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Contents

Bimonthly Volume 11 Number 4 July 20, 2021

ACADEMIC ACTIVITY REPORT

OPINION REVIEW

REVIEW

MINIREVIEWS

LETTER TO THE EDITOR

World Journal of Methodology

Bimonthly Volume 11 Number 4 July 20, 2021

Contents

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MINIREVIEWS

Wound irrigation for preventing surgical site infections

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Abstract

Wound irrigation (*i.e.* washing out a wound before wound closure) aims to reduce the microbial burden by removing tissue debris, metabolic waste, and tissue exudate from the surgical field before site closure. Although it is a popular procedure in every day surgical practice, the lack of procedure standardization, leads to studies with high heterogeneity and often controversial results. Thus, there are studies that advocate its use, while others discourage its implementation in clinical practice to reduce the risk of surgical site infection. The present article reviews the current literature on wound irrigation for preventing surgical site infections. Several irrigants are presented. Chlorexidine is generally considered to be less effective than povidone-iodine, while antibiotics are not that common nowadays, as they require prolonged exposure with the target to act. Hydrogen peroxide has several potential complications, which eliminate its use. Any differences in the incidence of surgical site infections between different irrigants, especially between antibacterial and non-bacterial ones, should be viewed sceptically. More randomized controlled studies are needed to provide better quality of evidence regarding the irrigants' effectiveness and safety.

Key Words: Wound irrigation; Surgical site infections; Antiseptics; Antibiotics; Patient Safety

Core Tip: Chlorexidine is generally considered to be less effective than povidone-iodine, while antibiotics are not that common nowadays, as they require prolonged exposure with the target to act. Hydrogen peroxide has several potential complications, which eliminate its use. Any differences in the incidence of surgical site infections between different irrigants, especially between antibacterial and non-bacterial ones, should be viewed sceptically.

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INTRODUCTION

Surgical site infections (SSI) arise from contamination of the surgical site in the period of time between incision and closure[1]. According to the Centers for Disease Control (CDC), SSI are defined as infections occurring at the site of surgery within 30 d after surgery, or, within 1 year if an implant is placed and the infection appears to be related to surgery[2]. CDC classifies SSI as incisional SSI (superficial or deep) and organ/space SSI. Superficial incisional SSI typically involve only the skin and subcutaneous tissue, while deep incisional SSI involve deep soft tissues, such as fascial and muscle layers. The term "organ/space" refers to any part of the anatomy (*e.g.*, organs or spaces), other than the incision, opened or manipulated during the operative procedure. Infections here are called organ/space SSI[2]. When organ/space SSI drain through the incision, they do not require reoperation and are classified as deep incisional SSI.

The CDC definitions have been criticized because they always end with the disclaimer that an infection exists if the surgeon or the attending physician declares that an infection exists. Similarly, as Fry states[3], "an infection may not exist if the surgeon says that an infection does not exist". Given the pressure for early discharge, it is likely that a substantial number of patients leave the hospital without having their SSI reported.

Wound irrigation (*i.e.* washing out a wound before wound closure) aims to reduce the microbial burden by removing tissue debris, metabolic waste, and tissue exudate from the surgical field before site closure[4]. Interestingly, although it has been shown to be beneficial in selected surgical disciplines, not only it is not a universally established standard-of-care preventive measure but there are guidelines that do not recommend its use to reduce the risk of SSI[5]. The present article the current literature on wound irrigation for preventing SSI.

IRRIGANTS

Irrigants are classified to normal saline, antiseptic agents and antibiotic agents. According to a Cochrane metaanalysis, there is only low-quality evidence available and, therefore, any differences in the incidence of SSI between different irrigants, especially between antibacterial and non-bacterial ones, should be viewed sceptically [6].

Normal saline

Warmed physiologic saline is universally considered the irrigation fluid of choice. It is widely available and safe for all surgical site surfaces, including the peritoneal and pleural cavities (serosal mesothelium)[4]. However, recent metaanalyses could not identify an advantage of irrigation with normal saline over no irrigation in patients undergoing abdominal surgery[7,8].

Pressurized (< 15 psi) pulse irrigation of subcutaneous tissue with saline may reduce bacterial counts by removing the desiccated tissue. It is considered a cost-effective infection prevention strategy, when applied in major laparotomy wounds in prolonged operative procedures (> 2 h) as it reduces SSI[9].

Antiseptics

Chlorhexidine: The most common antiseptic agent used is chlorhexidine gluconate (CHG), as it covers a broad spectrum of pathogens, including gram-negative, gram-positive and non-spore forming bacteria[10]. CHG disrupts the bacterial cell membrane within 30 s and in concentrations of 0.05%, it kills biofilm-based S. epidermidis in less than a minute.

