MIS: Decreasing Infections

A Continuing Nursing Education Activity

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MIS: Decreasing Infections

(A Continuing Education Self-Study Activity)

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OVERVIEW

Historically, surgery has been performed through traditional, open incisions; with the advent of minimally invasive surgery (MIS), many procedures are performed through small incisions. Compared to open surgical procedures, minimally invasive surgery offers distinct benefits for the patient including decreased postoperative pain and trauma to the tissues, a shorter recovery period and length of hospital stay, and a lower risk of infection. Because preventing infection in the surgical patient is a primary goal for the perioperative team, it is imperative that perioperative nurses remain aware of the reduction in infection associated with MIS techniques and the related interventions that can be implemented to further reduce the incidence of infection and thereby promote optimal patient outcomes. This study guide will provide an overview of the clinical and economic impact of surgical site infections today. A review of the literature documenting reductions in surgical site infection rates associated with minimally invasive techniques across multiple surgical specialties will be presented. Lastly, evidence-based perioperative nursing interventions to further reduce the incidence of infections in MIS procedures will be described.

OBJECTIVES

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

1. Identify the clinical and economic impact of surgical site infections today.
2. Describe research findings that demonstrate a reduction in surgical site infection rates associated with MIS procedures.
3. Discuss nursing interventions that can be instituted to further reduce the incidence of SSIs during MIS procedures.

INTENDED AUDIENCE

This continuing education activity is intended for use by perioperative registered nurses and surgical technologists who are interested in learning more about the role of MIS techniques and evidence-based perioperative nursing interventions in reducing surgical site infections.

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INTRODUCTION

One of the expected outcomes for every surgical patient is that he/she is free from signs and symptoms of infection.[1] For patients, the development of a healthcare-associated infection (HAI), specifically a surgical site infection (SSI), is associated with significant morbidity and mortality as well as increased costs. As the patient's advocate, the perioperative nurse must understand the impact of a surgical site infection as well as the differences in infection rates for open and laparoscopic procedures. Furthermore, as MIS techniques continue to evolve and expand across multiple surgical specialties, it is important for the perioperative nurse to recognize and implement evidence-based practices that further reduce the MIS surgery patient's risk for infection.

SSIs: CONTEMPORARY ISSUES

In order to appreciate the significance of the decreased infection rates associated with MIS procedures, it is helpful to review the impact of SSIs today on both the patient and the health-care system.

Impact of SSIs Today

A surgical site infection is an unexpected event that complicates a patient's postoperative course and adversely affects patient outcomes.[2] The occurrence of surgical site infections is recognized by the public as a major medical issue because articles and television exposés about medication errors, multidrug-resistant *Staphylococcus aureus* infections in hospitalized patients, and wrong-site surgery, as well as SSIs, are frequently presented in the public media.

In the United States, infections following surgery occur in approximately 3% to 5% of all procedures; on average, patients who develop an SSI will remain in the hospital for an additional week, resulting in an average of more than $25,000 in additional health-care costs per affected patient.[3] In addition, patients who develop SSIs are also 60% more likely to be admitted to the intensive care unit (ICU) and are twice as likely to die compared to patients who do not develop SSIs postoperatively. Moreover, at a time when profound changes in the United States health-care system have been enacted to control skyrocketing health-care costs, SSIs are estimated to add an additional $10 billion in national health-care costs annually. In addition to these economic costs, serious infections following surgery often cause considerable suffering among affected patients; in severe cases, SSIs can result in permanent disability or as noted, even death. The known causes of SSIs are multiple and complex; therefore, no single or simple solution is capable of eliminating all cases of SSIs.

In July of 2008, the increased costs associated with SSIs were addressed by the Centers for Medicare and Medicaid Services (CMS) when it announced new Medicare and Medicaid payment and coverage policies to improve safety for hospitalized patients.[4] The Inpatient Prospective Payment System (IPPS) 2009 final rule expanded the list of selected hospital-acquired conditions that have Medicare payment implications as of October 1, 2008. In addition, CMS has announced the initiation of three Medicare National Coverage Determinations proceedings for "wrong surgery," a category of "never events" included in the National Quality Forum's list of Serious Reportable Adverse Events. Further, the Agency issued a letter to State Medicaid Directors outlining the authority of State Medicaid Agencies to deny payment for selected hospital-acquired conditions. As a result, CMS will no longer reimburse hospitals for the increased care that a patient needs after an extreme medical error has occurred or for a condition that was not present on admission, but is subsequently acquired during the course of the patient's hospitalization. In addition, the patient is not responsible for the additional costs and therefore cannot be billed. Initially, hospitals were not reimbursed for infections associated with vascular catheters and coronary artery bypass graft surgery. As of October 1, 2008, hospitals were no longer reimbursed for surgical site infections after selected elective procedures, including certain orthopedic surgeries and bariatric surgery for obesity (see Table 1).

Table 1 – Hospital-Acquired Conditions: Surgical Site Infections (for which CMS no longer pays higher reimbursement)[5]

• Mediastinitis after coronary artery bypass graft.
• SSIs associated with certain orthopedic procedures involving the spine, neck, shoulder, elbow.
• SSIs associated with certain bariatric surgical procedures for obesity, specifically laparoscopic gastric bypass, gastroenterostomy, laparoscopic gastric restrictive surgery.

The importance of preventing healthcare-associated infections also is recognized by The Joint Commission in its National Patient Safety Goals (NPSGs). Noting that patients continue to acquire HAIs at an alarming rate, Goal 7 of the 2011 NPSGs is to reduce the risk of HAIs, including SSIs; this goal also outlines that evidence-based practices for preventing SSIs and HAIs due to multidrug-resistant organisms should be implemented.[6] The requirement for multidrug-resistant organisms applies to, but is not limited to, epidemiologically important organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA); clostridium difficile (CDI), vancomycin-resistant enterococci (VRE), and multidrug-resistant gram negative bacteria.

