterial anastomosis supplies blood inflow to the digit and venous anastomosis provides blood outflow. If, during the replantation process, inadequate veins exist for a primary arteriovenous anastomosis, the surgeon usually attempts a vein graft. At least one, and preferably two, veins should be repaired for each arterial anastomosis.[12]

Crush injuries to the hand are particularly high-risk situations because contusions to the dorsal veins of the fingers severely limit the ability to perform reanastomosis procedures on those vessels. The veins in the distal part of the finger are quite small (ie, less than 1 mm in diameter).[13] With a crush injury, the surgeon often anticipates venous insufficiency and begins leech therapy to remove engorged blood from the digit.

Venous congestion. Time is the critical element in reestablishing vascularity in the replanted digit when signs of venous congestion (ie, arterial obstruction, thrombosis, necrosis, loss of the digit) appear (Figure 2). Health care providers must differentiate between venous and arterial congestion before leech application because a leech often is not useful in treating arterial problems. Proper care must be taken to prevent edema, tissue necrosis, and thrombosis. If this regimen is not followed, the affected part may not survive.

One study supports the important role of leeches in treating venous congestion; leeches can extract up to six times their body weight before detaching spontaneously. The study also states that if a leech attaches or sucks slowly, the prognosis for the replanted digit is poor, even though the color of the replanted digit may appear satisfactory at the time.[14] The majority of patients faced with the likelihood of digital loss from venous congestion readily accept leech therapy. Experienced and supportive nursing staff members who can allay patients' fears are critical to the success of leech therapy.

EMERGENCY ADMISSION OF THE PATIENT WITH AN AMPUTATED DIGIT

Preoperative care of the patient requiring digital replantation begins in the emergency department (ED) of the nearest replantation center. When the patient arrives at the ED, the amputated part accompanies him or her. The severed digit should arrive at the ED wrapped in a slightly dampened piece of gauze or paper towel that is placed in a clean plastic bag or waterproof container. The emergency medical services personnel ensure that the bag or container is placed in a larger container that holds water and enough ice to keep the water cold during transport to the hospital.[15]

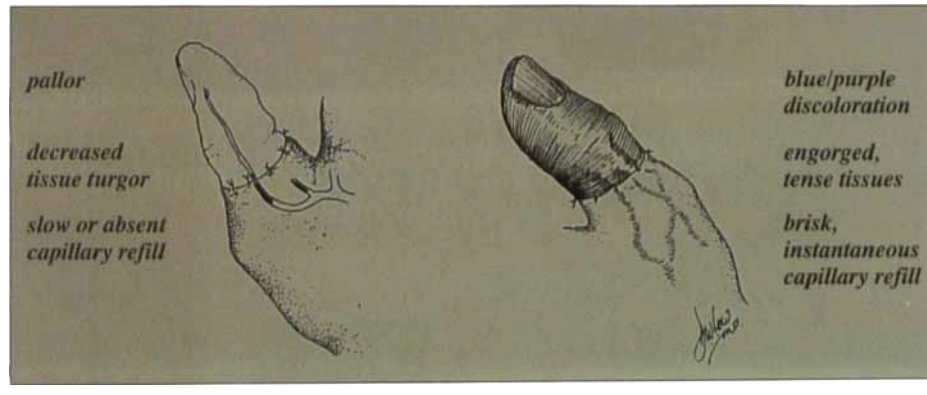

Figure 2 • Indicators of arterial occlusion (left) and venous occlusion (right).

Our facility has established specific guidelines and protocols for emergent care of the trauma patient requiring digital replantation. The surgeon obtains a comprehensive medical history and arranges all consultations concerning the patient's current medical status. The ED nurse performs specific patient interventions, including

- identifying patient allergies,
- starting an IV line to deliver pain medication and a broad spectrum antibiotic (eg, cephalosporin), and
- performing a physical assessment to determine other problems (eg, head injury).

