I. Introduction

When caring for any wound the physician is attempting to reclaim physical integrity and function of the injured tissue by:

1. Facilitating hemostasis
2. Decreasing tissue loss
3. Promoting wound healing
4. Avoiding scar formation.

Wound care involves a number of decisions based on:

1. Wound healing properties,
2. The nature and extent of the injury
3. The technical aspects of wound closure.

The spectrum of wound management techniques tends to complicate matters as does the fact that each situation demands individualization. The intent of the following treaties is to first discuss general guidelines of wound care and then specific precepts useful in care of the majority of wounds presenting to the emergency department.

II. Wound Healing

Even the most masterful wound care can never insure that a wound will heal! Healing is a function of the organism and is one of the hallmarks of living tissues. The function of wound management is to optimize the environment in which a wound is left to heal. The process of wound healing occurs in a sequence of four interdependent phases.

III. The Wound Evaluation

Although a cutaneous wound may be obvious and very dramatic when a patient is first brought into the emergency department, a detailed assessment of the wound should be deferred until the patient has been evaluated for other more ominous injuries. The primary survey and accompanying resuscitation assume first priority. If the wound is bleeding profusely, immediate direct pressure is applied. If bleeding is mild and of a venous nature, a pressure dressing should be applied and held in place by elastic wrap or, by an assistant's hand. All wounds should be covered with a sterile, saline moistened dressing after department arrival to minimize further contamination. Should an associated fracture be obvious or suspected or should a complaint of considerable pain be noted, a temporary splint should be applied to avoid further tissue injury and pain.

A. History

Once the primary survey is accomplished and the patient stabilized, a careful history should be obtained with specific attention to the time, location, circumstances and mechanisms of injury. This is best accomplished by asking the patient to reconstruct the events that lead to his or her injury. This knowledge will offer cues to possible associated injuries beyond the obvious wound. It will also give indications about the extent and degree of contamination of the wound. The dominant hand should be delineated by the history. The patient's past medical history should also be gathered at this juncture with attention to any allergies (e.g. local anesthetics), current medications (e.g. corticosteroid or chemotherapy) or pre-existent medical conditions (e.g. diabetes mellitus). An immunization status for tetanus is also obtained in this segment of the encounter. In the case of animal bites, rabies should be considered and the animal’s immunization status questioned.

The "golden period" of wound closure has historically been described during first 12 hours post-injury. However, with meticulous debridement, irrigation and antibiotic coverage closure is frequently undertaken after this period has elapsed. In as little as three hours post-injury bacterial propagation to a degree capable of producing a wound infection can occur.

B. Mechanism of Injury

There are two striking reasons for knowing the mechanism of injury: 1) determining the degree of bacterial contamination and 2) the amount of potential tissue damage which might have occurred. The resistance to infection varies with the mechanism of injury.

The three basic mechanisms of injury for soft tissue include: 1) shear, 2) compression and 3) tension. Shearing force occurs when a sharp piece of metal or glass interrupts the soft tissue's integrity. This mechanism accounts for approximately 80% of all soft tissue wounds seen in the emergency department. Compression and tension injuries are caused by a collision of two bodies will produces a characteristic stellate laceration. The energy needed to produce such tissue disruption is much greater than that occurring in a shearing type of mechanism; consequently, such wounds have a much greater susceptibility to infection. Wounds resulting from significant blunt, tearing trauma swell much more during the inflammatory phase than does a less traumatic sharp laceration. Should this increased swelling not be anticipated during initial closure, unnecessary suture marks can result.

Missile injuries produce considerably more damage to tissues when compared with blunt mechanisms, due to their inherent kinetic energy. As a missile strikes tissues, a combination of shear, tensile, and compressive forces interacts to produce a significant amount of destruction. The severity of the wound in the body is related to the amount of kinetic energy dissipated by the involved tissue. Missile injuries also result in a higher incidence of associated injuries, again associated with kinetic energy dissipation and depth of penetration.

C. Wound Contamination

Bacterial "seeding" of a wound can occur from either endogenous or exogenous sources. The accepted concentration of bacteria necessary to produce a wound infection in otherwise healthy tissue is 10^5. The endogenous source of bacteria includes those organisms residing on the surface of the skin or within skin appendicular structures (nail plate, hair follicles, etc.). In general the degree of bacterial colonization of the body can divide into three divisions:

Anatomic Location	Bacterial Concentration
Drier areas of the body (trunk, upper arms, legs)	10^1 - 10^3
Moist areas of the body (axilla, perineum)	10^4 - 10^6
Exposed areas of the body (head, face, hands, feet)	10^4 - 10^6

It is often helpful to ask the question - "Where did this injury occur?" -this information can aid the examiner in determining the potential for an infection as well as the type of infection which might ensue. Exogenous sources of importance include soil, feces and saliva.

When injury occurs in industrial or farming settings the clinician often will find soil or dirt within the wound. Soils and dirt are made up of both organic and inorganic (clay) components. Marshland soils are generally have a high organic material content. Infection-promoting clay elements are generally confined to the subsoil level. Wounds contaminated with both of these fractions of the soil are capable of becoming infected with as little as 100 bacteria due to the inhibition of leukocyte function.

Limitation of antibiotic function has also been observed when combine with soil fractions. Particulate material, such as sand, is non-toxic. Wounds contaminated with human or animal fecal material should be considered at great risk of developing a wound infection. It has been estimated that 20-30% or the net weight of stool is bacterial mass, the majority of which are anaerobic.

Lacerations incurred by contact with the oral cavity ("fight-bite" or closed fist injury) will, when involving the hands and feet, universally result in a wound infection if left untreated. Any patient

with a laceration over the metacarpal phalangeal joints must be questioned as to this possible mechanism and confirmed by the patient more than once. Bacterial concentrations of 10^{11}, composed of facultative and obligate anaerobes that are present in the mouth.