Definition and Classification of SSIs

For purposes of standardized reporting and discussion in the literature review below, SSIs have been defined and classified as superficial incisional SSIs, deep incisional SSIs, and organ/space SSIs (see Table2 for the complete definitions and Figure 1 for a graphic illustration).[7]

Table 2 - Definition of SSIs

Superficial Incisional SSI

- Infection occurs within 30 days of the operation.
- Infection involves only skin or subcutaneous tissue.
- At least 1 of the following:
  - Purulent drainage,
  - Positive culture from the incision,
  - At least 1 symptom of infection (pain or tenderness, localized swelling, redness, heat) and incision is opened by surgeon, unless incision is culture-negative, or
  - Diagnosis of SSI by surgeon or attending physician.

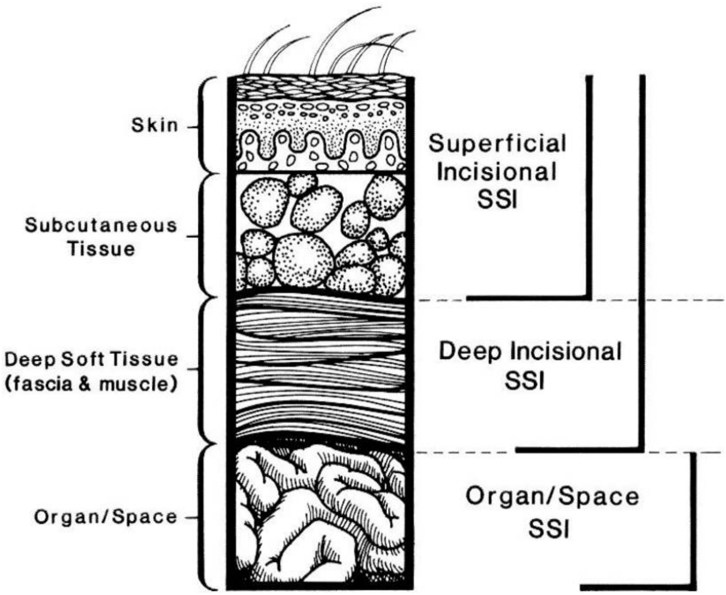
Deep Incisional SSI

- Infection within 30 days of 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.
- Infection involves deep soft tissues.
- At least 1 of the following:
  - Purulent drainage from the deep incision but not from organs/spaces associated with the surgical site,
  - Spontaneous dehiscence of deep incision or deliberate opening by a surgeon when the patient has at least 1 symptom of infection (fever, localized pain, or tenderness), unless site is culture-negative,
  - Abscess or other evidence of infection involving the deep incision found on direct examination, during reoperation, or by histopathology or radiography, or
  - Diagnosis of SSI by surgeon or attending physician.

Organ/Space SSI

- Infection within 30 days of 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.
- Infection involves any part of the anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation.
- At least 1 of the following:
  - Purulent drainage from drain placed into the organ/space,
  - Positive culture of fluid or tissue from the organ/space,
  - Abscess or other evidence of infection involving the deep incision found on direct examination, during reoperation, or by histopathology or radiography, or
  - Diagnosis of SSI by surgeon or attending physician.

Figure 1 – Surgical Site Infections



REDUCTION IN SSIs ASSOCIATED WITH MIS TECHNIQUES: A REVIEW OF THE LITERATURE

The early advances in MIS occurred long before the modern concerns of decreasing surgical costs and reducing the patient lengths of stay. Today, technology is often blamed for increasing health-care costs; however some medical advances, such as minimally invasive surgery, have demonstrated effectiveness in improving the efficiency of health care, enhancing the quality of care provided, and reducing overall expenses. The clinical advantages of MIS over open surgery (i.e., smaller incisions, reduced bleeding, decreased postoperative pain, shorter hospital stays, faster recovery time, and the lower rate of SSIs) have been well-documented over the years; these benefits take on even greater significance today in the face of escalating health-care costs in today's current economic crisis. Recent research studies provide robust evidence supporting the reduction in SSI rates associated with MIS techniques across multiple surgical specialties; several of these studies are summarized below.

Recently, Rodgers, et al. reported the results of their analysis of extreme lateral interbody fusion (XLIF) approach procedures that delineated and described intraoperative and perioperative complications in a large series of these procedures.[8] In this study, a total of 600 patients were treated with XLIF for degenerative spinal conditions. Data were collected prospectively on all patients and analyzed for demographic, diagnostic, and hospitalization information to identify operative and early postoperative complications. The documented complication types and rates in this large series were then compared with prior, smaller reports on lateral approach fusions, as well as other minimally invasive (i.e., mini-anterior lumbar interbody fusion and minimally invasive surgical transforaminal lumbar interbody fusion) and more traditional fusion approaches (e.g., posterior intertransverse fusion, anterior lumbar interbody fusion, posterior lumbar interbody fusion and transforaminal lumbar interbody fusion). Seven hundred forty-one levels were treated: 80.8% single level, 15.0% 2 level, 4.0% 3 level, 0.2% 4 level; 59.3%, including the L4 to L5 levels. A total of 99.2% included supplemental internal fixation; 83.2% included pedicle screw fixation (predominantly unilateral). The results included data that the hemoglobin change from pre- to postoperation averaged 1.38; hospital stay averaged 1.21 days; the overall incidence of perioperative complications (intraoperatively and out to 6 weeks postoperatively) was 6.2%: 9 (1.5%) in-hospital surgery-related events, 17 (2.8%) in-hospital medical events, 6 (1.0%) out-of-hospital surgery-related events, and 5 (0.8%) out-of-hospital medical events. In addition, there were no wound infections, no vascular injuries, no intraoperative visceral injuries, and 4 (0.7%) transient postoperative neurologic deficits. Eleven events (1.8%) resulted in additional procedures/reoperation. The authors concluded that, when compared with traditional open approaches, the MIS lateral approach to fusion by using the XLIF technique resulted in a lower incidence of infection, visceral and neurologic injury, and transfusion as well as markedly shorter hospitalization.

