Management and Prevention of

Infection in Orthopedic Surgical Procedures

by Amy Broussard, CST, CFA

In orthopedic operating rooms, even one surgical-site infection is too many. In today's operating rooms, a surgical-site infection stands out as a very serious complication. Health-care-associated infections constitute a great challenge in today's hospitals and surgical departments. According to the Institute of Medicine, hospital-acquired infections cost hospitals between $3.5-5.7 billion dollars per year.[1]

This article examines current practices in place at one facility, and through a literature review, attempts to seek out ways to improve the policies and procedures that are currently being practiced to prevent orthopedic surgical-site infections.

The key issues that will be addressed in this discussion are: the types of bacteria commonly seen in orthopedic infections; the chain of infection for these bacteria; current policies and procedures in place at many facilities; the types of orthopedic procedures performed and their associated infection-risk factors; the different types of precautions taken with orthopedic surgical patients; prophylactic antibiotic therapy preoperatively; and new recommendations and standards of care in relation to infection control in the surgical setting. By discussing these key issues and researching current recommendations, it is the author's hope to improve current practices, thereby decreasing surgical-site infection rates in the future. The ultimate goal is to increase the quality of care that is given to patients, making their surgical experience a safer one.

Commonly-performed orthopedic procedures include: total hip and knee arthroplasty; open reduction and internal fixation

LEARNING OBJECTIVES

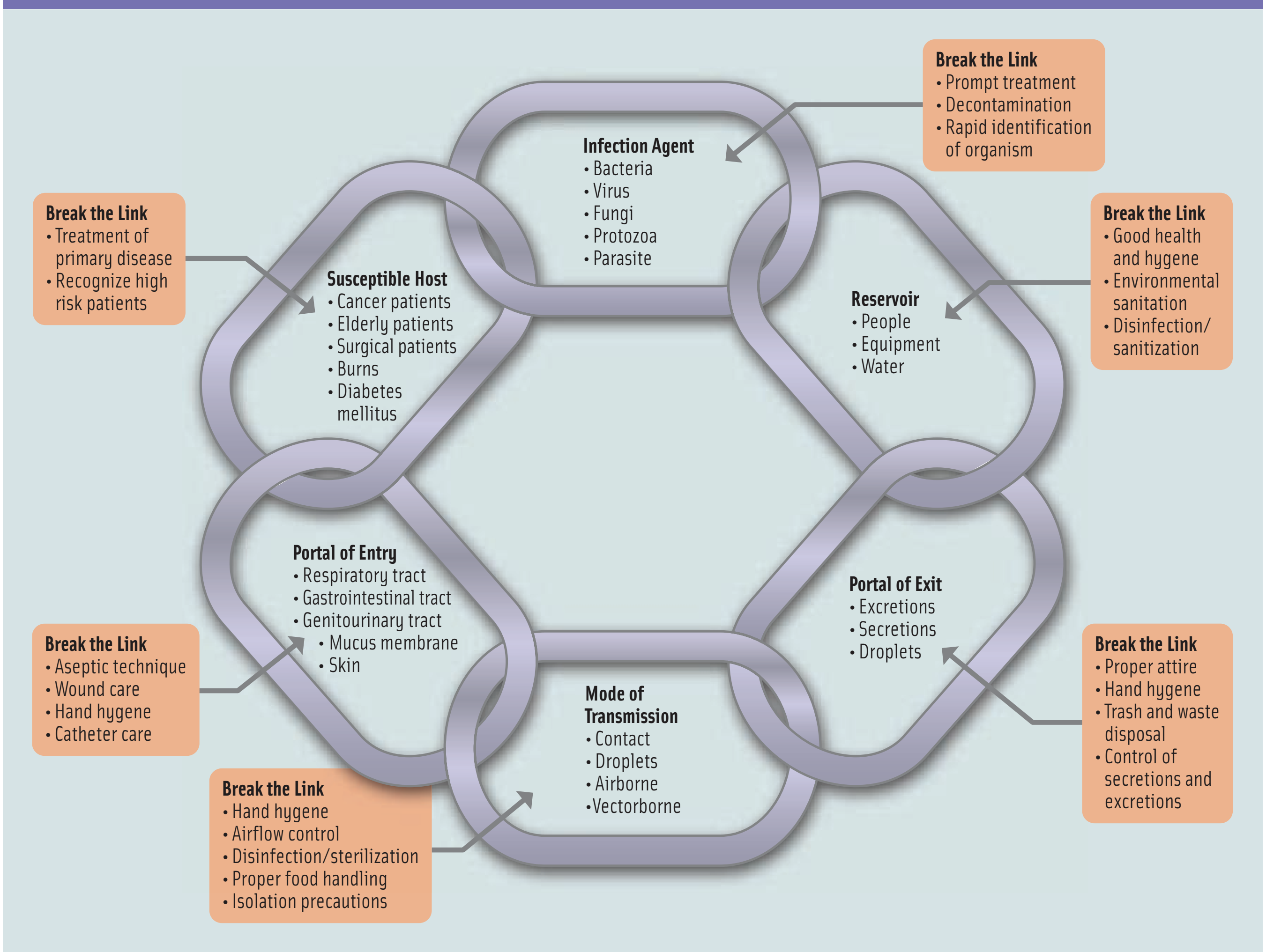
- Examine the causes of modern surgical-site infections
- Explore methods of decontamination for the modern O.R.
- Compare and contrast the different types of Staphylococcus bacteria
- Evaluate the decontamination practices in your own workplace
- Analyze the chain of infection for ways to improve your personal practice

