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AUTHORS

Elizabeth Fernandez, MD, Attending Physician, St. John's Riverside Hospital, Yonkers, NY; Adjunct Clinical Assistant Professor, Lake Erie College of Osteopathic Medicine, Erie, PA

Bjorn Bernhardsen, MD, MBA, MPH, Resident Physician, St. John's Riverside Hospital, Yonkers, NY

PEER REVIEWER

Steven M. Winograd, MD, FACEP, Mt. Sinai Queens Hospital Center, Jamaica Queens, NY; Assistant Clinical Profesor of Emergency Medicine, Mt. Sinai Medical School, New York City; Assistant Clinical Professor of Emergency Medicine, NYiTCOM, Old Westbury, NY

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Wound Care Review

It is 5 p.m. on a Saturday and you've just started your shift at your community emergency department (ED). In the waiting room, you see the frantic parents of a 4-year-old with a head laceration, a college student with a hand laceration resulting from a fight last night, and a 67-year-old woman who was bitten by her cat. As you get ready to see your first patient, you wonder, is the hand laceration too old to close? How likely is that cat bite to get infected? Is it even safe to suture it?

Introduction

Traumatic lacerations are a common ED presentation. Although managing most ED lacerations is routine, some cases are complex, requiring physician judgment for effective treatment. This review will discuss the principles of laceration management, incorporating recent research in wound care. The author performed a PubMed search using terms such as laceration, sutures, emergency department, closure, and wound to identify relevant articles to review. This article reviews evidence-based wound care practices, including prehospital presentation, anesthesia, irrigation, free closure methods, and post-closure care. As will be noted, many common practices in ED-based wound care have not been subjected to randomized, controlled trials, suggesting there might be room for improvement.

Wound Healing Etiology/Pathophysiology

Natural wound healing is a complex process involving multiple steps. After the initial insult, the first process is coagulation, which then progresses through the stages of inflammation, collagen deposition, contraction, and epithelialization.[1]

Platelets activated during coagulation stimulate an inflammatory cell response, attracting phagocytic cells to remove debris and bacteria. The inflammatory phase lasts about three to four days, followed by the proliferative phase, which is characterized by collagen deposition within the wound. Typically, through day 21, collagen is cross-linked in a disorganized manner, producing the firm tissue that is characteristic of a healed wound. This is followed by epithelialization and wound contraction over the year following injury.[2]

While it is not clinically relevant to readily recall all aspects of the wound healing cycle in the ED, it is important that the provider understand the factors that may interfere with wound healing. Patient factors, such as inherited collagen-vascular disorders, poor tissue oxygenation (typically found in smokers and patients with poorly controlled diabetes), and even poor diet all can contribute to poor wound healing. The provider's role is to ensure a clean, well-approximated wound that will best aid the body's natural wound repair ability.

EXECUTIVE SUMMARY

- There is no "golden hour" for wound repair. Clinically uninfected wounds in highly vascular areas can be closed many hours after injury with an acceptable risk for infection.
- Topical anesthetic or cryotherapy can reduce the pain of local anesthetic infiltration.
- Regional nerve blocks are a useful technique to anesthetize a large area without a large volume of local anesthetics.
- Adhesive strips, skin staples, and tissue adhesives are time-efficient methods to close wounds not under tension.
- The cosmetic outcome for absorbable and nonabsorbable sutures is generally equivalent.
- Prophylactic antibiotics are indicated for all cat, most human, and some dog bites.

Differential Diagnosis

Lacerations are caused most often by straightforward processes, such as impact from falls or sharp edges. Even in these common circumstances, consider complicating factors that may alter care needs. The history can be invaluable in guiding care considerations, but sometimes may be incomplete or missing entirely. All wounds should be assessed for cause and potential for morbidity due to possible foreign bodies and bacterial contamination. Also, patient cooperation can complicate wound care. Tetanus vaccination status and the need for prophylactic antibiotics should be considered. With some mechanisms of injury, such as a fall, other and less obvious injuries should not be overlooked. Finally, since providers may not reliably estimate wound size visually, proper measuring should be used.[3]

Prehospital Care

Prehospital care should follow Advanced Trauma Life Support (ATLS) guidelines, including hemorrhage control, dressing placement, and immobilization as needed. If direct pressure fails to control bleeding, elevation and/or tourniquet placement may be necessary. Any foreign objects within the wound, either from the initial injury or subsequent injury, ideally should be left in place until definitive care is undertaken at a hospital. Other ATLS principles, such as airway maintenance or protection and oxygenation, should be followed. Patients with complex lacerations, especially with severe bleeding or deep tissue involvement, may require direct transport to a trauma center for evaluation.[4]

Evaluating the Wound

History

Traditional practice has dictated the importance not only of the mechanism of injury, but also the duration of time since the injury in influencing the risk for wound infection. This is based on the concept of bacterial contamination of the wound at the time of injury or colonization of the wound after injury due to the exposure of subepithelial tissue. In 1975, Robson et al reported that between three and five hours after injury, bacteria count within traumatic wounds was at a level associated with infection, suggesting the potential for infection if the wound was closed after that time period.[5] This principle was observed in a study by Waseem et al published in 2012.[6] Of 297 patients analyzed, the 10 patients who developed a wound infection had a median wound closure time of 867 minutes compared to 330 minutes in the 287 patients who did not develop a wound infection (P = 0.03). As the authors noted, this result did not control for confounding factors known to influence the rate of wound infection after closure, nor were they able to identify a threshold value that differentiated the two groups.

The idea that there is a threshold value for the risk of wound infection after closure of traumatic lacerations has been challenged in clinical observational studies over the past 30 years, although the early studies were relatively small, had a low rate of follow-up, did not use current approaches to wound closure, and had less rigorous methods for assessing outcome. There are two recent studies of sufficient size and rigor to address the issue of traumatic wound closure timing.

