Reducing Surgical Site Infections: A Review

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Infection at or near surgical incisions within 30 days of an operative procedure contributes substantially to surgical morbidity and mortality each year. The prevention of surgical site infections encompasses meticulous operative technique, timely administration of appropriate preoperative antibiotics, and a variety of preventive measures aimed at neutralizing the threat of bacterial, viral, and fungal contamination posed by operative staff, the operating room environment, and the patient's endogenous skin flora. It is the latter aspect of contamination, and specifically mechanical methods of prevention, on which this review focuses.

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Infection at or near surgical incisions within 30 days of an operative procedure, dubbed *surgical site infection*, contributes substantially to surgical morbidity and mortality each year. Surgical site infection (SSI) accounts for 15% of all nosocomial infections and, among surgical patients, represents the most common nosocomial infection.[1] Postsurgical infection leads to increased length of postoperative hospital stay, drastically escalated expense, higher rates of hospital readmission, and jeopardized health outcomes. Accordingly, the first step in the treatment of SSIs is in their prevention. This encompasses meticulous operative technique, timely administration of appropriate preoperative antibiotics, and a variety of preventive measures aimed at neutralizing the threat of bacterial, viral, and fungal contamination posed by operative staff, the operating room environment, and the patient's endogenous skin flora. It is this latter aspect of contamination, and specifically mechanical methods of prevention, on which this review focuses.

Definition of SSI

There are 3 different types of surgical site infection defined by the Centers for Disease Control and Prevention (CDC).[2] In the criteria put forth by the CDC, SSIs are classified as either incisional or organ/space, with incisional SSIs being further subclassified as superficial (involving only skin and subcutaneous tissue) versus deep (involving underlying soft tissue). Table 1 further elaborates on the CDC classification system, which has been widely adopted by surveillance and surgical personnel.

Table 1
Centers for Disease Control and Prevention Surgical Site Infection (SSI) Classification System

Superficial Incisional SSI

Infection occurs within 30 days after the operation *and* infection involves only skin or subcutaneous tissue of the incision *and* at least *one* of the following:

1. Purulent drainage, with or without laboratory confirmation, from the superficial incision.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat *and* superficial incision is deliberately opened by surgeon, *unless* incision is culture-negative.
4. Diagnosis of superficial incisional SSI by the surgeon or attending physician.

Do *not* report the following conditions as SSI:

1. Stitch abscess (minimal inflammation and discharge confined to the points of suture penetration).
2. Infection of an episiotomy or newborn circumcision site.
3. Infected burn wound.
4. Incisional SSI that extends into the fascial and muscle layers (see deep incisional SSI).

Note: Specific criteria are used for identifying infected episiotomy and circumcision sites and burn wounds.

Deep Incisional SSI

Infection occurs within 30 days after the operation if no implant* is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves deep soft tissues (eg, fascial and muscle layers) of the incision *and* at least *one* of the following:

1. Purulent drainage from the deep incision but not from the organ/space component of the surgical site.
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38°C), localized pain, or tenderness, unless site is culture-negative.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of a deep incisional SSI by a surgeon or attending physician.

Notes:

1. Report infection that involves both superficial and deep incision sites as deep incisional SSI.
2. Report an organ/space SSI that drains through the incision as a deep incisional SSI.

Organ/Space SSI

Infection occurs within 30 days after the operation if no implant* is left in place or within 1 year if implant is in place and the infection appears to be related to the operation *and* infection involves any part of the anatomy (eg, organs or spaces), other than the incision, which was opened or manipulated during an operation *and* at least *one* of the following:

1. Purulent drainage from a drain that is placed through a stab wound† into the organ/space.
2. Organisms isolated from an aseptically obtained culture or fluid or tissue in the organ/space.
3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination.
4. Diagnosis of an organ/space SSI by a surgeon or attending physician.

