INTERNATIONAL SOCIETY FOR INFECTIOUS DISEASES

GUIDE TO INFECTION CONTROL IN THE HEALTHCARE SETTING

The Operating Room

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Topic Outline

KEY ISSUES

Two to five percent of patients undergoing surgical procedures suffer from surgical site infections (SSIs). These infections cause significant patient morbidity and mortality and burden healthcare systems with immense costs. SSIs are the most common cause of healthcare-associated infections, are a common type of adverse events among hospitalized patients, and are the most frequent cause of readmissions. Because SSIs are primarily acquired during the surgical procedure while the wound is open, a number of infection control practices merit scrutiny in the operating room (OR). The measures presented in this chapter address environmental and surgical issues as well as some patient-related factors which are implemented once the patient is in the OR. Recent guidelines to prevent SSIs in acute care hospitals have been published by the Society for Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA) and the Association of Professionals in Infection Control (APIC) and categorize many of the measures described here as essential practices. According to this review, essential practices are measures that should be adopted by all acute care hospitals. Essential measures to implement once the patient is in the OR are summarized in the table. All members of the surgical team should comply with these measures with particular attention, to decrease risk of infection for every surgical patient.

KNOWN FACTS

- Many factors contribute to the risk of SSIs and their prevention is complex and requires implementing measures before, during, and after surgery. Most SSIs arise from the patient's endogenous flora, which contaminates the wound by direct contact during the procedure.

Therefore, preparing patients for surgery aims at decreasing the microbiologic burden of the patient's bowels, skin, respiratory tract, genital tract, etc., depending on the procedure being performed. Examples of measures which decrease the microbiologic burden include: showering the patient with an antiseptic (such as chlorhexidine) or plain soap before surgery, giving proper antimicrobial prophylaxis immediately before skin incision and, in some surgical procedures like in orthopedic surgery, applying mupirocin to the nares for *Staphylococcus aureus* nasal carriers.

- Exogenous contamination of wounds is also important in the pathophysiology of SSIs, particularly for clean surgical procedures. The major exogenous source is transmission by air; airborne particles contaminated with live bacteria can enter sterile surgical fields during operation, particularly when implants are being placed (e.g., total hip prostheses).
- Airborne bacteria in the OR originate primarily from the skin and hair of individuals in the room. Caps, gowns, and masks are designed to prevent such shedding. The number of persons present in the OR as well as their level of activity, the type of surgery, the quality of air provided, the rate of air exchange, the quality of staff clothing, the quality of cleaning process and the level of compliance with infection control practices, all influence airborne contamination. Although these may seem trivial issues for contaminated or dirty procedures, they are important to consider in clean and clean-contaminated surgery.

SUGGESTED PRACTICE

Environmental Issues

- The surgical suite is usually divided into two designated areas: semi-restricted and restricted, defined by the physical activities performed in each area. The **semi-restricted area** includes the peripheral support areas of the surgical suite, including storage areas for clean and sterile supplies, sterile processing rooms, scrub stations, and corridors leading to restricted areas. The semi-restricted area is limited to authorized personnel and to the patient. Surgical attire as well as headgear are recommended in this area. The **restricted area** is primarily intended to support a high level of asepsis control. In the restricted area, which includes the ORs and clean core, surgical attire, head covering, and masks are required where open sterile supplies or scrubbed persons are present.
- Modern operating rooms which meet current air standards in the United States should be virtually free of particles larger than 0.5μm when no people are in the room. To achieve this, ORs should be equipped with positive-pressure systems to ensure that air travels from ORs to adjacent areas, thus minimizing inflow of air to the room. This positive pressure system is challenged every time a door is opened.
- Ventilation of ORs should filter air at a minimum of 20 air changes/hour of which at least four changes should be with fresh air. If resources allow, this air should be high-efficiency filtered (HEPA). The temperature of ORs should be kept between 68◦ F (20◦ C) and 75◦ F (24◦ C), with humidity of 20% to 60%.
- The inanimate theatre environment should make a negligible contribution to the incidence of SSIs. Cleaning and disinfection of the operating theatre should follow a precise schedule: for example, floors should be cleaned once a day, and at the end of each session.