The first was published by Van Den Baar et al in 2010.[7] It was a study of 408 patients treated at a Dutch Level I trauma center that found there was no difference in the rate of infection of wounds treated before and after six hours of injury. The second study, published by Quinn et al in 2014, evaluated 2,663 patients treated for traumatic lacerations in three U.S. EDs.[8] The researchers found no statistically significant difference in the rate of infection for wounds closed before or after 12 hours from injury. In a multivariate model for predictors of infection, they found that diabetes (odds ratio [OR] 3.1; 95% confidence interval [CI], 1.2-8.0); location not in the head or neck (OR 2.5; 95% CI, 1.4-4.5), length > 5 cm (OR 2.4; 95% CI, 1.4-4.0), and moderate to heavy contamination (OR 1.9; 95% CI, 1.04-3.3) were independent risk factors for infection, not length of time from injury to closure.

Based on published studies, there is no "golden hour" for wound repair.[9] Studies indicate scalp and face wounds have no time limit, provided there are no signs of infection. And, although the study numbers were small, the risk of infection with closure up to 19 hours after injury is essentially no different from early repair if the wound is not clinically infected.[8]

Exam

As with any trauma patient, the airway, breathing, and circulation must be assessed and stabilized before moving on to other concerns. Once the patient is stable, a careful neurovascular exam is necessary prior to anesthesia administration. A wound may be much more severe than it initially appears. Many injuries can happen quickly, and the

Table 1. Maximal Local Anesthetic Infiltrative Dosing

Anesthetic	Without Epinephrine	With Epinephrine	Maximum Dose (80 kg Adult)
Bupivacaine	2 mg/kg	3 mg/kg	160 / 240 mg
Lidocaine	4.5 mg/kg	7 mg/kg	360 / 560 mg
Procaine	7 mg/kg	9 mg/kg	560 / 720 mg

patient may not realize the extent of injury. Injuries also often occur in the setting of a heightened emotional state, and this can mask pain. As such, wound size and depth should be evaluated with this in mind. Simple and gentle exploration often will reveal the extent of injury as well as any foreign material. Likewise, any deficit in sensation or function can be used to pinpoint the extent of neurological injury.[10] At this time, wounds should be evaluated for distal neurovascular and/or tendon injury. Anesthesia usually is required for full wound exploration, as well as to facilitate wound cleansing, as these procedures can be extremely painful.

Diagnostics

Laboratory testing is rarely necessary, but may be considered if there is concern for infection, hemorrhage leading to anemia, or if the patient is on anticoagulants. Plain films and other imaging may be useful to rule out radiopaque foreign body and/or fracture that otherwise may remain undetectable.[11] Bedside ultrasound may be a useful adjunct to evaluate for non-radiopaque foreign body. CT also can be useful in determining the extent of injury in traumatic wounds if there is concern for underlying organ damage.

Treatment

Topical Anesthesia

Topical anesthesia has been used mainly in pediatric wounds; however, it has gained momentum for adults in recent years either alone or as pretreatment before local infiltration. Lidocaine, epinephrine, tetracaine (LET) and eutectic mixture of local anesthetics (EMLA) are efficacious in reducing the pain of local injection. EMLA cream as pretreatment before infiltrative local anesthesia increases patient satisfaction with treatment.[13,14,15] A Cochrane review published in 2011 identified that most data-generating studies regarding topical anesthesia efficacy were at medium to high risk of bias, and concluded that low-risk bias studies still are needed.[16]

If considering topical anesthesia, keep in mind that there will be an increased length of stay in the ED, as the onset typically is slower than local infiltration. Topical anesthetics usually require 10 to 30 minutes for maximum effect. There has been some consideration of the possibility of placing these medications on wounds upon arrival to ED triage for efficiency.[17,18] A randomized, double-blind trial exploring the ability of triage nurses to pretreat lacerations with topical anesthetics showed that the topical anesthetics significantly anesthetized the tissue to decrease pain of local injection by the time of physician evaluation.[19]

A recent study investigating cryotherapy for relief of local injection pain found that application of a cold compress to the wound site for just five minutes was enough to decrease pain scores significantly.[20] Other novel methods for local anesthesia may be available in the near future. A recent noninferiority trial compared the effectiveness of local infiltration with a topical anesthetic putty application, comparing pain scores with outcomes.[21] The lidocaine putty was found to be noninferior to an infiltrative technique. Lidocaine putty had the added benefit of not disrupting or distorting the tissue when applied, unlike with local anesthetic infiltration.

Infiltrative Anesthesia

With or without pretreatment, intradermal anesthesia is a quick and effective method to control pain before irrigation, exploration, and closure of the wound. Lidocaine 1% is the most commonly used local anesthetic with broad applications for approaching many types of pain, not only dermal but also visceral and central pain, renal colic, and more in the ED.[22] Other local anesthetics, such as procaine 1% and the longer-acting bupivacaine 0.25%, also may be used. (*See Table 1.*)

The addition of epinephrine 1% has the benefit of vasoconstriction, which allows the provider to have a clearer field with less blood loss. The addition of epinephrine traditionally has been discouraged if vascular compromise was suspected, although there is no evidence of harmful effect, even if used on the fingers, toes, or nose.[23] Epinephrine also allows higher total doses of anesthetic to be used, increasing the maximum dose of lidocaine from 4.5 mg/kg of body weight to 7.0 mg/kg of body weight. This raises the maximal total dose of lidocaine 1% from 36 mL to 56 mL in an 80-kg adult, which is particularly useful when dealing with larger wounds.

The injection of local anesthetics can be very painful. This can be mitigated by injecting slowly, warming the medication to body temperature, using small (27-30 gauge) needles, avoiding large injections in one location, and using distracting vibratory stimulation in the area. Another option is to add 1 mL sodium bicarbonate 8.4% for every 9 mL of 1% lidocaine, which not only decreases pain but also shortens time to anesthesia onset.

