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Surgical Site Infection Risk Factors and Risk Stratification

Anthony V. Florschutz, MD, PhD, **Ryan P. Fagan, MD, MPH&TM**, **Wadih Y. Matar, MD, MSc, FRCSC**, **Robert G. Sawyer, MD**, and **Sandra I. Berrios-Torres, MD**

Department of Orthopaedics, Orlando Regional Medical Center, Orlando, FL (Dr. Florschutz), from the Division of Healthcare Quality Promotion, Centers of Disease Control and Prevention, Atlanta, GA (Dr. Berrios-Torres and Dr. Fagan), the Department of Orthopaedic Surgery, Centre de santé et de service sociaux de Gatineau, Hull Hospital, Gatineau, Quebec, Canada (Dr. Matar), and the Department of Surgery, Division of Acute Care Surgery, University of Virginia, Charlottesville, VA (Dr. Sawyer).

Abstract

Preoperative identification of the risk factors for surgical site infection and patient risk stratification are essential for deciding whether surgery is appropriate, educating patients on their individual risk of complications, and managing postoperative expectations. Early identification of these factors is also necessary to help guide both patient medical optimization and perioperative care planning. Several resources are currently available to track and analyze healthcare-associated infections, including the Centers for Disease Control and Prevention's National Healthcare Safety Network. In addition, the Centers for Disease Control and Prevention and the American Academy of Orthopaedic Surgeons are exploring collaborative opportunities for the codevelopment of a hip and/or knee arthroplasty national quality measure for periprosthetic joint infection.

Several risk factors are associated with the development of surgical site infection (SSI) following orthopaedic procedures. Preoperative identification of these risk factors and patient risk stratification are critical to effectively inform and educate surgical candidates on individualized risks (ie, low, intermediate, high), postoperative expectations, and whether surgery is appropriate. Furthermore, early recognition of SSI risk factors can prompt specific interventions for medical optimization and aid in the development of comprehensive perioperative care plans to minimize the risk of SSI. The development of organizations and resources to track and analyze healthcare-associated infections (HAIs), including SSIs, has aided the establishment of guidelines and standards for management.

Risk Factors

Risk factors for SSI can be categorized as modifiable (eg, *Staphylococcus aureus* colonization, weight) and nonmodifiable (eg, age, sex). Scientific evidence supporting practices aimed at reducing the risk of SSI is lacking in some areas, highlighting the

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importance of decisions made and recommendations generated at meetings such as the International Consensus Meeting on Periprosthetic Joint Infection (PJI).[1]

Risk factors can be divided into host and perioperative factors, which can be further divided into preoperative, intraoperative, and postoperative factors.[2,3] Host optimization has been shown to lower the risk of infection and should be started at the initial consultation. Preoperative optimization can include glucose and ulcer control in diabetic patients, controlling nidi of infections, improving the immune system, and addressing malnutrition and obesity.[4] Other strategies include optimizing skin condition, improving vascular status, smoking cessation, modifying intake of immunosuppressive drugs, and *Staphylococcus aureus* decolonization. A patient history of excessive alcohol consumption, intravenous drug use, admission to a healthcare facility, chronic liver disease, or chronic renal failure is also known to increase the risk of SSI.

Several perioperative strategies are aimed at reducing the risk of SSI. The goal of skin preparation steps (eg, preoperative showering or bathing, hair removal, and intra-operative antiseptic skin preparation) is to reduce the skin bacterial counts. Chlorhexidine gluconate whole-body showering the night before surgery is commonly recommended; however, it has not been shown to lower the risk of SSI.[5–7] Hair removal by clipping (not shaving) at the time of surgery has been shown to lower the risk of SSI.[8] There is no clear scientific evidence regarding the optimal antiseptic skin preparation solution; however, some studies indicate that the use of an alcohol-based agent improves the elimination of skin flora compared with the use of aqueous solutions.[9,10] Antimicrobial prophylaxis with cefazolin is a common choice in orthopaedic procedures because this agent has excellent in vivo activity against common gram-positive and certain gramnegative aerobes (eg, *Escherichia coli*, *Klebsiella* species), long half-life, and good tissue penetration. In a systemic review and meta-analysis of seven studies, AlBuhairan et al[11] found that antimicrobial prophylaxis reduced the absolute risk of SSI associated with total joint arthroplasty by 8%. Vancomycin should not be used routinely as a surgical antimicrobial prophylactic agent. However, in patients with a cephalosporin allergy or in those who test positive for methicillin-resistant *Staphylococcus aureus*, clindamycin or vancomycin combined with an aminoglycoside (for gram-negative coverage) may be used in place of cefazolin.