Varela, et al. compared the incidence of SSIs after laparoscopic and open surgery, in light of the significant morbidity, mortality, and hospital costs associated with SSIs and the new CMS measures outlined to decrease and prevent hospital-acquired infections.[9] These authors conducted a retrospective analysis of a large administrative, clinical, and financial database of United States academic medical centers and affiliated community hospitals. The analysis included patients who underwent laparoscopic (n = 94,665) or open (n = 36,965) appendectomy, cholecystectomy, antireflux surgery, or gastric bypass between 2004 and 2008. The primary outcome measure was an inpatient diagnosis of SSI after laparoscopic and open surgery. During the 45-month study period, a total of 131,630 patients underwent one of the four selected procedures. Their results indicated that, overall, the incidence of SSI was significantly lower in laparoscopic (483 of 94,665, or 0.5%) than in open (669 of 36,965, or 1.8%) surgery. Largely, laparoscopic techniques offered a protective effect against SSI; the patients treated with laparoscopy were 72% less likely to experience an SSI. This protective effect was shown to be sustained after stratification by severity of illness, admission status (elective, urgent, or emergent), and wound classification. The authors concluded that, in United States academic medical centers, laparoscopy significantly reduces SSIs (i.e., patients treated with laparoscopic procedures are less likely to experience SSIs). After stratification by severity of illness, admission status, and wound classification, laparoscopic techniques showed a protective effect against SSIs.

Kiran, et al. conducted a study to compare SSI rates between laparoscopic (LAP) and open colorectal surgery using the National Surgical Quality Improvement Program (NSQIP) database.[10] The authors identified patients included in the NSQIP database from 2006 to 2007 who underwent LAP and open colorectal surgery and then compared the SSI rates for the two groups; the association between patient demographics, diagnosis, type of procedure, comorbidities, laboratory values, intraoperative factors, and SSI rates within 30 days of surgery was determined using statistical analysis. The investigators found that, among 10,979 patients undergoing colorectal surgery (LAP 31.1%; open 68.9%), the SSI rate was 14.0% (9.5% for LAP procedures versus 16.1% for open procedures). LAP patients were younger, with lower American Society of Anesthesiologists (ASA) scores, and fewer comorbidities involving benign and inflammatory conditions rather than malignancy, but the operative time was greater. On analysis, age, ASA score of greater than or equal to 3, smoking, diabetes, operative time greater than 180 minutes, appendicitis or diverticulitis, and regional enteritis diseases were found to be significantly associated with high SSIs; the LAP approach was associated with a reduced SSI rate. These authors conclude that the LAP approach is independently associated with a reduced SSI rate when compared with open surgery and should, when feasible, be considered for colon and rectal conditions.

Markides, et al conducted a systematic review and meta-analysis to evaluate the strength of available evidence in the literature on the use of laparoscopic appendectomy in complicated appendicitis.[11] Twelve retrospective case-control studies were included in their review of selected databases. The meta-analysis showed that laparoscopic appendectomy in complicated appendicitis has reduced surgical site infection rates in comparison to open appendectomy and no difference with regard to intra-abdominal abscess complication rates. The investigators concluded that, when compared to open appendectomy, laparoscopic appendectomy is advantageous in complicated appendicitis with regard to SSIs, with no significant additional risk of intra-abdominal abscess.

Howard, et al., citing that few studies have examined whether the incidence of SSIs differs between laparoscopic colorectal surgery (LCS) and open colorectal surgery (OCS), investigated the SSI incidence using the validated Surgical Site Infection Surveillance Service (SSISS) criteria for diagnosing wound infections.[12] Prospective data was collected over a one-year time period and recorded a total of 122 (43 underwent LCS and 79 underwent OCS) patients', including demographics, operative details, antibiotic use, wound evaluation and microbiological wound culture results, for consecutive patients undergoing elective resectional LCS and OCS. Postdischarge surveillance consisted of patient questionnaires sent out at 30 days and their communication with primary care providers. Patients' demographics and operative case-mix were similar for both groups, including body mass index (BMI) and diabetic and smoking status. The results showed that the operative duration was longer in the LCS group compared with OCS group, but the length of hospital stay was shorter for the LCS group. The SSI rate was significantly lower in the LCS than OCS group (7% versus 25%, respectively). Two factors that influenced the risk of SSI formation were a BMI greater than 30 and operation length of greater than 4 hour. These authors concluded that surgical site infection incidence is significantly lower following LCS when compared with OCS; confounding factors in this study include patient selection for LCS and nonrandomization.

Siddiqui, et al. performed a systematic review and meta-analysis of published literature (i.e., electronic databases were searched from January 1991 to March 2009) comparing the complications after open and laparoscopic elective sigmoidectomy for diverticular disease in order to obtain a summative outcome.[13] Nineteen comparative studies involving 2,383 patients (1,014 patients in the laparoscopic group and 1,369 patients in the open group) were analyzed. There was no significant heterogeneity among any of the complications analyzed. Patients in the laparoscopic sigmoid resection group had fewer wound infections, blood transfusions, and ileus compared with open sigmoid resections. No difference was seen for medical complications or the need for rehospitalization or reoperation. The authors concluded that laparoscopic sigmoid resection is safe and has fewer postoperative surgical complications. Further, this approach should be considered for elective cases; however, more randomized controlled trials are required to strengthen the evidence.

Fullum, et al., noting that despite evidence demonstrating the advantages of the minimally invasive approach, open appendectomy and colectomy occur with greater prevalence; therefore, controversy still exists as to whether the MIS approach is safer or more cost effective.[14] They performed a retrospective analysis using a large commercial payer database that included information on 7,532 appendectomies and 2,745 colectomies, reviewing data on the distribution of patient demographic and comorbidity characteristics associated with the MIS and open approaches. The corresponding complication rates and expenditures were analyzed. Summary statistics were compared using appropriate statistical tests constructed to estimate expenditures while controlling for patient characteristics. Their results demonstrated that patients undergoing MIS and open colectomy showed no significant variations in age distribution or marginal age differences for appendectomy. However, significantly more patients experienced an infection postoperatively, and procedure-specific complications were more common in the open group for both procedures. The postsurgical hospital stay was longer for the patients treated using the open techniques, differing an average of half a day for appendectomies and significantly more (4 days) for colectomy; there was little difference between the two approaches for readmission rates. Procedures performed through an MIS approach were associated with lower expenditures than for the open technique, with differences ranging from $700 for appendectomy patients to $15,200 for colectomy patients. These investigators concluded that minimally invasive appendectomy and colectomy were associated with lower infection rates, fewer complications, shorter hospital stays, and lower expenditures than open surgery.