D. Examination

The protective dressing that has been applied to the wound a short time after the patient was admitted to the emergency department should now be removed for detailed evaluation of the extent of soft tissue injury. Sterile gloves should always be worn during the examination and treatment of a wound. The best examination is performed patiently in a consistent, organized fashion. Good lighting is also mandatory for adequate wound evaluation.

Evaluation of the extent of injury includes a judgment of the: 1) amount of tissue loss, 2) remaining tissues' viability, 3) depth of the wound and 4) presence of any associated injuries. Determination of the degree of tissue loss is at times difficult due to the elastic nature of skin that allows the wound margins to retract from the central portion of the wound. Using a gloved finger a gross assessment of tissue can be performed by simply attempting to re-approximate the wound margins. If little difficulty is encountered with this maneuver and the "imaginary" closure is not disfiguring then a primary skin closure can be undertake. If difficulty is encountered then subcutaneous closure is necessary. However, subcutaneous closure in the hand is contraindicated.

The depth of a laceration should be assessed, keeping in mind the possibility of injury to underlying structures such as nerves, tendons, muscles, or bone. Different anatomical areas contain unique structures that must be evaluated (e.g., parotid duct, lacrimal duct, canthal tendon, and seventh cranial nerve in the face). Lacerations overlying bones should be probed with a gloved finger to determine whether or not there is a fracture. If a wound overlies a fracture site an open fracture should be assumed present. Patients who have small puncture wounds in the head and neck region and thoracoabdominal areas must be managed on the premise that there has been penetration and damage to deeper vital structures. A missile wound should be examined for 1) entry site, 2) exit site and 3) the extent of surrounding tissue damage along its tract and at the site of exit.

The presence, or absence, of a foreign body also needs to be determined. Should the history dictate, radiographs of the involved area are helpful. Remember that essentially all glass is radio-opaque. Organic material, on the other hand tends to be radiolucent

A *contusion,* usually caused by blunt force, is a disruption of dermal continuity with intact overlying dermis and epidermis. Signs include swelling and ecchymosis resulting from interstitial edema and hemorrhage or hematoma formation with gross extravasation of blood into the subcutaneous space. Contusion, like a laceration, may be associated with an injury to important underlying structures. An *abrasion,* caused by a shearing force, is a loss of epidermis and a variable depth of dermis. The depth of an abrasion can be assessed by the pattern of bleeding. A deep abrasion occurs at the level of a second-degree burn and exhibits a brisk bleeding pattern from damaged mid-dermal capillaries. Superficial abrasions bleed very little from injured capillaries in the papillary dermis. Vascular division in the epidermis and underlying dermal tissues produces an *ecchymosis*. A *hematoma* will result should disruption of the vascular structures occur in the subcutanea or deeper.

It is absolutely essential that documentation of the entire examination including exploration of the wound. Testing of tendon function, when appropriate should also be recorded. Neurovascular function (two-point discrimination, sharp-dull sensibility and motor function) also need be recorded for future reference.

Finally, any scar can be expected to improve in appearance during the year of normal maturation. Because of this, most surgeons do not consider revision surgery until the scar is completely flat and pale in color (approximately a year after the injury). The patient needs to be informed that there will be a scar.

IV. Technical Decision Making

After an appropriate history has been obtained and the wound inspected, treatment can begin. The individual's preexisting medical conditions and his or her ability to cooperate must be considered before any attempt at wound repair is undertaken. The first technical decision that must be undertaken is to determine who is the best individual to care for the wound. Should the wound be complex, involving imperative deep structures --necessitating exploration and repair -- surgical specialty consultation is warranted.

A. Environment

The Emergency Department should have specific areas designed for the care of minor trauma. The required materials should be readily available, including local anesthetics, suture materials, dressing materials, necessary instruments, and medications. Other requirements include good lighting (e.g., a portable or ceiling-mounted surgical light), a comfortable stretcher, or examination table and a stool for the comfort of the individual performing the examination and wound care.

B. Local Anesthesia

The local anesthetic agent can be selected on the basis of the estimated duration of the repair and the need for local vasoconstriction. Most commonly used is lidocaine (Xylocaine). Either 1% or 2% lidocaine produces rapid onset of anesthetic effects and permits adequate anesthesia for about one hour. This permits accurate, unhurried repairs of most common wounds. Currently we are using 1% lidocaine with sodium bicarbonate buffering (10:1 admixture). More involved wounds can be anesthetized with bupivacaine (Marcaine), which is longer-acting but requires more time to take effect.

Local anesthetics may be used for: 1) direct infiltration into the injured tissues or 2) to produce various nerve blocks. In trauma situations, local anesthetic can usually be injected through the cut margins of the wound. This is less painful than trying to inject the normal tightly woven connective tissue matrix of intact dermis. In the overwhelming number of cases, 1% lidocaine with sodium bicarbonate buffering is used for local anesthesia, producing almost immediate onset of action in 5-7 minutes. Dosage of lidocaine should not exceed a total of 4 mg/kg to avoid the possibility of systemic toxicity from local anesthetic overdose. Few patients are allergic to local anesthetics, but the clinician should be alerted to such through a history taken before wound anesthesia is performed.

The other method of using these anesthetics is for regional or nerve blocks (discussed in Advanced Wound Care). For example, finger injuries can be handled very adequately with bilateral metacarpal or digital nerve blocks. Other hand injuries can be treated with major nerve blocks (median, radial, and ulnar). Solutions containing epinephrine should be avoided for digital nerve blocks because they might cause arterial spasm that might be injurious.