Nerve Blocks

Regional nerve blocks can be extremely useful in the ED. They have the dual benefits of anesthetizing a large area with minimal time, effort, and pain to the patient while also requiring smaller volumes of local anesthetic medication. As the anesthetic is not injected directly into the wound area, it does not distort the tissue, allowing for alignment during repair and perhaps a better cosmetic outcome. Nerve blocks also may be considered when anesthetizing areas that are large or difficult to access, such as the face or fingers. This practice can lower patient pain scores by diverting the injection site from the inflamed local area of the wound and requiring fewer injections in total.[24]

While a full analysis of nerve blocks is outside the scope of this review, it is worth noting that a 2014 review of hand anesthesia revealed new best practice for performing digital anesthesia.[25] Evidence from multiple studies supports the use of single volar (palmar) injection in the middle of the proximal phalanx over traditional dual dorsal web space injection. The pain of injection was found to be no different than in the dorsal webbing of the finger and requires only one injection instead of two.

Personal Protective Equipment

Sterile gloves may be used if preferred for closer fit and more flexibility; however, studies have shown no decrease in infection rate when compared with non-sterile exam gloves.[24]

Irrigation and Cleaning

Normal saline has long been used for irrigation of wounds, but recent studies from Stanford University have shown that tap water is safe and effective in wound irrigation.[26] In fact, fewer wound infections actually were observed in the tap water group compared to the sterile saline group, although this finding was just shy of statistical significance. Tap water has the added benefit of easily allowing for copious irrigation without the expense of sterile fluids. However, this does come under the assumption that potable water is readily available. When this is not the case, sterile normal saline should be used.[27,12]

Perhaps counterintuitively, antibiotic solution use for washout actually has been shown to increase wound healing complications. One prospective, randomized study found a statistically significant increase in wound healing failures and dehiscence in the antibiotic group when compared to the group using non-sterile soap for irrigation.[27]

Low-pressure irrigation, defined as approximately 0.5 psi or lower, is achieved with a slow, gentle wash. Such pressure is sufficient for cleaning simple, non-bite, uncontaminated wounds in a highly vascular area, such as the scalp or face. High-pressure irrigation, defined as approximately 7 psi, can be obtained with forceful depression on the piston of a 30 mL or larger syringe through a 19-gauge catheter or needle, or with a commercially available splashguard. High-pressure irrigation is regarded as more effective for removal of debris and reduction in post-repair wound infection.

Many lacerations seen in the ED have little visible contamination, and there is little evidence regarding the amount of irrigation required to minimize post-repair infection. Recommendations by wound care experts range from 25 to 100 mL of irrigation fluid per centimeter of laceration.[17]

Wound Closure

Wound Adhesive/Adhesive Strips. Tissue adhesives and adhesive strips have been shown to be noninferior to sutures when used appropriately.[28,29,30] Both options have been well-evaluated over the last 20 years and found to be excellent, less painful or painless alternatives to sutures for the closure of appropriate lacerations. Either option can expedite care and improve efficiency in the ED, while improving patient experience. Suitable lacerations are those that are under low tension (so as not to risk wound dehiscence), do not require deep-layer sutures, and are not complicated by hair growth. Infection rates and cosmetic results have not been found to be significantly different in wounds closed in this manner when compared with wounds closed with sutures. Whereas tissue adhesive is used with a painting motion directly atop the wound edges, proper use of adhesive strips consists of placing closure devices perpendicular to the wound edge in the same locations where a suture would be placed.[29,31,32]

Staples. Staples are a quick, cost-effective, and noninferior technique for wound closure in the ED. One pediatric prospective, randomized trial showed staples resulted in shorter procedures at a lower cost with statistically equal outcomes as sutures.[33] Staples should not be used when CT or MRI may be needed while they are in place, as they may interfere with image quality.

Hair Apposition. For scalp laceration closure, the alternative method of hair apposition may be used.[34,35] Hair at least 1 cm long may be twisted together and secured with tissue adhesive to achieve wound closure. This method actually has been shown by retrospective observational study to be superior to scalp sutures for wounds that were less than 10 cm with hair greater than 3 cm in length.

Secondary or Delayed Primary Repair. Healing by secondary intention is considered when there is concern for infection (e.g., bite wounds or highly contaminated wounds) in non-cosmetically important locations. Alternatively, wounds at high risk also can be considered for delayed primary closure after four days of open wound management: cleaning, dressing, and with or without

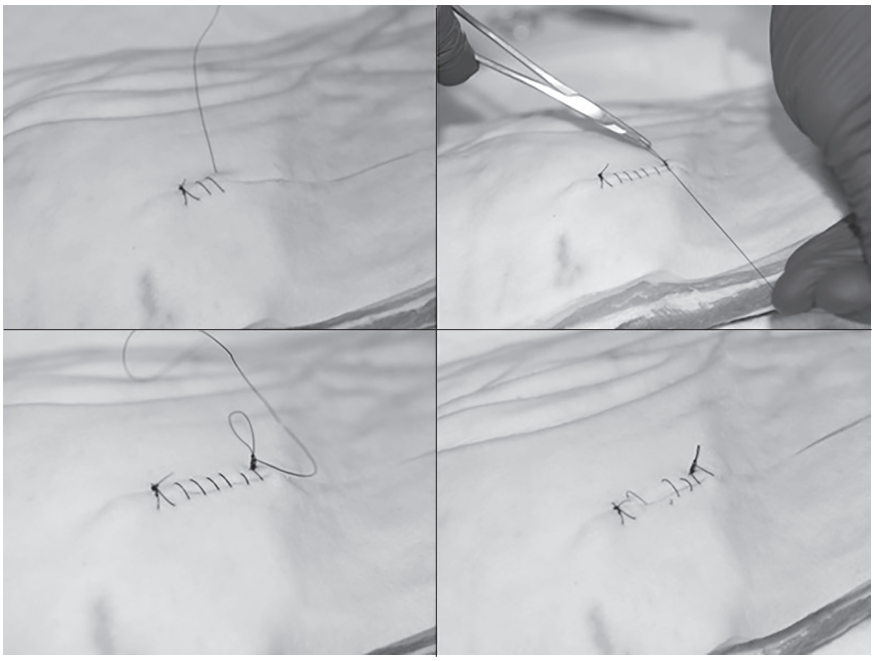
Table 2. Superficial Laceration Suture Choice