The surgeon orders 600 mg aspirin in suppository form and keeps the patient NPO in preparation for surgery. Aspirin acts as an antiagglutinate on platelets and begins the anticoagulation process to prevent venous congestion. The surgeon initiates laboratory studies, x-rays, and any other emergency procedures necessary.[16]

OR PREPARATION

When planning for the replantation procedure, surgeons may bring the amputated part to the OR before the patient arrives. This is one of the few times in which surgery can begin before the patient arrives in the OR. The scrub person prepares a sterile table with a soft tissue set and basins. The soft tissue set includes

- hemostats,
- iris scissors,
- small dissecting scissors,
- fine-toothed forceps,
- a bone cutter,
- curettes, and
- microsurgical instruments.

The first team of surgeons washes, debrides, and tags the neurovascular structures of the amputated part, which is still in ice. Having the vessels ready for anastomosis to the stump decreases the overall ischemia time. The surgeons remove splintered bone fragments with a bone cutter. Stainless steel surgical wires in the prepared bones (ie, osteosynthesis) permit a tension-free anastomosis of vessels and nerves while maximizing length and function.[17]

Before the surgical procedure begins, the circulating nurse verifies the strength of the microscope lens with the surgeons and cleans and attaches it to the microscope. The microscope should be double headed so the surgeon and assistant can view the surgical field simultaneously. A videotape camera can be attached to the microscope, and both instruments should be draped in a sterile fashion to allow the scrub person and other members of the surgical team to view the procedure. The OR bed should have a swivel base that enables it to rotate 90 degrees to facilitate movement of the microscope base into suitable positions. At our hospital, a gel-filled mattress is placed on the OR bed to protect the patient's bony prominences from undue pressure during the long procedure.

INTRAOPERATIVE PATIENT CARE

Although this surgical procedure can begin before the patient arrives in the OR, the circulating nurse realizes that the patient is his or her priority. When the patient arrives in the OR suite, the circulating nurse checks for informed surgical and blood transfusion consents, laboratory test results, and appropriate x-ray films. To alleviate some of the patient's anxiety, the circulating nurse reassures the patient that family members will be kept informed of his or her progress at two-hour intervals. The circulating nurse explains to the patient what to expect in the OR (eg, cool environment, bright lights, hemodynamic monitors). After the patient arrives in the OR, the circulating nurse explains OR procedures as they occur (eg, placement of electrocardiogram leads, application of pneumatic compression stockings).

During anesthesia induction, the circulating nurse assists the anesthesia care provider. Patients undergoing digital replantation often have full stomachs and are at risk for regurgitation of stomach contents into the lungs; therefore, a rapid-sequence induction may be performed. The anesthesia care provider administers a rapid-acting anesthetic agent, followed by a muscle relaxant (eg, succinylcholine). The circulating nurse applies cricoid pressure to partially occlude the esophagus, which prevents aspiration during intubation.

Conscious intubation may be appropriate if the patient has airway problems. In this situation, the circulating nurse has a cart available that contains a flexible bronchoscope and a local anesthetic to numb the patient's airway and inhibit the gag reflex. With conscious intubation the airway reflexes are preserved, which allows the endotracheal tube to pass through the patient's vocal cords on inspiration. Regional anesthesia, which requires that the patient lie still, can be used but is not recommended because of the length of the procedure.[18]

After induction, the circulating nurse provides

the following items to the anesthesia care provider:

- preoperative antibiotics (1 gm cefazolin sodium is the antibiotic of choice if the patient has no allergies),
- an IV infusion pump for infusion of dextran 40 later in the procedure,
- 5,000 U of heparin, and
- a temperature probe to monitor the patient's body temperature.

The patient's core temperature should be greater than 96.8° F (36° C). After induction, the circulating nurse inserts a 14-Fr Foley catheter to monitor the patient's urine output.