Drug (trade name)	***Supplied***	***Maximum permitted dose***	***Onset of action***	***Duration***	***Toxicity***
Cocaine (not for injection)	As powder 1-4% solution	100 mg total (6.6 mg/kg)	Rapid topical	1 hour	Convulsions, coma, respiratory arrest
Procaine *(Novocain®)*	1-2% solution	10-15 mg/kg	Rapid	30 min 1 hour	tinnitis, nausea, convulsions (rare)
Chlorprocaine *(Nesacaine®)*	1-2% solution	10-20 mg/kg	Very rapid	1 hour	less toxic than procaine
Tetracaine *(Pontocaine®)*	1-3% solution (topical)	1.5 mg/kg (not > 150 mg)	Moderate	2 hours	drowsiness to coma, convulsions rare

Lidocaine *(Xylocaine®)*	0.5 - 2% solution	4 mg/kg	5-30 minutes	2 hours	drowsiness to coma, convulsions rare
Mepivacaine *(Carbocaine®)*	1.0 - 2% solution	7 mg/kg	5-30 minutes	2 - 3 hours	drowsiness to coma, convulsions
Lidocaine with epinephrine)	0.5 - 2% solution	7 mg/kg	5-30 minutes	2 - 3 hours	drowsiness to coma, convulsions
Bupivacaine *(Marcaine®)*	0.25-0.75% solution	175 mg	7-30 minutes	12 hours	Tremor, shivering, nausea, rare convulsions

The some minor wounds should be infiltrated with local anesthetic containing epinephrine. The epinephrine has two distinct advantages: 1) it lengthens the duration of action and 2) minimizes bleeding.

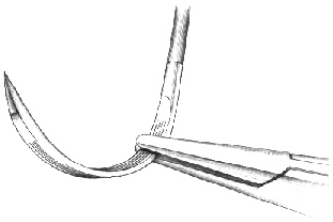
TAC is a combination of tetracaine, adrenaline and cocaine that can be applied for topical anesthesia. A variation on TAC, termed XAP, consists of Xylocaine, adrenaline and phenylephrine that is much less expensive and felt to be as effective. Three milliliters of this solution on a sterile gauze is applied to the wound directly for 5 - 10 minutes by a gloved hand. Contraindications are wounds on mucosal surfaces (due to risk of seizure) as well as the use of epinephrine for topical anesthesia.

C. Preparation

The wound must be cleaned before closure. Primary decontamination, riding the area of the "large chunks", can be carried out using a mild surgical soap. For patient comfort this is best done after anesthesia is accomplished. Preparation of the adjacent skin of an open wound in a trauma setting is more involved than that in an operating room because the open wound is contaminated and sensitive tissues are exposed. Generally, an iodophor solution (e.g., Betadine 10%) is employed to paint the surrounding skin, taking care not to introduce this material into the wound itself. Caustic substances, such as isopropyl alcohol, hydrogen peroxide, and harsh soaps, should not be applied directly to the open tissues. They will result in tissue destruction with increased pain, inflammation, and scarring. Soaking of hand and foot wounds have been found to actually increase the incidence of wound infection and inappropriate wound care. An area must be prepared large enough to permit accurate access to the wound and visualization of the surrounding structures. If facilitating a facial repair, it is best to prepare both sides of the face to ensure symmetry.

D. Instruments

The four basic instruments necessary for wound closure include a needle-holders, dissecting forceps, skin hooks and scissors.



The needle-holders normally used in general surgery are useless. Large, cumbersome and ill designed for the necessarily fine work of careful skin suturing, the locking mechanism in particular makes them impossible to use for knot tying. The Crile-Wood needle-holder or one of its modifications is essential.

Though it takes a little time to acquire skill in its use it is a most rewarding facility to possess. The needle is usually held transversely in its jaws, at the center of the needle. This acts to maintain the integrity of the needle and avoid bending.

The skin hook is the least traumatic instrument though its method of use is initially a difficult one to use with elegance and speed. Because of this dissecting forceps are more routinely used. The toothed Adson tissue forceps is the preferred instrument for routine suturing. The toothed forceps is less traumatic than it's smooth counterpart. Care to grasp the dermal (not epidermal) tissue should always be used.

Two types of scissors are usually employed, sharp pointed iris scissors for cutting tissue and a suture removal scissors. It should be kept in mind that scissors are "crushing" instruments.

E. Wound Irrigation and Debridement

Irrigation of a wound should be undertaken only after the wound has been properly anesthetized to ensure adequate irrigation with the least patient discomfort. After cleansing the surrounding skin, the second step is to clean the wound itself irrigating the wound with copious amounts of either normal saline or lactated Ringer's solution. Some feel that irrigation with 1% Betadine solution is beneficial in the process of irrigation. Truly "the solution to pollution is dilution" when dealing with traumatic soft tissue wounds. The optimum quantity of irrigant is 60 ccs per cm. of wound. A clean, sharp laceration may simply be irrigated. A more heavily contaminated wound should be very copiously irrigated (probably with pulsatile irrigation). A simple, effective irrigation system can be constructed using a standard IV solution set with a pressure bag or blood pressure cuff placed over the solution bag and an 18 gauge Angiocath attached to the end of the tubing. The pressure bag is then inflated to 300 mm Hg. Protective eyewear, mask and gown should always be worn during irrigation since "splash back" of the irrigant is common and problematic for the examiner.

During this process, the examiner can complete the wound evaluation. Tissue viability can be assessed and any foreign particles identified and removed. Fine, smooth forceps can be used to extract particulate matter, e.g., glass, grass, or small pebbles. Occasionally dirt, grease, or paint may be so embedded into the tissues that the only appropriate means of removal is conservative tissue debridement. Regardless of the technique used, one must be certain that the foreign matter is removed. This minimizes inflammation and consequent scarring and reduces the chances of infection. Also, matter that might later cause discoloration can be removed to avoid permanent traumatic tattooing.

**** Debridement is felt to be the single most important element of basic wound care.**

F. Suture Materials

In recent years, synthetic suture materials have almost completely replaced silk, cotton, and gut. The new synthetic materials are either non-absorbable or absorbable, monofilament or braided. In general, they are associated with less reactivity and inflammation than the older natural materials and thus can be expected ultimately to produce a finer scar.

1. Absorbable Sutures

Usually absorbable sutures are employed below the skin or in special areas such as the oral mucosa. They can also be used for skin suturing in situations where later removal would be awkward as in young children or inaccessible wound sites. Polyglycolic acid (Dexon®) and Polyglycol 910 (Vicryl®) are braided synthetic sutures of high tensile strength which are usually absorbed within 90 to 120 days. There is minimal associated tissue reactivity because sutures are dissolved by autolytic action and not by phagocytosis. Polydioxanone (PDS®) is a newer monofilament absorbable suture, felt to possess excellent workability and superior to the braided

precursors in terms of tissue reactivity and strength. The minimal inflammatory response, high tensile strength, and relatively long life of these materials make them the new standard for beneath the surface repairs.