Horizontal surfaces and all surgical items (e.g., tables, buckets) should be cleaned between procedures. Specific blood or body fluid spillages should be dealt with immediately. Walls and ceilings are rarely heavily contaminated; therefore, cleaning them twice a year is reasonable.

- Culturing the OR environment is unnecessary because inanimate objects and surfaces are seldom the cause of SSIs.

Preparation of the Surgical Team and of the Surgical Field

- All members of the surgical team who will work on the operating field should scrub arms and hands with antiseptic solution, for 2-5 minutes before the first procedure of the day, and a shorter period may be appropriate for subsequent procedures. The first scrub of the day should include a thorough cleaning underneath fingernails. A Cochrane review published in 2016 concluded that there was no firm evidence to suggest that one type of hand cleanser is superior to another in reducing SSIs. The investigators did find a weak superiority of chlorhexidine gluconate (CHG) over povidone-iodine in reducing colony-forming units (CFUs). The use of an alcoholic chlorhexidine solution has a greater residual antimicrobial activity, which could give a theoretic advantage during a long surgical procedure. Hand rubbing with aqueous alcoholic solution (without water) is as effective as traditional hand scrubbing and also better tolerated by the surgical team. The volume used with waterless scrub should keep the skin wet for the duration of the hand rub. Scrubbing with a brush may damage skin and increase bacterial counts on the hands.
- All jewelry should be removed, and artificial nails must not be worn as these are associated with enhanced hand colonization with bacteria and yeasts.
- The association between wearing nail polish by surgical team members and the risk of SSI has yet to be proved. Despite this, experts reviewing

guidelines to prevent healthcare associated infections through hand hygiene recommend against wearing fingernail polish or gel shellac among scrubbed personnel who will interact with the sterile field during surgery.

- After performing the surgical scrub, members of the surgical team should keep hands up and away from the body so that the water runs from the tips of the fingers toward the elbows.
- Sterile gloves should be of good quality. Wearing two pairs of gloves is suggested as many as 50% of gloves are punctured, particularly during cemented total joint arthroplasties, but studies of low quality cannot make this measure an essential practice. Gloves should be changed immediately after any accidental puncture. Some experts also recommend routine changing of the outer gloves after draping, as this procedure is likely to contaminate gloves.
- The operative site should be scrubbed with a combination of alcohol and antiseptic agent. Alcohol solutions are preferred to aqueous solutions for skin preparation, but it is important to allow the alcohol to dry after application and before the use of electrocautery. Alcohol should not be used for certain procedures where a fire risk exists such as when the agent may pool or not dry (eg: craniotomies and hair). The best antiseptic to combine with alcohol remains unclear but recent data support the use of CHG over povidone-iodine. CHG also presents the advantage of activity in the presence of blood or serum, and is the antiseptic of choice for patients colonized with *Staphylococcus aureus*. No study has clearly demonstrated that the ritual of skin preparation from the proposed operative site outward is superior.
- In cesarean delivery and hysterectomy, an antiseptic-containing (CHG or povidone-iodine) preoperative vaginal preparation agent applied immediately before the procedure has shown a reduction of endometritis, with a possible greater benefit among women in labor.
- Sterile drapes must be placed on the patient and on any equipment included in the sterile field. Once a sterile drape is in position, it must not

be moved. Plastic adhesive drapes (with or without antimicrobial properties) have gained popularity in recent years, with the intent to prevent contamination of the surgical incision by the skin and subcutaneous tissues. In a review of over 4 000 patients done by Webster and Alghamdi, no evidence was shown in support of their efficacy in reducing SSIs when compared to no adhesive drapes (woven or disposable/paper drapes). There was some evidence that they may increase SSI rates.