However, there are limited data regarding its effectiveness when used for intraoperative irrigation. In vitro, CHG is found to be less effective than povidone-iodine (see below)[4,11].

Goztok *et al*[10] compared 0.05% CHG to saline in patients undergoing temporary loop ileostomy closure. This was a retrospective study of a prospectively collected database. Irrigation of the surgical site with CHG was associated with significantly lower rates of incisional SSI (32% *vs* 5%), incision dehiscence (32% *vs* 5%) and seroma formation (14% *vs* 2%). The authors also observed an earlier site healing in the CHG group (10 d *vs* 7 d)[10]. In pilonidal disease, wound irrigation with CHG is associated with lower SSI rates but it does not prevent seroma formation or incision dehiscence [12].

In plastic surgery, CHG is considered unable to penetrate the biofilm forming on the breast implants' surface. An in-vitro model assessing SSI prophylaxis after breast implant surgery showed that a 0.05% CHG solution can achieve sterility after 15 min exposure, while its effectiveness against Pseudomonas was absent in 40% of the cases [13]. Some authors advocate the usage of hypochlorous solution as an irrigant, as hypochlorous acid has a wide spectrum of antibacterial efficacy against Gramnegative, Gram-positive bacteria and fungi. This solution has the advantage of bypassing the need for neutrophils to be present in the wound implant interface[14].

Moreover, CHG is superior to saline in resolving MRSA biofilm-mediated polypropylene mesh infections[4].

Iodophors: Iodine has traditionally been used for prevention and treatment of wound infection, as it is effective against a broad spectrum of microorganisms, including gram-negative and gram-positive bacteria, spores, mycobacteria, fungi, viruses *etc.* However, it is toxic to vital tissues. For this reason it is almost always combined with povidone.

Most povidone-iodine (PVP-I) solutions contain 10% iodine, although iodine has been shown to preserve its full effect even in solutions with 1:100 dilution of the full-strength (10%) solution[11]. PVP-I is effective against highly resistant gram-positive microorganisms as it not only destroys the cell wall but also inhibits the release of endotoxins, exotoxins and tissue-destroying enzymes[11]. Some authors let the solution soak in the wound for 3 min before been suctioned[15].

PVP-I can kill biofilm-forming strain of Staphylococcus but this requires concentrations as high as 10% for 1 min or 3.5% for 10 min. However, the 10% solution is recommended only for external use and 10-min irrigations can not easily be implemented in clinical practice, as irrigations usually last 1-2 min[4].

Irrigation with diluted PVP-I is very popular among surgeons. It is used from more than 50% of visceral surgeons and one third of orthopaedic surgeons[16]. It is more effective in preventing SSI in abdominal surgery compared to no irrigation, but less effective compared to antibiotics[7]. A randomised controlled trial in women undergoing ceasarean section showed that povidone-iodine irrigation prior to skin closure does not prevent SSI[17]. Surprisingly, elective cesarean section was associated with higher infection rates compared to emergency cesarean section during labour[17].

Hydrogen peroxide: Hydrogen peroxide (H_2O_2) is a highly reactive oxidizing agent, effective against a broad range of microorganisms. H_2O_2 forms oxygen species that react with macromolecules such as membrane lipids and destroy bacteria. Its disadvantages include its rapid decomposition upon contact with organic material and its low effectiveness against catalase-producing bacteria (11-Ulivieri 2011). It is commercially available at concentrations of 3% and 30%, which can be diluted with saline solution to any desired concentration[18]. The 3% solution is found to be cytotoxic but it does not seem to affect wound reepithelialization[19]. Apart from cytotoxicity, another potential serious complication of H_2O_2 is air embolism, especially in closed cavities, as large volumes are pressurized into small vascular channels. For this reason, wound irrigation with H2O2 should be followed by copious irrigation with normal saline or other liquid and accompanied by placement of a surgical drain [19]. Its potential complications are the main reason why it is in most cases used in combinations with other antiseptics (see below), making it difficult to estimate its effect alone. However, there is limited high-level evidence supporting its use as a wound irritant, as most available studies are small-scale case series.

Soap: Soap has also been studied as a wound irritant. It mainly acts as an emulsifier, dispersing one liquid into another one. It has several advantages, i.e. it is widely available, cheap, less toxic and not prone to antibioc resistance. However, according to a randomized controlled study, normal saline has proven superior to soap in terms of reoperation rates, when used in th initial management of patients with open fractures [20].