SURGICAL PROCEDURE

Two teams of surgeons and nurses work simultaneously to decrease the patient's time under anesthesia. In preparation for the digital replantation, the scrub person opens a basic microsurgical tray and provides the surgeon with specific instruments. A microsurgical tray includes

- microforceps,
- microscissors,
- microneedle holders,
- small bulb irrigators with cannulae, and
- vessel dilators.

All solutions in the surgical field must be labeled. The solutions include heparinized saline (ie, 5,000 U heparin in 100 mL normal saline) for irrigation, 40 mg/mL lidocaine, and 30 mg/mL papaverine hydrochloride to prevent muscle spasm.

The stump of the amputated digit is prepared in the same manner as the patient's amputated part. When the surgeons complete osteosynthesis, the scrub person disposes of the cut ends of the stainless steel surgical wires used in the procedure. The surgical wires are considered sharps and must be handled properly after they are passed through the patient's bone to decrease the risk of puncture wounds to the surgical team members.

The surgeons identify the patient's digital stump arteries and the recipient digit arteries for potential anastomosis. Arteries usually are repaired first to limit ischemia time and to aid in the identification of viable veins. After the surgeons complete the arterial anastomosis using 9-0 monofilament suture, the digit should be pink, indicating adequate arterial inflow. The scrub person provides the surgeons with another 9-0 monofilament suture when they are ready to begin the venous anastomosis. If there is poor venous flow after the venous anastomosis, the scrub person should be ready to assist the surgeons with any number of procedures (eg, reexploration, vein graft, release of skin sutures, partial nail plate removal, application of leeches).

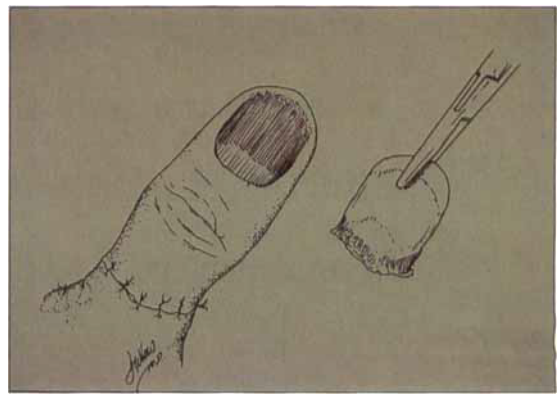

Figure 3 • Artist's rendering of partial nail plate removal, used to prevent blood coagulation.

Partial nail plate removal can be a useful adjunct in digital replantation. The surgeons accomplish this by introducing a hemostat under the patient's fingernail to elevate the nail plate from the nail bed (Figure 3). The exposed nail bed promotes venous drainage by allowing engorged blood to ooze from tissue when adequate venous channels are lacking.[19] The goal of nail plate removal is to prevent coagulation of blood on the nail bed and to encourage continuous drainage. The scrub person assists in promoting the desired bleeding by gently rubbing the exposed nail bed with a heparinized saline sponge. If leeches are to be used, the scrub person will assist with leech application after the nail bed is rubbed with a heparinized saline sponge. A leech may also be applied at the site of digit reattachment.

Wound closure is achieved by reattaching the digit and, therefore, closing the stump. To protect the replanted digit, we use a minimal dressing. An iodoform-impregnated nonadherent dressing is placed on the wound with a bulky dry dressing of cotton padding and plaster. Dressing changes should be limited and inspection of the replanted digit should be done frequently to decrease the risk of compression and constriction.

The patient usually is admitted to the postanesthesia care unit (PACU) or surgical intensive care unit (SICU) for 24 hours after surgery. Leeches applied to the patient during replantation will accompany him or her during transport to the PACU or SICU.

Fluoroscein dye is a useful method of monitoring circulation in a replanted digit.

The circulating nurse reports to the PACU nurse that leeches are being used and will be transported to the PACU attached to the patient's replanted digit. Information that is pertinent to the patient's condition also is reported (eg, types, number of arterial and peripheral IV lines; presence of Foley catheter; application of thermal regulating blankets if needed). The circulating nurse also informs the PACU nurse of where the patient's family members are waiting.