- Meticulous operative techniques reduce the risk of SSIs: surgeons should obliterate dead spaces, where possible, they should handle tissues gently, limit use of electrocautery and remove all devitalized tissue before closure. Good surgical technique may be reflected in shorter durations of procedures which are associated with a lower risk of SSIs.
- Some surgeons adopt a clean closure protocol which includes changing instruments, gloves and gowns before skin closure although no study has demonstrated a benefit of this measure on SSI rates.
- Scheduling dirty cases at the end of the day is a practice which should be abandoned.
- Antiseptic impregnated sutures may be used for the purpose of decreasing SSI rates when SSI rates remain high despite applying all infection control measures that are considered essential practices.
- Asepsis should be maintained from the start of preparation of surgical instruments on the sterile field until wound closure and dressing. Some investigators have demonstrated a direct correlation between the duration of open exposure of instrument trays and the risk of bacterial contamination. Therefore, the timing of opening trays should occur as close to the start of the procedure as possible, with a theoretical advantage of covering trays with a sterile drape when not in use but further study regarding timing and techniques of covering trays are needed.

Surgical attire

- The contribution of surgical attire to the development of SSI is unresolved. Surgical attire is often considered part of longstanding traditions but still merit scrutiny particularly in clean surgical procedures when implant are inserted.
- Members of the surgical team entering the OR when an operation is about to begin or already underway should wear a mask and headgear which fully covers hair, sideburns, and neckline. Experimental studies using tracer particles have shown that bacteria can be shed from hair, exposed skin, and mucous membranes of both OR personnel and the patient's skin. This is why we use barriers (masks, gowns, hood, and drapes) in the OR. But besides sterile gloves and impervious surgical gowns, no clinical studies have proved that the use of these barriers has led to a decrease in SSI rates. They are nonetheless recommended not only for the purpose of reducing the shedding of microorganisms in the OR but also as part of standard precautions. Barriers are most important when the procedure implies the insertion of an implant/prosthesis.
- The type of surgical headgear (bouffant, calotte style, in tissue) has been called into question. The 2016 edition of the US Association of perioperative registered nurses procedure manual suggested that all OR personnel wear disposable bouffant type hats. However, no definitive scientific evidence links bacteria in the hair to SSIs. A recent study suggests that cloth skull caps worn during mock surgical procedures were superior to disposable bouffant hats in preventing airborne contamination in the OR.
- Shoe covers can be replaced by ordinary shoes dedicated exclusively to the operating theater or clean shoes, because no significant difference

was found in floor contamination whether personnel wear shoe covers or ordinary shoes. These latter shoes must be easy to wash. The practice of wearing plastic/paper shoe covers for the purpose of decreasing SSIs should be abandoned.

- The Association of periOperative Registered Nurses (AORN) recommendation of scrub suits covering most bare skin to decrease shedding of microorganisms from uncovered skin is much debated.
- Strike-through in operating gowns is also a potential source for contamination, particularly at the sleeve or abdominal area. For procedures at high risk of blood contamination, a waterproof apron or more resistant gowns should be worn.
- No well-controlled studies evaluate whether restricting the use of surgical scrubs to the OR suite or allowing them outside the OR will make a difference on SSI rates. Some hospitals require covering gowns when surgeons/nurses leave the OR still wearing surgical scrubs. It would make sense to change grossly soiled scrubs, scrubs worn while changing dressings on wards between surgical procedures, and possibly changing scrubs after wearing them for 8 hours or more.
- Any member of the surgical team who suffers from a skin lesion such as a boil should refrain from working in the OR as such an individual may be dispersing tremendous amounts of bacteria, namely *S. aureus*, in the air of the OR. Dermatitis of the hands sometimes caused by glove allergy should also be taken seriously for the same reason. Cotton glove liners and consultation with dermatology are important measures to deal with this problem promptly.

Preparing the Patient in the Operating Room

- Because many infection control measures to decrease SSI rates are performed once the patient is in the OR, the surgical team should be meticulous in implementing the following essential practices.

