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Emergency Care of the Injured Hand, Part IX:
Mutilating Hand Injuries and Replantation

Introduction. Look at one of your own hands. Have you ever taken a few moments to study this amazing structure? The hand allows man to interact with and manipulate his environment. It can perform an infinite number of grasping or pinching functions with precision or power. It is a superior sense organ—able to determine hot and cold, ascertain the size, shape, and texture of objects, and even "see" for the blind. And, consider the communication performed by an expressive hand: fingers signaling victory to thousands, the anger expressed by a clenched fist, the wordless love transmitted with a caress. Does the incredible functional capability of this delicate yet powerful organ ever capture your mind?

If you are like most people, you take the human hand for granted. You expect that it will work, and do not consider the possibility that it might easily be rendered useless in an instant. Each year, hundreds of thousands of Americans will destroy a significant portion of a hand in a lawn mower, punch press, snow blower, table saw, or other device. Children will fail to discard fireworks or home-made bombs quickly enough. Carelessness will place the hand at risk.

We use the term mutilating hand injury to denote a heterogeneous group of problems. Despite the infinite variability possible in mechanism of injury and tissue involvement, the following are usually true:

- The injury is severe;
- Multiple tissues are damaged;
- Some tissues are probably beyond salvage;
- The hand will probably never again be normal.

When medical students, nursing students, or paramedical personnel in training first see a severe hand injury, the usual response is shock and revulsion; feelings of pity and helplessness follow. All these emotions interfere with the objectivity required to deliver the appropriate early care which is necessary to ensure the best long-term result. An understanding of the basic treatment goals allows us to approach these problems logically and systematically.

Treatment Goals. *Tables I* and *II* summarize the treatment objectives which must be borne in mind by all personnel involved in the treatment of these injuries. The immediate goals of emergency care help to accomplish the eventual treatment goals of the hand surgeon.

Emergency personnel can definitely influence the long-term results in the treatment of severe hand injuries. (See *Figures 1A* to *1G*.) Prevention of further tissue damage can only be accomplished when rescue teams and other paramedical staff aid and transport accident victims properly. The hand must be carefully removed from the injuring equipment or situation. It is never forcefully "torn" away. Occasionally, the patient will have to be transported with the hand entrapped, if the machine or device can be partially disassembled. Under these circumstances, the hand must be kept elevated and cooled to prevent massive swelling. If special tools will be necessary to disassemble the equipment, the rescue team should notify the emergency department so that those tools

Table I: Goals of emergency care.

- Prevent further tissue damage;
- Control bleeding and protect remaining circulation;
- Prevent contamination.

Table II: Goals of the hand surgeon.

- Preserve viable tissue;
- Prevent infection;
- Maintain or restore circulation;
- Remove non-viable tissues;
- Repair damaged tissues;
- Effect early wound closure or coverage;
- Institute an early therapy program.

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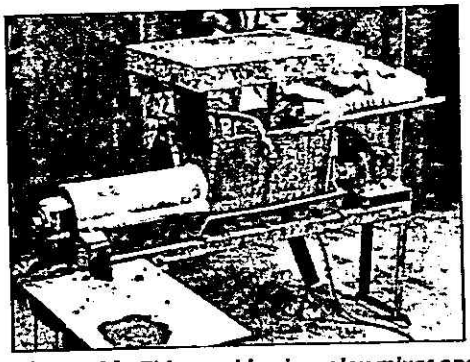

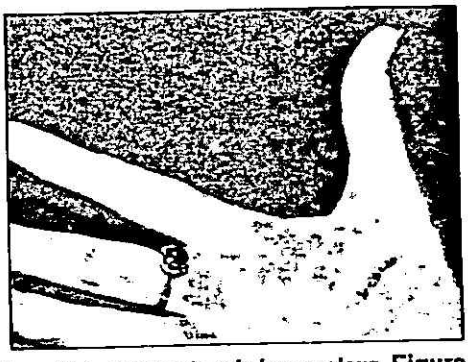

Figure 1A: *This machine is a clay mixer and contains large revolving blades which move with sufficient force to mix heavy clays.* **Figure 1B:** *The left hand of a 16-year-old high school girl became trapped in the clay mixer and sustained a severe crushing injury. Appropriate careful removal of the hand prevented additional injury.* **Figures 1C to 1G:** *Following surgery to repair the various damaged structures, the hand exhibits excellent appearance, finger flexion and extension, and independent thumb motion.*

(and the appropriate technician) will be available.