POSTOPERATIVE PATIENT CARE

The patient will have a Foley catheter and will remain NPO for 24 hours postoperatively. This is a critical time period during which most problems occur that may require the patient's return to the OR. The patient is maintained on bed rest for five days because he or she is fully anticoagulated and, therefore, at increased risk for bleeding should he or she fall when transferring out of bed or ambulating. A private room is ideal but not essential to guarantee the patient a calm and quiet environment in which movement is kept to a minimum. The postoperative nurses perform frequent vital signs and wound checks (ie, the digit's color and temperature, amount of swelling, presence of a pulse). Other key nursing functions include pain control, promotion of vasodilation, and prevention of constriction on the surgical site.

Vasoconstriction avoidance. In the immediate postoperative period, the PACU nurse promotes venous drainage by elevating the affected part and by avoiding direct pressure to it. A custom splint to maintain elevation has been found to be quite effective in ensuring satisfactory elevation and preventing constriction when patient compliance is unreliable. Vasoconstriction also can be avoided by raising the room temperature to 78° F (25.5° C), covering the affected area with a blanket, and using a heating lamp. Caffeine (eg, coffee, tea, caffeinated sodas, chocolate) must be eliminated completely from the patient's diet to prevent vasoconstriction. Smoking is absolutely forbidden because the carbon monoxide and nicotine in tobacco are potent vasoconstrictors.[20] Even secondhand smoke can cause failure of a digital replantation.

Circulation monitoring. Fluoroscein dye is a useful method of monitoring circulation in a replanted digit. After the surgeon injects fluoroscein systemically through the patient's IV line, it rapidly penetrates all perfused tissue.[21] The clinical use of fluorescein involves determining whether fluorescence occurs after fluorescein injection. An absence of fluorescence indicates a lack of arterial inflow. Prolonged fluorescence suggests a venous obstruction. Fluorescence is measured by shining a handheld fluorimeter or an ultraviolet lamp on the replanted digit and at a suitable control site on nearby normal skin.[22] More important than absolute numbers generated by the fluorimeter is the relative change in fluorescence seen before injection and shortly after injection (ie, peak) and the subsequent decrease in fluorescence, which indicates venous clearance of the dye from the digit and eventual renal excretion. It is the postoperative nurses' responsibility to record the peak flow times and note the fall-off times of the dye's fluorescence at the site of reattachment. Fluorescein may cause nausea, vomiting, and an allergic reaction (rare).

Postoperative medications. Postoperative medications include an anticoagulant in the form of aspirin suppositories. Heparin also may be ordered for crush injuries but may be contraindicated in the presence of other injuries (eg, head trauma). During surgery, the anesthesia care provider inserts a peripheral IV line and infuses a dextran 40 solution to serve as a volume expander. Dextran 40 encourages vasodilation by decreasing blood viscosity and inhibiting platelet aggregation, which decreases venous thrombosis.[23] Dextran 40 is continued for a five-day period. Medications to control pain and prevent anxiety also are routinely ordered. Systemic antibiotics are important in the postoperative period to help avoid wound infections, particularly with the use of leech therapy.

Leeches. Emotional support and participation by family members contribute significantly to the patient's acceptance of leech therapy. Removal of psychological stress is very important during this procedure. There should be a good understanding of the mechanics of the treatments. The patient and

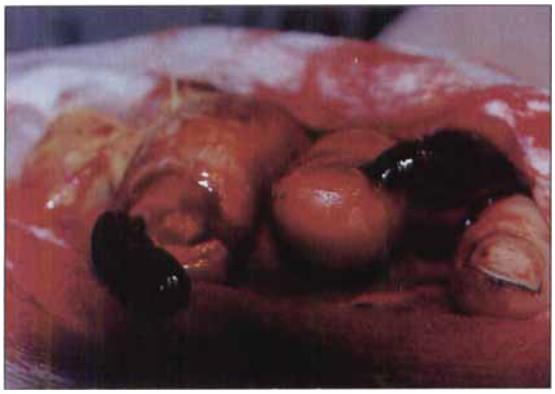

Figure 4 • Leeches applied to the fingers of a patient who has undergone digital replantation.

family members should be encouraged to voice fears and concerns. Special consideration should be given when leech therapy is used with pediatric patients.

