Hand Injuries

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THE HUMAN hand, with four limber fingers and an opposing thumb, is unequalled in the animal kingdom for its manipulative capability. It allows man to pinch, grasp, twist, bend, push and pull while doing a myriad of daily tasks such as hammering a nail, writing a letter, or playing a musical instrument.

Permanent injury to one or both hands severely limits normal activity and can result in unemployment. These circumstances, of course, are psychologically debilitating.

Recent advances in hand surgery, the latest being microsurgery, have made it possible, in many cases, to restore injured hands to their normal appearance and functional capability. But the surgeon, even armed with an operating microscope, cannot perform miracles. His success is predetermined by how the hand is treated before the victim gets to the hospital. The success of surgery, and the outcome of the patient's life, therefore starts with the Paramedic/EMT.

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The only aid that can be rendered for a nail bed injury before the patient gets to a surgeon is to help stop the bleeding by applying pressure near the wound and holding the arm in an upright position. At the hospital, the arm of the injured hand is thoroughly cleaned to above the elbow. This is done in case skin from the arm is needed for a graft to the nail bed or fingertip. Then, the wound itself is cleaned. Damaged tissue is removed only when necessary.

Amputations of fingers or hands require more elaborate care. The following protocols were developed by the Maryland Department of Health and Mental Hygiene, Division of EMS.

MEDEVAC ATTENDANTS:

1) Do not attempt to wash, rinse, scrub or apply antiseptic solution to the wound.
2) Apply dry sterile dressing. Wrap in kling or kerlix bandage. Apply pressure and elevate.
3) Do not wash, rinse, scrub or apply antiseptic solution to the severed part. Wrap it in dry sterile gauze or towel, depending upon size, and place it in a container, preferably styrofoam, containing coolant bags or ice in a separate plastic bag.
4) For a partial amputation, place severed part(s) in a functional position. Apply dry sterile dressing, splint and elevate. Apply coolant bags to the outside of the dressing.
5) If possible, control bleeding with pressure. If a tourniquet is necessary, place it close to the amputation site.
6) *The amputated part must not be submerged in ice water.* Do not allow the ice to melt, replace with another bag of ice.

EMERGENCY ROOM:

1) Evaluate the patient's condition to ensure that he does not need to be resuscitated before transfer.
2) The wound should be flushed with Ringer's lactate solution. *DO NOT SCRUB OR APPLY ANTISEPTIC SOLUTION TO THE WOUND.* Apply dry sterile dressing. Wrap in kling or kerlix for pressure and elevate.
3) The amputated part should be flushed with Ringer's lactate. *DO NOT SCRUB OR APPLY ANTISEPTIC SOLUTION TO THE AMPUTATED PART.* Wrap it in dry sterile gauze or a towel, depending upon size, and place in a plastic bag or plastic container. The enclosed part is then put in another container, preferably styrofoam and cooled by separate plastic bags of ice.
4) For a partial amputation, flush with Ringer's lactate and place part(s) in a functional position. Apply dry sterile dressing, splint and elevate. Apply coolant bags to the outside of the dressing. *DO NOT SCRUB OR APPLY ANTISEPTIC SOLUTION TO THE WOUND.*
5) If a patient's condition will not allow immediate transport, the amputated part(s) should be wrapped in a dry sterile towel, placed in a plastic container, and kept under refrigeration at 4 degrees Centigrade (20 degrees Fahrenheit), or kept cool in a styrofoam container surrounded by separate plastic bags containing ice.
6) Control bleeding with pressure. If a tourniquet is necessary, place it close to the amputation site.
7) Patient's medical record should accompany him, if possible.

"With immediate cooling to 4 degrees Centigrade (20 degrees Fahrenheit), an amputated part can be preserved for 12 hours," said Dr. Andrew Weiland, a hand surgeon and emergency medicine specialist at The Johns Hopkins Hospital. "But surgeons have only about half that amount of time to replace the amputated part if it is kept at air temperature," he added.

Chinese doctors claim to have extended survival time for an amputated arm to 33 hours and to 36 hours for a foot when these parts are cooled to 4 degrees Centigrade (20 degrees Fahrenheit).

Expert emergency care is not the only factor which determines the success of a replant operation, however. Dr. Weiland said the highest success rates have been achieved when 1) the patient is in the second decade of life; 2) the cut is sharp and clean; 3) the amputated part is large; and 4) the artery to vein anastomosis ratio is 1:2 or 2:4. (See Surgical Management of Hand Injuries.)

