Decreasing the Incidence of Surgical Site Infections Following Joint Replacement Surgery

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Abstract

Objective: Despite the generalized use of prophylactic antibiotics in orthopaedic surgery, Surgical Site Infections (SSIs) are still a major source of morbidity, mortality, and hospital cost. This is due in part to the increasing prevalence of antibiotic resistant organisms.

Methods: A review of local epidemiology, the importance of an antibiotic stewardship program, patient optimization, and risk stratification options to reduce SSIs.

Results: The proportion of revisions due to infection is projected to rise rapidly over the next 25 years. The economic burden of infections is expected to exceed 50% of the inpatient resources available for revision arthroplasties in 2016 total hip arthroplasty (THA) and 2030 total knee arthroplasty (TKA).

Conclusion: Appropriate evidence-based epidemiological strategies must be implemented to reduce SSIs.

Surgical site infections (SSIs) are a significant source of morbidity and mortality for surgical patients, comprising approximately 31% of total health care associated infections (HAIs). Over the past decade, the number of orthopaedic surgical procedures performed yearly has increased with studies predicting exponential growth over the next 30 years. Without appropriate evidence-based epidemiological strategies to reduce SSIs, the increase in the number of procedures performed yearly will result in a concomitant increase in the amount of SSIs. This will result in increased morbidity, mortality, and financial strain on the health care system.¹

Surgical site infections (SSIs) are any infection found at the wound site postoperatively. The Centers for Disease Control and Prevention (CDC) subdivides SSIs into three categories: superficial, deep, and organ/space.

Superficial infections are classified as infections within 30 days of surgery if no implant is placed in the area or within 1 year if there was an implant and the infection appears to be related to the procedure. Such a diagnosis should be made if any of the following criteria are present: organism identification from the superficial incision; pain, tenderness, localized swelling, redness, or heat at the location of the superficial incision; and diagnosis by a trained orthopaedic surgeon.²

Deep infections are defined by the CDC as infections within 30 days of surgery if no implant is placed in the area or within 1 year if there was an implant and the infection appears to be related to the procedure. These infections effect fascial and muscle levels of the tissue at the site of incision and include at least one of the following: purulent drainage from the incision but not from the deeper organ/space component of the surgical site; the incision dehisces or is opened by an orthopaedic surgeon after the patient presents with fever, localized pain, or tenderness; there is evidence of an abscess; or a diagnosis by a trained orthopaedic surgeon.²

Organ/space infections are defined by CDC as infections within 30 days of surgery if no implant is placed in the area or within 1 year if there was an implant and the infection appears to be related to the procedure. Organ/space infections are located beyond the incision site involving any part of the patients’ organ, spaces, or joint altered during surgery. For diagnosis, one of the following must be present: drainage of purulent discharge from the organ/space, organism identification from the organ/space, evidence of an abscess in the organ/space, or diagnosis by a trained orthopaedic surgeon.
surgeon. Surgical site infections regardless of location are a significant complication following surgery.2

Local Epidemiology
Over 310,800 hip arthroplasties are performed annually in the USA. The numbers of hip arthroplasties have increased by 124% between 2000 and 2010 among patients over the age of 45.3 Despite its high frequency, the rate of complications, particularly surgical site infections, are relatively low. Total hip arthroplasty (THA) infection rates range between 0.88% to 2.3%.4-7 Total knee arthroplasty (TKA) is also performed frequently. It is estimated that over 5 million TKAs were performed from 2000 and 2010 for patients above the age of 45.8 TKAs also have low infection rates, ranging from 0.90% to 2.0%.4,6 With the number of TKA and THAs expected to rise by 673% and 174%, respectively, by 2030, continued research into the causes, complications, and methods of prevention for surgical site infections are necessary.9

