Reduction of Surgical Site Infections

(A Continuing Education Self-Study Activity)

Activity Number: 1136

A Continuing Nursing Education Activity
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REDUCTION OF SURGICAL SITE INFECTIONS

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REDUCTION OF SURGICAL SITE INFECTIONS

(A Continuing Education Self-Study Activity)

OVERVIEW

This continuing education activity focuses on the reduction of surgical site infections. Perioperative nurses continue to implement aseptic practices that result in the surgical patient being free of infection. This is an important patient outcome that takes constant vigil on the part of all members of the surgical team. The risks of surgical site infections are identified and preventive strategies discussed. Background information on the significance of the Surgical Care Improvement Project (SCIP) on the requirement of hospitals to report surgical core measurement data in order to receive payment from Centers for Medicare and Medicaid Services (CMS) is addressed. Antiseptic surgical skin preparation solutions that have demonstrated efficacy in reducing surgical site infections are presented with evidence-based data. At the conclusion of this activity the perioperative nurse should be able to implement best practices for preventing SSIs.

OBJECTIVES

After completing this continuing nursing education activity, the participant should be able to:

1. Identify primary and modifiable risk factors for surgical site infections (SSIs).
2. Describe evidence-based infection prevention strategies and interventions that decrease the risk of SSIs in hospitalized patients.
3. Review results from recent clinical trials that have evaluated efficacy of antiseptic surgical skin preparation solutions.

INTENDED AUDIENCE

This continuing education activity is intended for perioperative registered nurses and surgical technologists who are interested in learning more about reducing surgical site infections.

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INTRODUCTION

Of the more than 30 million surgeries performed in the United States each year, surgical site infections (SSIs) are associated with approximately 500,000 procedures. The average SSI adds 7 to 10 days on to the length of the hospital stay and attributable costs for just one case can range from $12,488 to $36,462. Patients with SSIs experience a longer time to recovery, more pain, and a higher likelihood of developing additional complications compared to patients who do not acquire an infection. Moreover, the risk of death for those affected by SSIs is 2 to 11 times greater than non-infected surgery patients.

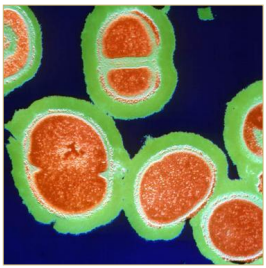
SSI RISK FACTORS AND RISK REDUCTION

Most infections are caused by endogenous factors, such as pathogens that inhabit the patient's skin. *Staphylococcus aureus* is the most frequently found microorganism on the skin and the most common isolate associated with the development of SSIs. Exogenous sources of microorganisms that contribute to SSIs include transient flora from the surgical team members' hands, fingernails, forearms, and jewelry that are transferred to patients. Likewise, instruments, tools, and other materials used in the operating room may be contaminated with bacteria if not properly sterilized.

Figure 1. SSI: Primary Risk Factors

- Endogenous microorganisms
  - Skin-dwelling microorganisms
    - Most common source
    - *S. aureus* most common isolate
- Exogenous microorganisms
  - Surgical personnel
  - OR environment
  - All tools, instruments, and materials

S. aureus



Reference: Mangram AJ, et al. *Infect Control Hosp Epidemiol.* 1999;20(4):250-78

Considering the high rate of morbidity and mortality associated with SSIs, infection prevention is a top priority necessary to improve patient safety. While not all bacterial infections can be prevented, research suggests a significant number can be avoided by the use of assiduous evidence-based infection control measures. Thus, a number of prevention strategies are recommended by the Centers for Disease Control and Prevention (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC) to reduce surgical site morbidity. These recommendations include:

- Ensuring tight glucose control in diabetic patients.
- Having the patient shower with an antiseptic before surgery to reduce bacterial load.
- Leaving hair intact or, if necessary, removing hair with clippers.
- Encouraging the surgical team to practice proper hand and forearm antisepsis to prevent exogenous contamination.

- Treating the surgical site with an antiseptic skin preparation before surgery.
- Initiating a prophylactic antibiotic immediately prior to surgery to reduce microbial burden.
- Ensuring normal body temperature intraoperatively. Hypothermia can cause vessel constriction, which decreases oxygen levels at the surgical site, lowers immunity, and impedes wound healing.

The consistent use of CDC evidence-based strategies has been demonstrated by multiple studies to be associated with lower SSI-related morbidity and mortality. However, successful infection prevention requires a consistent team approach within each facility to ensure that best practices are implemented. This means everyone involved in the surgery, including the patient, must work together to reduce the risk of SSI.