Size	Location	Duration
3-0 to 4-0	Sole of foot	7-10 days
4-0	Joints	10-14 days
4-0 to 5-0	Trunk/extremities/hands	7-10 days
5-0	Fingers/toes	12-14 days
5-0 to 6-0	Face/eyebrow	3-5 days

Table 3. Common Absorbable Suture Options

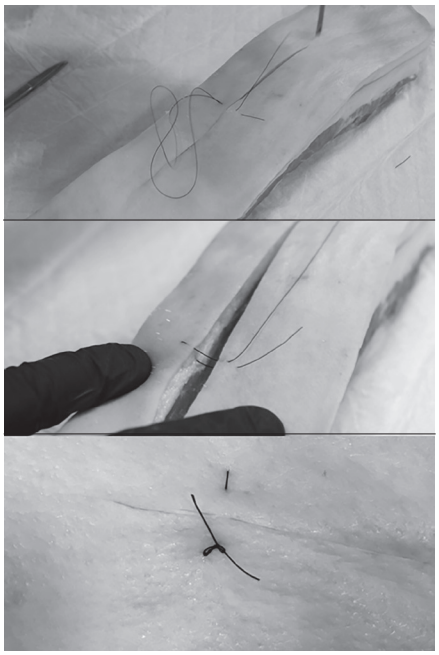
Type	Tensile Strength Time
Chromic gut	3-4 weeks
Absorbable synthetic	3 weeks
Fast-absorbing gut	5-7 days
Fast-absorbing synthetic (such as Vicryl Rapide™)	5 days
Nonabsorbable options of nylon and polypropylene do not lose tensile strength.	

Figure 1. Running Sutures



Top left: placement of running sutures; top right: securing sutures in place using final open loop and suture tail; bottom left: completed sutures; bottom right: one damaged suture can lead to a reopened wound

Figure 2. Vertical Mattress Sutures



Top: vertical mattress suture placement; middle: demonstrating the deep and superficial elements of vertical mattress sutures; bottom: secured suture

prophylactic oral antibiotics. The risk of infection rises as time passes after the injury, and closure after four days of such care can be done with an acceptable risk for wound infection.

Sutures. The major choice for sutures is between absorbable and nonabsorbable ones. Absorbable sutures are convenient for patients in that they do not require a follow-up visit for removal (*see Tables 2 and 3*); however, their use has been discouraged in visible and cosmetically important areas because of the belief that the enzymatic process responsible for suture dissolution will leave a visible mark. Newer research has shown no increase in adverse appearance between the two types of sutures when used properly, and that cosmetic outcomes for absorbable and nonabsorbable options generally are equivalent.[36,37]

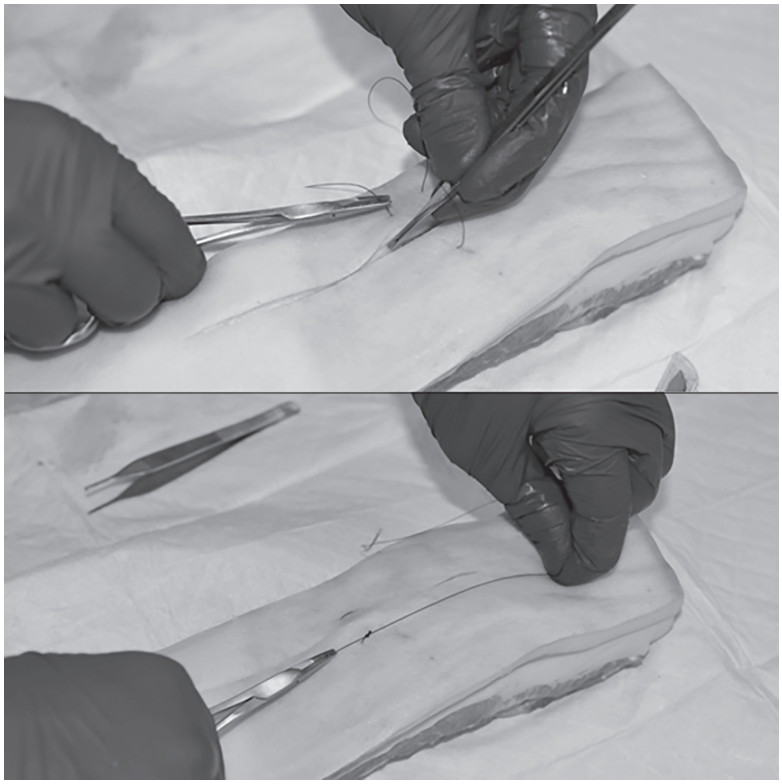
It is important to consider the amount of time that the sutures will last, compared with how much time is needed for the wound to heal.[36] For example, an absorbable synthetic suture (such as Vicryl™) will last approximately 21 days, so it would be unnecessary for a wound that is expected to heal in less than a week. Likewise, an absorbable suture that will dissolve in five days would not be appropriate for use over joints or on the extremities, which typically take longer to heal to tolerate the stress of movement. When choosing a suture, consider monofilament vs. braided material. Although monofilament sutures have less of a local inflammatory effect than braided sutures, braided sutures, by their nature, will maintain knot integrity more readily.

Techniques. Simple interrupted sutures are the most versatile type but may be the most time-consuming option. A running or "baseball" stitch is a much faster technique; however, should a single stitch break, the entire repair may fail and lead to wound dehiscence.(*See Figure 1.*) For wounds under high tension, consider either undermining the wound with a deep suture or using mattress sutures.