- Antibiotic prophylaxis, when indicated, is a very important preoperative practice and excellent guidelines have been published. The choice of antibiotic according to the procedure, the dose according to the patient's weight, the timing of administration before incision, and the timing of intra-operative re-dosing, where appropriate, are all important issues to consider. Proper antimicrobial prophylaxis involves administering the dose within 60 minutes before incision to obtain adequate tissue levels of antibiotic before contamination occurs. Thus, the antibiotic should be administered in the OR by a designated person who should also make sure that it is repeated if the intervention exceeds two half-lives of the antimicrobial agent (in a patient with normal renal function), (for example, cefazolin should be repeated every 4 hours if the procedure lasts longer than 4 hours) or if there is excessive blood loss during the intervention (i.e > 1500 ml). An automatic alert may help with compliance with repeating antibiotic intraoperatively. The redosing interval has to be measured from the time of administration of the preoperative dose and not from incision time or start of surgery, assuring a normal renal function for the patient. Using a checklist for preoperative briefing ensures that the antibiotic is correctly administered in the OR. The antibiotic used as prophylaxis should also be stopped at the time of wound closure, in the OR.
- Every surgical patient should properly be questioned on penicillin allergy and every effort should be made to give a ß-lactam such as cefazolin if the allergy is not considered severe. Studies have shown that not receiving a ß-lactam for antimicrobial prophylaxis when presumed allergic to penicillin is associated with increased risk of SSI.
- Any perioperative event that causes vasoconstriction, for example hypothermia or subtle hypovolemia, alters the oxygenation of normal soft tissues, which in turn may result in higher infection rates. Hypothermia also may directly impair neutrophil function, and may increase blood loss creating hematomas which subsequently favor SSI. The effect of hypothermia on the development of SSI has been studied

particularly well in patients undergoing colorectal surgery, but also in breast, varicose vein, and hernia surgeries, and is now recommended for all types of surgical procedures. Maintaining normothermia (temperature > 35.5 C) during the pre-operative period is considered an essential practice, and appears to be most beneficial 30 minutes before incision time.

- Another process measure considered an essential practice is hair removal. As hair removal with a razor is clearly associated with increased risk of SSI, hair removal before surgery should be done with a clipper, immediately before the intervention if necessary, or no hair removal if hair does not interfere with the procedure. Hair removal should be done outside the OR.
- The use of plastic ring wound protectors for gastro-intestinal and biliary tract surgery is another approach for shielding exposed tissues from microbes during the procedure. Such devices help retraction of an incision during the procedure without the need for other mechanical retractors. According to a recent meta-analysis studying 2689 patients undergoing abdominal surgery, this type of device was associated with a 30% decrease in SSI rates.
- Data on irrigation of the compartmentalized wound to wash away any contaminates before skin closure are also encouraging. Recent guidelines now recommend that surgeons perform intraoperative antiseptic wound lavage before closure. This is a common practice among surgeons and evidence now shows that irrigation with dilute povidone-iodine may decrease the risk of SSI. The systematic review by Norman et al. does not support saline lavage nor antibiotic irrigation. Bacitracine is now contraindicated for this purpose, following reports of intraoperative anaphylactic shock associated with bacitracin irrigation of the surgical wound.