THE SURGICAL CARE IMPROVEMENT PROJECT (SCIP)

SCIP is a national quality partnership of organizations with a common goal to improve patient care by significantly reducing the incidence of surgical complications. SCIP specifications are part of the National Hospital Quality Inpatient Measures of the Centers for Medicare and Medicaid Services (CMS) and The Joint Commission. Because SCIP reporting is a CMS pay-for-performance initiative, hospitals are required to document and publically report specific surgical core measurement data in order to receive full annual payment.

Surgical Care Improvement Project (SCIP)

- SCIP initiative is part of a national campaign to reduce surgical complications 25% by 2010
- Includes the assessment of performance and process measures to reduce SSIs
- CMS has identified specific measures that hospitals are required to report publicly in order to receive full annual payment

Of the modifiable risk factors for SSIs addressed by the CDC guidelines, antibiotic prophylaxis, glucose control, and appropriate hair removal are specifically cited in SCIP as target areas that help reduce the incidence of infection and improve patient care.

Table 1. SCIP Measures

Infection (7)	SCIP-Inf 1:	Prophylactic antibiotic received within one hour prior to surgical incision
	SCIP-Inf 2:	Prophylactic antibiotic selection for surgical patients
	SCIP-Inf 3:	Prophylactic antibiotics discontinued within 24 hour after surgery end time (48 hours for cardiac patients)
	SCIP-Inf 4:	Cardiac surgery patients with controlled 6 a.m. postoperative serum glucose (#200 mg/dL)
	SCIP-Inf 5:	Postoperative wound infection diagnosed during index hospitalization
	SCIP-Inf 6:	Surgical patients with appropriate hair removal
	SCIP-Inf 7:	Colorectal surgical patients with immediate postoperative normothermia
Cardiovascular (3)	SCIP-Card 1:	Non-cardiac vascular surgery patients with evidence of coronary disease who received beta-blockers during perioperative period
	SCIP-Card 2:	Surgical patients on a beta-blocker
	SCIP-Card 3:	Intra- or postoperative acute myocardial infarction (AMI) diagnosed during index hospitalization and within 30 days of surgery
Thromboembolic (4)	SCIP-VTE 1:	Surgical patients with recommended venous thromboembolism prophylaxis ordered
	SCIP-VTE 2:	Surgery patient who received appropriate venous thromboembolism prophylaxis within 24 hours prior to surgery to 24 hours after surgery
	SCIP-VTE 3:	Intr- and postoperative pulmonary embolism (PE) diagnosed during index hospitalization and with 30 days of surgery
	SCIP-VTE 4:	Intra- and postoperative deep vein thrombosis (DVT) diagnosed during index hospitalization and within 30 days of surgery

The Surgical Care Improvement Project (SCIP). Available at: www.qualitynet.org/dcs/ContentServer?c=MQParents&pagename=Medqic/Content/ParentShellTemplate&cid=1122904930422&parentName=Topic.

MODIFIABLE RISK FACTORS: SURGICAL SITE AND SKIN PREPARATION

Antibiotic Prophylaxis

A brief course of an appropriately administered antibiotic prior to surgery reduces bacterial burden and lowers risk of SSI. The CDC recommends adhering to several principles in order to maximize the prophylactic effect of the antibiotic:

- Choose an appropriate antimicrobial agent that will combat the intraoperative pathogens most likely to be associated with the particular surgical procedure.
- Administer a proper dose based on weight/BMI and renal function 1 hour before surgery. Evidence indicates that lower rates of SSIs occur when prophylactic antibiotics are appropriately selected and administered prior to the surgical incision. Most of the appropriate antibiotics should be infused no more than 60 minutes prior to surgery. The longer the duration of time of dose administration prior to surgery, the greater risk of SSI development. Vancomycin is an exception as it can be infused 1-2 hours before the incision.
- Re-dose for prolonged procedures.
- Discontinue antibiotic use within 24 hours of surgery.

Hair Removal

Preoperative shaving of the surgical site is associated with a significantly higher risk of infection than removing hair by depilatory products or by clippers. Shaving creates microscopic abrasions on the skin, which allow an entryway for pathogens. Some studies have reported a higher rate of SSIs related to hair removal by any means. Therefore, CDC guidelines recommend not removing hair prior to an operation unless it is at or around the incision site and will interfere with the procedure. Furthermore, if hair must be removed, it should be clipped immediately before surgery with clippers.