Vertical mattress sutures have the benefit of placing a deep and superficial suture simultaneously and have an excellent cosmetic effect. (*See Figure 2.*) In addition, vertical mattress sutures place the knots outside the wound, so there is less concern for the knots fusing into the wounds. Horizontal mattress sutures are particularly useful for edematous, large, and/or high-tension wounds. (*See Figure 3.*) Another alternative for higher-tension wounds is the locked running suture. This differs from the running suture in that each "throw" is locked by passing the suture through the loop that has been created. (*See Figure 4.*) Compared to the standard running suture, each loop of the locked running suture will hold more tension.

If the wound includes a pointed edge, consider a corner stitch when there is sufficient tissue on the pointed edge to run the suture parallel to the skin surface. This minimizes tip retraction and scar formation. Finally, a running subcuticular stitch may be used, but it often is less favored in the ED because it is the most technically difficult suture. This technique eliminates any possibility of visible scarring from the thread running into and out of the surface of the

Figure 3. Placement of Horizontal Mattress Sutures



Top: horizontal mattress suture placement; bottom: secured suture

skin, as horizontal stitches are placed just below the epidermis and run back and forth. However, if not placed correctly, this technique may distort the appearance of the wound.

Additional Treatment

Prophylactic Antibiotics

There is no clear evidence that antibiotic prophylaxis reduces the rate of post-repair infections for the majority of traumatic wounds repaired in the ED. Moreover, many wounds considered at high risk, such as hand lacerations, do not have a lower rate of infection if antibiotics are prescribed. A prospective observational study found that age, gender, diabetes, wound closure method, and prophylactic antibiotics did not affect wound infection outcomes for simple hand lacerations.[38]

Most non-bite wound infections are due to staphylococci or streptococci. Despite the increase in community-associated methicillin-resistant *Staphylococcus aureus* (MRSA) skin infections, MRSA has not been a common isolate in traumatic wound lacerations. For prophylactic coverage of these non-bite lacerations, a beta-lactam is adequate. For plantar puncture wounds through athletic shoes, there is the theoretical risk for *Pseudomonas* infection, and prophylaxis with ciprofloxacin can be considered; however, local antibiotic resistance patterns must be taken into account.

Tetanus

According to Centers for Disease Control and Prevention (CDC) guidelines, tetanus antibiotic prophylaxis is not required for clean, minor wounds in a vaccinated individual (three or more doses to build initial immunity, as well as less than 10 years since the last tetanus toxoid). For deep wounds, crush wounds, or any wound contaminated by dirt, soil, or saliva, Td or Tdap should be given if it has been more than five years since the last tetanus toxoid booster. Anyone with a laceration that is "neither clean nor minor," and who has had fewer than three prior doses of tetanus toxoid or who has an unknown history should receive tetanus immunoglobulin (TG) as well as Td or Tdap to provide immediate immunity and to promote immune response.[40]

Of note, the Academy of Emergency Medicine and Care and the World Society of Emergency Surgery recently published a position paper concerning management of traumatic wounds that considered tetanus prophylaxis.[41] The position paper was based on 10 questions submitted to an expert panel, and two of its eight recommendations on traumatic wounds concerned tetanus and proper administration of the toxoid. Expert consensus agreed with the CDC recommendations that every patient who presents with a traumatic wound should be evaluated for immunization status and that tetanus infection is a potential risk in all traumatic wounds.[41] Vaccination status should be documented in all lacerations, and Tdap may be given in the thigh muscle or deltoid as a 0.5 mL dose when needed.[41,42]

Wound Care

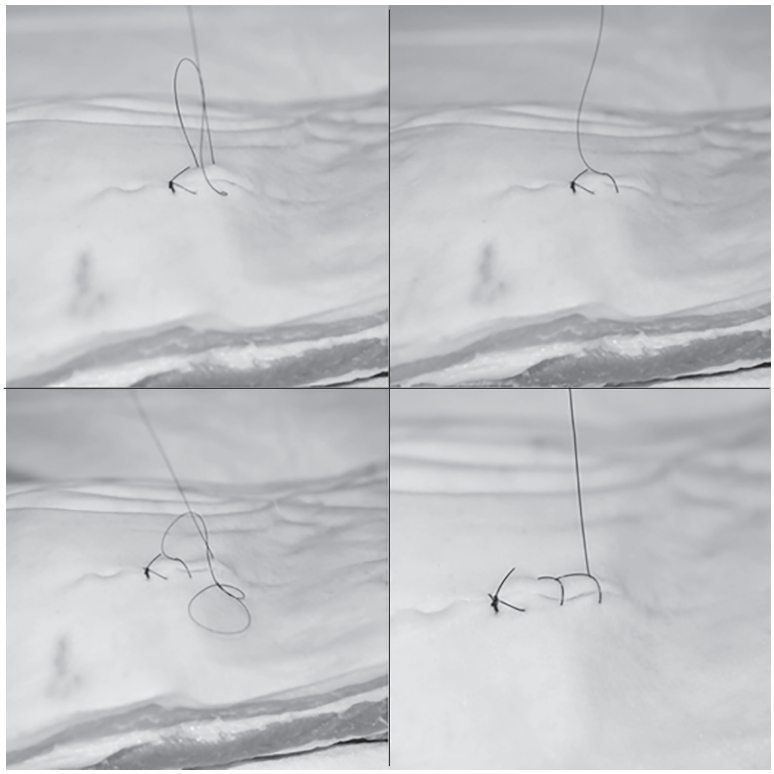
When it comes to outpatient wound care recommendations for patients, traditional teaching has been to place non-adherent dressings over the wound to provide a moist, clean environment for wound healing to take place. While such dressings have not been proven to prevent bacterial contamination, they help contain drainage and minimize dried crust formation.[43]

Patients typically are advised not to get sutured wounds wet. Studies previously have shown that uncovered wounds that were exposed to water (e.g., washing or showering) after 12 hours had no increase in infection rate.[44] There are no data on immersion restrictions, although it makes sense to avoid immersing the wound in water until the wound has closed and the sutures are removed. Of course, tissue adhesives and adhesive strips cannot get wet, or they will lose their strength.