of fractures; external fixation of fractures using Steinmann pins or an external fixation unit; and spinal laminectomy and discectomy. All of these procedures carry a chance of infection because a portal of entry is made either by surgical incision or from traumatic laceration. In addition, all of these procedures have very unique infection risk factors, although the chain of infection for all orthopedic procedures has a thread of commonality. Contamination of the surgical site by either direct or indirect means is a common cause of surgical-site infections.

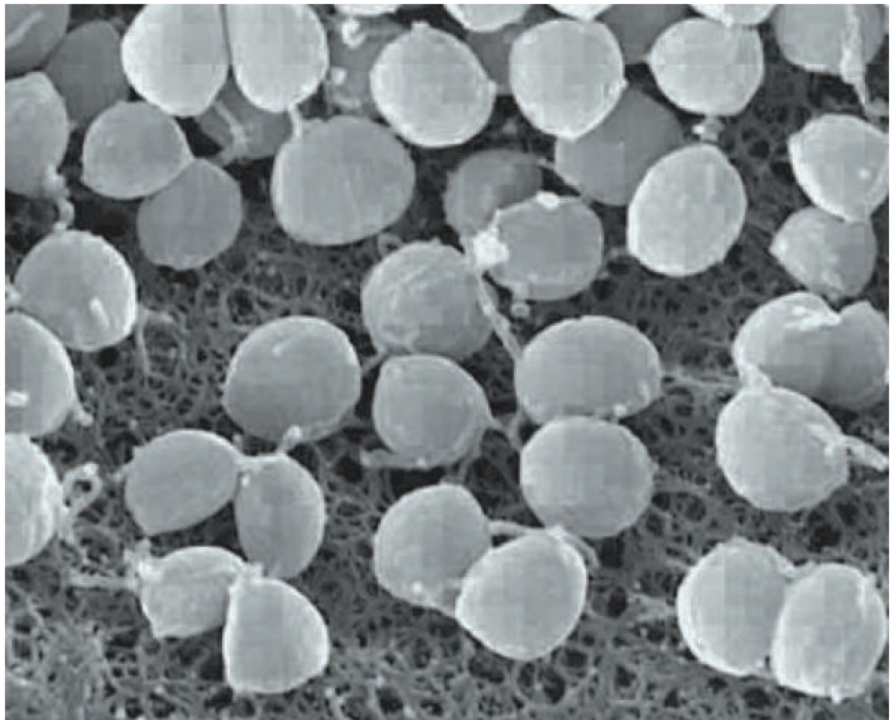
The most common microorganism responsible for orthopedic surgical site infections (SSI) is *Staphylococcus*.[2] The three prevalent strains of these bacteria seen in surgical-site infections are *Staphylococcus aureus*, *Staphylococcus epidermidis*, and methicillin-resistant *Staphylococcus aureus* (MRSA). Of the three, *S. aureus* is the cause of the majority of SSI.[3] The normal habitat for these microbes is on the human skin, and is most commonly spread by direct contact and airborne routes. However, *S. aureus* thrives in the nares of 25 percent of the population.[3] According to Bamberger & Boyd, *Staph aureus* is the most commonly isolated microorganism in osteomyelitis.[4]