Dobson, et al. conducted a study to compare the morbidity of surgical site infections and the charges for wound care in 2,849 patients who underwent open (OS; 603 patients) versus laparoscopic (LS; 2,246 patients) colorectal surgery by prospectively recording the relevant data.[15] The morbidity of SSIs was assessed by the need for emergency department (ED) evaluation, subsequent hospital readmission, and reoperation. The charges for wound care were measured by the need for home health care, a wound V.A.C. (i.e., negative pressure [vacuum] at the wound site), or independent patient wound care. The study results identified SSIs in 25 of LS patients and 65 of OS patients. ED evaluation for the infection was needed in 24% of the LS group and 42% of the OS group. Hospital readmission was needed in one LS patient, and in 52% OS patients. No LS patient needed reoperation, while 12% of the OS patients required reoperation for their SSI. Home health care (at a cost of $162/dressing change) was required in 63% of the OS group compared to only 8% of LS group. A home wound V.A.C. system (at a cost of $107.46/day) was utilized in 12% of the OS patients but in none of the LS patients. Dressing changes were managed independently by the patient or his or her family in 92% of the LS patients as compared to 37% of the OS group. Based on these results, the authors concluded that laparoscopic colorectal surgery patients experience less morbidity when they develop SSIs and require fewer healthcare dollars to manage their wounds compared with open colorectal surgery patients.

O'Toole, et al., noting that postoperative surgical site infections have been reported after 2% to 6% of spinal surgeries in most large series and that the incidence of SSI can be less than 1% after decompressive procedures and greater than10% after instrumented fusions and that anecdotal evidence has suggested there is a lower rate of SSIs when minimally invasive techniques are used, conducted a retrospective review of prospectively collected databases of patients who underwent minimally invasive spinal surgery.[16] Minimally invasive spinal surgery was defined as any spinal procedure performed through a tubular retractor system. All surgeries were performed under standard aseptic conditions with preoperative antibiotic prophylaxis. The databases were reviewed for any infectious complications. Cases of SSI were identified and reviewed for clinically relevant details. The incidence of postoperative SSIs was then calculated for the entire group as well as for subgroups based on the type of procedure performed, and then compared with an analogous series selected from an extensive literature review. The authors performed 1,338 minimally invasive spinal surgeries in 1,274 patients averaging 55.5 years of age. The primary diagnosis was degenerative in nature in 93% of cases. A single minimally invasive spinal surgery procedure was undertaken in 1,213 patients, 2 procedures in 58 patients, and 3 procedures in 3 patients. The region of surgery was lumbar in 85% of the patients, cervical in 12%, and thoracic in 3%. Simple decompressive procedures comprised 78%, instrumented arthrodeses 20%, and minimally invasive intradural procedures 2% of the collected cases. Three postoperative SSIs were detected, 2 were superficial and 1 was deep. The procedural rate of SSI for simple decompression was 0.10%, and for minimally invasive fusion/fixation was 0.74%. The total SSI rate for the entire group was only 0.22%. These investigators concluded that minimally invasive spinal surgery techniques may reduce postoperative wound infections as much as 10-fold compared with other large, modern series of open spinal surgery published in the literature.

In gynecological surgery, Warren, et al. compared minimally invasive procedures (MIP)-laparoscopic and vaginal hysterectomy with the traditional open abdominal hysterectomy method by evaluating clinical and economic outcomes and use.[17] They performed a retrospective analysis with de-identified claims data and enrollment information from a large United States managed care plan. Data were collected on intraoperative and postoperative complications, length of stay, rates of readmission, and insurer and patient payment totals for inpatient and outpatient procedures. The results of this analysis demonstrated that, of 15,404 patients, MIP was performed in 43% of the patients, with 23% (3,520 patients) undergoing laparoscopic hysterectomy and 20% (3,130 patients) undergoing a vaginal hysterectomy. Postoperative infection rates were higher for patients undergoing open abdominal hysterectomy: 18% as compared with 15% of laparoscopic and 14% of patients undergoing vaginal hysterectomy. For patients undergoing open abdominal hysterectomy, the length of stay was 3.7 days versus 1.6 days and 2.2 days for patients undergoing MIP laparoscopic and MIP vaginal hysterectomy, respectively. Unadjusted expenditures for patients undergoing open abdominal hysterectomy averaged $12 086 whereas MIP (laparoscopic and vaginal) patients accrued costs of $10,868 and $9544, respectively. When the expenditures were adjusted for differences in patient mix, there was no difference for open abdominal hysterectomy versus MIP laparoscopic; however, there were significantly lower expenditures for MIP vaginal versus open abdominal hysterectomy with a mean difference of $1,270. Adjusted expenditures associated with outpatient MIP were markedly lower than expenditures for inpatient open abdominal hysterectomy. These authors concluded that both the clinical and economic outcomes of this analysis should encourage clinicians to consider greater use of minimally invasive hysterectomy procedures in patients who have no contraindications for laparoscopic or vaginal approach to hysterectomy. Significant savings are realized when appropriate candidates receive minimally invasive procedures and are thus able to transfer from the inpatient to outpatient setting.