*National Nosocomial Infection Surveillance definition: a nonhuman-derived implantable foreign body (e.g., prosthetic heart valve, nonhuman vascular graft, mechanical heart, or hip prosthesis) that is permanently placed in a patient during surgery.
†If the area around a stab wound becomes infected, it is not an SSI. It is considered a skin or soft tissue infection, depending on its depth.
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Cost of SSIs

Surgical site infections raise costs due to prolonged hospitalization, additional diagnostic tests, therapeutic antibiotic treatment, and, rarely, additional surgery.[3] In 2009, it was estimated that SSI extended the length of hospital stay on average by 9.7 days and increased costs by $20,842 per admission; this amounts to additional hospital costs exceeding $900 million, with hospital readmission due to SSI accounting for an additional $700 million in health care spending.[4] Deep SSIs tend to raise costs more than superficial infection.[5] A recent study synthesizing the results of 16 various studies examining the cost of SSIs revealed a mean increase of 115% for the cost of care of a patient with an SSI as compared with noninfected control subjects.[6]

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Microbiology

In the majority of SSI cases, the pathogen source is the native flora of the patient's skin, mucous membranes, or hollow viscera.[7] When skin is incised, underlying tissue is exposed to overlying endogenous flora.[8] Most typically, aerobic gram-positive cocci such as *Staphylococcus* serve as the contaminant, with resistant pathogens such as methicillin-resistant *S aureus* (MRSA) representing an increasing proportion of such infections in recent years.[9,10] Entry into hollow viscera exposes surrounding tissue to gram-negative bacilli such as *Escherichia coli*, gram-positive organisms such as enterococcus, and, occasionally, anaerobes such as *Bacillus fragilis*.[2] Yeast species and viral pathogens also pose a risk.[11] In rare cases in which an unusual pathogen is identified in an outbreak cluster, an epidemiologic investigation should be conducted to rule out a focal contamination source, such as colonized surgical personnel, contaminated bandages, contaminated disinfectant solutions, or other such niduses.[12-15] Table 2 further expands upon various surgical procedures and the most common pathogens encountered in the surrounding tissues.[2]

Patient Risk Factors

Several patient characteristics have been shown to have a significant, independent association for SSI prediction. These include, but are not limited to, diabetes, cigarette smoking, obesity, and coincident remote site infections or colonization.[2] Although the contribution of diabetes to SSI remains controversial, significant relationships have been demonstrated between elevated hgA_{1c} level and SSI rates, as well as postoperative serum glucose levels higher than 200 mg/dL in cardiac surgery populations.[16] Moreover, obesity poses an independent risk for SSI separate from its association with diabetes.[1,17] Cigarette smoking interferes with primary wound healing, possibly secondary to constriction of peripheral blood vessels, leading to tissue hypovolemia and hypoxia.[18,19] Consistent with these findings, in 2003, a randomized, controlled trial demonstrated abstinence from smoking for as little as 4 weeks significantly reduces incisional wound infections.[20] *S aureus* colonization, found in the nares of 20% to 30% of healthy humans, has been strongly implicated as a predictor of SSI involving this organism.[21,22] In a 2008 Cochrane Database review, analysis of 8 randomized, controlled trials demonstrated that mupirocin significantly reduced the incidence of *S aureus*–associated SSIs.[23]

Operative Characteristics

Wound classification (Table 3), a system developed by the National Academy of Sciences and the National Research Council, is a strong predicting factor for subsequent development of SSI.[24] Clean wounds are characterized by incision into nonviscus, uninfected, noninflamed tissue that is subsequently closed primarily. Clean-contaminated wounds result from intentional, controlled entry in a hollow viscus (respiratory, alimentary, genital, or urinary tract) without subsequent contamination. Contaminated wounds, on the other hand, involve accidental visceral entry, operations complicated by gross spillage, departure from sterile technique, or incision into an area of purulent inflammation. Dirty wounds involve surgery on tissue with retained devitalized tissue, foreign bodies, fecal contamination, perforated viscus, or existing, ongoing clinical infection. A near-linear relationship of escalating wound classification and subsequent SSI has been demonstrated in the

A near-linear relationship of escalating wound classification and subsequent SSI has been demonstrated in the literature, with as low as 1.3% of clean wounds and as many as 40% of dirty cases complicated by SSI.