The second strain, *S. epidermidis*, is a normal resident of human skin, mouth and nose. This bacterium has a distinct affinity for plastic,[5] making it a common contaminant of orthopedic prostheses. The last strain, MRSA, is a strain of *S. aureus* that is resistant to methicillin-containing medications, such as penicillin, oxacillin and amoxicillin. The most common cause of osteomyelitis cases are MRSA.[6] Although many different microorganisms have been found to cause orthopedic surgical infections, for the purpose of this analysis, the main infectious agent that the article will focus on is *Staphylococcus* and the different strains of this bacteria.

Figure 1. Breaking the Chain of Infection



To understand methods of preventing the spread of *Staphylococcus* in surgical-site infections, one must first look at the chain of infection. (see Figure 1)[7]



MRSA: The most common cause of osteomyelitias cases.

RESERVOIR

The reservoir for *Staphylococcus* is humans; specifically the nose, skin and peritoneal areas of the body. This means that health care workers in the operating room could potentially contaminate surgical wounds by exposing the sterile fields to bacteria if they touch surgical instruments with bare skin; break sterility by touching a nonsterile area with their sterile gowns or gloves; fail to recognize a perforation or tear in the gloves during a procedure; fail to recognize strike-through of the surgical gown during long procedures; not properly wearing the surgical mask covering the nose since *S aureus* can populate the nose; or poorly perform the patient skin prep to remove bacteria and other contaminants. Surgical employees must know the principles of asepsis and possess a strong surgical conscience. To help with this, a strong employee continuing-education program should be in place in every facility to keep surgical personnel up-to-date on proper sterile technique. Surgical technologists complete a one- or two-year comprehensive accredited surgical technology program in which the principles of asepsis and sterile technique are learned in detail and emphasized on a daily basis. Due to this expertise in sterile technique, the surgical technologist is in an optimal position to be the advocate for maintaining current knowledge in aseptic principles and current trends in infection control.

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PORTAL OF EXIT

The portal of exit for *Staphylococcus* is the human skin and nares, through contact or sloughing of bacterial cells. Standard Precautions should be used in every practice, with all patients, regardless of infection risk. Standard Precautions protect the patient from any microbes that the staff member may be hosting that could be transmitted to the patient via an open wound, and protect staff members from potential infection from patients. These precautions include the use of personal protective equipment (PPE) and hand washing. The purpose of PPE is twofold, as it protects the patients and the staff. PPE includes gloves, gowns, masks, and eye protection that must be worn when contact with blood, bodily fluids or other potentially-infectious material (OPIM) is expected.

