Surgical Site Infection: What Is It and Why Does It Happen?
Cynthia Spry, MS, MA, RN, CNOR

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Objectives

After completion of this self-study activity, the learner will be able to:
1. Define a surgical site infection.
2. Describe the impact of a surgical site infection.
3. Identify possible causes of a surgical site infection.
4. Discuss contribution of Sterile Processing to prevention of surgical site infection.

Test Questions

1. *Staphylococcus epidermidis* are the most common organisms implicated in surgical site infection.
   A. True  B. False

2. Approximately two out of every 100 patients who have surgery sustain a surgical site infection.
   A. True  B. False

3. An infection that occurs at the surgical site is considered a surgical site infection if it occurs within 30 days of surgery.
   A. True  B. False

4. The 5 components of the chain of infection always include: an infectious agent, a reservoir for the agent, a mode of escape from the reservoir, a mechanism of transmission and an open surgical incision.
   A. True  B. False

5. Personnel who process surgical instruments can break the chain of infection.
   A. True  B. False

6. A bronchoscope is an example of a fomite.
   A. True  B. False

7. The Joint Commission requires that hospitals seeking accreditation must collect data about whether normal body temperature was present immediately following surgery for patients undergoing colorectal surgery.
   A. True  B. False

8. It is a well-known fact that most surgical site infections (SSI) are caused by improperly processed surgical instruments.
   A. True  B. False

9. Most SSIs are endogenously acquired.
   A. True  B. False

10. Administration of an antibiotic to a patient 8 hours prior to surgery reduces the risk of SSI.
    A. True  B. False
Prevention of surgical site infection (SSI) is a major component of patient safety and a very high priority. Patients undergoing surgical procedures are at risk of infection and the job of every health care provider is to assist in preventing an infection. A surgical site infection can be minor or it can lead to death. When it occurs the impact is felt by the patient and the patient’s family and or support system. The healthcare facility where the infection occurs is also impacted. The impact is not only financial but can also adversely impact the reputation of the facility where the surgery was performed. The battle to prevent surgical site infection must begin with an understanding of what a surgical site infection is, what causes a SSI and how or why a patient sustains such an infection.

**Introduction**

There are two basic categories of surgical site infection; incisional and organ space. Incisional surgical site infections are of two kinds, superficial incisional and deep incisional.

**Incisional SSI**

**Superficial incisional SSI**

A superficial incisional surgical site infection is an infection that occurs at the incision site. It involves only the skin and subcutaneous tissue at the incision site. It occurs within 30 days of the operation and one of the following criteria must be met:

1. Purulent drainage from the incision.
2. Organisms are isolated from a culture of the fluid or tissue from the incision.
3. One of the following symptoms: swelling at the site, pain or tenderness, redness, or heat.
4. Diagnosis of a superficial incisional SSI made by the surgeon or other attending physician.

Superficial incisional SSI is the most commonly occurring surgical site infection and is also the most easily treated. Local wound care is usually all that is required. Antibiotics may be required for immunocompromised patients or for severe cases.

**Deep incisional SSI**

A deep incisional surgical site infection involves the deep soft tissue, e.g., fascia or muscle, of the incision. It occurs within 30 days of the operation and at least one of the following criteria must be met:

1. Purulent drainage from the incision.
2. A deep incision that spontaneously dehisces (breaks open) when the patient has one of the following signs or symptoms: fever, pain or tenderness.
3. Examination reveals evidence of infection.
4. Diagnosis of a deep incisional SSI made by the surgeon or other attending physician.

A deep incisional SSI is more difficult to treat and may involve repeated treatments or debridement, readmission(s) to the healthcare facility, and systemic antibiotics.

**Definition of a Surgical Site Infection (SSI)**

**Organ/Space SSI**

The most difficult to treat and the most serious SSI is an organ/ space SSI. Treatment involves systemic antibiotics and may involve open drainage similar to open surgery.

An organ/space SSI involves any part of the anatomy (e.g., organs or spaces) other than the skin incision, fascia or muscle layers, which was opened or manipulated during the operation. An organ/space SSI occurs within 30 days of the operation unless an implant is left in place, in which case, an organ/space infection is categorized as a SSI if it occurs within one year of the operation. At least one of the following criteria must be met:

1. Purulent drainage from a drain that is placed into the organ or space.
2. Organisms are isolated from a culture of the fluid or tissue in the organ/space.
3. Evidence of infection found upon examination.
4. Diagnosis of an organ/space SSI made by the surgeon or other attending physician.