Table 2
Common Pathogens by Surgical Procedure

Operations	Likely Pathogens*†
Placement of all grafts, prostheses, or implants	*Staphylococcus aureus*; coagulase-negative staphylococci
Cardiac	*S aureus*; coagulase-negative staphylococci
Neurosurgery	*S aureus*; coagulase-negative staphylococci
Breast	*S aureus*; coagulase-negative staphylococci
Ophthalmic Limited data however, commonly used in procedures such as anterior segment resection, vitrectomy, and scieral buckles	*S aureus*; coagulase-negative staphylococci; streptococci; gram-negative bacilli
Orthopedic Total joint replacement Closed fractures/use of nails, bone plates, other internal fixation devices Functional repair without implant/device Trauma	*S aureus*; coagulase-negative staphylococci; gram-negative bacilli
Noncardiac thoracic Thoracic (lobectomy, pneumonectomy, wedge resection, other noncardiac mediastinal procedures) Closed tube thoracostomy	*S aureus*; coagulase-negative staphylococci, *Streptococcus pneumoniae,* gram-negative bacilli
Vascular	*S aureus*; coagulase-negative staphylococci
Appendectomy	Gram-negative bacilli, anaerobes
Biliary tract	Gram-negative bacilli, anaerobes
Colorectal	Gram-negative bacilli, anaerobes
Gastroduodenal	Gram-negative bacilli; streptococci; oropharyngeal anaerobes (eg, peptostreptococci)
Head and neck (major procedures with incision through oropharyngeal mucosa)	*S aureus*; streptococci; oropharyngeal anaerobes (eg, peptostreptococci)
Obstetric and gynecologic	Gram-negative bacilli; enterococci; group B streptococci; anaerobes
Urologic May not be beneficial if urine is sterile	Gram-negative bacilli

*Likely pathogens from both endogenous and exogenous sources.
†Staphylococci will be associated with surgical site infection following all types of operations.
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Table 3
Wound Classification

Class I/Clean: An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.
Class II/Clean-Contaminated: An operative wound in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.
Class III/Contaminated: Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (eg, open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered are included in this category.
Class IV/Dirty-Infected: Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.

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In addition to wound classification, emergency procedures, long procedure length, the use of nonabsorbable suture, foreign bodies, copious use of subcutaneous electrocautery, excessive blood loss, and hypothermia have all been correlated with increased risk of SSI.[24,29]

Surgical Attire

Few studies have examined whether a correlation between surgical attire and SSI exists. Several studies have questioned whether the routine use of surgical masks in the operating room reduces SSI risk.[30-32] Several other practices, such as the standard use of "scrub suits," surgical caps, and shoe covers have never been definitively demonstrated to reduce rates of surgical infection, although SSI outbreaks have been traced to hair or scalp organisms (regardless of whether a cap was worn), and increased foot traffic through the operating room has been demonstrated to increase ambient microbial levels and ensuing infection risk.[2,33-35]

Preoperative Antiseptic Showering

Six randomized, controlled trials involving a total of 10,007 patients were examined in a 2007 Cochrane Database review regarding preoperative bathing with skin antiseptics to prevent SSI.[36] Chlorhexidine gluconate was not demonstrated to result in any improvement in SSI as compared with placebo or with bar soap, with the exception of 1 large study revealing a benefit to chlorhexidine washing as compared with no bathing preoperatively.[37] Consistent with these findings, a Swedish-based study examining preoperative vaginal cleansing with chlorhexidine on postoperative infectious morbidity in total abdominal hysterectomy failed to demonstrate a benefit.[38]

Preoperative Hair Removal

Numerous randomized, controlled trials have examined the practice of preoperative hair removal and its relation to operative site infection.[39] Hair has often been perceived to be associated with a lack of cleanliness, and its removal linked to infection prophylaxis.[40] Various modalities of hair removal include shaving, clipping, and depilatory creams. Routine preoperative shaving was not shown to decrease the risk of SSI in laparotomies in 2 randomized, controlled trials, and has been implicated in higher rates of infection.[41,42] Studies have shown that shaving the skin as compared with clipping results in a statistically significant increase in the rate of SSI.[43-45] Shaving results in microscopic cuts and abrasions, thus acting as a disruption of the skin's barrier defense against microorganism colonization. Clippers, when used correctly, should not cut into the patient's skin, potentially explaining the differences in infection rates observed in the above-mentioned trials.

Although shaving does seem to increase the risk of postoperative infection, whether shaving occurs at the time of the surgery or 1 day prior has not been shown to make a difference in terms of rates of infection.[46]

Similarly, the temporal relationship of clipping to surgery has not been shown to result in statistically significant numbers of SSIs, although the above-noted study did reveal a slightly higher rate of infection of those patients undergoing clipping longer than 24 hours prior to surgery.[46]

The CDC recommends that hair not be removed unless it will interfere with the operation, and if hair is to be removed it is done immediately before the operation with electric clippers rather than shaving.[2] Patients who insist on hair removal prior to surgery should be told to clip rather than to shave, but the decision whether to do so the morning of the surgery or the day prior can be left to patient preference.