Leeches usually are applied every two hours, or as otherwise ordered by a physician. As venous congestion resolves, this regimen often is relaxed to a PRN basis. The postoperative nurse is responsible for applying and removing leeches. The number of leeches and application times are recorded by the nurse. During leech therapy, the postoperative nurse closely monitors the patient's hemoglobin, hematocrit, and bleeding times. Approximately 50% of patients who undergo replantation require blood transfusions because the anticoagulation and continuous oozing from leech bites causes their hematocrit levels to fall.[24]

Leeches are stored in a freshwater solution in the pharmacy and an immediate supply may be kept in the patient's room for ongoing use. Pretreating the live leech with antibiotics before application is presently being tested to help minimize infection from *Aeromonas hydrophilia*, the potentially harmful bacteria found in leeches. At our hospital, we are experimenting with adding the antibiotic ciprofloxicin to the solution in which the leeches live for 24 hours before they are applied to patients. The number of necessary leeches depends on the severity of the patient's venous congestion. Leeches range in price but are approximately six dollars each. This expense usually is covered by the patient's insurance company as a medication.

LEECH APPLICATION

Factors influencing leech application are related to the leech's behavior. The leech must be "hungry" and must exhibit feeding behavior; that is, it must attach to a host and suck blood. If a leech does not show interest in attaching, a different leech should be applied. If a second leech does not attach, the postoperative nurse should consider the possibility of "lazy leech syndrome." This behavior is not actual laziness but a reaction to the anesthetic agents that have infiltrated its gut.[25]

Successful attachment depends on scrupulous skin preparation. Ointments, old blood, and skin antiseptics must be removed or the leech will not attach to the area. The postoperative nurse must wear gloves and use forceps to handle the leech. After the site is cleansed with saline, a small needle puncture is made into the congested digit to initiate bleeding. The leech is then placed on the digit near the bleeding site. The leech should move toward the blood, attach firmly, bite, and then suck the patient's blood.[26] A drop of 10% dextrose solution can be used to encourage the leech to attach to the digit if necessary. To keep the leech from roaming from the intended bite site, a tent of gauze dressing can be constructed around the leech (Figure 4). The postoperative nurse initially stays at the bedside to ensure that the leech does not crawl up into the dressing. Alternately, a paper cup with a hole in the bottom allows the replanted digit to be inserted from underneath and may serve to contain the leech and limit migration away from the digit.

If, after feeding, the leech does not detach spontaneously, the nurse can touch the leech with a cotton tip dipped in alcohol to relax the leech bite.[27] The nurse then kills the leech by placing it in a small container of alcohol. The leech is handled like biohazardous waste and disposed of in a container for contaminated items.

REHABILITATION

When a replanted digit is deemed viable and successful, the patient enters extensive occupational therapy aimed at achieving maximal return of function. Depending on the method of bony fixation (ie, rigid versus stainless steel surgical wires), mobilization might start as early as the first week after digital replantation. The patients have regular follow-up schedules with surgeons, initially making weekly visits and progressing to monthly visits. During this time, patients also see hand therapists several times each week. Patients often are out of work for six months after digital replantation. Approximately one half of all patients will require some form of adjunctive surgery (eg, tenolysis, capsulotomies) to deal

with the postoperative complication of stiff fingers. Approximately 90% of all digit replantations are successful.[28]

CONCLUSION

Leech therapy can be an important adjunct to surgeons in the treatment of congested digital replantation. Perioperative nurses play a crucial role in ensuring the success of this surgical procedure by helping the patient meet the outcome goal of restored digital function. ▲

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