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Impact of a Surgical Site Infection

The 10th leading cause of death in the United States is healthcare-associated infection (HAI). Surgical site infection makes up 20% of all healthcare-associated infections. Surgical site infection occurs in approximately 2% of all surgeries. Estimates for the costs associated with a SSI vary significantly. It is difficult to ascertain the true financial impact to a healthcare facility of an SSI as reimbursement rates vary and additional length of hospital stay and costs for care also vary. Some SSIs require significantly more care than others which impacts costs as well. Although the real cost is unknown, one study that looked at 723,490 surgical hospitalizations for 7 categories of surgery (neurologic; cardiovascular; colorectal; gastrointestinal; orthopedic; skin, subcutaneous tissue and breast; and obstetrics/gynecology) that resulted in 6,891 instances of SSI estimated that on average, the additional length of stay was 9.7 days and additional costs for care were $20,842 per admission. Overall nationally it is estimated that hospital costs for SSIs are as much as $10 billion annually.2,3 This does not include lost revenue that results when a bed occupied by the patient with a SSI is lost to a revenue producing patient. Regardless of the exact financial impact, a SSI increases the cost of care significantly and is reflected in personal, city, state, and national expenditures for health care.

In addition to the financial implications to the healthcare facility for costs associated with SSI the facility’s reputation may also suffer. As a result of increased focus on SSI prevention, many states require reporting of a SSI for a variety of surgeries. The number of states requiring reporting of SSIs is growing as is the list of types of surgeries for which reporting is required. This information is available to the public and may be used by a patient when making a decision as to where to have surgery.4 By gathering accurate data on numbers of SSIs a more accurate estimate of the financial impact for care can be determined.

In a landmark study in 1999 it was determined that for patients who develop a SSI, the risk of death is twice that of patients who do not sustain a SSI; that patients who develop a SSI are 60% more likely to spend time in the intensive care unit; and are 5 times more likely than non-infected patients to be readmitted to the hospital.5 Recognition of the risks associated with SSI and the knowledge that many SSIs could be prevented led to the Surgical Infection Prevention (SIP) program that identified interventions to reduce risk. In 2003 these interventions were added as “core measures” to The Joint Commission requirements. SIP has since transitioned into the Surgical Care Improvement Project (SCIP) which mandates evidence-based interventions known to reduce risk of SSI.

The impact of a SSI to a patient and the patient’s family and or support system can be overwhelming. These include but are not limited to:

- Prolonged pain, suffering and treatment;
- Inability to maintain gainful employment;
- Loss of income;
- Permanent disability/possible deformity;
- Loss of self-esteem;
- Increased workload for family and or support system; and
- Depression.

What Causes a Surgical Site Infection?

Surgical site infections result from the interaction of microorganisms (living things too small to be seen by the naked eye) in the healthcare environment, a compromised host (a patient who is vulnerable to infection), and the chain of transmission. Stated in another way — infection is caused by exposure to an infectious agent that multiplies in a susceptible host. The chain of infection has 5 components (see Figure 1):

- An infectious agent;
- A reservoir for the agent;
- A mode of escape from the reservoir;
- A mechanism of transmission; and
- A portal of entry into the host.

The goal of patient safety related to infection control and prevention is to break the chain of infection so that a patient does not sustain a SSI.
Infectious Agent

Infectious agents include bacteria, viruses, fungi, protozoa and prions. Most SSIs are caused by bacteria. Bacteria have a variety of shapes: spheres, rods and spirals. Bacteria that are spherical or round are called cocci. Rod shaped bacteria are called bacilli. Spirals are called spirilli. Scientific naming of bacteria is such that each organism has two names. The genus is the first name and is capitalized. The second name is the species and is not capitalized. Both are italicized, e.g., *Staphylococcus aureus*. *Staphylo* describes the clustered arrangement of the cells and *coccus* indicates they are shaped like spheres (kokkosis meaning berry in Greek). The species, *aureus*, is the Latin word for golden which is the color of the colonies of bacteria. *Staphylococcus aureus* and *Staphylococcus epidermidis* are two recognized species of staphylococcus. *Staphylococcus aureus* is the most commonly identified bacteria in SSI.

