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REVIEW

Infection management following ambulatory surgery

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Anne B Chin
Elizabeth C Wick

Department of Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

Abstract: Surgical site infections (SSIs) are frequent postoperative complications that are linked to measures of surgical quality and payment determinations. As surgical procedures are increasingly performed in the ambulatory setting, management of SSIs must transition with this trend. Prevention of SSIs should include optimization of patient comorbidities, aggressive infection control policies including appropriate skin decontamination, maintenance of normothermia, and appropriate antibiotic prophylaxis. Systems must also be set in place to provide adequate surveillance for identification of SSIs when they do occur as well as provide direct feedback to surgeons regarding SSI rates. This may require utilization of claims-based surveillance. Patient education and close follow-up with the clinical team are essential for early identification and management of SSIs. Therapy should remain focused on source control and appropriate antibiotic therapy.

Keywords: ambulatory surgery, SSI, infection

Introduction

Surgical site infection (SSI) rate is one of the leading outcome measures of surgical quality, and is currently tied to payment determinations.[1] SSIs are a common postoperative complication and account for approximately 20% of all hospital-acquired infections.[2] The overall impact of these infections is undoubtedly larger than we can conclude based on these numbers alone, as SSIs are underreported and surveillance data is only available for limited procedures. It has been well established that SSIs following inpatient surgery result in increased morbidity, length of hospital stay, and cost.[3,4]

Currently, the majority of surgical procedures are performed in ambulatory settings, and the number increases each year.[5,6] However, there is little data about SSIs following ambulatory surgery. In fact, the majority of ambulatory surgical centers (ASCs) are not required to report hospital-acquired infection to the National Health Safety Network (NHSN). Only facilities located within the states of Colorado, Massachusetts, Nevada, New Hampshire, New Jersey, and Texas are currently required to report SSIs to the NHSN.[7]

Inspections of Medicare-certified ASCs in 2008 revealed that lapses in infection control at these facilities were common, with 67.6% of ASCs having had at least one lapse in infection control during the study time period.[8] Fortunately, despite the commonality of these breakdowns in protocol, reported rates of SSIs following ambulatory surgery, as assessed by administrative data, are generally low and comparable with rates reported for inpatient surgery.[9–11]

Correspondence: Elizabeth C Wick
The Johns Hopkins University School of Medicine, Blalock Room 658, 600 N Wolfe St, Baltimore, MD 21287, USA
Email ewick1@jhmi.edu

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Defining SSI

The NHSN was established by the Centers for Disease Control and Prevention to monitor quality control measures including SSIs. As part of this monitoring process, the NHSN has developed a widely used set of criteria for defining SSIs. In this model, infections are categorized based on depth of involvement (Table 1). The categories are superficial incisional, deep incisional, and organ/space.

Most SSIs are the result of contamination either from the skin, the tissues surrounding the incision, or from other structures involved in the operative procedure. The most common pathogens associated with SSI are *Staphylococcus aureus*, coagulase-negative *Staphylococci*, *Escherichia coli*, *Enterococcus faecalis*, and *Pseudomonas aeruginosa* according to the NHSN surveillance report from 2009 to 2010.[12]

Risk factors

There are a number of variables that influence the likelihood of developing an SSI. SSIs develop as the result of a complex interaction of variables ranging from type of procedure involved to patient-related factors.

Procedure

All surgical procedures carry a risk of infection. However, SSI rates can vary greatly between procedures. This is in part