Type	*Trade Name*	*Strength*	*Reactivity*	*Infection*	*Comment*
Plain Gut		2+	2+	1+	looses strength rapidly, absorbed quickly, rarely used
Chromic Gut		2+	3+	1+	used to close intra-oral laceration
Polyglycolic Acid	Dexon®	4+	1+	4+	difficult to tie due to "hang-up"
Polyglycol 910	Vicryl®	4+	1+	3+	easy workability
Polydioxanone	PDS®	4+	4+	1+	large knot mass

2. Nonabsorbable Sutures

The ideal non-absorbable suture material should be strong, non-reactive and nonporous (resisting residence of bacteria within it's interstices). Synthetic suture materials have almost completely supplanted the previous silk and steel standards. They cause less tissue reactivity than the older natural substances but retain similar handling characteristics. Many physicians believe that the monofilament nature of these sutures makes them less reactive than braided materials, but their handling characteristics demand special suturing techniques. The knots must be well "locked down" or they tend to slip.

Type	*Trade Name*	*Strength*	*Reactivity*	*Infection*	*Comment*
Silk		1+	4+	2+	
Mersiline	Mersiline	2+	3+		facial repair material
Nylon	Dermalon Ethilon	3+	2+	3+	knot slippage a problem
Polypropylene	Prolene Surgilene	4+	1+	4+	requires 5-6 knots, tends to untie
Polyester	Tycron Ethibond	4+	2+	3+	expensive
Polybutester	Novofil	3+	1+	1+	slight elasticity allows wound swelling

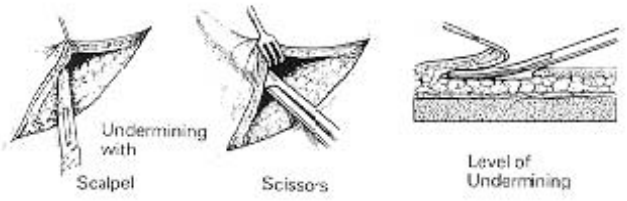
3. Other Closure Materials

In addition to the newer suture materials, skin closure tapes (e.g., Steri-Strips® and Shur-strips®) and surgical staples have recently gained considerable popularity. Linear skin wounds with low static skin tensions and minimal retraction of their edges do well with closure by either sutures or tape. Tape closures of such lacerations heal with superb cosmetic results and most patients will require no further intervention. The incidence of infection of contaminated wounds whose edges are approximated even with the least reactive suture is significantly higher than the infection rate of taped wounds subjected to a comparable level of contamination. Bacterial proliferation under a tape may be a source of infection during the time in which wound epithelialization is incomplete. In the experimental model, wounds closed by tape show a superior resistance to infection when compared to the stapled and sutured wounds. The superior resistance to infection of taped wounds, as compared to sutured wounds, indicates that tape closure is an important, often forgotten, clinical tool. The use of the tape for closure has another obvious advantage of eliminating time-consuming suturing and the need for local anesthetic injections. Skin closure by

tape, however, is normally not as precise as a sutured closure, and the intentional eversion of wound edge is not possible.. Wounds in some anatomic sites are not amenable to tape closure. The copious secretions from the skin of the axillae, palms, and soles discourage tape adherence. Also, wounds whose edges are subjected to strong static skin tensions are not susceptible to a secure tape closure. Wounds whose direction are perpendicular to either the wrinkle lines or the transverse axes of joints will dislodge the skin tapes when their underlying skeletal muscles contract.

Surgical staples are useful for the closure of many types of wounds. They must be carefully placed and can cause permanent marks if inappropriately employed. Linear lacerations subjected to weak static skin tension may quickly, economically, and with a lower incidence of infection than sutured wounds be closed with staples. An additional advantage of staples is their low level of tissue reactivity. In recent experimental studies, stapled skin wounds show a greater resistance to infection than wounds approximated by the least reactive suture, monofilament nylon. These significant benefits of staples account for their increasing usage by physicians. These advantages, however, must be weighed against the aesthetic result following stapling. Staple closure of the skin wound does not provide the meticulous re-approximation of the skin edges that physicians can affect with sutural closure. As a result, most clinicians reserve staples for critically ill patients with non-facial, long, linear lacerations, particularly scalp.

G. Undermining Wound Edges



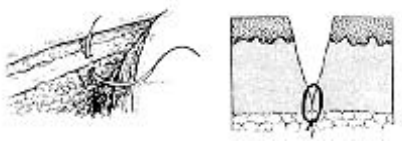
Another approach to reducing the static skin tensions on the wound is to undermine its edges prior to closure. Despite the common usage of this technique, only one experimental study objectively evaluates its effects on wound closure.

In this study, undermining the wound margin decreased the forces required for wound closure and, thereby, limited the width of the ultimate scar. However, physicians must weigh this benefit against the potential damage undermining does to the skin blood supply and, hence, the host defenses to infection. In essence, physicians should reserve undermining for wounds that are subjected to strong static and dynamic tensions with low levels of bacterial contamination.

H. Suture Techniques

Any discussion of suture techniques must accept the premise that the end result takes precedence over the methods used to obtain it. Whether sutures are simple or mattress, running or interrupted, is of no real importance. What matters is that the end result is a well-healed, fine scar. There are some important general principles and guidelines that may make the process easier and more understandable.

1. Deep Layer Approximation



If a wound involves the full thickness of the skin and injures the underlying tissues, it is important to approximate the deeper structures as well as the skin itself.