*Staphylococcus epidermidis* is associated with infections in surgeries involving a prosthesis, most notably vascular prostheses. Staphylococcal, enterococcal, pseudomonal, and streptococcal species also cause SSI. Bacteria are typically only a few micrometers long which means that even a very tiny hole in a sterile package could permit the passage of many millions of bacteria and create the potential for a surgical site infection.

Gram staining is a method used to differentiate bacterial species into two groups; gram stain positive — results in a blue-purple stain and gram stain negative — results in a red stain (see Figure 2). The Gram stain method is used to determine which drug might be most effective against the infection or a disease.

Figure 2. *Staphylococcus aureus* (gram positive cocci in blue-purple) and *Escherichia coli* (gram negative rods or bacilli in red)

It is not uncommon to think of microorganisms as harmful: however, many do no harm and are essential to life and to maintaining a healthy balance in nature. Many are normally found in or on the human body and most are not pathogenic — do not cause disease. However some organisms that normally live on or in the body without causing infection take advantage of certain opportunities to cause infection. These are referred to as opportunistic conditions. Examples are when the skin is broken and microorganisms usually on the skin or in the nose invade a surgical wound or when a person’s immune system is compromised and unable to raise an adequate response. Microorganisms take advantage of this and multiply to the point where they overwhelm the body’s weakened defense system.

Surgical site infection is either endogenously or exogenously acquired. Most SSIs are endogenously acquired. Endogenously acquired infection occurs from organisms that are present in or on the body and that gain access to the surgical wound. Examples are when *Staphylococcus* in the nose or on the skin of a person invades a surgical wound. Exogenous SSIs result from encounters with microorganisms in the environment — such as when microorganisms on a contaminated instrument come in contact with the surgical wound.

Although a variety of microorganisms are implicated in SSI the organisms most commonly associated with SSI are Gram-positive cocci. *Staphylococcus aureus* is the most frequently identified organism.

Prions are a unique infectious agent. They are actually misfolded proteins, or proteinaceous infectious particles that are responsible for rare neurodegenerative diseases, among them Creutzfeldt-Jakob disease. Because prions are especially difficult to destroy, special processing protocols are required when instruments are contaminated with or suspected to be contaminated with prions.

Factors related to the infectious agent include the ability of the microorganism to cause disease (pathogenicity), virulence or the severity of the disease, invasiveness or the ability of the infectious agent to invade tissue, and the amount of microorganisms necessary to cause disease (infective dose). Not all microorganisms are created equal with some being more virulent than others or having a better ability to invade a host.

Viruses also cause infections that can be contracted during surgery. Patients undergoing surgery and healthcare workers whose job places them at risk for exposure to blood are at risk of contracting the Hepatitis B or Hepatitis C Virus, or the Human Immunodeficiency Virus (HIV) when exposed to blood carrying these viruses. Compliance with the Occupational Safety and Health Organization (OSHA) Bloodborne pathogens standard 1910.1030 is critical to prevention of infections with these viruses.

The Reservoir

The reservoir is where the infectious agent lives, the place from where it passes to the susceptible host. Reservoirs can be animate or inanimate. Examples of animate reservoirs are a healthcare worker’s hands or a patient who is infected or is colonized. Colonized means a person harbors the organism/bacteria but is not infected by it. For example approximately 30% of healthy people carry *Staphylococcus aureus* organism on their skin or in their nose and in some populations the percentage is much greater.

Most SSIs are from the patient’s own body flora (e.g., microorganisms in their own skin or nose). Although increasingly, contaminated
surfaces and surgical instruments have been identified as causing SSIs.

Examples of inanimate reservoirs are environmental surfaces such as computer keyboards, bed rails, door handles, medical equipment, and surgical instruments. Many of the microorganisms that cause SSIs can live for long times on environmental surfaces — some for hours, some for days, and others for weeks or months. Recognition of the longevity of microorganisms on environmental surfaces and their role in healthcare-associated infection has led to an intense focus on environmental cleaning.