Figure 2. Hair Removal: Clippers vs. Razor

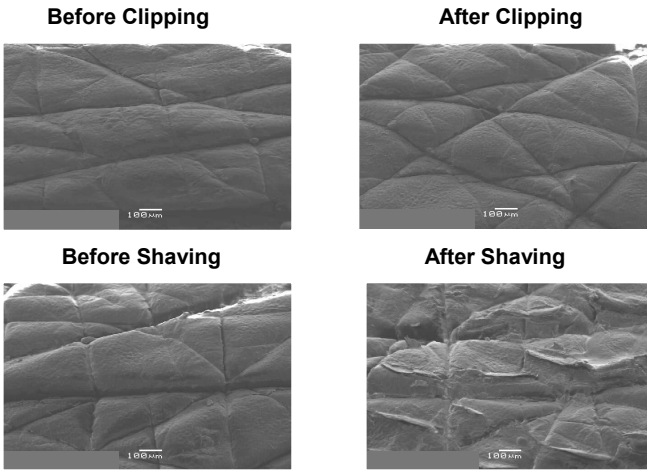
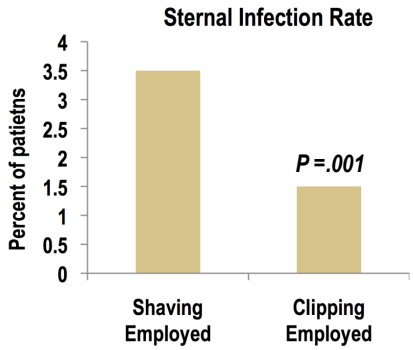


Figure 3. Recent Evidence

- 39-month study on 1827 CABG procedures
  - Patient care pathway
  - Included switch from shaving to clipping, timely antibiotic administration, and tighter blood glucose control
- Sternal infections fell from 3.5% to 1.5%



Reference: Trussell J, et. al. *Am J Surg.* 2008;196:883-9

Glucose Control

Hyperglycemia leads to lower levels of oxygen and compromised blood perfusion in diabetic patients, which consequently slows wound healing and increases infection risk. However, maintaining perioperative blood glucose control has been found to reduce incidence of SSIs. For example, results of one study that evaluated 2467 diabetic patients who underwent open-heart surgery found that keeping blood glucose levels less than 200 mg/dL via continuous insulin infusion during surgery significantly decreased the incidence of serious SSIs.

OTHER MODIFIABLE RISK FACTORS: SURGICAL SITE AND SKIN PREPARATION

Preparing the patient's skin at the site at which surgery will be performed is essential to reduce microflora and decrease risk of postoperative infection. The prepared area should be large enough to accommodate an extension of the incision and additional drainage sites.

The most commonly used skin preparation antiseptics are chlorhexidine gluconate, iodophors, such as povidone-iodine, and alcohol-containing products.

Antiseptic Surgical Skin Preparation Solutions

Alcohol is an inexpensive and rapid-acting germicide that has a broad spectrum of activity against gram-positive and gram-negative bacteria, fungi and viruses. However, the agent has a number of disadvantages to its use as a skin preparation, including a short duration of action, no residual activity, inactivity when exposed to blood or organic materials, minimal to no effect against spores, and it promotes dry skin. In addition, alcohol cannot be used on mucosal membranes.

Iodine/iodophors, like alcohol, kill most gram-positive and gram-negative pathogens, fungi, and viruses, and have some activity against spores. Despite their antiseptic ability, iodophors neutralize rapidly in the presence of organic material (such as blood and serum proteins), vary in persistence, and irritate the skin.

Chlorhexidine is a highly potent and persistent antiseptic that works against gram-positive and gram-negative pathogens, fungi, and viruses, but does not have activity against spores. It remains active in the presence of organic material, is minimally absorbed, and does not cause skin irritation. Furthermore, chlorhexidine has been proven to be highly efficacious at reducing microbial load in numerous studies evaluating hand hygiene practices, IV catheter care, preoperative showers and baths, and skin preparation prior to surgery.

Chlorhexidine in the ICU

Multiple clinical trials have demonstrated the efficacy of chlorhexidine in reducing bacterial colony counts in individuals admitted to the ICU. In one 15-month study conducted in an Illinois teaching hospital, 1787 ICU patients were bathed or cleansed daily with either non-medicated cloths, soap and water-soaked cloths, or cloths saturated with 2% chlorhexidine, and then evaluated for acquisition of vancomycin-resistant *Enterococci* (VRE). Compared to non-medicated or soap and water baths, cleansing with chlorhexidine cloths produced significantly less VRE contamination on patients' skin, ICU workers' hands, and environmental surfaces.