In 2008, reviews of the literature had concluded that additional, well-defined studies were needed to clarify the superiority of laparoscopic versus open surgery; for this reason, Brill, et al. conducted a study to estimate the nosocomial infection risks associated with laparoscopic as compared to open surgery in three procedures: cholecystectomy, appendectomy, and hysterectomy.[18] In this study, the investigators retrospectively analyzed data from 11,662 surgical admissions to 22 hospitals that used the nosocomial infection marker (NIM) to identify nosocomial infections that occurred during hospitalization and post discharge. (The NIM is a computer algorithm that identifies the existence of nosocomial infections at the microbiological level, distinguishing likely pathogens from contaminants, identifying duplicate isolates, and temporally determining hospital- versus community-acquired pathogens. A previous multihospital study showed 86% sensitivity and 98.5% specificity of the NIM algorithm for detecting nosocomial infections.) The dataset was limited to admissions with laparoscopic or open cholecystectomy (32.7%), appendectomy (24.0%), or hysterectomy (43.3%); data were analyzed by source of infection: urinary tract, wounds, respiratory tract, bloodstream, and others. The effect of certain potentially confounding variables, such as sex, age, insurance type, complexity of admission, admission through the emergency department, and hospital case mix index also was examined. Overall infection rates were 4.09% for open surgery and 2.11% for laparoscopic procedures. In analyses based on 399 NIMs identified in 337 patients, laparoscopic cholecystectomy and hysterectomy were each associated with a greater than 50% reduction in the overall odds of acquiring nosocomial infections compared with open surgery (66% reduction for laparoscopic versus open cholecystectomy; 52% reduction for laparoscopic versus open hysterectomy). Laparoscopic appendectomy did not significantly change the odds of acquiring nosocomial infections over open appendectomy. The authors concluded that, when compared to open surgery, laparoscopic cholecystectomy and hysterectomy are associated with statistically significantly lower risks for nosocomial infections. For appendectomy, when comparing open versus laparoscopic approaches, no differences in the rate of nosocomial infections were detected.

Romy, et al. noted that lower rates of SSIs had been reported among the various advantages associated with laparoscopy when compared with open surgery, particularly in cholecystectomy.[19] However, biases and confounding factors associated with existing observational studies may have contributed to the reported differences between the two techniques; for example, the lack of post-discharge followup might generate a significant underestimation of SSI rates in patients who have undergone MIS procedure because they leave the hospital sooner than patients who undergo open procedures. Therefore, they conducted an observational study to compare SSI rates in open or laparoscopic appendectomy, cholecystectomy, and colon surgery and to investigate the effect of laparoscopy on SSIs in these interventions. Their study was based on prospectively collected data from an SSI surveillance program in eight Swiss hospitals between March 1998 and December 2004, including a standardized post-discharge follow-up. Surgical site infection rates were compared between laparoscopic and open interventions. Procedures that began laparoscopically but ended as open surgery were considered open. Factors associated with SSIs were identified by using statistical models to adjust for potential confounding factors. Post-discharge followup consisted of standardized telephone interviews with the patients and their treating physicians, in cases where a patient's responses could suggest an SSI. Their results demonstrated significantly lower rates of SSI after laparoscopic compared to open surgical interventions for all three procedures, respectively, reported as follows:

- For appendectomy: 59 out of 1,051patients (5.6%) versus 117 out of 1,417 patients(8.3%);
- For cholecystectomy: 46 out of 2,606 patients(1.7%) versus 35 out of 444 patients (7.9%); and
- For colon surgery: 35 out of 311 patients (11.3%) versus 400 out of 1,781 patients (22.5%).

The observed effect of laparoscopic techniques was due to a reduction in the rates of incisional infections rather than in those of organ/space infections. The researchers concluded that, when feasible, a laparoscopic approach should be preferred over open surgery in order to reduce the risk of SSIs. Furthermore, it is expected that increasingly more of these procedures will be performed using a minimally invasive approach; therefore, perioperative managers should ensure that personnel are adequately trained to assist in these procedures. In addition, perioperative nurses should understand that the appropriate and timely administration of antibiotic prophylaxis prior to incision is still required in most procedures, regardless of whether an open or MIS approach is used.

Boni, et al. conducted a review of the literature to compare the incidence of postoperative infections following the most common laparoscopic surgical procedures with their corresponding open operations, and to review the possible mechanisms behind these results.[20] The authors noted that one of the primary benefits of minimally invasive surgery compared with open surgery is the significant reduction in the incidence of postoperative infections and that possible explanations include the smaller incision, minimal use of central venous catheters for parenteral nutrition, faster mobilization, reduction in postoperative pain, and better preservation of immune system function with a limited inflammatory response to tissue injury. The authors reported that several randomized controlled trials, as well as most retrospective studies, show a significant reduction in incisional complications with laparoscopic cholecystectomy in comparison with open surgery (mean 1.1% versus 4%, respectively), as well as in urinary tract and pulmonary infections. In colorectal resection, laparoscopic surgery was characterized by a significant reduction in surgical site infections (mean 5% versus 9.5%, respectively), and the infections that did occur tended to be less severe; again, there were fewer urinary and pulmonary infections postoperatively. Acute appendicitis represented an interesting setting to study the effect of minimally invasive surgery on infections, as it involves a potentially contaminated field. Most of the results confirmed that the rates of surgical site (mean 2% versus 8%) and respiratory (mean 0.3% versus 3%) infections favor laparoscopic surgery, but minimally invasive surgery seemed to be characterized by a higher incidence of postoperative intra-abdominal abscess. The authors concluded that the majority of published studies indicate that laparoscopic surgery is associated with better preservation of immune function and a reduction of the inflammatory response compared with open surgery; therefore the rate of postoperative infections seems to be significantly lower.