Portal of Exit

Portals of exit from the reservoir most often include the respiratory tract — coughing, sneezing, spitting. For example, pathogens responsible for tuberculosis, whooping cough, pneumonia, mumps, and measles exit through the respiratory tract. Some pathogens exit through the gastrointestinal tract in feces and others through body fluids, the skin or wounds.

Transmission

A mechanism of transmission is necessary to bridge the gap between the portal of exit from the reservoir and the portal of entry into the host. Transmission may be direct or indirect. Direct transmission occurs immediately and involves direct contact with the reservoir. An example is when aerosols produced by coughing or sneezing come into direct contact with the susceptible host. This is the way many respiratory diseases are spread and why it is best to avoid proximity to a person when he or she has a cold or tuberculosis and is sneezing or coughing. Another example of direct transmission is via a contaminated surgical instrument used on a patient during surgery. A further example of direct contact is through hand to hand contact. It is well known that infectious agents are often transmitted via the hands of healthcare workers. Although there is widespread recognition that hand hygiene is an important step in breaking the chain of infection, compliance with hand hygiene policies and procedures is often lacking. Recent hand hygiene campaigns, education, and literature stressing its importance have increased compliance, however, compliance is often short lived.

Indirect transmission is person-to-person transmission via an inanimate object. For example, a healthcare worker may apply a stethoscope to a patient’s chest, the stethoscope becomes contaminated, is not properly disinfected and is then used on a subsequent patient. The term used to describe an inanimate object implicated in infection transmission is fomite. In these examples the stethoscope and surgical instrument are fomites. Other examples of fomites are TV remote controls, a call bell, and an operating room table.

Portal of Entry

The portal of entry is an opening that permits the microorganism to enter into the host. Entry may be through inhalation, ingestion, sexual contact, or non-intact skin such as occurs during surgery. Portals result from tubes inserted into the body, i.e., a urinary catheter, punctures from IV procedures or incisions made during a procedure or surgery. A portal of entry may be the same as the portal of exit. Examples include: mucous membrane, (e.g., nose, mouth and eyes), the respiratory tract (entry through a bronchoscope), the genitourinary tract (entry through a cystoscope) or the gastrointestinal tract (entry through a colonoscopy).

The Susceptible Host

The host is the person/patient who is a risk for developing an infection. Infection is dependent upon the susceptibility of the host. Several factors increase the host’s susceptibility. Persons with a compromised immune system, such as patients who have had a liver transplant, make them more susceptible to infection because they are less able to fight infection than those with an intact immune system. Susceptibility is increased in the very young and the very old. The presence of underlying chronic diseases such as diabetes, cancer, HIV or other co-morbidities increase susceptibility and risk of infection. Smokers — smoking delays primary wound healing and people who are obese or have poor nutritional status are also at increased risk.

Antibiotic Resistance

Many organisms have become resistant to the drugs that were once able to effectively destroy them. A prime example is Staph aureus. The antibiotic of choice has been methicillin. However, many of the infections caused by Staph aureus no longer respond to methicillin. The acronym MRSA refers to methicillin resistant Staph aureus. Patients colonized with methicillin resistant Staph aureus (MRSA) are at significant risk of SSI since many SSIs originate from the patients themselves. For example a patient who is colonized with MRSA in the nose may transfer those organisms to the surgical site postoperatively and infection with MRSA may develop. MRSA infections are difficult to treat and there are few drugs that are effective against them. Many facilities screen patients prior to high risk surgeries to determine if they are colonized with MRSA and if so, measures may be taken to reduce the risk of SSI by decolonizing them prior to surgery. Overall Gram-stain negative bacteria are more resistant to antibiotics than Gram-positive bacteria.
Other Factors

Wound classification is a risk factor for SSI. Wound classification is based on the type of surgery performed and the expected risk of infection. It stratifies the likelihood of bacterial contamination and the expected degree of contamination which in turn relates to the risk of SSI. Surgeries are classified as clean, clean contaminated, contaminated and dirty. A clean case is one in which the surgeon does not open any part of the body where infection or inflammation is encountered. Examples would include breast biopsy and inguinal hernia repair. Clean-contaminated refers to an operative wound where the respiratory, alimentary, and/or genitourinary tract is entered under controlled conditions with no unusual contamination. Contaminated refers to open, fresh accidental wounds or where spillage from the GI tract occurs during surgery involving the colon. Dirty or infected cases are wounds that involve old traumatic wounds with dead tissue or wounds with existing clinical infection. As would be expected the incidence of SSI is significantly greater when the surgical wound classification is contaminated than when the classification is clean.