Bleeding can nearly always be controlled by sterile, gently compressive dressings and elevation. Tourniquets are to be avoided except for hemorrhage unresponsive to direct pressure. Some contamination is present in any open wound; any gross debris should be removed prior to wound irrigation and dressing, but only if the removal can be accomplished safely. Foreign materials which have penetrated the hand and are protruding should *not* be removed for two reasons: removal may damage additional tissues, and the wound tract may then be difficult to trace for proper debridement at surgery. Contaminated debris lying on the surface of the wound should be removed, and the wound gently irrigated with sterile saline or non-cytotoxic disinfectant solution. The sterile dressing is not applied until tissues have been replaced to desirable positions. This does not usually include reduction of fractures or dislocations, but refers to the repositioning of partially amputated tissues or skin and soft tissue flaps to maintain any undamaged circulation.

Rapid transportation is important but does not need to be overdone. Helicopter transport is not justified to save a few minutes or even an hour or two, if the patient's condition is stable and there is not a major vascular injury or amputation. Careful, direct ground transportation is usually adequate and preferred.

Emergency Department Care. Upon arrival in the emergency department, the general condition of the patient is assessed, and fluid loss, hypotension, continued bleeding, or other problems receive first attention. Intravenous fluids are instituted, and antibiotic prophylaxis is wise. One or two grams of cephalothin or cefamandole are added to the IV solution. Tetanus immunization status is ascertained and tetanus