In another recent study, ICU patients who also received daily baths with chlorhexidine were significantly less likely (61%) to acquire a primary blood stream infection (BSIs) or catheter-associated BSI compared to subjects who were bathed in soap and water.

Table 2. Skin Preps: Comparison

Active Agents	Traditional Iodophors	Alcohol	CHG
Broad Spectrum	X	X	X
Rapid Activity		X	
Residual Activity			X
Activity in Blood/Organic			X
Non-Irritating			X

References: Larson EL. *Am J Infect Control.* 1995;23(4):251-69.

Boyce JM, et al. *MMWR Recomm Rep.* 2002;51(RR-16);1-45.

Preoperative Showers

Prior to surgery, the CDC recommends that patients take an antiseptic shower to decrease skin microbial density. The 2 most common antiseptic agents used for preoperative showers and baths are chlorhexidine gluconate and povidone-iodine. Although both drugs have broad-spectrum activity against numerous microorganisms, the CDC guidelines stated that showering with chlorhexidine prior to surgery has been demonstrated to reduce skin bacterial colony count significantly more than a shower with povidone-iodine (9-fold vs 1.3-fold, respectively).

EFFICACY OF ANTISEPTIC SURGICAL SKIN PREPARATION SOLUTIONS: RECENT STUDIES

Due to the unique anatomy of the foot, successful elimination of bacteria on the skin around and in between the toes prior surgery is challenging. Consequently, wound contamination and higher SSI rates have been reported in foot and ankle procedures compared to other types of surgery.

One recent study assessed the effectiveness of 3 skin antiseptic preparation solutions in eliminating bacteria from the foot preoperatively. Before incision, patients were randomized to be cleansed with either chlorhexidine/isopropyl alcohol (IPA), iodine/IPA, or chloroxylenol. After skin preparation, cultures of bacteria were obtained from the hallux nail fold, between the toes, and from the anterior tibia (control site). Results revealed that overall, chlorhexidine/IPA was the most effective antiseptic skin prep among the 3 study agents. Compared to iodine/isopropyl alcohol and chloroxylenol, chlorhexidine/IPA significantly reduced bacteria colony counts of the halluces and toes.

In another recent study, chlorhexidine/isopropyl alcohol was more effective than iodine/isopropyl or povidone-iodine in eliminating overall bacteria from the shoulder region of 150 surgery patients. Significantly lower positive culture rates of coagulase-negative *Staphylococcus* and *Propionibacterium acnes* were found in the chlorhexidine/IPA group versus the other 2 skin prep cohorts.

While these studies and numerous others have established chlorhexidine as a potent antiseptic that provides meaningful reductions in skin bacterial colony counts in many different types of surgery, until recently there was no definitive proof that the agent lowered SSI rates. However, a recently published trial of 897 patients undergoing clean-contaminated surgery demonstrated that chlorhexidine-alcohol scrub was significantly more effective than povidone–iodine scrub for the prevention of SSIs. In this multi-institutional prospective study, subjects were randomized to be prepped with either chlorhexidine and alcohol scrub or a povidone-iodine skin scrub and paint. All patients were similar with respect to demographics, other medical conditions, individual risk for infection, and length and type of surgery.

The investigators followed the subjects for 30 days after surgery to identify the incidence of any SSI. Results revealed a significant 41% reduction in overall SSI rate in those who were prepped with chlorhexidine-alcohol versus individuals who received povidone-iodine prep (9.5% vs 16.1%; P=0.004, respectively). Chlorhexidine–alcohol was also significantly more effective than povidone–iodine in preventing both superficial incisional infections (4.2% vs 8.6%, P=0.008) and deep incisional infections (1% vs 3%, P=0.05). However, there were no notable differences between the 2 cohorts in the rate of organ-space infections or sepsis due to SSI. Additionally, the occurrence of adverse events was similar in both groups.

Table 3. Proportion of Patients with Surgical-Site Infection, According to Type of Infection (Intention-to-Treat Population).