Another important Standard Precaution is hand washing. There is great importance placed on the practice of hand disinfection among health care workers, especially in the operating room environment. Proper hand washing has been proven as the most effective form of infection control in the hospital setting to prevent hospital-acquired infections, or nosocomial infection, and is a recommended practice before and after contact with a patient. All operating room personnel working within the sterile field use either a waterless hand antiseptic or a traditional antimicrobial scrub solution and engage in a vigorous three-to-five minute hand scrub prior to and after surgical procedures. With proper practice of Standard Precautions, the portal of exit link of the chain of infection can be broken. For more specific guidelines regarding hand washing, please reference the *AST Recommended Standards of Practice for Hand Hygiene and Fingernails.*[8]

MODE OF TRANSMISSION

The mode of transmission for orthopedic SSIs can be either direct or indirect contact or airborne transmission.[2] Recently, the authors became curious about the cleanliness of the laptop computers used for patient charting in the operating room and the possibility of their direct relationship to the cause of SSIs. The laptop computers are only used within the operating rooms and are never removed except for maintenance purposes. It is the policy of this particular health care facility to disinfect the computers after every procedure with a mild disinfectant solution. The authors conducted an experiment in a single facility by preparing aerobic and anaerobic microbial cultures from the laptop computers. The cultures revealed *S. epidermidis* on all four computers, and MRSA on two of the four computers. These findings are extremely important considering that the computer charting system was implemented within the last three years and an increase in SSIs at this facility has been documented within that time.

Further studies are currently underway in the health care facility to provide definitive evidence that the laptop computers could be a source of microbial contamination. Recommendations for autoclavable keyboards and plastic covers have been made by the infection control nurse in light of the initial findings. If these precautions are approved by the health care facility administration, this may be a huge step forward in breaking the chain of infection for *S. epidermidis* and MRSA at this particular facility.

Autoclavable keyboards are easier to disinfect than standard keyboards.

Another mode of transmission is the O.R. environment. Environmental controls are established to reduce the ability of microbes to colonize and reproduce. These include the temperature, humidity and air flow in the operating room, and keeping traffic through the operating room to a minimum. According to the AORN Perioperative Standards and Recommended Practices, the temperature in the operating room should be maintained between 65-72 degrees Fahrenheit, and the humidity is maintained at 30-60 percent. This is controlled because most microbes do not survive well in colder temperatures and low humidity.[9] Laminar air flow, which is a form of positive pressure ventilation, is used in many health care facilities to decrease the rate of air exchange from the semi-restricted area of the outside hallway to the operating room. Additionally, traffic in the operating room should be kept to a minimum while a procedure is in progress to prevent contaminants from becoming airborne, thus reducing the contact patients have to airborne microbes and fomites, as discussed and described in AST's Recommended Standards of Practice for creating the sterile field.[10] Disinfectants used in the operating room setting must be tuberculocidal, antiviral, antimicrobial and antifungal. The surfaces in the operating room, including the operating room table, Mayo stands, back table, prep table, sitting stools, operating room lights and floors are disinfected with an antimicrobial solution at the beginning of each day and between each procedure. In addition, terminal cleaning of every surface including the walls, lights, floors, and working surfaces should be performed at the end of each working day to decrease overnight microbial colonization. These practices help to reduce the amount of cross contamination between patients and operating room personnel and provide a clean environment for the patient. If a procedure is performed on a patient with an existing infection, it is recommended that this procedure be performed in an operating room where orthopedic procedures, especially joint replacement procedures, are not performed to decrease the risk of cross contamination. Preferably, a patient with a pre-existing infection should be scheduled as the last procedure of the day in an operating room. The mode of transmission on the chain of infection is a factor that can be affected with strict vigilance of proper procedure and following recommended practices.

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PORTAL OF ENTRY

The portal of entry is either a surgical incision made by a surgeon's scalpel, a traumatic wound or a pin site, as in the case of an external fixation of a fractured bone. *Staphylococcus* can spread very rapidly when introduced to the mucous membranes and underlying tissues in a surgical incision. A traumatic open wound usually becomes a portal of entry at that time of the injury and is usually exposed to debris and contaminants before entering the operating room. Pin sites allow for a continued portal of entry, even after the surgery is over, because they remain in place for six to eight weeks.