Replantation should not be performed, said Dr. Weiland, for severe crushing injuries, degloving injuries and multiple level injuries in the same fingers, or when the amputated part has been frozen or kept in nonphysiologic solutions. In addition, he recommended that single digits other than the thumb not be replanted, if there is no damage to adjacent fingers. The functional use of the hand is not restricted appreciably by loss of a single finger, and replanting one can result in "significant social and economic morbidity," he reasoned.

Despite some failures, Dr. Weiland said replantation is popular with patients. "Without exception, every patient with both successful and unsuccessful replantations said that they would go through the procedure again if the situation arose and would not elect to have closure of the amputation stump," he said.

The idea of preserving fingers or the hand, rather than merely amputating the damaged part and closing the wound, goes as far back as 1877 when Dr. William Halsted, the first chief of surgery at The Johns Hopkins Hospital experimented with replanting limbs. But the first limb replant on a human did not occur until 1962, when Dr. Ronald Malt reconnected the amputated arm of a 12-year-old boy at Massachusetts General Hospital.

Meanwhile, a breakthrough came in hand surgery with the development of the operating microscope. Drs. Julius Jacobson and Ernesto Suarez first demonstrated the instrument at the University of Vermont College of Medicine in 1960.

By 1964, Chinese doctors had reported partial success in replanting fingers. However, developments in the last four years, such as smaller needles and improved microsurgical techniques, have boosted the success rate to 75 percent. That's good news for a lot of people, namely, the estimated one million Americans who need surgery for upper extremity injuries each year.

One recent beneficiary of microsurgery is Wendell Mason, who works at a Rust-Oleum plant in Williamsport, Maryland, located 65 miles from Baltimore. He was working on a Rust-Oleum job with his two teenage sons at the plant last June, when an 80-pound piece of tin fell off a nearby roof and, like a guillotine, almost completely severed Mason's hand from his arm.

One son, remembering what to do from a magazine article he had read, laid his father on the ground and put a tourniquet on the bleeding arm. Then he elevated the arm with the severed hand, which was only hanging on by a thin piece of skin and one blood vessel.

When the Williamsport ambulance squad arrived, attendants worked on Mason's hand to restore its color and then dressed the wounded arm. Next,

they relocated the hand to its approximate normal position and immobilized the area by applying a splint. Mason was also treated for shock.

He was first taken to Washington County Hospital, but when doctors saw the severity of the injury, they arranged for him to be transported by ambulance to the Raymond M. Curtis Hand Trauma Center at the The Union Memorial Hospital in Baltimore. Mason's condition deteriorated rapidly en route to Union Memorial, so a Maryland State Police helicopter was dispatched to meet the ambulance and fly the patient the rest of the way. Mason arrived at Union Memorial a little more than an hour after the accident had occurred.

The Curtis Hand Center at Union Memorial is the latest addition to the Maryland State and Regional EMS System, and is the first hand center to be established under such a system. The system, which consists of specialized treatment centers at various Baltimore City hospitals, serves Maryland, the District of Columbia, and parts of Virginia, West Virginia, Pennsylvania and Delaware. Radio communication and ambulance telemetry are used to link hospital-based physicians with EMTs on the scene, and to facilitate transport to the appropriate treatment center in the system.

The Curtis Hand Center has an acute trauma unit for inpatients, a microsurgical laboratory and an extended care facility where therapists help patients regain the functional use of their hands. The microsurgical laboratory is used by the surgical replant teams to practice their techniques on animals. Practice is necessary to maintain their skills, since replant operations are not performed daily. The rehabilitation unit soon will have kitchen and workshop areas to help patients return to their normal activities.

The Curtis Hand Center is also a major teaching facility. Instructors of paramedics and ambulance attendants from all parts of Maryland come to the center to learn how to care for hand injuries. They, in turn, pass on their knowledge to the emergency medical personnel in their communities. Doctors from the center have also participated in orthopedic workshops sponsored by the Maryland EMS to train emergency room and orthopedic nurses in the management of acute hand trauma.

The concept of a regional trauma center for the treatment of the upper extremity injuries originated during World War II, when nine Army Hand Centers were established under Dr. Sterling Bunnell. Previously, soldiers with hand injuries were sent from one Army hospital to another for treatment because doctors were not trained to deal with the hand in its entirety, according to Dr. Raymond Curtis, after whom the center at Union Memorial is named.

