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WOUND CARE AFTER INJURY (H KAAFARANI AND J GOVERMAN, SECTION EDITORS)

Update on Prevention of Surgical Site Infections

John T. Schulz III [1]

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Abstract

Purpose of Review This review summarizes recent surgical site infection (SSI) prevention guidelines/guideline updates that are relevant to surgery and wound care after injury and reviews a sample of recent literature relevant to SSI.

Recent Findings The quality of evidence supporting guidelines/guideline updates is quite variable. The strongest support is for appropriately timed preoperative antibiotics when indicated and for alcohol-based skin preparation before incision when feasible.

Summary New guidelines for SSI prevention are available from the American College of Surgeons, the Centers for Disease Control, and the World Health Organization. There are recommendations common to all three reports that trauma/acute care surgeons should be aware of.

Keywords Perioperative antibiotics · Surgical site infection · Skin preparation · Guidelines

Introduction

Surgical site infections (SSIs) make up almost one third of hospital acquired infections and are a target of quality improvement efforts by all stakeholders in the US healthcare system. Ranging from relatively rare for clean surgical cases to very common in lower extremity amputations, SSIs are the bane of patient, surgeon, and hospital. At over 150,000 cases annually in the USA [1], SSIs have been estimated to cost the country's acute care hospitals $3.2 billion per year [2] and the cost to an individual patient can range from minor annoyance to death [3]. SSI risk reduction through uniform implementation of evidence-based practices is imperative for hospitals, surgeons, and all perioperative caregivers; and prevention is increasingly incentivized financially by the federal government and other payors.

This section of Current Trauma Reports comes soon after updates to SSI prevention guidelines from multiple organizations, including the American College of Surgeons [4••], the Centers for Disease Control [5••], and the World Health Organization [6••]. A detailed examination of the evidence underlying these guidelines and the associated commentary is beyond the scope of this chapter and readers are referred to the guideline publications themselves. Some of the guidelines are pertinent to wound care after injury and others are not.

The purpose of this review is to summarize recent SSI prevention guideline updates that are relevant to surgery and wound care after injury; to briefly examine the scientific support (or lack of support) underlying some of these guidelines; and to mention SSI-relevant Cochrane reviews and other studies published during the last few years (Table 1).

Relevant CDC Guidelines with Comparison to WHO and ACS

The strength of the evidence underlying published guideline is highly variable and evidence quality is exhaustively reviewed in the guideline publications referenced above [4••, 5••, 6••]. The strongest evidence base in the recent CDC guideline update supports the following recommendations which are emphasized in *italics* and are accompanied by comments regarding the relationship of the ACS and the WHO guidelines to the CDC guidelines.

Parenteral antibiotics should be delivered only when clinically indicated at a time before incision that results in bactericidal serum and tissue levels at the time the

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✉ John T. Schulz, III
jschulz@partners.org

[1] Division of Burns, Department of Surgery, Massachusetts General Hospital, GRB1300, 55 Fruit Street, Boston, MA 02114, USA

Table 1 Summary of evidence-based measures to reduce the incidence of SSI (see text for details)

Preoperative	Intraoperative	Postoperative
Appropriately timed preoperative parenteral antibiotics	Re-dose antibiotics to maintain appropriate tissue levels (based on antibiotic half-life or quantity of blood loss)	No prophylactic antibiotics to be administered after incision is closed
Keep serum glucose < 200	Keep serum glucose < 200	Keep serum glucose < 200
Maintain normothermia	Maintain normothermia	Maintain normothermia
	Administer higher than atmospheric oxygen to intubated patients	Maintain higher than atmospheric oxygen in the recovery room
Have patients bathe with soap and water within 24 h of surgery		
	Prep skin with an alcohol-based antiseptic	
	Do not use plastic adhesive drapes	

start of surgery. The WHO guidelines recommend that antibiotics be given within 2 h before incision and that the drug's serum half-life should be considered when deciding on dosing time. The ACS guidelines specify that all antibiotics except vancomycin and fluoroquinolones should be given within 1 h of incision time (recommends that the two exceptions be given within 2 h of incision). The ACS guidelines further recommend that antibiotics be re-dosed to maintain appropriate tissue levels based on drug half-life or for every 1.5 l of blood loss.