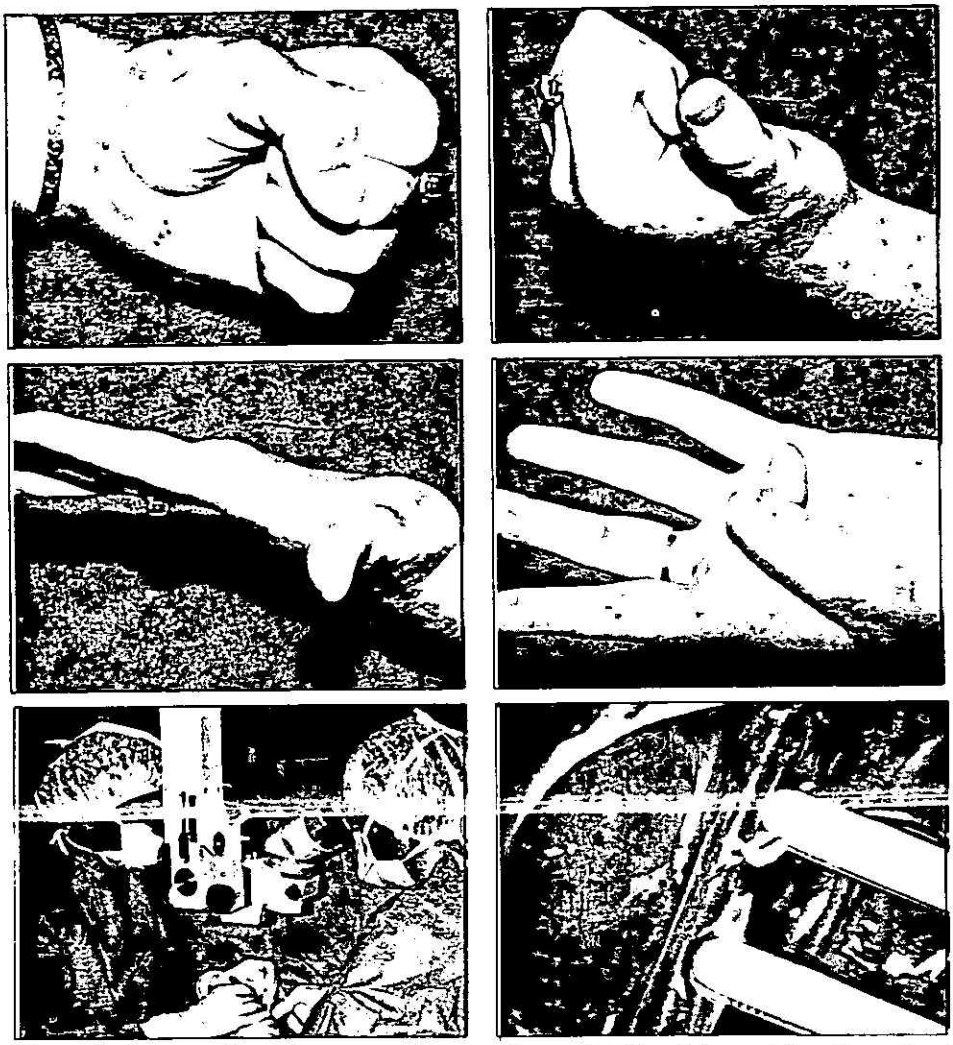

Figure 2: *The operating microscope allows surgeons to use precision instruments and techniques to repair damaged vessels and nerves measuring 0.2 mm to 1.0 mm in diameter. Magnifications of 4-20x are commonly employed.*

Figure 3: *This picture—taken through an operating microscope—shows the placement of a 50 micron needle through the wall of a 0.8 mm artery. The suture is so small (18 microns) that it is virtually invisible if dropped or misplaced at surgery.*

toxoid administered if appropriate.

The hand is then examined. Much information can be obtained *before* removing the dressing, particularly if the digits are exposed. Circulation can be assessed; sensory nerve function can be tested, and even intrinsic muscle activity often can be partially examined. Flexor and extensor tendon function also may be tested. The extent of the injury may thus become apparent before the wound is even exposed.

The dressing should be removed under controlled conditions. A padded tourniquet (with adequate pressure monitor) is placed uninflated on the arm if significant bleeding is possible. Adequate lighting, wound-cleansing materials, and replacement dressings should be available. The old dressing is removed carefully so as not to injure tissues, excessively move injured parts, or agitate bleeding. The location and probable depth of the wound(s) is noted and correlated with the initial assessment. The necessity for hand surgical consultation and likelihood of surgery is usually apparent at this point, and obviates the need for wound probing or exploration. Little additional information will be obtained, and further injury could result. Only when the wound appears minor, and no functional deficit is apparent, is wound cleansing and exploration (usually under tourniquet control) in the emergency department wise.

Virtually all mutilating hand injuries will require surgery. Basic laboratory studies, chest x-ray and EKG (if needed) are obtained, and the patient is allowed no oral intake. Additional wound cleansing may be necessary prior to application of a new sterile dressing. Appropriate roentgenograms should be obtained with minimal dressing materials or splints in place. These measures will accom-

plish the goals of emergency care and greatly facilitate the initial surgical treatment.

Replantation. Microsurgical technique and instrumentation have dramatically changed the surgical approach to mutilating hand trauma. Amputated tissues which previously would have been discarded now often can be reattached through the repair of minute vessels. Devascularized tissues which would have been debrided can frequently be restored. The operating microscope (see *Figure 2*) allows surgeons to use precision instruments to repair divided or damaged vessels smaller than 1 mm in external diameter with excellent patency rates (see *Figure 3*). It has now become necessary to consider replantation* or revascularization** as potential treatment alternatives for many severe hand injuries.

Care of Amputated Parts. Recovery of amputated tissues at the site of injury may be necessary—retrieval has been made from sawdust bins, construction sites, grass catchers, and lake bottoms! If tissues have been severed, some attempt should be made to recover them and transport them with the patient. Amputated parts are cleansed, placed in saline-soaked sterile sponges or towels, sealed in a plastic bag, and cooled on ice (avoid freezing). They must be kept with the patient. Rapid transportation is somewhat more important under these circumstances, since ischemic tissues will begin to show irreversible changes in three to six hours.