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Preoperative Hand/Forearm Antisepsis

The risk of SSI stems not only from exposure to the patient's own natural flora, but also from the inadvertent transfer of microorganisms from surgeons and surgical staff to the patient. Sterile gloves are worn in the operating room as a primary barrier against such transfer. This method of antisepsis, however, is not foolproof. Barrier methods depend on use in conjunction with meticulous sterile technique and can be perforated during the course of surgery, leading to transfer of pathogens from surgical staff to patients and vice versa.[46-49] Only 1 large study has examined the impact of glove perforation on the risk of SSI.[50] In that study, 677 of 6540 procedures were complicated by glove perforation; multivariate analysis revealed that SSI was significantly increased in those cases in which no antimicrobial prophylaxis was administered. However, it did not result in increased infection rate in those cases in which prophylaxis was administered. The most effective method for decreasing the frequency of perforation resulting in exposure remains double gloving, which reduces glove failure significantly; double gloving with an indicator glove has also been shown to further reduce inner glove perforation.[51-56]

Although it would seem that finger rings and nail polish would be a potential reservoir for bacteria and should be removed prior to hand preparation, a 2001 Cochrane Database review concluded that there was insufficient evidence to recommend removal of finger rings or nail polish based on SSI rate.[57]

As with patient skin preparations prior to surgery, there exist a number of options for surgical hand and forearm preparation prior to entry to the operating room theater. Aqueous scrubs are water-based solutions, typically contain chlorhexidine or povidone iodine (PI), and require a surgical scrub of 3- to 5-minutes duration. Conversely, newer alcohol rubs, containing concentrated ethanol, isopropanol, or *n*-propanol, involve simple hand washing at the start of the day followed by application of the alcohol solution as a rub prior to surgery, provided the hands are not grossly soiled. Chlorhexidine, iodine, and various other active ingredients can be added to hand rubs to supplement the rapid bactericidal effect of alcohol with extended bacteriostatic activity.

Studies examining hand preparations have been complicated by the use of different endpoints and surrogate outcomes.[58] Three of 4 trials have demonstrated chlorhexidine gluconate to be significantly more effective than PI; however, these studies examined the number of colony forming units subsequent to skin preparation rather than examining actual rates of SSI.[59-61] Similarly, studies examining efficacy of various aqueous rubs have failed to consistently demonstrate supremacy of any given preparation.[62]

Only 1 randomized, controlled trial has directly examined the rate of SSI and the type of hand/forearm antisepsis performed.[63] In this study, surgical staff were randomized to hand rubbing with a 75% aqueous alcohol solution versus traditional hand scrubbing with 4% PI or 4% chlorhexidine gluconate. The 2 protocols were comparable in regard to SSI, but compliance with the recommended duration of hand antisepsis was significantly better in the hand-rubbing protocol, which required 2.5 minutes of hand rubbing as compared with 5 minutes of hand scrubbing. The authors concluded that hand rubbing with an alcohol-based solution after a 1-minute hand wash to remove soil and debris from hands was as effective as traditional hand-scrubbing practices in the prevention of SSIs, and was sometimes better tolerated in terms of skin dryness and irritation.

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In the absence of clear evidence pointing to the supremacy of any single hand/forearm antisepsis practice, surgeons and operating room staff may follow their preference for hand rub versus the traditional hand scrub made available at their institution, taking care to follow the guidelines for the specific antiseptic product chosen.

Patient Skin Preparation in the Operating Room

The purpose of preoperative skin antisepsis is to remove soil and transient organisms from the skin. The skin is a dynamic home to a large number of bacteria, with up to 3 million microorganisms on each square centimeter of skin.[64] Most commonly, SSI occurs from commensal organisms such as staphylococci, diphtheroid organisms, *Pseudomonas*, and propionibacterium species that are consistently present on a patient's skin, compared with transient organisms that are more easily removed. Any chemical agent for microbial reduction of the skin ideally kills all skin organisms, is nontoxic and hypoallergenic, does not result in significant systemic resorption, has residual activity, and is safe for repetitive use.[65] Antiseptics are split into 3 major types: iodine/iodophor, chlorhexidine, and alcohol-based preparations (Table 4).[2]