No antibiotics to be given after surgical incision is closed regardless of leaving a drain. The WHO guidelines specify that no antibiotics should be given after surgery is completed (after closure of incision) based on 44 randomized controlled trials. The WHO guideline document also discusses that the evidence underlying "carve outs" to this guideline for specific types of surgery is weak. The ACS agrees, but recognizes that appropriate antibiotic duration for a few procedures (breast reconstruction, cardiac procedures, arthroplasty) is unknown. For the acute care surgeon, the message is to give appropriate antibiotics before and during surgery, NOT after surgery, to reduce the risk of SSI.

Keep serum glucose below 200 mg/dl (CDC relied only on RCTs for this recommendation). The ACS guideline is somewhat more stringent, recommending that perioperative serum glucose be maintained between 110 and 150 mg/dl and less than 180 mg/dl for cardiac surgery cases. The WHO guidelines recommend "intensive" perioperative glucose control, but do not specify a target serum glucose concentration, given the variation in targeted serum glucose concentration among multiple studies.

Maintain normothermia. There is good evidence that hypothermia is accompanied by a higher risk of SSI. The ACS recommends that normothermia be maintained pre-, intra-, and postoperatively. The WHO and CDC guideline papers agree, but comment that there is no randomized data addressing the optimal duration of normothermia or the lower temperature limit for normothermia.

Administer higher than atmospheric FiO2 during surgery and postoperatively to endotracheally intubated patients undergoing general anesthesia. Higher concentrations of oxygen appear to have a salutary effect on the risk of SSI and the WHO guideline publication has the best discussion of the data underlying this recommendation. The ACS guidelines recommend 80% FiO2 be administered intraoperatively and during recovery for those undergoing general surgery.

Have patients bathe/shower with soap and water or antiseptic and water within 24 h of surgery. There is no difference between soap and antibacterial soap in decreasing skin colonization. Clearly, this recommendation is not an option for the emergency general surgery or trauma patient who needs an emergent procedure; but the guideline does apply, if feasible, for any necessary subsequent procedures. A recent meta-analysis addressing this issue was published in 2017 [7].

Prep skin with an alcohol-based antiseptic (unless contraindicated). Based on moderate quality evidence, the ACS guidelines note that chlorhexidine "might" be better than iodine if there are only aqueous antiseptic options available. A recent meta-analysis addresses the issue of chlorhexidine vs iodine [8].

Relevant Issues Addressed by WHO and/or ACS, But Not by the CDC Update

Both the ACS and WHO guidelines strongly recommend against the use of antibiotics for postoperative drain prophylaxis. Such prophylaxis has been common practice in the past. There is no evidence to support the practice and it is poor antibiotic stewardship.

The WHO recommends triclosan antimicrobial sutures for any surgery, while the ACS notes that the evidence is strongest for surgery with clean or clean-contaminated wound classes. Regardless, for those who have triclosan sutures as an option, it probably makes sense to use them. A meta-analysis published in 2017 supported the use of

triclosan-coated vicryl sutures when compared to non-coated PDS in abdominal fascial closure [9]. On the other hand, a UK study of triclosan-coated versus uncoated sutures in joint arthroplasty found no significant difference in SSI rates [10].

The WHO guidelines recommend against the use of plastic adhesive drapes and a Cochrane review on the topic noted that the plastic adhesive drapes are more likely than not to increase the SSI rate (see below).

The ACS guidelines support the use of wound protectors while admitting that the evidence supporting their use is strongest in colorectal and biliary surgery. Support for this guideline can be found in a meta-analysis published in 2015 [11]. The authors of the meta-analysis also present detailed subgroup analyses based on surgical wound class.

The WHO guidelines recommend providing appropriate fluid resuscitation to prevent ischemia. Although this seems a simplistic recommendation, the discussion accompanying it in the guideline publication [6••] is a good review of trials looking at the impact of intraoperative standard of care resuscitation/goal directed therapy/restrictive fluid management on SSI risk.

WHO guidelines specify that antibiotic wound irrigation should NOT be used; the jury is still out on saline; and povidone iodine irrigation is indicated for clean and clean-contaminated cases. This recommendation applies to the surgical incision, not to cavitary irrigation/lavage.

The WHO guidelines support the position that NPWT over closed incisions may reduce the risk of SSI in high risk patients (and see below).

The WHO guidelines specify that laminar flow ventilation in the operating room is NOT recommended for prevention of SSI. Related to this is an observational study from England reporting that the SSI rate did not differ in orthopedic trauma cases between operating rooms with laminar flow ventilation versus plenum flow ventilation [12]. Another interesting paper addressed the topic of whether increased air exchange in the operating room results in cleaner air. The authors concluded not necessarily [13].