Centralizing treatment for hand injuries provided the opportunity for such training and resulted in better treatment, Dr. Curtis said. An additional unexpected benefit of hand centers is that patients with hand injuries motivate each other toward regaining hand function when they are brought together, he said, adding, "This greatly decreases the period of disability and loss of time from work."

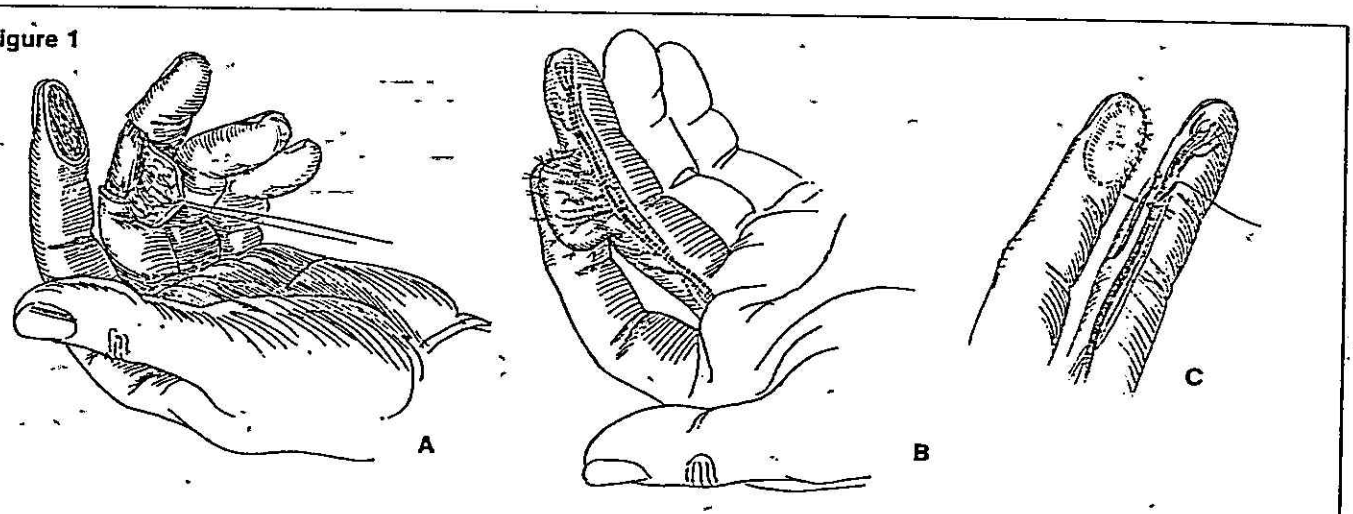
More than 700 hand patients were treated at the Curtis Hand Center in 1976. About one-fourth of these cases involve acute injury to the hands.

But microsurgery probably is not the last word in the treatment of hand injuries. Therapy may one day include hooking up the patient to an electrical current.

Dr. Robert Becker, an orthopedist at the Upstate Medical Center of the State University of New York, has found that electrical currents cause partial regeneration in higher animals, such as rats. No test animals have grown a complete limb, but he has obtained limited regeneration of normal bone, cartilage, marrow, muscle, nerve and blood vessel tissues. Similar results have been obtained by researchers at Purdue University who are using electricity to regenerate frog legs. Dr. Becker does not anticipate that his work will benefit amputees in the near future, but he does expect that electromagnetic stimulation will be used to promote the healing of wounds.

If that sounds farfetched, don't forget that finger replantation seemed futuristic a mere 20 years ago.

Figure 1



Cross finger flap procedure demonstrated.

SURGICAL MANAGEMENT

Once the patient is transported to an appropriate medical facility, such as a hand trauma center, the surgeon takes over. The following summary (representing the work of Dr. Harold Kleinert and his associates at the University of Louisille, Kentucky, School of Medicine) shows the surgical procedures used to treat nail bed injuries and amputations.

NAIL BED INJURIES

Treatment of nail bed injuries varies depending on the condition of the fingertip. However, the surgeon's prime concern in repairing the nail bed injury is the position of the nail matrix or root from which the fingernail grows. If the root is displaced, a deformed fingernail could grow over the nail bed in almost any direction.

A dislocated nail root is sewn back into place. If the nail root is removed, either in the accident, or by the

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surgeon because the root is displaced too far to be repositioned, the fingernail will never grow back. Such defects are covered with a skin graft to obtain a smooth non-tender surface in place of the nail.