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Iodine-Based Preparations

Iodine-based surgical antiseptics are effective against a wide range of gram-positive and -negative organisms (including MRSA), as well as tubercle bacillus, fungi, and viruses.[66] Their mechanism of action is via oxidation after penetration of the cell wall.[2] Iodophors such as PI are iodine formulations prepared with a stabilizing agent that liberates free iodine, and can be prepared in aqueous or alcohol preparations. Commercially prepared PI solutions or paints contain approximately 90% water, 8.5% PI, and 1% iodine. PI scrubs contain 7.5% PI, 0.75% available iodine, and detergent. PI may be inactivated by blood or serum proteins, but as long as they are present on the skin exert a bacteriostatic effect.[65,67] However, a newer iodine-based copolymer, iodine povacrylex (74% isopropyl alcohol and 0.7% available iodine) dries to form a lasting film that has been shown to resist being washed away by fluids and blood.[68] A study in 2002 compared PI paint/scrub versus iodine povacrylex in an alcohol film–forming antiseptic. Only 1 patient receiving iodine povacrylex developed a SSI compared with 7 in each of the PI groups (scrub vs paint), which was a statistically significant observation.[69]

Systemic absorption of iodine can occur, and in rare cases has led to iodine toxicosis and death; care should thus be taken when using this preparation in especially high-risk populations such as severe burn victims and newborns.[70,71]

Table 4
Characteristics of Antiseptic Solutions

		Antimicrobial Coverage							
Antiseptic	Mechanism of Action	GPB	GNB	Mtb	Fg	Vi	Onset	Duration	Examples
Aqueous-iodophor	Oxidation/substitution by free iodine	E	G	G	G	G	Moderate	2 h	Betadine® Scrub Care®
Aqueous-CHG	Disrupts cell membranes	E	G	P	F	G	Moderate	6 h	Hibiclens®
Alcohol	Denatures proteins	E	E	G	G	G	Most Rapid	None	
Alcohol-iodine povacrylex	Denatures proteins Oxidation/substitution by free iodine	E	E	ID	ID	G	Rapid	48 h	DuraPrep™
Alcohol-CHG	Denatures proteins Disrupts cell membranes	E	E	ID	ID	G	Rapid	48 h	ChloraPrep®

CHG, chlorhexidine gluconate; E, excellent; F, fair; Fg, fungi; G, good; GNB, gram-negative bacteria; GPB, gram-positive bacteria; ID, insufficient data; Mtb, *Myobacterium tuberculosis*; P, poor; Vi, virus.
Betadine® Microbicide, Purdue Products L.P., Stamford, CT; ChloraPrep®, CareFusion, Inc., Leawood, KS; DuraPrep™ Surgical Solution, 3M Health Care, St. Paul, MN; Hibiclens®, Mölnlycke Health Care Inc., Norcross, GA; Scrub Care®, Cardinal Health, Dublin, OH.

Chlorhexidine-Based Preparations
Chlorhexidine gluconate is a water-soluble cationic biguanide that binds to negatively charged bacterial cell walls, altering the bacterial osmotic equilibrium, which at high concentrations results in cell death.[72] Similar to iodine-based preparations, chlorhexidine is commercially available in aqueous or alcohol formulations, and has broad activity against gram-positive and -negative bacteria, anaerobes, yeasts, and some lipid-enveloped viruses, although fungal coverage is reduced when compared with iodophor- and alcohol-based solutions.[2,73,74] Resistance to chlorhexidine and other biocides has been observed in strains of *S aureus* and *Pseudomonas aeruginosa*, with genetic linkage through plasmid encoding.[75] Unlike iodophor-based preparations, chlorhexidine is not inactivated by blood or serum proteins, and has been demonstrated to have a greater residual activity than traditional PI after single application.[67,76-79]

Alcohol-Based Preparations
Alcohol, in contrast, denatures cell wall proteins, leading to rapid lysis. Coverage is similar to iodine-based preparations. Effectiveness is contingent on concentration rather than on the type of alcohol used.[80] Although rapidly bactericidal, alcohol, once evaporated, has no persistent antimicrobial effect.[81] For this reason, alcohol is often combined with either iodine or chlorhexidine in surgical preparations that take advantage of alcohol's potential for rapid bacterial killing over aqueous preparations. Moreover, in addition to rapid antisepsis, alcohol may prolong the effects of other disinfectants. In a study comparing PI to iodine povacrylex in alcohol solution for skin preparation prior to epidural catheter insertion, iodine povacrylex in isopropyl alcohol solution resulted in more rapid reduction of positive skin cultures, longer duration of action, and lower absolute numbers of organisms cultured from the skin.[82] A common factor noted in many recent studies is the increased effectiveness in antimicrobial agents when they are combined with alcohol.