Both the ACS and the WHO guidelines recommend against the use of antibiotics postoperatively as SSI prophylaxis for drains. Neither WHO nor ACS guidelines address the issue of how long a drain should remain in place.

Based on multiple randomized controlled trials, the WHO guidelines contend that advanced wound dressings are of no benefit (10 RCTs) in prevention of SSI. This WHO recommendation does not include NPWT and is particularly relevant in the face of aggressively marketed advanced wound care products.

The ACS guidelines recommend closing stomas with a purse-string. Examples of evidence supporting this recommendation include a meta-analysis of RCTs [14] and an observational study from Japan [15].

Cochrane Reviews

In the past 3 years, the Cochrane Group has published a number of reviews and meta-analyses with relevance to wound care after injury. Each of the enumerated items below represents a separate publication:

1. If anything, plastic adhesive drapes increase the rate of SSI [16].
2. There is no clearly correct systemic or topical antimicrobial to use in pressure ulcers, whether infected or not. The quality of evidence here is relatively poor and for those who treat chronic wounds there is little useful guidance in the literature regarding infection [17].
3. There is insufficient evidence to support leaving a drain for SSI prevention after open appendectomy for complex appendicitis [18]
4. There is no evidence to support silver or hydrocolloid wound dressings over something simpler [19].
5. One type of surgical hand scrub cannot be deemed superior to another in terms of preventing SSI [20].
6. Evidence supporting intracavitary lavage is weak [21] and in a non-Cochrane publication, Barnes et al. [22] argued that the need for carefully designed studies to standardize irrigation practices is urgent.
7. An overview publication highlighted the fact that evidence underlying many intraoperative SSI prevention measures is very weak [23].
8. Surgical masks may have no effect on SSI prevention [24].
9. There is only very weak evidence supporting nasal decolonization of MRSA carriers in prevention of SSI [25].
10. Topical antibiotics applied to a closed surgical wound probably reduce SSI rate [26], BUT the ACS guideline document comments that there is not enough evidence to support routine use.
11. Negative pressure wound therapy does not clearly reduce SSI/dehiscence in surgical wounds [27]. It may reduce graft loss in split thickness skin grafts. The ACS guideline document supports the position that NPWT will reduces SSI in groin vascular incisions and abdominal colorectal incisions. A recent paper found that NPWT made a difference in neither SSI nor 12 month follow-up disability in patients with severe open leg fractures [28]
12. There is no evidence to support early vs late showering after surgery in SSI prevention [29]. The ACS guideline document supports showering 12 h after surgery.
13. Timing of primary dressing removal may have no influence on SSI [30]. The ACS guideline document also notes that no evidence supports the contention that timing of primary dressing removal influences the rate of SSI.

Other Studies

Finally, there are a number of other publications in the last 3 years with relevance to wound care after injury:

An Italian meta-analysis addressed the poor quality of evidence supporting antibiotic prophylaxis in open long bone fractures and in penetrating abdominal trauma with hollow viscus penetration and emergent surgery [31].

Antibiotic stewardship is getting increasing attention as exemplified in a recent publication in Annals of Surgery [32] and a call for monitoring of topical antibiotic irrigation in the operating room as part of antibiotic stewardship programs [33].

The Journal of the American College of Surgeons published a provocative study examining the variation in Surgical Wound Classification (SWC), introducing some uncertainty into studies linking wound class to rate of infection. The authors reported that concordance between operative note based and electronic medical record based wound class varied from 47 to 66% among 11 institutions [34]. The conclusion of the authors is worth quoting: "Surgical site infection risk stratification by SWC is likely invalid due to the unreliability of SWC within institutions and variability between institutions…. Surgical wound classification should not be used for SSI risk stratification until a more consistent process can be developed and validated."

And in keeping with the theme that we might not know what we know as well as we think we know it, work out of the Mayo Clinic gives pause to those who believe that analysis of "big data" is straightforward, which has implications for our understanding of both the incidence of SSIs and for the effect of intervention on SSIs [35].

Conclusion

The important take-home lessons from the SSI prevention literature of recent years for the practicing trauma/acute care surgeon are relatively few:

1. Appropriately indicated and timed preoperative antibiotics should be given and re-dosed based on drug half-life or blood loss.
2. An alcohol-based skin prep is preferable unless contraindicated.
3. Normothermia and higher oxygen concentrations during general anesthesia are beneficial.
4. In general, antibiotics are of *no* prophylactic benefit after the surgical incision is closed, regardless of the presence or absence of operatively placed drains.

Compliance with Ethical Standards

Conflict of Interest The author declares no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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