A lacerated nail bed and root is mended simply by closing the cuts with sutures. A detached nail bed is replaced with a skin graft. A "stent dressing" is placed over the graft to prevent blood from accumulating underneath the graft.

If the fingernail is torn off, the skin folds which surround the margins of the nail would normally adhere to the nail bed and nail root during healing. This is prevented by inserting non-adherent gauze packing in the fold space, or if necessary, by applying a thin skin graft.

Loss of the skin fold covering most of the nail root is restored with a local rotational pedicle flap when feasible. A thin graft is placed over the area left exposed by cutting the flap.

Deeper lacerations, which involve a fracture in the underlying bone, are fixed by reducing or cutting away a small segment of the bone to allow the severed fingertip to rejoin the stump. Also, loose and protruding bone fragments are removed to obtain a flat surface for nail growth.

Lost skin and soft tissue from the fingertip can be restored with a full-thickness skin graft. The thickness of the graft is reduced where it covers the nail bed.

However, a better solution is the cross-finger flap (See Figure 1). This procedure involves incising an area of skin on an adjacent finger to cover the injured soft tissue. The donor site is then covered with a full thickness skin graft. The advantage of this procedure over a skin graft is that the sensitivity of skin and soft tissue in the hand is more highly developed than it is in tissue from the arm or elsewhere. Cross-finger flaps can be used even when the loss of soft tissue in the fingertip leaves the bone exposed.

AMPUTATIONS

Amputated fingertips are too small to be replanted through microsurgery, but the cross-finger flap again comes to the rescue. It can restore the length of the finger unless pre-existing disease precludes the procedure. Another way of handling an amputated fingertip is with a triangular volar flap. This technique involved cutting a triangular flap of skin from the palm side of the amputated finger. The base of the triangle is the cut edge of the skin where the amputation occurred and should be at least the width of the amputated edge of the nail root. The apex of the triangle extends to the crease in the finger nearest the cut. After smoothing the sharp edges of the exposed bone, the flap is advanced over the bone and sewn to the nail bed. The "V" incision which remains is then closed with sutures to form a "Y". The denuded nail bed can be covered with a skin graft. Sometimes, a portion of the flap can be defatted to cover the defect.

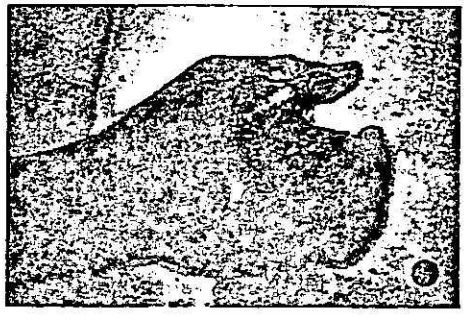
Surgical treatment may not be required for an amputated fingertip where the patient is 11 years old or younger. Youths in that age group can re-epithelialize the fingertip, if the wound is not extensive.

When the amputation involves more than a fingertip, the severed part can be replanted using microvascular surgery. Prior to replantation, high doses of antibiotics are administered. Exposed bones are shortened to allow severed parts to rejoin without tension.

Then the long, tedious work of sewing nerves, tendons and blood vessels back together begins. One team of surgeons prepares the stump while another team works on the amputated part to minimize fatigue and to decrease the time of interrupted circulation to the amputated part.

The initial success of a replant depends on skillful vascular repair. Veins and arteries should be repaired in a ratio of 2:1. The largest cause of replant failures is due to blood clots forming in the veins. To compensate for this problem, a greater number of veins than arteries are reconnected.

SUCCESSFUL TRANSPLANT.



The wounded stump.

The replanted fingers.

The full extent of Mims' extending ability.

IN MARCH, 1976, Jim Mims, a 33-year-old grocery store employee in Baltimore, Maryland, had his middle and index finger slashed off by a meat blade while cleaning a ground beef mixer in a conveyor belt system. A co-worker retrieved the fingers and they were put in a plastic bag and brought with Mims to Prince George Hospital.

The fingers were put on ice in a styrofoam box and transferred with Mims to the Union Memorial Hospital for transplant at the Curtis Hand Clinic.

It took a team of four hand surgery specialists 14 hours and 30 minutes to perform the delicate surgery. Working under a microscope, the surgeons sewed together bones, arteries, nerves, tendons and veins with suture that is barely visible.

Mims transplant was successful and as shown in the photos, the use of his fingers has been restored. The extent of use is limited somewhat because the tendons were cut in two.