This serves two main purposes: 1) it closes any potential spaces in which blood and serum could accumulate, thereby lessening the likelihood of secondary wound infection; and 2) it helps minimize the tension on the wound margins, aiding in a resultant narrower scar. Additionally, closure of deep structures can prevent their dehiscence, which would result in a depression in the healed wound. If underlying muscles are not brought together during the early healing, un-sutured muscle ends retract and the skin dips down, producing an unacceptable defect. This depression can be especially conspicuous in areas such as the lip and the forehead. The physician should

avoid suture closure of the adipose tissue beneath the skin. Obliteration of this potential dead space between the cut edges of adipose tissue by even the least reactive suture increases the incidence of infection.

Usually absorbable sutures, Dexon® or Vicryl®, are used for this deep layer closure. If permanent sutures are selected, there is always the possibility of later *stitch abscess* formation, and occasionally permanent sutures can be felt or seen, *suture tattoo*, if they are just deep to the skin.

In addition to deep layer closure, a few 4-0 or 5-0 Dexon® or Vicryl® sutures can be placed in the underlying layers of the skin itself (deep dermal technique) to minimize wound tension and ultimate spreading. These sutures can be a continuous "subcuticular" closure or interrupted simple sutures placed with the knot on the undersurface of the wound. These dermal sutures must be accurately placed and cut on well-tied knots so that skin edges are well approximated and level and suture ends do not protrude through the healing wound margins.

2. Cuticular Closure

After deep layer closure, the skin can be approximated with permanent sutures which are removed later. Of course, staples or Steri-Strips may also be used, but the overwhelming majority of good wound closures are obtained with monofilament synthetic sutures. When selecting a suture size keep in mind that the magnitude of the damage to the local tissue defenses relates directly to the quantity of the suture within the wound (e.g., diameter and length). The smallest diameter suture whose strength is ample to resist disruption of the wound is preferable. Generally when suturing the face, hands or feet, 5-0 and 6-0 sutures are used, for trunk and extremity wounds use 4-0 and 5-0 sutures.

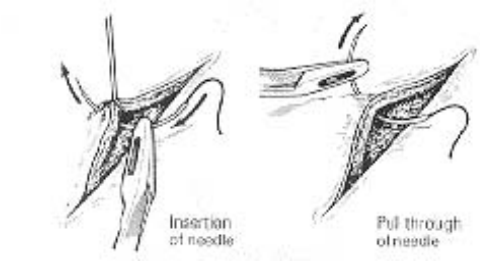
A suture can do no more than hold the wound edges in proper approximation. Excessive suture tightness does not produce a finer scar but does produce the undesirable railroad-type crosshatched scarring. Always remember that the ensuing 48 to 72 hr after a wound is inflicted is a period of inflammation and local swelling, and any suture that is of even slightly excessive tightness becomes strangulating during that period. If running sutures or mattress sutures are used, it is important to avoid excessive suture tension. In these cases, the loop of the suture can cut into the skin and literally necrose the tissue encompassed by the foreign body material. Approximation of the ends of the wound then the midportion and then bisecting remaining portions of the unclosed wound facilitates using the least amount of suture necessary for skin closure. Interrupted dermal sutures may be placed in each quadrant of those wounds subjected to strong static and dynamic skin tensions providing sufficient strength to permit early suture removal.

In addition to avoiding any significant tightness when suturing, another valuable principle that can help ensure a more acceptable final scar is wound edge eversion. Although it seems reasonable to assume that the direct level approximation of the two sides of an incision or laceration should result in the finest ultimate scar, this is not the case. During the period of collagen deposition and later scar remodeling, the wound edges separate and produce a scar of some finite width. This wound edge separation is most apparent when the wound is opposite or perpendicular to the lines of skin tension or in areas under extreme lateral tension, e.g., the sternal area, deltoid area, and knees. In these locations, wide scars are almost always anticipated. One way to achieve proper looseness is to lift the initial loop upward while snugging down successive knots. The upward traction allows locking of the knots without causing the loop to slip too tightly. Even on areas such as the face where there is less tension, some scar widening can be expected. If one achieves eversion of the edges during the initial suturing, the amount of consequent widening is reduced.

Achieving wound edge eversion is one of the reasons mattress sutures have been popular over the years. It is difficult to achieve adequate eversion with simple interrupted or running sutures or with subcuticular closures of either an interrupted or running nature. Skin tape also often produces an unsatisfactory scar because of improper eversion.

If simple sutures are to be used for wound edge eversion, it is essential that the deep part of the suture be wider than the part nearest the skin surface and the suture should be deeper than wide. When the suture is tied, the wide, deep part is pulled together in a way that everts the surface layers. To adequately accomplish this requires some experience. On the other hand, mattress sutures of either a vertical or horizontal nature can achieve predictable initial wound edge eversion and ultimately a finer scar.

Satisfactory healing can be expected if dermal sutures are placed to eliminate skin edge tension, and cuticular sutures achieve good wound edge eversion. Sutures most often employed in the underlying tissues are Dexon® and Vicryl®. The aim is to produce an absolutely accurately coapted wound atraumatically and technique of handling and suturing is merely a means to this end. First time accurate placing of the suture is a habit to acquire, the second attempt is all too often worse than the first and only results in a moth-eaten wound edge and poor scar.



The needle is curved and so moves most readily in a circle. The wrist must therefore be brought freely into play so that insertion and pull through of the needle are in the line of its curve.

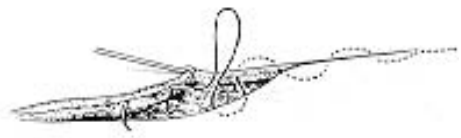
After a wound is sutured slight edema of the wound tends to develop and though a pressure dressing can reduce it, allowance must be made for it in tying the suture.

If the suture is too tight it will surely cut in more rapidly and make a suture mark. The correct suture tension just avoids blanching the skin held by the suture.

Sutures may be **interrupted** or **continuous.** When the cosmetic result is all-important the interrupted suture is best but the continuous is often adequate in other circumstances.