Surgical implants can become a fomite, which can contaminate the surgical portal of entry if contaminated either before or during a joint-replacement procedure. This author's facility's implant policy states that orthopedic implants that are to be placed in a patient's body are to come to the hospital sterile from the manufacturer. It is the policy of the facility not to flash or sterilize any implant devices. The health care facility policy is supported by the standard stated in ANSI/AAMI ST79 2006, "Comprehensive Guide to Steam Sterilization and Sterility Assurance in Health Care Facilities," which recommends implantables not be flash-sterilized.[11] The only implants that may be reprocessed are plates and screws that are part of fixation sets. In addition, any outside instrument sets from either another health care facility or an instrument company are packaged in the facility's sterile wrapping and sterilized in accordance with the manufacturer's recommendations.

Sterilization by steam, irradiation, gas, filtration or chemical sterilization is required for all instrumentation. Steam autoclaves and chemical sterilization are utilized in this author's hospital's surgical department. Steam sterilization is the most commonly used sterilization process for facilities worldwide.[12] For items that are unable to withstand steam sterilization, microbial eradication is achieved by chemical methods. Glutaraldehyde is an example of one type of liquid chemical disinfectant and sterilant used for heat-sensitive items. Disinfection can be achieved by placing the instruments in glutaraldehyde for 20 minutes at room temperature. To render the item sterile, it must be immersed for 10 hours.[13]

SUSCEPTIBLE HOST

The surgical patient is a susceptible host who, by simply having a surgical procedure, is exposed to acquiring a SSI. The body's primary defense against infection is an intact integumentary system. When a procedure is performed, the integrity of the skin is compromised and a route for bacteria to enter the body has been created. One way to help decrease this susceptibility is the use of preoperative antibiotics. A vast body of evidence supports the theory that preoperative antibiotic therapy can significantly lower the risk of, or even prevent SSIs. Two national organizations, including the Centers for Disease Control and Prevention (CDC) and the American Society for Health System Pharmacists (ASHP) support this premise.

Antimicrobial prophylaxis refers to antibiotics administered in a brief course approximately 30-60 minutes before a surgical procedure is to be performed. This action will give the highest probability that the serum concentration of the agent used will be at a therapeutic level. It is optimal that this serum level is maintained at most a few hours after the surgical procedure is performed. This course of antibiotics is to reduce the possibility of a SSI occurring while not overwhelming the surgical patient's defenses. Many studies have shown a marked decrease in SSIs, including orthopedic surgical sites, with the use of preoperative antibiotic therapy.[14, 15]

This author's hospital's surgical department has used this evidence as a model for a preoperative antibiotic policy and it is considered a standing order for all patients. The antibiotic of choice for preoperative prophylaxis is acephalosporin. It has been shown to have great effectiveness on both gram-positive and gram-negative microorganisms.[16] If a patient is allergic to penicillin, the drugs of choice are either vancomycin or clindamycin. Although vancomycin and clindamycin are not recommended as first choice antibiotics for any operative procedure, an exception to this is the presence of MRSA in the patient who must undergo the procedure and time does not allow for the eradication of the infection before the procedure.

CONTRIBUTING FACTORS OF SUSCEPTIBILITY

Intraoperative core hypothermia, another factor that increases susceptibility, can result in impaired immune function and vasoconstriction. The body temperature of an operative patient may fall between one- and one-and-a half degrees Celsius during the first hour of general anesthesia. In addition, regional anesthesia also poses a risk for core hypothermia. This increases the risk for SSIs by decreasing the oxygen saturation of the body's tissues.[17] Measures should be taken to maintain core body normothermia in the surgical patient. This may include warmed intravenous fluids, forced air warming blankets, other types of warming blankets using warmed fluid, increased ambient temperature in the operating room during the time of the procedure, decreased surgical time, exposure of the patient kept at a minimum, and continuous monitoring of the patients core body temperature during the surgical procedure, as cited in AST's Guideline Statement for the Maintenance of Normothermia in the Perioperative Patient.[18]

The susceptibility of a host is also related to surgical wound classification of the wound that is present or that will be made by surgical incision. There are four different categories. [13] (See Table 1.)

