((volume or amount or quantity).ab,ti.) **AND** ((emergen* or immediate* or urgen*).ab,ti. or "Emergency Service, Hospital".sh.) **AND** ((infection* or sepsis).ab,ti. or Infection/ or "Wound Infection".sh. or "Cross Infection".sh. or "Sepsis".sh.)

Scopus: ((open w/3 fracture*) AND (irrigat* OR lavage OR wash*) AND (volume OR amount OR quantity) AND (emergen* OR immediate* OR urgen*) AND (infection* or sepsis)) in Title, Abstract, Keywords

CENTRAL: ((open near/3 fracture*) AND (irrigat* OR lavage OR wash*) AND (volume OR amount OR quantity) AND (emergen* OR immediate* OR urgen*) AND (infection* or sepsis)) in Title, Abstract, Keywords

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QUESTION 3: What is the recommended volume and composition of irrigating fluid in the operating room for open fractures and post-traumatic wounds?

RECOMMENDATION: Irrigation in open fractures should be performed with normal saline and gravity flow irrigation. 3-9L is a reasonable volume to use. Bactericidal washes with agents like chlorhexidine or povidone-iodine have not been adequately studied in orthopaedic trauma patients, but basic science studies raise concern that they may damage tissues.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

Irrigation is a central tenet in open fracture management, reducing bacterial concentrations and removing foreign materials from traumatic wounds. The goal in these injuries is to reduce the known risks of infection, wound healing problems and nonunion. Irrigation requires a balance between removing contaminants and causing further trauma to tissues or spreading contamination. Questions about irrigation include the ideal volume, fluid composition and pressure of irrigation solutions.

The one identified randomized controlled trial comparing different osmolality irrigating agents of distilled or boiled water and isotonic saline did not have clearly-defined outcome measures or follow-up criteria, but reported a 25.5% overall infection rate without any significant difference between the irrigation solutions [1].

Regarding antiseptic solutions, the majority of data is in animal or cadaveric models. This literature raises concerns about host cell toxicity that could affect wound healing or fracture union when utilizing agents such as ethanol, povidone-iodine, bacitracin solution, chlorhexidine solution, or hydrogen peroxide [2–8]. Additionally, there is some data showing that bacterial count reductions from soap or antiseptic solutions may be temporary and followed by disproportionate rebound at later time points, which has led some authors to recommend saline irrigation [9]. Regarding human clinical data, there is one moderate-quality randomized controlled study comparing bacitracin to castile soap for the irrigation of 458 open fractures in 400 patients. Minimum follow-up was 180 days, with an overall infection rate of 15.3%, a wound complication rate of 6.8% and a nonunion or delayed union rate of 23.9%. They reported similar infection and nonunion rates but increased wound-healing complications in the bacitracin group [10].

Volume

We were unable to identify any studies that specifically compared the volume of irrigation in a controlled manner in open or traumatic wounds. However, most studies used a minimum of 3L of irrigation and increased this amount by 3L per additional Gustilo type (3L for Gustilo type I, 6L for Gustilo type 2, 9L for Gustilo type 3), as in the 400-patient RCT by Anglen et al. [10].

Pressure

Pulsatile lavage theoretically improves dislodgement by cyclically compressing tissues then allowing them to decompress and recoil, freeing bacteria and foreign material. Pulsatile lavage has a proven clinical track record in reducing debris and bacterial counts in traumatic wounds when compared to gravity or bulb syringe irrigation [11–14]. However, basic science studies have raised concerns that pressurized lavage may be detrimental to bone healing and may seed bacteria distant to sites of initial contamination [5,15–18].