Suture Technique	***Indication***	***Disadvantage***
Interrupted		
Simple	majority of wounds	
Vertical mattress	wounds tending to invert wound margins	
Horizontal mattress		
Deep dermal		
Continuous		
Simple ("over & over")	speed of repair	may invert wound margins, total removal needed if suture fracture
Subcuticular	wounds with sharply demarked margins	total removal needed if suture fracture

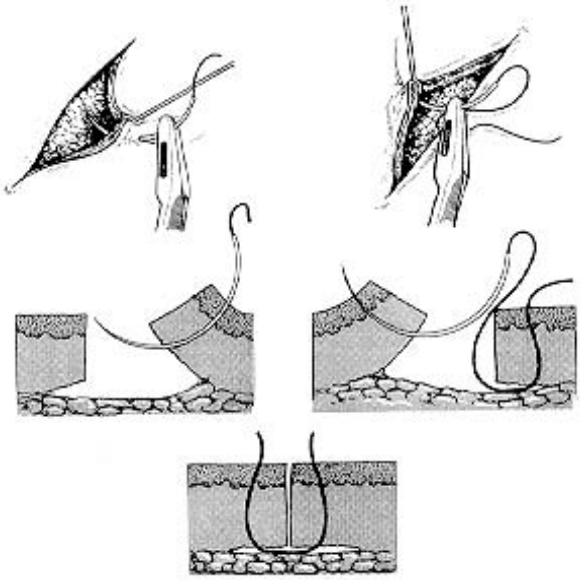
3. Continuous Sutures



The **continuous intradermal** or **subcuticular suture** has the merit that it can be left in for 10 to 12 days without leaving suture marks. Though it may be used by itself it will be found that really accurate skin edge apposition is only possible if additional interrupted skin sutures are used. Its role then is to take any tension from the interrupted sutures. Monofilament nylon or prolene® can be used.

The most useful continuous suture is the "over and over" or whip stitch. This suture unfortunately does tend to bunch the wound. Such sutures cannot be placed as accurately as the interrupted suture but where an exquisite scar is not essential they certainly save time. It is sometimes stated that the continuous suture tends to strangulate the wound edge but this is due to tying the knot too tight rather than any inherent defect of the method.

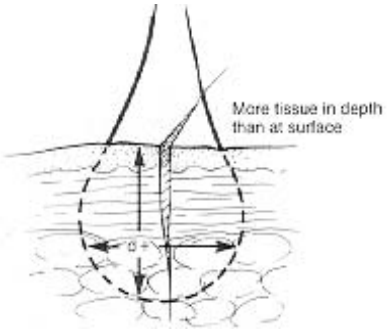
4. Interrupted sutures



The **simple loop suture** which consists of a simple loop knotted at one side of the wound is the most commonly used technique for traumatic wound closure. It aims to accurately bring the skin edges together without overlap of either wound margin. Inversion of the wound margins must be avoided, since inverted edges impede healing and result in a poorer scar.

The entire dermis should be included in each bite and the needle should take an equal bite of each side (3-4 mm from the wound margin).

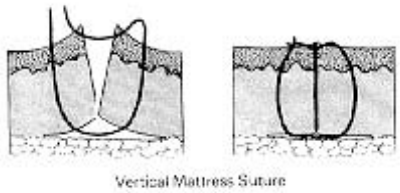
Sometimes, however, one or other edge is slightly higher than its companion and the lower side can be raised a little by manipulating the knot in tying to that side of the wound. Every suture has an optimal side for its knot.



By making the suture take a slightly greater bite of the deeper part (dermis) the whole face of wound margin is approximated and the very slight eversion achieved. When a curved needle is used the wound edge is held everted and the needle directed so that its path will make a curve in the appropriate direction when the skin is allowed to fall back into its "resting" position. This eversion is carried out with the least trauma when a skin hook is used or by grasping the dermal tissues with a fine toothed forceps.

As a rule it is technically much easier to suture toward yourself and to suture from the more mobile side of the wound to the more fixed side. The side of the thumb can also be used to evert the skin during insertion of sutures.. The operator must be careful not to drive the needle into his or her thumb, destroying the sterility of the needle and involved gloved hand

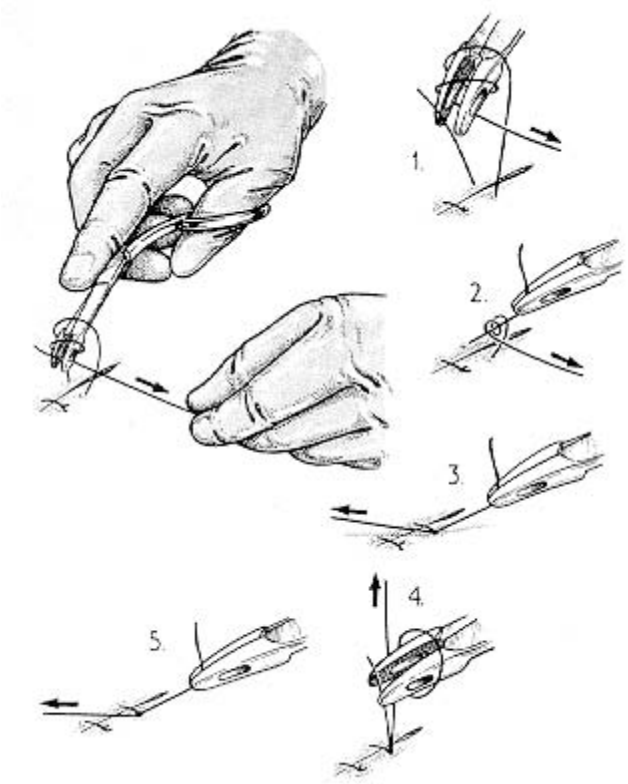
Where the skin is thin and poorly supported or mobile on its deep surface, e.g. around the eyelids, it is particularly difficult to avoid inversion and the best solution is often to use the **vertical mattress suture**. This suture has no greater tendency to leave stitch marks than any other if the sutures are not tied too tightly and are removed early, and if the superficial bite is minimal the tendency to invert is corrected.