Indications for Replantation. Most of these patients initially are taken to community hospitals rather than directly transported to replantation centers. It is therefore necessary for local emergency department personnel to be familiar with the location of regional centers equipped to provide replantation services. By keeping a list of those

Replantation—reattachment of a completely severed part.

**Revascularization—restoration of circulation to an incompletely amputated part, no matter how minimal the tissues which remain in continuity.*

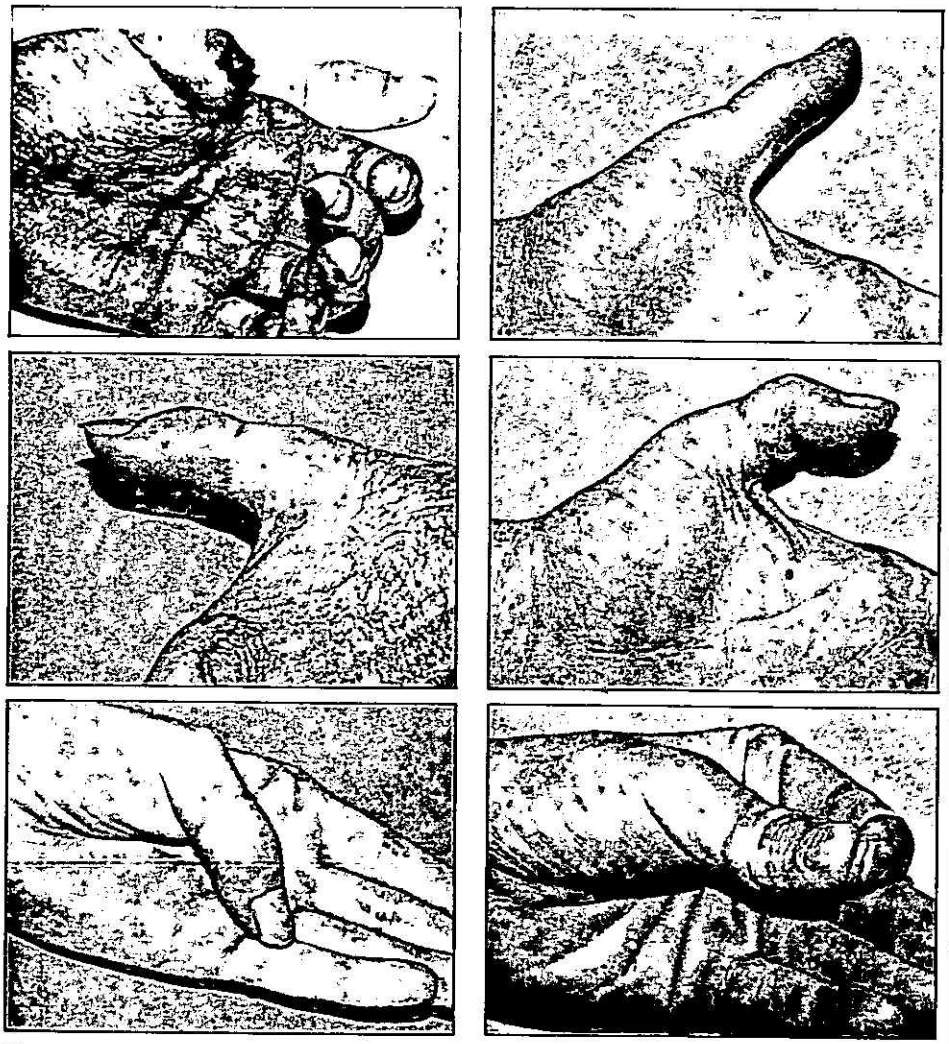

Figure 4A: *A meat saw accident has severed the left thumb of this 20-year-old man. The amputation is through the proximal phalanx.* **Figures 4B to 4F:** *Following successful replantation, the thumb has excellent mobility, reasonable return of tactile sensibility, and adds greatly to the function and appearance of the hand.*

Figure 5A: *Loss of the complete hand is a devastating injury. Here is the total severance of the left hand of an 18-year-old male.* **Figures** *motion and some return of tactile sensibility. The result is obviously superior to a prosthesis in both functional capability and cosmetic*

centers (complete with telephone numbers, since these can be hard to track down at the last moment), the referring emergency department can contact the replantation team prior to transport. This accomplishes several things: Advice about further care and transport can be obtained; the replantation team and ancillary personnel will have time to assemble and plan in advance; on occasion, the replantation team will already be committed to a lengthy procedure and referral to a different center will be necessary; some cases will not be realistic considerations for replantation, and an ill-advised, costly transport can be avoided.