Type of Infection	Chlorhexidine–Alcohol (N=409)	Povidone–Iodine (N=440)	Relative Risk (95% CI)*	P Value†
	no. (%)			
Any surgical-site infection	39 (9.5)	71 (16.1)	0.59 (0.41–0.85)	0.004
Superficial incisional infection	17 (4.2)	38 (8.6)	0.48 (0.28–0.84)	0.008
Deep incisional infection	4 (1.0)	13 (3.0)	0.33 (0.11–1.01)	0.05
Organ-space infection	18 (4.4)	20 (4.5)	0.97 (0.52–1.80)	>0.99
Sepsis from surgical-site infection	11 (2.7)	19 (4.3)	0.62 (0.30–1.29)	0.26

* Relative risks are for chlorhexidine–alcohol as compared with povidone–iodine. The 95% confidence intervals were calculated with the use of asymptotic standard-error estimates.
† P values are based on Fisher's exact test.

Reference: Darouiche RO, et al. *N Engl J Med*. 2010;362:18-26.

Table 4. Proportion of Patients with SSI, According to Type of Surgery (ITT).

Type of Surgery	Chlorhexidine–Alcohol		Povidone–Iodine	
	Total No. of Patients	Patients with Infection	Total No. of Patients	Patients with Infection
		no. (%)		*no. (%)*
Abdominal	297	37 (12.5)	308	63 (20.5)
Colorectal	186	28 (15.1)	191	42 (22.0)
Biliary	44	2 (4.6)	54	5 (9.3)
Small intestinal	41	4 (9.8)	34	10 (29.4)
Gastroesophageal	26	3 (11.5)	29	6 (20.7)
Nonabdominal	112	2 (1.8)	132	8 (6.1)
Thoracic	44	2 (4.5)	57	4 (7.0)
Gynecologic	42	0	40	1 (2.5)
Urologic	26	0	35	3 (8.6)

Reference: Darouiche RO, et al. *N Engl J Med*. 2010;362:18-26.

Figure 4. Standards of Pre-Operative Skin Prep.

- Use a combination of a rapid-acting agent (alcohol) and a longer lasting agent (chlorhexidine)
- Greater activity of chlorhexidine compared to iodine/iodophors
  - Both in the laboratory and on patient's skin
- Continued antimicrobial activity of chlorhexidine in presence of blood and serum
  - Iodine/iodophors become inactivated in the presence of these fluids
- Accumulative benefit of chlorhexidine when repeatedly applied
- 50% reduction in intravascular catheter-related infections when chlorhexidine is used as skin prep

Reference: Milstone AM, et al. *Clin Infect Dis.* 2008;46:274-81.

CONCLUSION

SSIs are common and costly complications that increase morbidity and mortality in hospitalized patients. While not all SSIs can be prevented, research has established that a significant portion can be avoided by following evidence-based infection control principles, such as tight glucose control in diabetic patients, timely prophylactic antibiotic administration, appropriate hair removal, and aseptic skin and surgical site preparation. However, in order for prevention strategies to be successful, a team approach within each facility is necessary to ensure that best practices are implemented consistently.

GLOSSARY

Cohort	To place two or more residents colonized or infected with the same pathogen in the same living quarters.
Endogenous	Produced within or caused by factors within the organism.
Exogenous	Originating outside or caused by factors outside of the organism.
Healthcare-Associated Infection (HAI)	An infection acquired by patients during hospitalization, with confirmation of diagnosis by clinical or laboratory evidence.
Multi-Drug Resistant Organisms (MDRO)	Bacteria, viruses and other microorganisms that have developed resistance to antimicrobial drugs.
Surgical Site Infection (SSI)	An infection occurring at the site of a surgical incision within the first 30 days after surgery or the first year after a procedure involving an implantable device.

ABBREVIATIONS AND ACRONYMS

AMI	Acute myocardial infarction.
BMI	Body mass index.
BSI	Blood stream infection.
CABG	Coronary artery bypass graft.
CDC	Centers for Disease Control and Prevention.
CMS	Centers for Medicare and Medicaid Services.
CHG	Chlorhexidine gluconate.
CPI	Consumer Price Index.
CVC	Central venous catheter.
CLABSI	Central line-associated bloodstream infection.
DVT	Deep vein thrombosis.
HAI	Healthcare-associated infection.
HICPAC	Healthcare Infection Control Practices Advisory Committee.
IPA	Isopropyl alcohol.
ITT	Intent-to-treat.
IV	Intravenous/Intravascular.
ICU	Intensive care unit.
MRSA	Methicillin-resistant *Staphylococcus aureus.*
PE	Pulmonary embolism.
PI	Povidone-iodine.

S. aureus	*Staphylococcus aureus.*
SCIP	Surgical Care Improvement Project.
SSI	Surgical site infection.
VRE	Vancomycin-resistant *Enterococcus.*
VTE	Venous thromboembolism.

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