A study conducted by Szomstein, et al. that was undertaken to assess the outcome of laparoscopic adhesiolysis in comparison to laparotomy with open adhesiolysis reported additional benefits of the minimally invasive approaches including a decreased incidence of wound infection and postoperative pneumonia, as well as a more rapid return of bowel function, resulting in a shorter hospital stay.[21]

Two early studies demonstrated the benefits of laparoscopic bariatric procedures in reducing SSIs. Podnos, et al., noting the dramatic increase in laparoscopic Roux-en-Y gastric bypass procedures (GBP), reported results of a comparison of the type and frequency of complications after laparoscopic and open GBP.[22] The investigators searched MEDLINE from January 1, 1994 through December 31, 2002, using the keywords morbid obesity, laparoscopy, bariatric surgery, and gastric bypass and selected studies on laparoscopic or open GBP with more than 50 patients; they excluded studies with reoperative Roux-en-Y GBP cases or other bariatric procedures. The type and frequency of postoperative complications were recorded from each study. Ten laparoscopic GBP studies with 3,464 patients and 8 open GBP studies with 2,771 patients were considered for comparison. The average age for the patients undergoing laparoscopic GBP was 41 years, compared with 43 years for open GBP. The mean percentages of female patients were 87% for laparoscopic GBP and 82% for open GBP; the mean reported average body mass index was 48.7 and 49.5, respectively. Compared with open GBP, laparoscopic GBP was associated with a decrease in the frequency of iatrogenic splenectomy, wound infection, incisional hernia, and mortality; however, there was an increase in the frequency of early and late bowel obstruction, gastrointestinal tract hemorrhage, and stomal stenosis. There were no significant differences in the frequency of anastomotic leak, pulmonary embolism, or pneumonia. The authors concluded that the type and frequency of postoperative complications after laparoscopic and open GBP are different. Certain complications increase with laparoscopic GBP, probably due to the learning curve of this complex procedure, whereas other complications decrease because of the advantages of the smaller access incision. Blacar and Federle also reported that infection of an abdominal wall wound, as well as incisional and ventral hernias, both of which were frequent and serious complications in open Roux-en-Y gastric bypass procedures in morbidly obese patients, were uncommon with the laparoscopic approach.[23]

PERIOPERATIVE NURSING INTERVENTIONS TO FURTHER REDUCE INFECTIONS RATES ASSOCIATED WITH MIS

As noted above, the medical literature abounds with studies that demonstrate the reduction of surgical site infection associated with MIS techniques across various surgical specialties. However, there are additional evidence-based perioperative nursing interventions that can be implemented to further reduce SSI rates during minimally invasive procedures.

Causes of SSIs

When discussing measures to reduce the risk of SSI in MIS patients, it is important to first review the causes of SSIs and relevant risk factors. The perioperative nurse, as well as all members of the perioperative team, must keep in mind that microbial contamination of the surgical site is a prerequisite for an SSI and that the risk of an SSI further increases with the dose of bacterial contamination and the virulence of the bacteria.[24]

SSIs may be caused by either endogenous flora (e.g., the bacteria on the patient's skin) or exogenous sources (e.g., personnel, the environment, or materials and equipment used for surgery).[25] Most SSIs are caused by the patient's own bacterial flora; the pathogenic potential of endogenous microorganisms increases when introduced into body tissues by surgery or through medical devices and surgical instruments. The most common microorganisms causing surgical site infection are:

- *Staphylococcus aureus* (20%);
- Coagulase negative staphylococcus (14%); and
- Enterococcus (12 %).

In addition, there are both patient-related and procedure-related factors that expose patients to increased risk for SSIs (see Table 3). Patient-related factors include but are not limited to age, diabetes, nicotine use, obesity, malnutrition, altered immune response, prolonged preoperative stay, preoperative nares colonization, and coexistent infections at a remote body site.

Table 3 - Characteristics That May Influence The Risk of Surgical Site Infection Development[26]

Patient-Related Factors	Procedure-Related Factors
• Age • Nutritional status • Diabetes • Smoking history • Obesity • Coexistent infections at a remote body site • Colonization with microorganisms • Altered immune response • Length of preoperative stay	• Duration of surgical scrub • Skin antisepsis • Preoperative shaving • Preoperative skin prep • Duration of operation • Antimicrobial prophylaxis • Operating room ventilation • Inadequate sterilization of instruments • Foreign material in the surgical site • Surgical drains • Surgical technique • Poor hemostasis • Failure to obliterate dead space • Tissue trauma

While the patient-related factors that increase a patient's risk for the development of a surgical site infection obviously cannot be controlled by perioperative personnel, there are several procedure-related factors that can be influenced to minimize the risk through evidence-based practices, as outlined below.

Prophylactic Antibiotics[27]

It is estimated that 40% to 60% of SSIs are preventable with appropriate use of prophylactic antibiotics; furthermore, overuse, under use, improper timing, and misuse of antibiotics occur in 25% to 50% of procedures. A large number of hospitalized patients develop infections caused by *Clostridium difficile,* and 16% of this type of infection in surgical patients can be attributed to inappropriate antibiotic prophylaxis alone. Inappropriate use of broad spectrum antibiotics or prolonged courses of prophylactic antibiotics puts all patients at even greater health risks due to the development of antibiotic-resistant pathogens. Recommendations to improve the administration of prophylactic antibiotics include the measures listed below.

- Designate responsibility and accountability for preoperative prophylactic antibiotic administration to a person (e.g., preoperative nurse, circulating nurse, anesthesia provider) connected to the key point in process;
- Standardize the administration process to occur within one hour prior to incision;
- Through the use of antibiotic standing orders specific to surgical site, administer prophylactic antibiotics according to guidelines based on local consensus;
- Ensure that the agreed-upon antibiotics are available in the operating room (OR);
- Standardize the delivery process to ensure timely delivery of preoperative antibiotics in the holding area;
- Provide a visible reminder or checklist to give antibiotics on each case (e.g., a brightly colored sticker);
- Ensure systematic documentation of antibiotic administration on every patient record, whether it is paper or electronic;
- Develop a system where antibiotic is hanging at head of patient's stretcher or bed, ready for administration;
- Design protocols to deliver the antibiotic to the OR with the patient;
- Educate OR staff regarding the importance and rationale of antibiotic timing, selection, and duration;
- Provide monthly feedback on prophylaxis compliance and infection data;
- Involve the pharmacy staff to ensure proper timing, selection, and duration are maintained;
- Institute a computerized physician order entry system with procedure-specific fields for antibiotic selection, timing, and duration;
- Improve screening for allergies to beta lactam antibiotics to eliminate false positives;
- Consider weight-based antibiotic dosing (i.e., higher dose for larger patients); as this may be cumbersome, protocols may be written to increase cephalosporins from 1 to 2 grams for all patients due to minor issues regarding toxicity; and
- Re-dose with antibiotics for longer procedures (e.g., after 3 hours for short half-life cephalosporin).