Vertical Mattress Suture

When there is no tension of the wound the interrupted suture alone is adequate. When there is tension two possible additional measures are described which are said to allow early removal of skin sutures without wound disruption or stretching, namely the use of buried Dexon sutures or a continuous intradermal suture.

5. Instrument Tie Technique



It is preferable to use the instrumental method of suture tying for the small needles and fine suture materials make tying by hand clumsy, difficult and wasteful. With instrumental tying tension can be regulated and knot placement carried out with much greater finesse, accuracy and dispatch after a little practice. The more a wound edge is traumatized the less cosmetic the result and so the implements for holding wound margins steady for suturing must be as atraumatic as possible.

1. A double loop of suture is placed over the tip of the needle driver and drawn to the clinician
2. The initial tie is secured down
3. Knot locked in place
4. A second single loop is placed over the tip of the needle driver
5. Second knot secured down

I. Drains

The decision of whether to use surgical drainage in a clinical setting requires a delicate balancing its potential benefits and injurious effects. The obvious benefit of drainage is its ability to evacuate potentially harmful collections of certain fluids, such as pus and blood, from wounds. Drains act as retrograde conduits through which skin contaminants can gain entrance into the wound. Both Silastic and Penrose drains dramatically increase the infection rate of soft tissue wounds. The drain itself has been implicated in producing deleterious effects; therefore drainage of wounds is discouraged.

J. Follow-Up Care

1. Dressings

The major purpose of surgical dressings is to prevent contamination. The length of time that dressings should cover the primarily closed wound derives from knowledge of the period during which the wound is susceptible to bacterial penetration. Experimental studies demonstrate that as sutured wounds heal they become increasingly resistant to the development of infection following surface contamination. The ideal dressing selected for wound coverage should be strong, microporous, absorbent, nonadherent, and

impervious to bacterial penetration. Unfortunately, no comprehensive scientific studies document the performance of commercially available dressings.

Primarily closed wounds, with the exception of those located on the face, should have coverage with Micro-pad® or Telfa® attached to the surrounding skin by wide strips of microporous tape that has no reinforcing fibers. Abrasions on the other hand may be covered first with a thin layer of bacitracin ointment or with one of the commercially available dressings (Adaptic® or Xeroform®) followed by a sterile gauze pad. This should be fixed in place by tape or gauze roll.

In facial lacerations, the clinician should be concerned about the development of blood clot between the edges of the sutured wound. Unless removed by meticulous suture line care, a healing, unsightly scar will replace it. Despite washing the wound with hydrogen peroxide,. a proteinaceous coagulum (scab) develops on the injured skin, making suture removal tedious and often painful to the patient. Recent studies have found moist wounds heal faster and with less scaring, due to the dissolution of this coagulum. Swabbing the wound and adjacent skin with bacitracin ointment appears to limit the development of a dry coagulum. The selection of this agent is more for its carrier cream than its antibiotic, which has little clinical value. Patients should repeat suture line care every six to eight hours until the wound edge is free of blood. An added benefit of this treatment is that sutures are devoid of attached blood, facilitating their later removal. Sutured wounds in abraded skin are refractory to this method of suture line care. In fact, the use of a carrier cream without an antibiotic satisfies all clinical needs.

2. Immobilization

Immobilization of the site of injury has great value in the care of contaminated wounds. When the site of any injury is immobilized, lymphatic flow decreases, and this minimizes the spread of wound microflora. Furthermore, immobilized tissue demonstrates a superior resistance to the growth of bacteria than that of non-immobilized tissue. Whenever possible, elevate the site of injury above the patient's heart. Elevation of the injured site limits the accumulation of fluid in the wound's interstitial spaces. The injured wound with little edema proceeds more rapidly to complete rehabilitation than does the markedly edematous wound.

3. Medications

There are two basic categories of medication to be considered here: 1) antibiotics; and 2) rabies and tetanus prophylaxis.

4. Antibiotics

Prophylactic antibiotics in the emergency department setting is a misnomer, all wounds of traumatic origin are contaminated. Antibiotics are frequently used unnecessarily. Most wounds do not become infected if they are appropriately irrigated and débrided, because the quantitative bacterial count is within the acceptable range of less than 10^5 organisms per gram of tissue. Certain infection-prone wounds can benefit from antibiotic administration. A cephalosporin can be used for the majority of wounds. Antibiotics usually do not need to be continued for more than a few days. One must not rely on drugs to prevent infection. Proper techniques are generally more productive.

5. Tetanus Prophylaxis

Appropriate prophylaxis for these life-endangering conditions is essential. The American College of Surgeons has published very clear-cut guidelines for the selection and use of these prophylactic preparations. These guidelines must be readily available and strictly followed. **Td** = tetanus and diphtheria toxoids adsorbed (for adult use). **TIG** = Tetanus immune globulin (human).

Tetanus-Prone Wounds: older than 6 hours, stellate wound, avulsion, abrasion, greater than 1 cm depth, produced by missile, crush, contusion, or frostbite, presence of infection, devitalized tissue, and contaminants, such as dirt, feces, soil, saliva, etc.

Prior Tetanus Immunization (doses)	Td1	TIG
Uncertain or less than three	Yes	Yes

Three or more immunization	No5	No

Non-tetanus-Prone Wounds: less than 6 hours old; linear wound, less than l cm depth, produced by sharp surface, such as a knife or glass, absence of infection, devitalized tissue, and contaminants, listed above.

Prior Tetanus Immunization (doses)	Td1	TIG2
Uncertain or less than three	Yes	No
Three or more immunization	No4	No

1. For children less than seven years old, diphtheria and tetanus toxoids and pertussis vaccine (or diphtheria and tetanus toxoids, if pertussis vaccine is contraindicated) is preferable to tetanus toxoid alone. For persons seven years old and older, Td is preferable to tetanus toxoid alone.
2. When administering TIG and Td concurrently, uses separate syringes and separate sites.
3. Yes, if wound is more than 24 hours old.
4. Yes, if more than ten years since last dose.
5. Yes, if more than five years since last dose. (more frequent boosters are not needed and can accentuate side effects.)