SUGGESTED PRACTICE IN UNDER-RESOURCED SETTINGS

- For hospitals with limited resources, less expensive strategies to keep air in the OR as clean as possible might include:
  1. Keep personnel to minimum in the OR during a procedure.
  2. Limit idle conversations as this creates dispersion of bacteria.
  3. Keep doors closed, and
  4. Keep entries into the OR to a minimum during a procedure, as the opening/closing of doors can generate significant air currents and increase the probability of bacteria being deposited in the surgical site. Agreeing on the equipment needed prior to surgery can lead to fewer door openings.
- Because chlorhexidine is more expensive, some evidence may support the use of alcohol based antiseptics with iodine for surgical skin preparation.
- Evidence of alcohol-based handrub as surgical hand preparation does exist in cost-effectiveness studies. Local production should be encouraged as access to clean water may be a challenge in poor rural areas (see Guide to Local Production: WHO-recommended Handrub Formulations. 2010; http://www.who.int/gpsc/5may/Guide_to_Local_Production.pdf)
- Simple blankets instead of electrical or active forced-air warming systems might function as efficiently to warm patients during surgical procedure and preoperatively.
- Perform audits to assess OR processes to identify lapses is important (eg; antimicrobial prophylaxis such as dose according to patient's weight, timing of antibiotic before incision, hair removal, skin preparation, level of traffic, environmental cleaning processes, etc)
- Use a checklist to ensure that all infection control practices are controlled in the OR.

- Educate Surgical team on the importance of these measures in the OR and provide feedback regarding rates of compliance with process measures.

SUMMARY

- Preparation of the surgical team and maintaining a clean operating environment are important because a number of intraoperative risk factors contribute to the development of SSIs. Very little has changed over the years concerning the surgical rituals of scrubbing, gowning, and gloving perhaps because of a lack of scientific data or for ethical reasons. Many of these rituals still hold today not only for the prevention of SSIs but also for the protection of the surgical team. In clean surgical procedures, particularly when an implant is inserted, these rituals merit attention because airborne contamination by members of the surgical team from their skin may contribute to SSIs. Wearing proper surgical attire, keeping OR doors closed, and traffic to a minimum are simple measures that decrease airborne contamination. Applying basic principles of antisepsis in the OR should be a priority for every member of the surgical team. Every OR department should develop its own infection control policy.
- Prevention of SSIs by well approved measures (categorized as essential practices in recently published guidelines) performed in the OR (e.g. normothermia, antimicrobial prophylaxis) will decrease morbidity and mortality associated with SSIs and healthcare costs.

TABLE: ESSENTIAL PRACTICES ACCORDING TO SHEA/IDSA/APIC GUIDELINES for prevention of SSI, to implement in the OR

Patient related measures	
Administer antimicrobial prophylaxis according to evidence-based guidelines	-Proper choice according to procedure (consult guidelines) and proper dose according to patient's weight -administer antibiotic in the OR to ensure timing within 60 minutes of incision - repeat antibiotic if procedure exceeds two half-lives of antibiotic or if excessive blood loss -discontinue antibiotic at the time of wound closure -question surgical patient on penicillin allergy and do not avoid B-lactam if allergy not considered severe -Do not routinely use vancomycin for antimicrobial prophylaxis
Use antiseptic-containing preoperative vaginal preparation for patient undergoing cesarean delivery or hysterectomy	Apply antiseptic CHG or povidone-iodine immediately before procedure.
Do not remove hair unless it interferes with procedure	If hair has to be removed, use a clipper immediately before intervention but outside of OR
Use alcohol containing antiseptic for skin preparation	Combination of alcohol with CHG appears to be more effective. Do not use alcohol if the agent may pool or not dry (eg: in the presence of hair) because of fire risk
Perform intraoperative antiseptic wound lavage before closure	Irrigation with dilute povidone-iodine may decrease the risk of SSI.

	Do not use bacitracin, antibiotic or saline lavage.
Maintain normothermia during the preoperative period	Temperature > 35.5 Studies show benefit of both preoperative and intraoperative warming in decreasing SSI risk
Surgical team	
Surgical scrub for hands and forearms antisepsis	Scrub arms and hands with antiseptic solution, for 2-5 minutes before the first procedure of the day, and a shorter period may be appropriate for subsequent procedures Prohibit jewelry, nail polish and artificial nails for every member working on the sterile field.
Use impervious plastic wound protectors for gastro-intestinal and biliary tract surgery	The plastic sheath wound protector facilitates retraction of incision during the procedure and decrease SSI risk
Use a checklist to ensure all measures are meticulously implemented and followed	The use of a bundle approach can decrease SSI but the exact measures to include in the checklist should be decided locally.

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