In the largest study on wound irrigation in open fractures, the Fluid Lavage of Open Wounds (FLOW) Group conducted an international, 41-center, blinded, randomized controlled trial assigning 2,447 patients with open extremity fractures to irrigation with high (> 20 psi), low (5-10 psi) or very low (1-2 psi) pressure with either castile soap or normal saline [19]. Irrigation for Gustilo type I injuries was 3L and types II and IIIA/B were 6L, with type IIIC injuries excluded from the trial. Of note, this study had the additional benefit of relatively standardized care in the pre-, intra- and post-op settings regarding components such as prophylactic antibiotic type and timing, skin prep solutions, debridement, skeletal stabilization and wound management including closures, dressings and soft tissue coverage. They reported no statistically significant difference between the pressure groups for the primary endpoint of reoperation within 12 months for promotion of wound or bone healing or for a wound infection. This study reported an overall 6.8% infection rate, 3.6% wound complication rate and 6.8% nonunion rate at 12 months.

The overall reoperation rate for infection, wound or bone healing was 13.2%. There was a significantly lower reoperation rate in the saline group than the castile soap group (14.8% vs. 11.6%, hazard ratio 1.32, 95% confidence interval 1.06–1.66, p = 0.01). Neither pressure nor solution composition led to significant difference in the secondary outcomes of non-operatively managed infection, wound-healing problem or bone-healing problem. In the subgroup analyses, there was a trend toward superiority without reaching statistical significance for very low-pressure irrigation in tibial fractures [19].

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QUESTION 4: What is the most appropriate management of early (prior to complete wound healing) infection after fracture fixation with stable fixation?

RECOMMENDATION: The most acceptable treatment strategy for trauma patients with early postoperative infection is to perform proper irrigation and debridement, administer intravenous (IV) followed by oral antibiotic therapy and retain stable hardware in place.

LEVEL OF EVIDENCE: Moderate

DELEGATE VOTE: Agree: 100%, Disagree: 0%, Abstain: 0% (Unanimous, Strongest Consensus)

RATIONALE

The definition and classification of early infection after isolated fracture fixation (IFF) is a dilemma among orthopaedic trauma surgeons [1–3]. However, the clinical picture of early infection including local (e.g., hematoma, wound discharge and dehiscence, erythema around the incision) and systemic (e.g., fever, lethargy) symptoms are usually diagnostic in most situations. Although it is not clear whether the biofilm formation process during the early postoperative infection period will be stopped or delayed with appropriate treatment, the goal of the treatment at this stage is to control the infection until complete union is achieved at the fracture site. After fracture healing, removal of the implant will help to eradicate the infection. This strategy is different than the typical treatment of a periprosthetic joint infection (PJI) in which the infected implant is replaced in two stages (spacer and then re-implantation of the total joint arthroplasty). The treatment strategy might be different based on the evaluation of the local and systemic clinical picture in each individual case. However, based on the available literature and our experience, it is possible to suggest some general recommendations.

The most significant difference between IFF and PJI is the higher chance of infection control and eradication by removing the implant during or after bone healing is complete for IFF cases. Therefore, especially in early postoperative IFF cases, infection control is the main goal of medical and surgical treatment [4,5]. The treatment options are described as ranging from simple antibiotic suppression to removal of the current implant to multiple stage revisions [4,5]. The most reasonable treatment strategy that is applicable to most cases is performing irrigation and debridement, retaining the stable fixation, and administering IV antibiotic therapy [4–7]. More than one washout or debridement may be necessary to clean the operative site and optimize wound healing [8,9]. Local antibiotic delivery (e.g., bead pouch, calcium sulfate beads) may be helpful. Proper soft-tissue coverage and aggressive debridement are the main principals of the surgical part of the treatment. Early flap coverage is critical if hardware is exposed [10].

The use of negative-pressure wound therapy coupled with continuous instillation of an antibiotic solution containing gentamicin and chymotrypsin has also been shown to facilitate a healthy wound bed for healing while maintaining fracture fixation with or without additional surgery for secondary closure [11]. In patients who are at high risk for wound healing problems, incisional negative-pressure therapy may be helpful following the washout [12,13].

Empiric systemic antibiotic therapy followed by organism susceptibility-based therapy should be started after early irrigation and debridement. Systemic antibiotic therapy can be curative or suppressive [14]. After a period of two weeks, IV antibiotic therapy can be replaced by appropriate oral therapy based on the available culture results [15–17]. It is recommended to continue the oral therapy for an additional four to six weeks to prevent chronic