6. Rabies Prophylaxis

Any patient with a bite from an animal suspected of being rabid or an animal that is not in custody should receive immunization with RIG and HDCV immediately. If the animal is available for testing and/or observation, immunization may wait except in head and neck wounds or in very young children. If the patient has been previously immunized for rabies or you have any other questions the State Department of Health has a 24-hour hot line.

Active immunization with human diploid cell vaccine (HDCV) is given on day 0, 3, 7, 14, and 28 as a 1 cc. intramuscular injection. Antibody titers can be expected to rise within 7 to 10 days and persist for at least 1 year. Rabies immunoglobulin (RIG) provides rapid passive protection that persists for a short period of time. The recommended dose is 20 IU/kg. Half of this should be infiltrated around the wound if possible and the other half given intramuscularly at the initial evaluation. RIG is only given once. This may be given up to day 8 but should be given as early as possible. Head and neck wounds should be treated in less than 48 hours as well as any small child who is bitten. RIG and HDCV should be given at separate sites. Local reactions are common to these vaccines and are not indications for cessation of treatment. Pregnancy is not a contraindication to post-exposure prophylaxis.

Wound cleansing for bites of this nature is the same as that given other wounds. However: copious irrigation and debridement is stressed.

A 15% risk of developing rabies after a bite in a proven rabid dog exists.. Bites to the head, neck or hands by a rabid animal are at greater risk of developing rabies because of a more abundant nerve supply to these areas.

Dogs, cats, bats, skunks, raccoons, wolves and foxes are associated with the transmission of rabies. Livestock may also be infected (e.g.. cattle). Rodents and lagomorphs are rarely infected with rabies. Only dogs and cats will show signs of rabies within two weeks. Other suspect animals (including pets) may harbor the virus for long periods of time without signs and therefore must be sacrificed. The most common method of transmission is via the bite of an infected animal though scratches or inhalation may transmit it.

Species of Animal	*Condition of Animal at time of Attack*	*Treatment of Exposed Human*
Wild Skunk Fox Coyote Raccoon Bat Other Carnivores	Regard as rabid unless proven negative by laboratory test	RIG† and HDV‡
Domestic	Healthy, under surveillance	None§
Dog Cat	Unknown (escaped) Rabid or suspected as rabid	RIG† and HDV‡
Other Livestock, Rodents, Lagomorphs (rabbits & hares)	Consider individually - based on exposure risk	

- *† RIG = Human Rabies Immune Globulin.*
- *‡HDVC = Human Diploid Cell Vaccine. Discontinue vaccine if fluorescent antibody stains of tissues from the animal killed at the time of attack are negative for rabies antigen.*
- *§ Begin RIG + HDCV at the first sign of rabies in a biting dog or cat during a holding period (10 days).*
- ** These recommendations are only a guide. They should be applied in conjunction with knowledge of the animal species involved, circumstances of bite or other exposure, vaccination status of the animal and presence of rabies in the region.*

7. Discharge Instructions

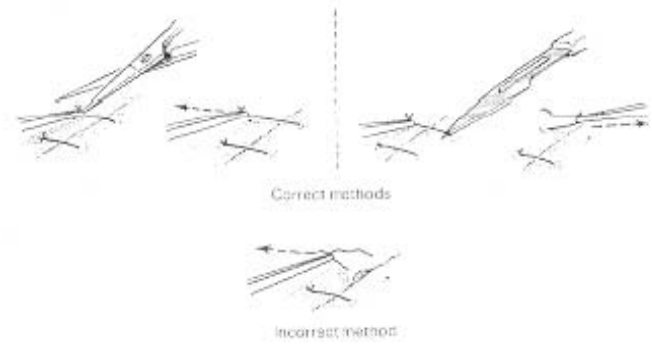
Post-repair instructions are essential. The patient must be made aware of the warning signs of wound infection including local increase in pain, increased temperature and an increase redness of the wound. Wound and dressing management must also be discussed. Rest and elevation of the wound must be clearly stated. Once delivered it is good to ask the patient, "Now - how are you going to care for your wound?". Written wound care instructions if possible should be offered the patient for his or her future reference.

8. Suture removal

It is usual to lay down set days for the removal of sutures in various sites and under varying circumstances but this is quite a wrong approach. Clinical experience soon tells the clinician when a suture may safely be removed. Naturally the principle is to remove at the earliest time judged safe and this depends on so many factors, degree of tension, site, line of wound, etc., that it is quite impossible to lay down rules. Regardless some rough guidelines for patient return for probable suture removal are:

- Face - 3 to 5 days,
- Ear - 4 to 6 days,
- Scalp - 7 to 12 days,
- Trunk - 7 to 12 days,
- Arms and legs - 10-12 days,
- Hand - 10 to 12 days
- Feet - 10 to 14 days.

In actually removing the suture one must remember that the tensile strength of the wound is minimal and dehiscence is liable to occur on the slightest provocation. Where most care is needed the sutures are usually smallest and therefore before beginning there must be a good light, fine, sharp scissors that cut to the point and fine dissecting forceps that grip properly. With these prerequisites the actual technique of removal is not radically different from ordinary suture removal except that absolute gentleness is necessary and the cut suture being pulled out must always be pulled out towards the wound.



Scissors of course are not invariably sharp and do not always cut to the point and a good alternative method is to use the tip of a triangular scalpel blade to cut the suture. In a difficult situation its extremely sharp fine point will often cut the suture with much less disturbance of the wound than scissors.

In removal as in insertion of the suture the surgeon should support his elbows and work from wrist and fingers to give smooth movements without tremor. The patient equally should be carefully supported so that the suture line stays absolutely still.

a. Subsequent support of the wound

As already stated, early suture removal leaves a wound devoid of strength so that a sudden ill-judged tension strain may cause it to open. For this reason the wound is best supported or at least protected up to a week after stitch removal and micropore skin tape (Steri-Strips®) works well in this role. It is seldom practicable to support the wound much beyond this and indeed attempts to prevent later stretching of the wound by prolonged support are of little avail.