In addition to host factors and wound classification, there are risk factors associated with the surgical environment. Duration of surgery is a factor that correlates to increased infection rates. The longer the surgery the greater the risk for developing an infection.

In 2003, the Centers for Medicare and Medicaid Services (CMS) in collaboration with the Centers for Disease Control and Epidemiology (CDC) implemented the Surgical Infection Prevention Project (SIP) in an effort to decrease mortality associated with SSI. The SIP subsequently transitioned into the Surgical Care Improvement Project (SCIP). SCIP is a quality partnership of 10 national organizations committed to improving surgical care. SCIP includes a list of evidence-based initiatives shown to have the potential to reduce the incidence of SSI. The initiatives include:

- Administration of prophylactic antibiotic within one hour prior to surgery.
- Appropriate antibiotic selection — consistent with national guidelines.
- Discontinuance of prophylactic antibiotic within 24 hours after surgery.
- Cardiac surgery patients with controlled 6AM blood glucose postoperatively.
  - Diabetes is a risk factor for requiring cardiac surgery and a well-known risk factor for postoperative complications. Chronic hypoglycemia associated with diabetes leads to decreased vascular circulation and reduced tissue perfusion which impairs healing. Immunity is also compromised and increases risk of SSI.
- Appropriate hair removal.
  - Hair should not be removed unless necessary for the surgery. If hair must be removed it should be carried out with a clipper, not a razor. Shaving with a razor can create minute nicks in the skin which provide an inviting reservoir in which bacteria can proliferate (see Figure 3).
- Perioperative temperature management
  - Normothermia is a body temperature of 37°C in the perioperative period. Although originally aimed at patients having colorectal surgery many facilities warm all patients having surgery. Patients undergoing surgery are at risk of unplanned hypothermia due to vasoconstriction from anesthesia, skin exposure, exposure of internal organs, wet skin prep, cool IV, and irrigation fluids and cool room environment. Hypothermia can affect medication metabolism and electrolyte levels and can impair function of the immune system responsible for fighting infection. It has been shown that warming patients in the preoperative period as well as the intraoperative period is more effective at preventing unplanned hypothermia than warming in the intraoperative period only. As a result pre-warming with forced air is now common in all patients, regardless of age, undergoing procedures or neuraxial anesthesia of 60 minutes or longer as addressed in SCIP-Infection 10. (See Figure 4.)
- Removal of urinary catheter by second day after surgery.

Catheters can serve as a portal of entry for bacteria.

Figure 3. Appropriate hair removal with a clipper
The Joint Commission requires that hospitals gather data on these “core measures”. The consumer can go online and research a facility’s compliance with these measures. As patients increasingly become their own health-care advocates it is possible this data may factor into the decision to choose or not choose a particular facility for care.

Because there are so many variables that contribute to development of a SSI it is often difficult to determine the exact cause. In the case of a surgical instrument, it is especially difficult to be certain that a SSI was caused by a contaminated instrument. The exception to this is the ability to trace an infection to an improperly processed GI endoscope. Typically only one reprocessed device, an endoscope, is used in GI procedures. This makes it possible to trace the exact device to the patient on whom it was used and to then obtain cultures from the device to determine if organisms on the device are identical to the organism isolated from the patient. A match usually indicates the device was the source of the infection.

In surgery it is not uncommon for 50 or more instruments to be used in a single procedure. Tracking which instrument may have been responsible for an infection is difficult. Knowing whether the SSI was caused by an improperly processed device or another factor is sometimes impossible. It is usually only when a series of similar infections occur in similar procedures that it becomes possible to trace the source of the infection. There is a growing awareness that removing debris from many surgical instruments is problematic and can become the source of infection. Many devices are difficult to clean because of their complex design and many instructions for processing are inadequate.