Sub-specialty Follow-up

With complicated lacerations or highly visible areas where cosmetic appearance is important, there is often a question of whether a plastic

Figure 4. Placement of Locked Running Sutures



surgery consultation would yield better outcomes. Specialty consultation is not always available, such as when presentation occurs in a remote environment or late at night. Fortunately, a study of facial laceration repair found that patient satisfaction scores were similar between wounds repaired by plastic surgeons and those repaired by ED physicians.[45] A subset of females and parents of small children tended to be more satisfied with plastic surgeon repair, but this bias is thought to be because of patient awareness of provider specialty. Dermatology referral also may be considered for scar management, as advances with laser surgery and pharmacologic management can assist with scar mitigation once the wound has healed.[46]

Nail Bed Laceration

Nail bed injuries add another layer of complexity to wound closure. (*See Figure 5.*) Preserving the nail serves more than just a cosmetic outcome. The fingernail allows for increased tactile control, promotes proper circulation, and serves as protection for the sensitive fingertip. At this time, there is some controversy regarding proper repair techniques, but it has long been agreed that an improperly repaired nail bed will lead to permanent deformity.[47]

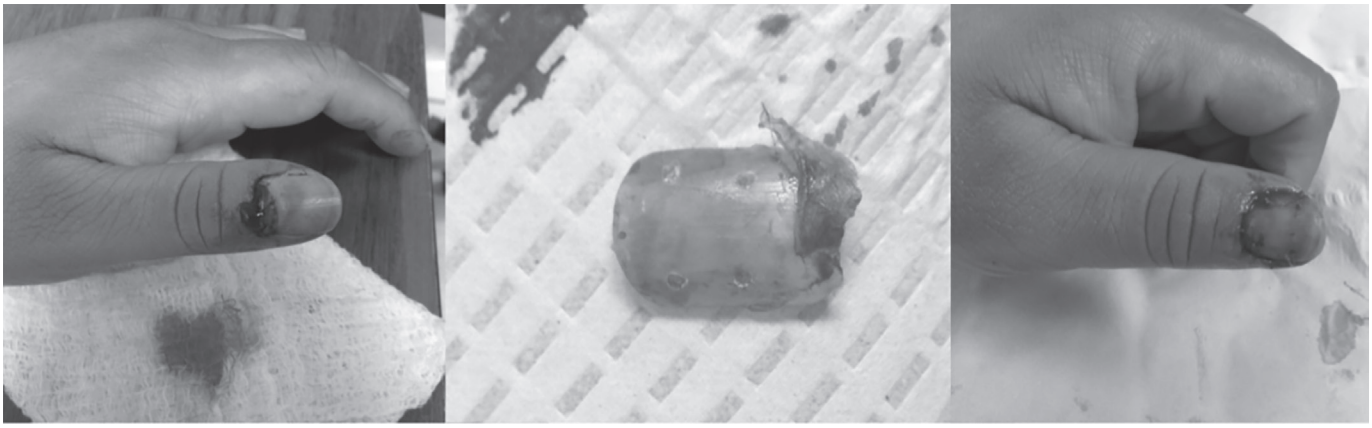
Classic teaching is that leaving a nail bed laceration open can lead to abnormal regrowth of the fingernail, and, as such, all nail bed lacerations should be repaired in the ED with removal of the nail to facilitate primary closure. This was challenged in 1999 by Rose et al in a prospective study comparing outcomes in 52 children with crush injuries involving the nail bed.[48] Patients were divided into two equal groups: one group had nail removal with primary repair and one had simple nail trephination. No significant difference was found between the two groups regardless of subungual hematoma size, mechanism, child age, or underlying fracture.[48]

Often, the nail has been removed because of the actual injury prior to the patient's arrival, and, as such, the decision to remove or keep the nail is already made. However, when there is a choice, the options are to replace the natural nail (when present), stent the matrix with an artificial substance, or leave the nail bed open following primary laceration closure. A 2014 retrospective study of 401 patients revealed far superior outcomes with native nail replacement when compared to the use of silicone nail splints.[49] Native nail replacement yielded significantly fewer nail deformities, whereas silicone nail splints led to twice the infection rate. It is also worth noting, however, that a 2015 randomized feasibility trial from the United Kingdom of 60 children who underwent nail bed repair found increased complication and infection rates among patients with nail replacement when compared to patients whose nails were discarded with the nail bed left open.[50] Because of the small study size, the results were not statistically significant, and the authors noted plans for a definite randomized, controlled trial. More evidence is needed regarding nail splinting vs. discarding after nail bed repair.

If the nail is to be replaced, common practice is to secure the nail with absorbable sutures, as there is less risk of granuloma formation when compared with nonabsorbable sutures. A 2008 prospective trial compared the use of standard suture fixation with the use of tissue adhesive to reattach the nail and found no difference in both physician- and patient-perceived outcomes, pain scores, and subsequent functional ability between the two groups.[51] This trial also evaluated the use of tissue adhesive against absorbable sutures for primary laceration repair with similar results. The researchers found that the average time required for nail bed repair with tissue adhesive was 9.5 minutes, compared with an average time of 27.8 minutes for suture repair. Thus, tissue adhesive may be considered for both primary nail bed laceration repair and nail replacement.

When there is a laceration through the nail with minimal adjacent damage, the laceration and nail may be reapproximated with the same application of tissue adhesive, without removing the nail. When the nail must be reattached, some providers anecdotally recommend

Figure 5. Nail Bed Laceration



Left: initial injury noting partial avulsion of nail; middle: nail removed intact; right: after nail bed repaired, nail placed back under basal cuticle and on nail bed, then held in place with two lateral distal sutures
Images courtesy of Salim R. Rezaie, MD

pre-drilling the nail with an 18-gauge needle and exiting sutures through this hole to prevent foreign body granuloma. This also may cause less trauma to the nail bed, as it avoids having to forcibly push the suture needle through the nail. However, no comparison studies are known to have evaluated this method.