Table 1. Wound Categories Contributing to the Susceptibility of a Host[13]

Class I – Clean	Uninfected, uninflamed operative wound in which the respiratory, alimentary, genital, or uninfected urinary tracts are not entered.
Class II – Clean-Contaminated	Uninfected operative wound; respiratory, alimentary, genital or uninfected urinary tract is entered under controlled conditions without unusual contamination
Class III – Contaminated	Acute, nonpurulent, inflamed operative or open, fresh wound, or any surgical operation with an obvious break in the sterile technique or gross spillage from the GI tract.
Class IV – Dirty-Infected	Old traumatic wounds with retained devitalized tissue or clinically infected operative wound or perforated viscera. This category suggests that microorganisms that are capable of causing a postoperative infection were present in the operative field before the operation.

There are also a number of pre-existing health conditions that greatly increase a patient's risk for a SSI. Smoking and diabetes are two of the most recognized conditions. Smoking causes vasoconstriction in a patient's entire body. In the surgical patient's case, the importance of this is the vasoconstriction that occurs around the surgical site, cutting off oxygen and nutrients to the healing tissue. This risk can be decreased if the patient stops smoking at least seven to 14 days before the surgical procedure. Vasoconstriction is also the cause for the increased infection risk in the diabetic patient in addition to delayed wound healing. This risk factor can be decreased by maintaining a normal serum glucose level during the perioperative period. It is the policy of this author's hospital's surgical department to monitor a patient's serum glucose level preoperatively upon arrival in the patient holding area, intra-operatively by anesthesia personnel and postoperatively by the post-anesthesia recovery room nurse. If any fluctuation of the patient's glucose level is detected, the primary care physician for that patient is notified.

DIAGNOSIS AND TREATMENT

Symptoms of a SSI are important keys that must be recognized in order to prevent treatment delays, which can increase patient morbidity and mortality. Orthopedic SSIs can manifest as superficial incisional infections, infections of the deep incision space, infections of the bone or infections involving a newly-implanted prosthetic device. Management of these infections depends on the extent of the involvement. Infections that involve a localized area may only require antibiotic therapy with the appropriate agents and may involve irrigation and drainage of the wound. Because of the increasing concern of community-acquired MRSA, purulent lesions that require systemic therapy should be cultured so that antimicrobial susceptibility testing can be performed and initial empiric treatment should consider the local prevalence of community-acquired MRSA.[4] Bone and joint infections are treated in much the same way that superficial infections are treated—with antibiotics and drainage of the wounds. Usually, a four-week antibiotic therapy is ordered. Prosthetic joint infections, like those seen in total knee and total hip arthroplasty, are difficult to eradicate with the foreign prosthesis still in place. Removal of the prosthesis is usually indicated with a follow-up of antibiotic therapy of four to six weeks.

TRACKING

There are two national studies currently underway in the United States that are monitoring SSIs: the National Nosocomial Infection's Surveillance System Report (NNIS) and the Surgical Care Improvement Project (SCIP). The NNIS system was established in 1970, when selected hospitals in the United States routinely started reporting their nosocomial infection surveillance on a national database. All of the data collected for the NNIS system are collected using standard protocols set by the CDC. SCIP describes itself as a national quality partnership of organizations committed to improving the safety of surgical care through the reduction of post-operative complications, including SSIs. The ultimate goal of the partnership is to save lives by reducing the incidence of surgical complications by 25 percent by the year 2010. The partners participating in the SCIP project feel that a meaningful reduction in complications requires that surgeons, anesthesiologists, surgical technologists, pharmacists, infection control managers and hospital executives work together to make surgical care and a decrease in infection and other surgical complications a priority.

CONCLUSION

It has been shown through a literature review that some precautions currently being practiced at this author's health care facility are adequate, such as the implementation of Standard Precautions and prophylactic antibiotics, but other measures can be taken to decrease the occurrence of SSIs. These include an increase in employee continuing education and new and improved ways of disinfecting the laptop computers in the operating rooms. If all of these additional measures are taken, the infection rate in the surgical department may decrease.

ABOUT THE AUTHOR

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