Surgical Hand Antisepsis[28]

Skin is a major source of microbial contamination in the surgical practice environment; therefore, hand hygiene has been recognized as a primary method for reducing HAIs. All perioperative personnel should follow established hand hygiene practices for maintaining healthy skin and fingernail condition, as well as those regarding the wearing of jewelry in the perioperative practice setting. A surgical hand scrub should be performed prior to donning sterile gloves for surgical or other invasive procedures, using either an antimicrobial surgical scrub agent intended for surgical hand antisepsis or an alcohol-based antiseptic surgical hand rub with documented persistent and cumulative activity that have met the United States Food and Drug Administration (FDA) regulatory requirements for surgical hand antisepsis.

Preoperative Skin Preparation[29,30]

The goal of preoperative preparation of the patient's skin is to reduce the risk of postoperative surgical site infection by removing soil and transient microorganisms from the skin; reduce the resident microbial count to subpathogenic levels in a short period of time and with the least amount of tissue irritation; and inhibit rapid, rebound growth of microorganisms. Two aspects of preoperative skin preparation for MIS procedures are shaving and surgical skin antisepsis.

Shaving. Hair adjacent to the operative site is often removed to prevent the wound from becoming contaminated with hair during the procedure. However, several research studies have found that shaving with a razor can abrade the skin and increase the risk of infection by enhancing microbial growth; shaving also results in higher SSI rates than using a depilatory cream or clipping. Therefore, hair at the surgical site should be left in place whenever possible. If the presence of hair will interfere with a surgical procedure, it should be removed in a location outside of the operating or procedure room; only the hair that will interfere should be removed; and hair should be clipped using a single-use or battery-operated clipper, or a clipper with a reusable head that can be disinfected in between patients. Further, clipping hair the morning of surgery has been shown to result in fewer SSIs than shaving or clipping the day before surgery; limiting the amount of clipping minimizes the risk of microscopic nicks. Hair at the surgical site should not be removed with a razor. Depilatories may be used for hair removal, if testing has been performed without tissue irritation.

Surgical skin antisepsis. Several antiseptic agents are available for preoperative preparation of skin at the incision site. The iodophors (e.g., povidone-iodine), alcohol-containing products, and chlorhexidine gluconate (CHG) are the most commonly used agents. Iodophors act by disrupting cell membranes by oxidation and substitution; their activity is shorter than CHG and they must be allowed to dry in order to maximize their action. The disadvantages of iodophors include that they can be inactivated by blood or serum proteins and their associated tissue toxicity. CHG also disrupts cellular membranes, but is long-lasting against both gram-positive and gram-negative organisms. CHG kills on contact and cannot be inactivated by organic components (e.g., blood). Preoperative skin antiseptic agents that have been approved or cleared by the FDA and approved by the health-care organization's infection control personnel should be used for all preoperative skin preparation.

Bacterial Dispersion and OR Ventilation

Air in the perioperative environment contains microbial-laden dust, lint, skin squames and respiratory droplets; outbreaks of SSIs have been traced to airborne contamination from colonized healthcare workers.[31] Operating room ventilation systems dilute and remove contaminants from the air and control air-flow patterns; the key components of an effective ventilation system are proper air quality, air volume changes, and air flow direction.[32] A properly functioning ventilation system carries microbial-laden skin squames, dust, and lint away from the sterile field and removes them through the exhaust ducts at the periphery of the room; as a result, contamination of the sterile field is minimized, which reduces the risk of infection to the patient.

In the OR environment, in order to control bioparticulate matter, ventilating air should be delivered to the room at the ceiling and exhausted near the floor and on walls opposite to those containing inlet vents; airflow should be in a downward directional flow, moving down and through the location with a minimum of draft to the floor and exhaust portals.[33] Air pressure in the OR should be greater than that in the surrounding corridor (i.e., “positive pressure” in relation to corridors and adjacent areas). Every operating room should have a minimum of 15 total air exchanges per hour, with the equivalent of at least three replacements being of outside air to satisfy exhaust needs of the system. Furthermore, doors to the OR should be kept closed in order to maintain proper ventilation, airflow, and air pressure.

Proper Care and Handling of MIS Instrumentation

Today, with the increasing infection control concerns presented by newly discovered pathogens as well as pathogens that have developed resistance to standard treatment modalities, proper care and handling of MIS instruments and accessories are vital in order to reduce the patient’s risk for SSI. Proper care and handling are further complicated by the development and use of new, more sophisticated instruments that are delicate and may be more difficult to clean adequately. In its 2008 Guideline for Disinfection and Sterilization in Healthcare Facilities, the Centers for Disease Control and Prevention (CDC) notes that failure to properly disinfect and sterilize equipment carries not only the risk associated with breach of host barriers, but also the risk for person-to-person transmission and transmission of environmental pathogens; further, thorough cleaning is required before disinfection and sterilization because inorganic and organic materials that remain on the surfaces of instruments interfere with the effectiveness of these processes.[34]