Intraoperatively, the use of laminar flow and body exhaust suits in total joint arthroplasty is common; however, both of these strategies, which are aimed at lowering surgical site contamination, have conflicting support in the literature.[12–14] A systematic study in the 1970s (that has not been challenged since then) established that operating room (OR) personnel are the primary source of bacteria in the OR; therefore, limiting traffic is essential.[15] Although the evidence is limited, frequent glove changes after draping and during long cases could also be considered because of high contamination rates and puncture rates.[16] The optimal wound irrigation method and content of the irrigation solution remain controversial, whereas the use of antibiotic-laden cement has been shown to be cost-effective and associated with a lower risk of PJI.[17] Longer OR times have been associated with an increased risk of PJI, and the use of strategies aimed at improving efficiency with dedicated OR teams should be considered.[18]

Wound optimization for healing should be sought in all cases with the use of meticulous closure techniques, sealed dressings, infrequent dressing changes, and close observation.[19] During the postoperative period, hematoma formation has been shown to be associated with the use of certain anticoagulation agents as well as an increased risk of PJI.[20] Persistent wound drainage has also been associated with a greater risk of PJI compared with incisions that heal normally.[21,22] Therefore, persistent postoperative drainage should be promptly assessed (eg, serum erythrocyte sedimentation rate, C-reactive protein, interleukin-6, aspiration) and closely followed, maintaining a low threshold to proceed with surgical débridement as appropriate.

The American College of Surgeons and National Surgical Quality Improvement Program Risk Calculator

The American College of Surgeons has developed a risk calculator to assist surgeons, patients, and families in understanding the risks of major complications after surgical procedures. This calculator uses data collected from hundreds of thousands of patients through the National Surgical Quality Improvement Program.[23] This risk calculator can be used to estimate the chance of an unfavorable surgical outcome. Risk is estimated using information on prior health history provided by the patient. Data from a large number of patients who had a similar surgical procedure are then used to estimate the risk of complications.

The risk calculator is available for free online. Data include procedure, sex, age, certain elements of the medical history, functional status, American Society of Anesthesiologists Physical Status Classification System, wound classification, case urgency, height and weight (to allow the calculation of body mass index), and the presence of sepsis. With these data, the risks of developing the following complications are displayed: serious complications, any complication, pneumonia, cardiac complication, SSI, urinary tract infection, venous thromboembolism, renal failure, return to the OR, death, and discharge to nursing or rehabilitation facility. In addition, the predicted length of stay can be estimated, as well. The surgeon is then able to slightly modify the output if he or she thinks the patient is at either slightly higher or lower risk based on other elements of the medical history not captured with the standard data input.

The risk calculator is available for arthroplasty, spine procedures, arthroscopy, and many other major orthopaedic procedures. For example, the estimated risk of SSI in a 70-year-old woman with type I diabetes mellitus and hypertension who is undergoing a total knee arthroplasty is 0.6%. This resource could readily be incorporated immediately into clinical practice to help patients and surgeons make better informed choices.