Table 1 Surgical site infection criteria

Category	Criteria
Superficial incisional SSI	Infection occurs within 30 days after the operative procedure (where day 1= the procedure date) AND Involves only skin and subcutaneous tissue of the incision AND Patient has at least one of the following: a. purulent drainage from the superficial incision b. organisms isolated from an aseptically obtained culture from the superficial incision or subcutaneous tissue c. superficial incision that is deliberately opened by a surgeon, attending physician, or other designee and is culture positive or not cultured AND Patient has at least one of the following signs or symptoms: pain or tenderness; localized swelling; erythema; or heat. A culture negative finding does not meet this criterion d. diagnosis of a superficial incisional SSI by the surgeon or attending physician or other designee
Deep incisional SSI	Infection occurs within 30 or 90 days after the operative procedure (where day 1= the procedure date) AND Involves the deep soft tissues of the incision (eg, fascial and muscle layers) AND Patient has at least one of the following: a. purulent drainage from the deep incision b. a deep incision that spontaneously dehisces or is deliberately opened or aspirated by a surgeon, attending physician or other designee and is culture positive or not cultured AND Patient has at least one of the following signs or symptoms: fever (>38°C); localized pain or tenderness. A culture negative finding does not meet this criterion c. An abscess or other evidence of infection involving the deep incision that is detected on gross anatomical or histophathologic exam or imaging test
Organ/space SSI	Infection occurs within 30 or 90 days after the operative procedure (where day 1= the procedure date) AND Infection involves any part of the body deeper than the fascial/muscle layers, which is opened or manipulated during the operative procedure AND Patient has at least one of the following: a. purulent drainage from a drain that is placed into the organ/space (eg, closed suction drainage system, open drain, T-tube drain, CT-guided drainage) b. organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space c. an abscess or other evidence of infection involving the organ/space that is detected on gross anatomical or histopathologic exam, or imaging test AND Meets at least one criterion for a specific organ/space infection site

Note: Data from: Centers for Disease Control and Prevention (CDC).[42]
Abbreviations: SSI, surgical site infection; CT, computed tomography.

due to variability in exposure to microbes during a procedure. For example, SSI rates have been reported as low as 0.5% in laparoscopic cholecystectomy to greater than 20% for colectomies.[3,11,13,14]

Wound class

Furthermore, the class of a surgical incision carries varying levels of risk for wound infection (Table 2).

Assessment of the National Nosocomial Infections Surveillance (NNIS) System hospitals data, the predecessor to NHSN, by Culver et al demonstrated increasing risk of infection with each wound class.[15] This increased risk associated with wound class is included in the NNIS risk index for predicting SSI risk. This index was developed based on data obtained from the NNIS system hospitals and is measured on a scale of 0–3.[15] The components of the index are 1) American Society of Anesthesiologists preoperative assessment score of 3, 4, or 5; 2) an operation with a wound classified as contaminated or dirty; and 3) an operation lasting longer than the 75th percentile in duration for the specific procedure.[15,16] Each factor included in the index contributes one point to the risk index score.

Table 2 Classification of wounds

Category	Definition
Clean	An uninfected operative wound in which no inflammation is encountered, and the respiratory, alimentary, genital, or uninfected urinary tracts are 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
Clean-contaminated	Operative wounds 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
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 including necrotic tissue without evidence of purulent drainage (eg, dry gangrene) are included in this category
Dirty or infected	Includes 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

Note: Data from: Centers for Disease Control and Prevention (CDC).[42]

Patient risk factors

Patient-related factors that have been associated with an increased risk of developing an SSI include age, obesity, smoking, diabetes mellitus, malnutrition, dyslipidemia, and immunosuppression.[17] Optimization of these comorbidities is critical to reducing the incidence of SSI. For example, careful optimization of glucose control has been shown to reduce SSI rates.[17] Recommendations for glycemic control include a reduction in $HgbA_{1c}$ to $<7.0\%$ in addition to a reduction in serum glucose levels.[18] Studies have also shown that smoking cessation reduces wound-related complications with current recommendations for smoking cessation at least 30 days prior to an operation.[17,19]

Perioperative prevention

There are numerous preventative measures in the operative period designed to reduce SSI rates. These include skin decontamination, perioperative warming, and antimicrobial prophylaxis.

It has been long recommended that skin decontamination be performed with topical antiseptic agents to help prevent infection.[17] Chlorhexidine- and iodophor-based agents are the two most common classes of topical antiseptics. There have been numerous studies comparing the efficacy of these two groups of agents, although there has not been definitive evidence of a clinically significant difference between the two agent groups.[20,21] It is clear that an alcohol-based skin preparation is superior. The two most commonly available preparations are solutions of isopropyl alcohol combined with either chlorhexidine gluconate or iodine povacrylex.

Perioperative hypothermia has been correlated with an increased risk of SSI.[17,22,23] This is attributed to a number of factors including increased total oxygen consumption and decreased peripheral perfusion, induced coagulopathy, and reduced immune response secondary to the hypothermia.[24] Although recent studies have called policies of strict temperature regulation into question, showing no significant difference between continuous measures of intraoperative temperature and the incidence of SSI, extreme hypothermia is detrimental.[25] It is best practice to monitor the patient's temperatures in the operating room and to maintain core temperature $>36°C$. For longer procedures, this may require use of a forced air warming device, but for shorter outpatient procedures, this is likely not necessary but providers should also be cognizant of trying to avoid having patients uncovered for any period.