Combinations: Several antiseptic combinations have been shown to have synergistic

effect. The combination of CHG with H_2O_2 is synergistic against species of Streptococcus and Staphylococcus. The combination of PVP–I with H_2O_2 is reported to reduce the rate of post-operative infection in spine surgery from 1.5% to zero[11]. In single stage exchange arthroplasty for hip and knee periprosthetic joint infections, a combination of 1% PVP-I and a 50:50 dilution of 3% H_2O_2 can prevent from recurrences of infection[19]. The effect can be explained by the fact that the combination is bacteriocidal, while both substances are bacteriostatic when used separately[19].

Antibiotic agents

Antibiotic agents are still widely used in irrigation fluids in almost all surgical disciplines, with rates as high as 22% in plastic surgery and 50% in general surgery. Main reason for this wide use is the failure to appreciate the mechanistic nature of how antibiotic agents work. Antimicrobial activity requires sufficient contact time for the antibiotic agent to bind to its target site. A second requirement is a persistent drug concentration above the MIC90, *i.e.* the concentration of the antibiotic agent that is required to kill 90% of the microbial population. These requirements are not met during antibiotic irrigation, as the irrigating fluid is rapidly removed[4]. In fact, antibiotic activity should be present in the tissue at the time of contamination of the surgical incision for infection to be prevented[3].

On the contrary, the use of antibiotics for wound irrigation may cause harm. Except for the risk of potential development of antimicrobial resistance, it may induce severe anaphylaxis, whereas some antibiotics, *i.e.*, neomycin and vancomycin, have been associated with tissue irritation or systemic toxicity when added in the irrigation fluid. Bacitracin for injection, an agent that is mostly used off-label for wound irrigation, has found to have severe side effects, i.e. nephrotoxicity and anaphylaxis, that outweigh its potential benefits. The FDA requested its voluntary withdrawal from the market on January 31, 2020[1].

In open appendectomy, layer-by-layer wound irrigation is shown to decrease the rates of incisional SSI compared to the no-irrigation group. However, adding gentamicin to saline solution did not further decrease SSI rates[21]. A recent meta-analysis showed no benefit of irrigation with antibiotic agents in reducing incisional SSI and discourages its use[22]. A network metaanalysis found that antibiotic and antiseptic irrigation had the lowest odds of SSI. Aminoglycosides had the lowest OR of SSI compared to non-antibacterial irrigation, followed by penicillin. However, there was high heterogeneity and irrigation of antibiotic agents was more likely to enroll patients undergoing operations with higher levels of contamination[23].

Although antimicrobial wound irrigation is reported to be superior to placebo for surgical prophylaxis in some studies, no study supports its superiority over parenteral administration of antimicrobials[1].

The combination of intrawound vancomycin powder and betadine irrigation was found to reduce SSI rates after posterior spinal fusion in patients with idiopathic scoliosis[24]. In another study of spine surgery patients, the same combination was found to reduce the proportion of gram positive cultures from 53% to 80% and MRSA infections from 7% to 30%. Multibacterial infections also decreased from 27% to 37% and were found to consist of just 7 different organisms, compared to 15 organisms without intervention. Based on these findings, the authors recommend adding one more prophylactic agent targeted for further reduction of the proliferation of gram positive bacteria. However, the addition of antibiotic agent that reduce gram negative bacteria is also important, as such organisms are found in SSI[25].

On the contrary, intraoperative irrigation with ceftriaxone did not reduce SSI in clean neurosurgical procedures when prophylactic intravenous antibiotics are administered (Okunlola 2020). Rifampicin has also been tested as a washing and irrigation solution in spinal instrumentation. However, both were found to be ineffective in preventing or reducing spinal implant infections[26].

In plastic surgery, combined antibiotic solutions are proven effective to *in vitro* eliminate MRSA and MSSA after breast implant reconstruction. Interestingly, adding of vancomycin did not increase in their effectiveness. However, all combinations required prolonged irrigation time to achieve sterility of the experimental surgical site [13].

CONCLUSION

Although wound irrigation is a popular procedure in every day surgical practice, the lack of procedure standardization, leads to high heterogeneity that downgrades the

level of evidence of the available studie. The existing studies have often controversial conclusions. Any differences in the incidence of SSI between different irrigants, especially between antibacterial and non-bacterial ones, should be viewed sceptically. Chlorexidine is generally considered to be less effective than povidone-iodine, while antibiotics are not that common nowadays, as they require prolonged exposure with the target to act. Hydrogen peroxide has several potential complications, which eliminate its use. More randomized controlled studies are needed to provide better quality of evidence regarding the irrigants' effectiveness and safety.

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