Although ethanol preparations have excellent antimicrobial profiles, caution must be taken to avoid the risk of fire associated with inadequate drying of these alcohol-based products. Any surgical preparation containing alcohol should be allowed to fully dry (> 3 min) to eliminate the risk of fire with the use of electrocautery, and care should be taken to avoid these preparations in especially hirsute patients, as copious amounts of hair

Main Points

- Surgical site infection (SSI) accounts for 15% of all nosocomial infections and, among surgical patients, represents the most common nosocomial infection. Postsurgical infection leads to increased length of postoperative hospital stay, drastically escalated expense, higher rates of hospital readmission, and jeopardized health outcomes.
- In the majority of SSI cases, the pathogen source is the native flora of the patient's skin, mucous membranes, or hollow viscera.
- Diabetes, cigarette smoking, obesity, and coincident remote site infections or colonization have been shown to have a significant, independent association for SSI prediction.
- Any chemical agent for microbial reduction of the skin ideally kills all skin organisms, is nontoxic and hypoallergenic, does not result in significant systemic resorption, has residual activity, and is safe for repetitive use. Antiseptics are split into 3 major types: iodine/iodophor, chlorhexidine, and alcohol-based preparations.
- Iodine-based surgical antiseptics are effective against a wide range of gram-positive and -negative organisms (including methicillin-resistant *Staphylococcus aureus* [MRSA]), as well as tubercle bacillus, fungi, and viruses. Systemic absorption of iodine can occur, and in rare cases has led to iodine toxicosis and death; care should thus be taken when using this preparation in especially high-risk populations such as severe burn victims and newborns.
- Chlorhexidine is commercially available in aqueous or alcohol formulations, and has broad activity against gram-positive and -negative bacteria, anaerobes, yeasts, and some lipid-enveloped viruses, although fungal coverage is reduced when compared with iodophor- and alcohol-based solutions.
- Although rapidly bactericidal, alcohol, once evaporated, has no persistent antimicrobial effect. For this reason, alcohol is often combined with either iodine or chlorhexidine in surgical preparations that take advantage of alcohol's potential for rapid bacterial killing over aqueous preparations. Alcohol may also prolong the effects of other disinfectants.
- Evidence seems to suggest a benefit of preparations combining chlorhexidine or iodine formulations with alcohol, compared with chlorhexidine or iodine formulations alone. Among the different iodine, chlorhexidine, and alcohol families, effectiveness varies depending on concentration, temperature, level of acidity, the particular germ or virus, contact time, and dry versus wet states.

interferes with the drying process and fires have been reported.[83]

Preparation Comparison

Few randomized studies have compared iodine- to chlorhexidine-based antiseptics for preoperative skin preparation. A recent trial by Swenson and colleagues[84] prospectively compared skin preparation using PI scrub-paint combination with alcohol, 2% chlorhexidine, and 70% alcohol and iodine povacrylex in isopropyl alcohol in all general surgery patients over an 18-month period (6 months for each product) at a single institution. This study demonstrated a 2.5% absolute risk reduction for all SSIs when iodine povacrylex in isopropyl alcohol was used as compared with either PI or chlorhexidine and alcohol.

Overall, the evidence does seem to suggest a benefit of preparations combining chlorhexidine or iodine formulations with alcohol, compared with chlorhexidine or iodine formulations alone. Further, when comparing solutions, care needs to be taken to avoid confusing older PI products with newer film-forming iodine povacrylex in alcohol formulations. Finally, even among the different iodine, chlorhexidine, and alcohol families, effectiveness varies depending on concentration, temperature, level of acidity, the particular germ or virus, contact time, and dry versus wet states.

Conclusions

Methods aimed at prevention of infection in the operating room have varying levels of data to substantiate their practice, in some cases vetted by strong randomized, controlled trials showing clear benefit, whereas in others propagated through lore or common sense. Either way, awareness of the important implications of SSI for patient health and costs of care is paramount for any surgeon, and surveilling one's own practices in the operating room with respect to the existing literature is an important step in controlling infection and maximizing beneficial outcomes. ■

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