In general, the following are reasonable *anatomical* indications for replantation:

- Thumb amputations (particularly those at or proximal to the interphalangeal joint);
- Multiple digit amputations;
- Major extremity amputations through the palm, wrist, or distal forearm;
- Lesser amputations in previously compromised hands, or hands with unusual functional requirements.

These indications may be modified in light of the patient's age, sex, hand of dominance, occupation, and general health status. Single finger amputations (particularly index or small finger alone) are generally not good indications, since overall hand function is unlikely to be improved by successful replantation of an isolated digit. Indeed, function of the hand may in fact be compromised, and the expense, risk, loss of work time, lengthy rehabilitation, and need for subsequent reconstructive surgery usually do not warrant attempted replantation.

There are certain unfavorable circumstances which, though not necessarily contraindicating replantation, may make the procedure impossible or unlikely to succeed. These include:

- Badly contaminated wounds;
- Avulsion or severe crushing injuries;
- Time delay following injury;
- Inappropriate care of amputated tissues;
- Psychological problems likely to prevent the patient from obtaining a satisfactory result.

It is extremely important that personnel at the referring emergency department not make predictions or promises to the patient about the feasibility of replantation or the possible outcome. The patient is told that the replantation center has agreed to accept him in transfer and to evaluate him for possible replantation surgery. He must realize that the procedure may be impossible or unsuccessful.

The Replantation Procedure. While a detailed discussion of the actual techniques of replantation surgery is obviously beyond the scope of this article, the brief description which follows outlines the basic steps taken in the attempt to restore an amputated part.

The procedure commences almost immediately following the patient's arrival at the replantation center. While he is being evaluated and prepared for surgery, the amputated part is taken to the operating room where surgeons cleanse, debride, and examine the tissue using the operating microscope. Minute vessels and nerves are identified and "tagged" for subsequent repair. The patient is soon brought to the operating room, and

5B to 5F: ***Successful replantation has restored a hand with good mobility and useful function. The fingers have good independent appearance.***

similar preparation of the amputation stump is undertaken. The sequence of repairs is usually the following:

- Bone fixation;
- Tendon repairs;
- Vessel repairs;
- Nerve repairs;
- Closed compartment decompression (if necessary);
- Wound closure, with skin grafting or flap coverage when needed.

The operative procedure is usually lengthy; replantation of several digits may require 10 to 18 hours of surgery and anesthesia.

Current Results. Because replantation is a relatively new surgical subspecialty, the study of long-term results has only recently been possible. One fact has become obvious, though: *Tissue survival does not ensure functional success.*

Under favorable circumstances, most replantation centers expect an 80%-90% tissue survival rate. Only rarely, however, does replanted tissue achieve function approaching normal. Usually function is compromised by joint stiffness, tendon scarring, and diminished sensibility. This is another reason why predictions about the eventual results of replantation surgery are impossible, and why no promises can be made to the patient. *Figures 4A* to *5F* demonstrate cases of good indications for replantation and the results achieved.

Summary. Severe, mutilating hand injuries are not uncommon in a world filled with dangerous tools and machines. Loss of hand function can be devastating to anyone sustaining major upper extremity trauma. Fortunately, advances in surgical technique and instrumentation allow improved chances for tissue repair and survival. Under certain conditions, even completely amputated tissues may be restored to the hand and achieve useful function.

Emergency personnel can influence the results achieved in the care of mutilating hand trauma by employing basic principles at the site of injury and in the emergency department. Awareness of the possible applications of microsurgery and the locations of replantation centers will ensure that appropriate patients receive the highly specialized care now available. •