National Healthcare Safety Network

The National Healthcare Safety Network (NHSN) is a secure, internet-based surveillance system that was established by the Division of Healthcare Quality Promotion at the Centers for Disease Control and Prevention (CDC) in 2005, and it is used by the CDC, healthcare facilities, state health departments, and other agencies and organizations to track HAIs,

including SSIs.[24–28] As of 2012, 2,130 facilities in 48 states and Washington, DC reported SSI data for at least one type of surgical procedure (Cathy Rebmann, NHSN, personal communication, April 2014).[25] In 17 states, the legislature or health department requires reporting of SSI associated with hip and/or knee arthroplasty procedures (Cathy Rebmann, NHSN, personal communication, April 2014). The CDC and the American Academy of Orthopaedic Surgeons (AAOS) are collaborating to improve NHSN risk modeling for hip and knee arthroplasty, and both organizations are considering codevelopment of clinical quality measure proposals for SSIs following these procedures.

NHSN Surveillance Definitions

A working group of the federal Healthcare Infection Control Practices Advisory Committee (HICPAC) completed a comprehensive review of NHSN SSI definitions in 2011 and 2012. Representatives from the AAOS and the Musculoskeletal Infection Society as well as other subject matter experts provided input. The HICPAC working group supported NHSN adoption of the International Consensus Meeting on PJI's definition of PJI as the hip and knee arthroplasty "organ/space" SSI (PJI).[1,29]

NHSN Risk Modeling

Since 2012, the Centers for Medicare and Medicaid Services (CMS) rulemaking, authorized by the Healthcare and Education Affordability Reconciliation Act of 2010,[30] has required that all Inpatient Prospective Payment System healthcare facilities participating in the CMS Inpatient Quality Reporting program report their SSI data for colon and abdominal hysterectomy procedures to NHSN, as outlined in the *US Department of Health and Human Services Action Plan to Prevent Healthcare Associated Infections*.[25,31] NHSN reports facility-level HAI data on behalf of hospitals to CMS using the standardized infection ratio (SIR) as the summary measure.[32] The SIR is the ratio of the number of SSIs reported to the number of SSIs predicted.[25,33–35] In calculating the SIR, the predicted number of SSIs is based on the procedure-specific, patient-level risk factors.

Current risk factor variables in the NHSN hip and knee arthroplasty risk model include age, American Society for Anesthesiologists Physical Status Classification score, procedure duration, trauma, hospital bed size and teaching status, primary versus revision arthroplasty, and total hip arthroplasty versus hemiarthroplasty.[36] At the recommendation of the HICPAC working group, NHSN began collecting patient height, weight, and diabetic status for all procedure types in 2014. Additionally, a new variable to identify revision hip and knee arthroplasties that are associated with prior infection at the index joint is scheduled to be added in 2015. The NHSN and AAOS are working to develop reporting specifications for this new variable and to better define International Classification of Disease, ninth revision (and eventually the 10th revision), clinical modification mappings to denominator-procedure characteristics (eg, revision, primary, resurfacing). These new variables will be considered when NHSN risk models are updated, which is tentatively planned for 2016 using 2015 data.

Proposed Development of Prosthetic Joint Arthroplasty Quality Measure

As mentioned previously, the CDC and AAOS are exploring collaborative opportunities to develop a hip and/or knee arthroplasty PJI quality measure. The goal would be to achieve consensus on reporting definitions, including surgical procedures, and risk adjustment that would be mutually agreeable to both organizations. The initial step is to work on refining the NHSN risk adjustment for PJI. The ultimate goal is to gain National Quality Forum endorsement of a national PJI measure.[37]

Summary

Early evaluation of perioperative SSI risk factors and patient risk stratification could be of great value in the development of predictive risk models. Predictive risk models could, in turn, assist surgeons and their patients in the clinical decision-making process (eg, counseling patients on the appropriateness and risks of surgery). In addition, risk models could be used to develop targeted perioperative prevention strategies and diagnostic care process models and improve risk adjustment for risk modeling used in the public reporting of SSI as a quality metric.[38,39] However, development of these models is challenging.

Risk factor data collection is commonly performed through a manual review of patient medical records or through electronic mining of administrative data. There is a critical need to reduce the data collection burden by making better use of existing electronic medical record systems in the capture of risk factor data. Furthermore, there is a need to evaluate current barriers to the use of Current Procedural Terminology codes, whose granularity might be more useful for SSI surveillance purposes.

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