Financial Implications
The proportion of revisions due to infection is projected to rise rapidly over the next 25 years. The economic burden of infections is expected to exceed 50% of the inpatient resources available for revision arthroplasties in 2016 (THA) and 2030 (TKA). The average cost of a revision THA in the USA is currently $45,000. In a four year study conducted in England of 102 hospitals, hip arthroplasty infection resulted in a doubling of length of stay from a median of 9 days to 17 days. Prevention of infection is essential for the financial health and reputation of surgeons and health care facilities as well as the wellbeing of patients.10

In a study performed by Bosco and coworkers, a total of 2,572 patients were identified of which 1,263 were TKA and 1,077 were THA. Of these, there were 55 readmissions following TKA accounting for an average cost of $13,008 and 57 readmissions following THA for an average cost of $17,103. The three main causes of readmissions were wound complications, surgical site infections, and medical issues. Surgical site infections are the costliest of these complications to treat.11 In another study conducted by Kapadia and colleagues, patients having periprosthetic joint infections had significantly longer hospitalizations (5.3 versus 3.0 days), a higher rate of readmissions (3.6 versus 0.1), and more clinic visits (6.5 versus 1.3). The mean annual cost for an infected joint was $116,383, while that of a non-infected joint was $28,249.12 This highlights the need to understand the complication and readmission profile and how they occur over the continuum of a patient’s lifetime.11

Antibiotic Stewardship
Despite the generalized use of prophylactic antibiotics in orthopaedic surgery, SSIs are still a major source of morbidity, mortality, and hospital cost. This is due in part to the increasing prevalence of antibiotic resistant organisms. Methicillin-resistant Staphylococcus aureus infections have increased significantly over the past 30 years and have been a major source of infections in orthopaedic procedures. The number of infections caused by Gram-negative bacilli that are resistant to antibiotics are also increasing.13 It is widely accepted that there is a direct correlation between the use of antibiotics and development of antibiotic resistance. Despite the recognized expertise required to prescribe antibiotics, in reality the decision process is usually left to junior staff who may not receive instruction from their supervisors or who have little expertise required to make informed choices regarding antibiotic prescribing. The sub-optimal prescribing decision process has led to widespread inappropriate use of antibiotics with studies estimating 25% to 68% of hospital antibiotic prescribing to be suboptimal.14

Implementing an antibiotic stewardship program can lead to improved patient outcomes and cost-effective medical care.13 Antimicrobial stewardship refers to the multifaceted approach, including policies, guidelines, surveillance, prevalence reports, education, and audits of practices that health care organizations have adopted to optimize prescribing.14 The principles of antibiotic stewardship include determining appropriate indications for antibiotic administration, choosing the correct antibiotic based on known or expected pathogens, determining the appropriate dose, and duration of treatment. It is crucial to have a multidisciplinary team that can help to guide antibiotic selection and dosage.13 The effectiveness of antibiotic stewardship programs is well proven in the literature. After initiating an antibiotic stewardship program, Nowak and colleagues observed an almost 10% decrease in antibiotic spending, saving roughly $1.7 million dollars.15 Despite decreased spending, Nowak and colleagues saw a significant decrease in nosocomial infections (MRSA, C. difficile, and VRE) and did not see an increase in patient hospital length of stay and 30-day readmission rates.15

Patient Optimization and Risk Factors
Although the majority of total joint arthroplasties are elective in nature, physicians have an obligation to follow the ethical law of non-maleficence. Due to the extensive literature on pathology associated with surgical site infections, physicians have the responsibility to evaluate risk reduction with their patients prior to surgery as illustrated by Bronson and colleagues.16 Multiple risk factors for orthopaedic surgical site infection have been identified. Optimizing the patient’s medical condition prior to surgery and eliminating or even diminishing modifiable risk factors for infection should lower the risk of surgical site infection. Modifiable risk factors include local or remote orthopaedic infection, rheumatoid arthritis, poor oral health, urinary tract infection, obesity, patients at risk for MRSA, preoperative and anticipated postoperative anemia, smoking, malnutrition, diabetes, and HIV illness burden.17 These modifiable risk factors are real, and some are expected to increase due to the changing landscape of American society. For example,
obesity in America is expected to increase by 33% to 51% of the population by 2030; the prevalence of diabetes is expected to increase by 165% to 7.2% of the population by 2050.18,19 Physicians must be aware of these risk factors going forward.