Endoscopes and instrumentation used for minimally invasive surgical procedures must be clean and free from all bioburden before sterilization or high-level disinfection.[35] During routine use, bioburden can accumulate in the channels, ports, and other movable parts of the instruments; therefore, gross blood and bioburden should be removed periodically throughout a procedure by flushing the channels and wiping the surfaces with sterile water. Sterile saline should never be used to routinely clean this debris since the salt solution can leave mineral deposits in or on the device. This routine cleaning during the procedure helps to prevent the debris from drying, which not only protects the device, but also facilitates the cleaning process after the case. Upon completion of the procedure, all instruments and devices must be thoroughly decontaminated as soon as possible. Immersible equipment should be cleaned or flushed with an enzymatic or other appropriate detergent solution in order to loosen organic material and facilitate its removal. Instrumentation that can withstand cavitation or ultrasonic cleaning can be placed in an ultrasonic device; endoscopes cannot be placed in an ultrasonic device because the vibrations can damage their tiny fiberoptic bundles. All instruments and equipment should be carefully rinsed and flushed with copious amounts of water after the cleaning process. Once the devices have been thoroughly cleaned, rinsed, and dried, their integrity and functionality must be assessed. Perioperative personnel who are responsible for reprocessing MIS instruments and devices must be aware of an instrument's composition, design, and use; it is critical, therefore that personnel who are responsible for reprocessing MIS instrumentation and accessories receive education on how a device is used in order to ensure that their functionality is not compromised during reprocessing. Because the FDA requires that any device purchased as reusable must have written instructions for reprocessing, the manufacturer's written, validated instructions for handling and reprocessing of instruments should be obtained and evaluated prior to purchase to determine the ability to adequately clean and reprocess the equipment within the facility. Once the instrumentation is obtained, these instructions should be followed for the type of water that should be available for cleaning; the types of cleaning agents to be used for decontamination; the types of cleaning methods (e.g., manual or automated); and inspection for damage.[36] Personnel handling contaminated instruments must wear appropriate personal protective equipment to protect themselves from exposure to bloodborne pathogens and other potentially infectious materials. Sterilization and/or high-level disinfection should be performed according to the manufacturer's written instructions.

Special Considerations in MIS Surgery[37]

The perioperative nurse should be aware of special considerations to prevent surgical site infections with all MIS as well as computer-assisted procedures. The specialized cells that line the peritoneal cavity serve as the first line of defense for the immune system in the abdomen. This defense system of the peritoneum may be adversely affected by the creation of the pneumoperitoneum used in many MIS procedures, as the mechanical distension changes the peritoneal microstructure, thereby allowing the passage of bacteria. This systemic response, coupled with the amount of tissue damage and the duration of the procedure, may potentially lead to an increased risk for infection. This is an important consideration because intra-abdominal infections often begin in the peritoneal cavity.

Care should be taken when retrieving specimens during MIS procedures in order to prevent cross-contamination and to ensure complete extraction. Some MIS procedures may carry a higher risk for infection (e.g., extraction of an infected appendix or extraction of infected cysts through a small incision); in these types of procedures, there is a need for careful handling with atraumatic grasping forceps or specimen bags to avoid rupture and subsequent contamination into the peritoneal space. Morcellators may be used to cut up and remove large specimens.

SUMMARY

Infection prevention is a primary goal for all patients undergoing surgical intervention. The development of an SSI in any patient is associated with significant patient morbidity and mortality, and also results in unnecessary discomfort, increased lengths of stay, and additional health-care costs. In today's complex economic climate, with various initiatives in place to reduce the incidence of HAIs, perioperative personnel and facilities must take appropriate measures to prevent SSIs. For the foreseeable future, SSI rates will continue to be used as a measure the quality of health care.

The perioperative nurse should know and understand the role of MIS in decreasing infections in the surgical patient, based on robust evidence in the medical literature supporting both the clinical and economic benefits of MIS and positive impact on overall patient care. As advancements in MIS techniques continue to expand the scope of surgical applications, and both the number and types of minimally invasive surgical procedures continue to grow, MIS will continue to be a key strategy in reducing the incidence of SSIs. In addition, the perioperative nurse must understand the patient-related and environmental factors that increase a patient's risk for SSIs and therefore implement evidence-based strategies shown to reduce these associated risks in order to make an SSI a "never event." Through this knowledge, the perioperative nurse involved in the care of patients undergoing MIS procedures will play an integral role in proactively decreasing the risk for surgical site infections and ultimately improving patient outcomes.

GLOSSARY

Antisepsis	The process of inhibiting the growth and proliferation of microorganisms.
Antiseptic Agent	Antimicrobial substance that is applied to the skin to reduce the log number of bacterial flora. Examples of antiseptic agents include alcohols, chlorhexidine gluconate, chlorine, hexachlorophene, and iodine.
Bioburden	The number of microorganisms (i.e., microbial load) with which an object is contaminated.
Contamination	The presence of potentially infectious pathogenic microorganisms on animate or inanimate objects or surfaces.
Decontamination	The use of physical and/or chemical means to remove, inactivate, or destroy pathogenic microorganism on a surface or item to the point where they are rendered safe for handling, use, or disposal.
Deep Incisional SSI	An infection involving deep soft tissue, fascia, and muscle.
Endogenous	Growing from or on the patient; caused by factors on or in the patients body or arising from internal structural or functional causes.
Exogenous	Growing from or on the outside; caused by factors (as food or a traumatic factor) or an agent (as a disease-producing organism) from outside the organism or system; introduced from or produced outside the body.
Healthcare-Associated Infection (HAI)	An infection acquired by a patient during hospitalization, with confirmation of diagnosis by clinical or laboratory evidence. The infective agents may originate from endogenous or exogenous sources. HAIs, which are also known as nosocomial infections, may not become apparent until the patient has been discharged from the hospital.
Infection	The invasion and multiplication of microorganisms in body tissues that cause cellular injury and clinical symptoms.

Laparoscopy	Endoscopic examination of the peritoneal body cavity through a percutaneous access portal, placement of expansion medium to create a working space, and manipulation of intra-abdominal organs.
Minimally Invasive Surgery (MIS)	Surgical procedure performed through one or more small incisions using endoscopic instruments, computer-assisted devices, robotics, or other emerging technologies.
Microorganism	An organism that is too small to be seen with the naked eye and requires a microscope. Bacteria, viruses, fungi, and protozoa are generally called microorganisms.
Morcellator	A device that crushes tissue for laparoscopic removal of large, hardened masses.
Multidrug-Resistant Organisms (MDRO)	Bacteria that may be resistant to one or more antibiotics (e.g., MRSA, VRE).
Never Event	Preventable medical errors that result in serious consequences for the patient.
Organ or Space SSI	An infection that involves any part of the anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation.
Pathogen	A microorganism that causes disease.
Pneumoperitoneum	The presence of air or gas within the peritoneal cavity of the abdomen often induced for diagnostic or procedural purposes.
Squames	Scales or flakes of skin.
Surgical Site Infection (SSI)	An infection involving the skin and subcutaneous tissue as opposed to deep tissue.

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