Antibiotic prophylaxis is indicated when the risk of perioperative bacterial contamination is high, as in

clean-contaminated or contaminated procedures. It is also indicated in patients at high risk for serious morbidity as a consequence of infection, such as those undergoing cardiothoracic or neurosurgery procedures.[26] Postoperative complications of cardiothoracic and neurosurgical procedures such as endocarditis, mediastinitis, sternal osteomyelitis, or meningitis can be devastating and warrant antimicrobial prophylaxis. Additionally, patients can have increased morbidity and risk of infection due to insertion of prosthetic materials or other foreign bodies, and should therefore also receive prophylaxis. This includes hernia repair with mesh and any orthopedic procedure using internal fixation devices. Other common ambulatory procedures that require antibiotic prophylaxis include appendectomy, most procedures involving the urinary tract, and adenotonsillectomy.

Clinical trials have shown significant reduction in SSI rates for moderate-to-high risk procedures with use of routine antibiotic prophylaxis.[27,28] For low-risk procedures, such as clean operations without the use of prosthetic materials or other foreign bodies, the risks (adverse reactions) outweigh the potential benefit, and it is not recommended that they be administered.[26] The basic principles of antibiotic prophylaxis are for the administration of a safe and appropriate antimicrobial agent administered in the preoperative period to allow serum and tissue concentrations to reach effective levels at the time of incision, and these antibiotics should be discontinued as soon as possible.[17] In 2013, the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, the Surgical Infection Society, and the Society for Healthcare Epidemiology of America released an update to clinical practice guidelines for antimicrobial prophylaxis.[29] These guidelines recommend administration of antibiotic prophylaxis, if appropriate for the procedure, within 60 minutes of incision, or within 120 minutes for antibiotics requiring longer infusion times.[29] In addition, weight-based dosing should be utilized to obtain appropriate levels of antibiotic in the obese patient.[29] Another key component to maximizing effectiveness of antibiotics in reducing SSI is adequate redosing of antibiotics for longer operative procedures. It is recommended that antibiotics are redosed at intervals of two half-lives of the antibiotic used.[29] This is supported by the TRAPE trial, which showed a reduction of SSI in the cohort who received antibiotic redosing.[30]

Recently, in attempts to further reduce SSIs, Schweizer et al implemented a bundled intervention of screening, decolonization, and targeted antimicrobial prophylaxis to prevent complex *S. aureus* in select cardiac and orthopedic patients.[31] Patients were screened for colonization with MSSA or MRSA. Those who were positive were treated with intranasal mupirocin and chlorhexidine bathing. MRSA carriers received vancomycin and cefazolin or cefuroxime for perioperative prophylaxis, while all others received cefazolin or cefuroxime alone. This intervention resulted in a decrease in mean SSI rate per 10,000 operations from 36 in the preintervention period to 21 in intervention period. They also noted a dose response association of bundle adherence and SSI rate reduction.[31] There is potential for further reduction in SSIs by utilizing bundled tactics such as this in addition to other established techniques.

Another important component of preventing infection is proper decontamination of reusable surgical instruments. These instruments provide potential routes of transmission of pathogenic microorganisms between patients. Studies have shown lack of compliance with established guidelines for disinfection and sterilization and failures in decontamination have led to numerous outbreaks.[32] The Centers for Disease Control and Prevention released guidelines for disinfection and sterilization in health care facilities in 2008. These guidelines should be used to direct sterile processing practices in surgical facilities. Per these guidelines, surgical instruments, cardiac and urinary catheters, implants, and ultrasound probes used in sterile body cavities are critical items that confer a high risk for infection if they are contaminated. As such, the majority of these items should be purchased sterile or sterilized with steam if possible. Heat-sensitive objects can be treated with ethylene oxide, hydrogen peroxide gas plasma, or by liquid chemical sterilants. Liquid chemical sterilants include ≥2.4% glutaraldehyde-based formulations, 0.95% glutaraldehyde with 1.64% phenol/phenate, 7.5% stabilized hydrogen peroxide, 7.35% hydrogen peroxide with 0.23% peracetic acid, 0.2% peracetic acid, and 0.08% peracetic acid with 1.0% hydrogen peroxide. Of note, liquid sterilants only produce sterility if cleaning precedes treatment and if proper guidelines for use are followed.[33,34] All heat-sensitive endoscopes (gastrointestinal endoscopes, bronchoscopes, nasopharyngoscopes) must be properly cleaned and subjected to high-level disinfection after each use. This can be achieved using ethylene oxide sterilization or liquid chemical sterilants.[33] Users should check with device manufacturers for specific information about germicide compatibility with their device, as there have been reported cosmetic and functional damage to endoscopes as a result of some of the chemicals in the liquid chemical sterilants.