Bite Wounds

Canine

In 2015, 80-90% of the estimated 3 to 6 million animal bites per year in the United States were from canines.[52] They occur most often in young children (especially males) between the ages of 5 to 9 years. Knowledge of the proper care of such wounds is extremely important. Often there is the question of whether these wounds should be closed or if this will lead to a significant risk for infection. A randomized, controlled trial evaluated 200 patients over three years for this very reason, looking at full-thickness wounds presenting to the ED within 48 hours of injury.[53] All wounds were cleansed using high-pressure irrigation with iodine antiseptics, and all patients received the same antibiotic treatment of amoxicillin/clavulanic acid, 500/125 mg BID for five days. Outcomes were measured for presence of infection and for cosmetic appearance. No significant difference in infection rates was found between the two groups. However, cosmetic appearance of the wounds was found to be significantly better in the primary closure group. It is important to note that wounds treated later than eight hours from injury demonstrated a 22.2% infection rate vs. 4.5% for those with earlier treatment times.

Regardless of closure, the first-line antibiotic choice is amoxicillin-clavulanate in patients who are not allergic to penicillin. In severe wounds, consider an initial dose of IV ampicillin-sulbactam, ticarcillin-clavulanate, piperacillin-tazobactam, or a carbapenem. If wounds are infected at presentation, a 10-day minimum course is recommended.[52,54] For penicillin-allergic patients, metronidazole plus doxycycline or trimethoprim/sulfamethoxazole or ciprofloxacin may be used.[52]

Feline

Cat bites are more likely puncture wounds, while dog bites are more likely to tear or crush tissue. Approximately 50% of untreated cat bites will become infected compared to about 8% of dog bites.[55] (*See Figure 6.*) In a retrospective analysis from 2004, Mitnovetski et al recommended prophylactic antibiotics for small cat bite wounds, avoidance of primary closure (with evaluation at 24 and 48 hours for delayed closure), and drainage and debridement with irrigation for deep space infection.[56] Of note, the majority of patients already had signs of infection — erythema and swelling — when seen in the ED. Puncture wounds from felines should not be closed, but should be allowed to heal by secondary intention.[57]

Antibiotics must include coverage for *Pasteurella multocida*. First-line antibiotic coverage consists of amoxicillin-clavulanate (500/125 mg TID or 875/125 BID) in combination with dicloxacillin (500 mg QID) for *S. aureus* coverage.[52] A retrospective review from 2013 also suggested hospitalization be considered for bites affecting tendon sheaths and joints, or when erythema, pain, and swelling are present.[59] These infections can spread along fascial planes quite rapidly and ultimately may require surgical washout and/or debridement.

Human

As with cat bites, human bites should be irrigated and debrided as needed. Although human oral flora can have up to 190 bacteria species, most human bite infections are caused by *Eikenella corrodens* or *Streptococcus* sp.[24] Antibiotic prophylaxis after human bites includes amoxicillin/clavulanate. Thereafter, human bites may be closed by primary closures as needed.

Snake/Scorpion

There is no increase in wound infection or specific pathogen associated with snake bites or scorpion stings, so prophylactic antibiotics for these bites/

Figure 6. Hand Infection Due to Cat Bite

Pasteurella multocida isolated from wound
Image courtesy of J. Stephan Stapczynski, MD

stings have no benefit. However, these wounds may require antivenom.[52]

Rabies

When caring for bite wounds, give rabies prophylaxis when there is any suspicion of rabies exposure. Although there are now five cases of survival from human rabies documented using the Milwaukee protocol, treatment with vaccine before the onset of symptoms is a more efficacious and cost-effective rabies solution.[59,60]

Wound Follow-up

Hypertrophic Scars and Keloids

Hypertrophic scars and keloids can be misidentified. Hypertrophic scars are hard, red or pink, raised scars, elevated but remaining within the limits of the original wound, usually emerging within the first month after injury, and may regress over time. Keloids are raised, reddish-purple, nodular scars, harder than hypertrophic scars, invading adjacent tissue extending beyond the margins of the original wound, and rarely regressing over time. Keloid formation is a fairly common occurrence, particularly in patients with African American, Asian, and Hispanic heritage. The actual pathogenesis is as yet unclear. While there is evidence that hypertrophic scar formation can be minimized by careful wound closure, there is no evidence that keloid formation can be prevented.[61]

Suture Removal

A 2012 prospective single-blind trial found that most patients are willing to remove and are capable of removing their own sutures from simple lacerations, provided they receive sufficient removal instructions.[62] Complications were not significantly higher than among patients who presented to the ED for suture removal. However, high-risk wounds that should be re-evaluated within 48 hours by a physician do not fall into this category.

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CME/CE Questions

1. The maximum amount of lidocaine without epinephrine administration at one time is:
   a. 4.0 mg/kg.
   b. 4.5 mg/kg.
   c. 5.0 mg/kg.
   d. 5.5 mg/kg.
2. Wound irrigation should be equal to:
   a. 0-50 mL/cm laceration
   b. 25-100 mL/cm laceration
   c. 100-150 mL/cm laceration
   d. 150-200 mL/cm laceration
3. What size suture is recommended over joints?
   a. 3-0
   b. 4-0
   c. 5-0
   d. 6-0
4. Which closure technique is best for a high-tension laceration?
   a. Single interrupted
   b. Running closure
   c. Staples
   d. Horizontal mattress
5. Which injury does *not* require a tetanus booster shot?
   a. A fully immunized child with last dose two years ago who stepped on a metal nail
   b. A child with two tetanus vaccine doses who got cut on the playground
   c. A woman immunized six years ago with a laceration caused by heavy steel girder that landed on her leg
   d. A middle-aged man last immunized in high school who cut himself chopping carrots for his son's lunch
6. Which of these injuries is *improperly* paired to the bacteria commonly associated with it?
   a. Human "fight bite," *Eikenella corrodens*
   b. Plantar puncture wound, *Pseudomonas*
   c. Cat bite, *Pasteurella multocida*
   d. Snake bite, *Streptococcus pyogenes*