The Food and Drug Administration (FDA) and the Association for the Advancement of Medical Instrumentation (AAMI) convened a summit in October 2011 to address issues of device reprocessing and identified priorities to address improvements in instrument processing. At least one state has begun to collect reports describing cases where sterilized items have been contaminated from a prior procedure. Although these devices may not have made their way to surgery there is growing evidence that retained debris is not uncommon. Even material that has been sterilized becomes a foreign body inside the patient and causes the patient’s defense mechanisms to reject this foreign substance with resultant inflammation. Professional journals and the popular press have recently published accounts of SSIs caused by improperly processed/cleaned surgical instruments. NBC News aired a segment “TODAY Investigates: Dirty Surgical Instruments: A Problem in the OR” that reported on infections caused by an inadequately cleaned arthroscopic shaver. In this episode a patient who underwent rotator cuff repair sustained an infection that was traced to an arthroscopic shaver. Debris was discovered by threading a tiny optical camera inside the cannula of the shaver. The device had been cleaned according to the manufacturer’s instructions; however, the nature of the device resulted in inadequate cleaning. In the end, the patient required seven additional surgeries and what was expected to be a six week recovery became a painful two and a half year ordeal. In the patient’s own words, “It changed my life; it changed every aspect of it, thousands of days waking up in pain.” Six other patients who had the same shaver used in their surgeries also sustained infection. Other recent articles have reported on SSIs related to contaminated surgical instruments. A judge recently awarded $1.25 million for a Hepatitis C infection sustained by a patient who underwent a procedure with an improperly processed endoscope. With the heightened focus on the role of surgical instruments in infection transmission it is certain that other such articles and news stories
will appear. With the introduction of instrument tracking systems it is now possible to tract a surgical instrument set to the patient on whom it was used. At this time individual instruments within the set that were actually used are not routinely tracked. Slowly it is becoming increasing possible to determine whether a contaminated instrument was the cause of a SSI.

Sterile Processing personnel play a key role in preventing SSI by breaking the chain of infection. The chain is broken when potential reservoirs are cleaned and sterilized and do not become reservoirs harboring pathogenic microorganisms, and there are no pathogenic microorganisms to be transmitted. Devices that are improperly or inadequately processed increase the risk of SSI. The first step in ensuring proper processing is to consult the medical device manufacturer’s instructions for use which includes processing instructions. Following a procedure because “that is the way I was shown” is not acceptable. Every Sterile Processing professional and anyone processing surgical instruments is responsible for complying with instructions for use and to practice in a manner that reflects the most current instructions and recommended practices. Persons processing surgical instruments must have knowledge of the recommended practices and guidelines in ANSI/AAMI ST79 Comprehensive guide to steam sterilization and sterility assurance in health care facilities and must practice accordingly.25

In addition, “Senior management is accountable for ensuring that healthcare personnel, including licensed and unlicensed personnel are competent to perform their responsibilities.”26 Instrument processing typically takes place in the basement of the hospital. Although the work done in Sterile Processing is not well known by hospital employees and even less so by patients it is critical to a safe patient outcome. Personnel who process instruments wage war against powerful enemies that cannot be seen with the naked eye. It is through dedication and commitment to making a difference by preventing infection that allows patients to have the confidence that they will not sustain an infection following surgery.
References

Answers

1. B
2. A
3. A
4. B
5. A
6. A
7. A
8. B
9. A
10. B

Cynthia Spry, MA, MS

Cynthia Spry, MA, MS in Education & Nursing is an independent consultant. She retired from Advanced Sterilization Products after 12.5 years where she worked as an international consultant in sterilization and disinfection. Cynthia is a member of APIC, IAHCSMM and AORN where she was a past national president and is now the Professional Practices Issue Chair for the AORN Specialty Assembly for Sterilization Processing and Materials Management. She has authored over 75 publications and two nursing texts. She has presented seminars on many healthcare related topics across the world. Cynthia is also a member of several AAMI Working Groups writing and updating recommended practices, including co-chairing the committee responsible for the ST79 Comprehensive guide to steam sterilization and sterility assurance in health care facilities recommended practice.

Ms. Spry is an education consultant for 3M Health Care, Infection Prevention Division.
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