Surveillance

Critical to management of SSIs in the setting of outpatient surgery is surveillance. Since these patients do not undergo

a period of inpatient observation, the development of an SSI can be missed. Unfortunately, a reliable or standardized method for postdischarge surveillance has not yet been established. Research has shown that surveillance programs with feedback of SSI rates to surgeons can reduce subsequent rates by 30%–40%.[35] Critical components of a successful surveillance program include intensive surveillance activities, infection control activities, and regular feedback of SSI rates to the surgeons.[35]

There are three main approaches to SSI surveillance: clinical registry with chart abstraction, administrative claims data, and patient-reported outcomes. Today, clinical registry-based surveillance is considered the gold standard. Comparison of registry data with administrative claims data for SSI surveillance has demonstrated that, for complex in patient procedures, registry data is far more sensitive and specific.[36] This approach requires a large investment (data abstractors, program participation fees, etc); most hospitals limit this approach to high-risk procedures, especially those tied to reimbursement programs like cardiac, colorectal, or gynecologic surgery. It is rare for hospitals or ambulatory surgery centers to invest in this type of surveillance for outpatient procedures. An alternative approach that may decrease the resources needed for surveillance while maintaining data integrity is to monitor SSI rates through administrative claims-based SSI surveillance in conjunction with targeted medical record review.[11,37,38] Claim codes from both inpatient and ambulatory encounters can be used to identify potential SSIs following ambulatory procedures. Hospital-based surveillance methods alone are inadequate to monitor SSI following ambulatory surgery as many SSIs are managed purely in the outpatient setting.[11] Furthermore, it is likely that patients who undergo surgery at a freestanding ambulatory center will be managed at another facility should they develop an SSI. Until we have true interoperability of the electronic health record, accurate SSI surveillance for procedures done in the outpatient setting is going to be challenging.

Close follow-up of patients for evidence of SSI should be undertaken in the ambulatory surgery population. Essential to the success of this process is patient education regarding the risks of developing SSIs, the methods to prevent SSIs, and the signs and symptoms of an SSI once it has developed. Ideally, SSI education should take place during the preoperative visit to allow the outpatient patient time to process the information appropriately. At discharge from surgery, patients should also receive additional information regarding SSI as a supplement to their preoperative education.

Therapy

Once an SSI has been identified, the basic principle of SSI therapy remains the same whether the patient has undergone inpatient or outpatient surgery. This principle is to control the infectious source.

Incision and drainage with local wound care are the standard management for a superficial incisional SSI.[39,40] It is important that the wound is opened enough to allow for adequate drainage. Often, no antibiotic therapy is required for these infections.[41] However, antibiotics should be considered in patients with systemic features or widening erythema.[41]

More complicated SSIs require antibiotic therapy in addition to source control. It is important that appropriate antibiotics are selected. Selection should be based on the expected microbial causes for infection.[39,40]

Conclusion

Surgical procedures are increasingly performed in ambulatory settings. The nature of outpatient surgery complicates the management of SSIs. Despite the fact that it has been established that SSIs are a common postoperative complication and constitute a large proportion of hospital-acquired infections in the inpatient population, there are limited data regarding SSIs in outpatient settings due to underreporting and difficulties with surveillance after surgery. However, what little data we have demonstrated compare SSI rates in ambulatory surgery with inpatient surgery.

Even with low SSI rates, the burden on the health care system is significant because of the large number of surgeries performed in the outpatient setting. It is critical to reduce SSI rates through optimization of patient factors and perioperative factors. Furthermore, improved surveillance of SSI in the outpatient setting is essential.

Disclosure

The authors report no conflicts of interest in this work.

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