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Wound Care Review

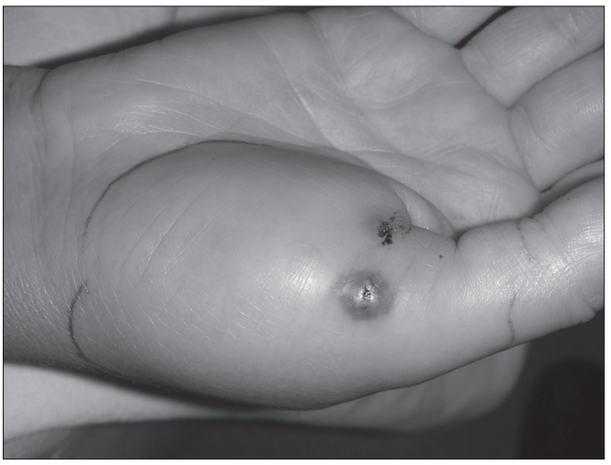
Maximal Local Anesthetic Infiltrative Dosing

Anesthetic	Without Epinephrine	With Epinephrine	Maximum Dose (80 kg Adult)
Bupivacaine	2 mg/kg	3 mg/kg	160 / 240 mg
Lidocaine	4.5 mg/kg	7 mg/kg	360 / 560 mg
Procaine	7 mg/kg	9 mg/kg	560 / 720 mg

Superficial Laceration Suture Choice

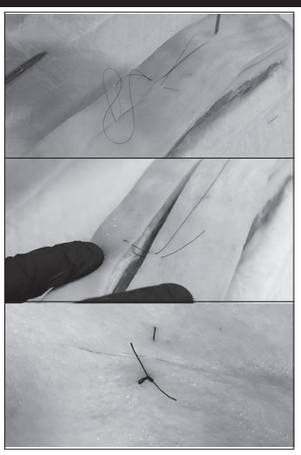
Size	Location	Duration
3-0 to 4-0	Sole of foot	7-10 days
4-0	Joints	10-14 days
4-0 to 5-0	Trunk/extremities/hands	7-10 days
5-0	Fingers/toes	12-14 days
5-0 to 6-0	Face/eyebrow	3-5 days

Hand Infection Due to Cat Bite



Pasteurella multocida isolated from wound
Image courtesy of J. Stephan Stapczynski, MD

Vertical Mattress Sutures

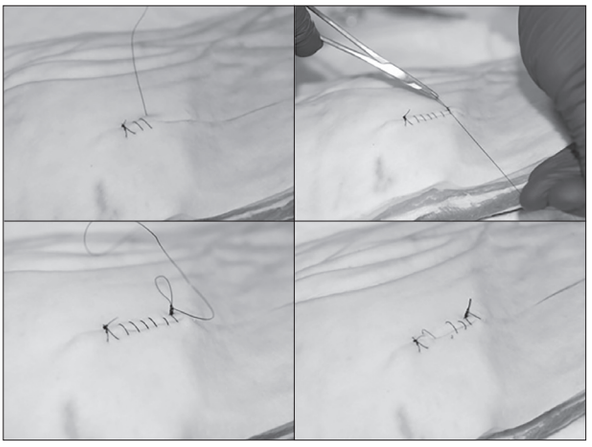


Top: vertical mattress suture placement; middle: demonstrating the deep and superficial elements of vertical mattress sutures; bottom: secured suture

Common Absorbable Suture Options

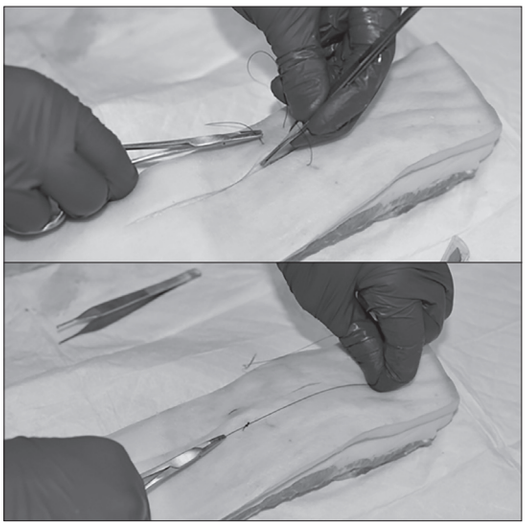
Type	Tensile Strength Time
Chromic gut	3-4 weeks
Absorbable synthetic	3 weeks
Fast-absorbing gut	5-7 days
Fast-absorbing synthetic (such as Vicryl Rapide™)	5 days
Nonabsorbable options of nylon and polypropylene do not lose tensile strength.	

Running Sutures



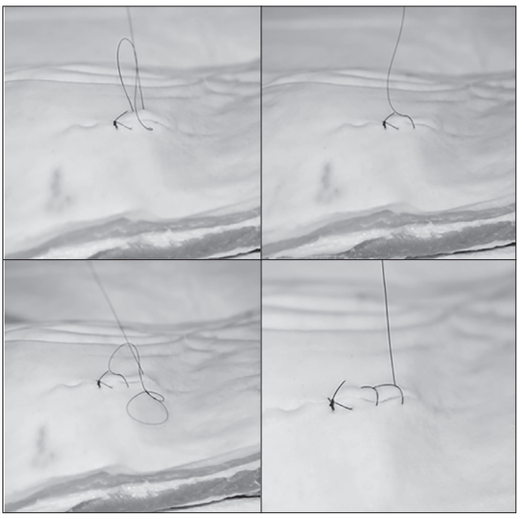
Top left: placement of running sutures; top right: securing sutures in place using final open loop and suture tail; bottom left: completed sutures; bottom right: one damaged suture can lead to a reopened wound

Placement of Horizontal Mattress Sutures



Top: horizontal mattress suture placement; bottom: secured suture

Placement of Locked Running Sutures



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