**Risk Stratification**

Currently orthopaedic surgeons and hospitals are able to undertake any type of surgical procedure consistent with their willingness and access to resources. An orthopaedic surgeon may perform joint replacement provided the surgeon has developed the necessary skills to perform the procedure and is credentialed by the hospital. A patient may obtain a joint replacement as long as there is a surgeon at a particular facility willing to perform the procedure. Yet volume and experience are known to be predictive of better outcomes.20

Certain risk factors are related to a surgeon’s experience yet others are patient dependent. Orthopaedic surgeons routinely perform total joint replacement on patients who have one or more risk factors. Given the elective nature of the procedure and the knowledge that modifiable factors exist, the arbiter of the decision to proceed with surgery in patients with these factors is unclear. Under programs such as value based purchasing and payments based on episodes of care, payers and hospitals have a financial interest in reducing complication rates, length of hospital stay, and readmissions as these all have major financial implications. Poor performance results in a decrease in Medicare and Medicaid reimbursement per procedure for the hospital. High quality hospitals will also reap financial bonuses for good performance. Achieving specific goals and preventing poor outcomes in the metric by which orthopaedic surgeons and hospitals performing total joint replacement will be judged. Hospitals and surgeons performing total joint replacement must prevent infection, venous thromboembolism, and readmission, or plan to face financial penalties. Given the emerging fiscal and societal pressure on the American health care system, delay with the goal of risk mitigation for high risk total joint replacement is morally obligatory.16

**Pre-, Intra-, and Postoperative Interventions to Reduce Infections**

To effectively prevent surgical site infections, the physician must consider preoperative, intraoperative, and postoperative factors as well as interventions. Preoperative strategies for reduction of infection rates include identification of high risk patients, screening and decolonization of patients with MRSA colonization, preoperative preparation of the patient with chlorhexidine gluconate, utilization of proper hair removal techniques, and addressing preexisting dental and nutritional issues prior to surgery.21

Due to the fact that nasal colonization is one of the most important risk factors for surgical site infection in orthopaedic surgery, decolonization programs should be a key part of any orthopaedic unit.22 Decolonizing patients is essential; the risk of complication is real. Wertheim and associates illustrated that up to 80% of patients with Staphylococcus associated bacteremia were found to be staphylococcal carriers before surgery.23 Staphylococcus aureus is frequently found in the anterior nares of much of the general population. One study found that Staphylococcus aureus nasal colonization is present consistently in 20% of the population and is intermittently present in as much as 60%.24

*Staphylococcus aureus* infection is not only prevalent in patients but also health care providers. One study found that 35.7% of physicians were colonized with methicillin-sensitive *Staphylococcus aureus* while 1.5% were colonized with methicillin-resistant *Staphylococcus aureus*.25 Providers may have similar colonization rates compared to their patients in regards to MRSA, but providers appear to be colonized with MSSA at higher rates than their high risk patients.26 Although mupirocin, a common antibiotic used in TKA antibiotic prophylaxis, is not recommended for use with health care workers to avoid increasing resistance, proper hand hygiene is recommended by the CDC to minimize pathogen transmission from provider to patients.

Decolonization programs are also relatively well taken by patients. One study found that 86.7% of patients deemed recruitment into a decolonization program as a positive experience. Additionally most participants appear to be compliant with prescribed protocols, over 80% of elective orthopaedic patients report following these protocols.27

Decolonization programs are effective in both reducing surgical site infections and reducing cost. Studies have shown that surgical site infections are reduced by over 40% following the implementation of decolonization programs.28,29 Research has also shown that after implementation of a decolonization program, hospitals can not only see a reduction in MRSA prevalence rates within in their own institution but also prevalence rates 30% lower compared to other hospitals without a decolonization program.30 Estimates indicate that if all 7.2 million patients undergoing elective surgical procedures partook in a decolonization program, the USA could see $231 million dollars in cost savings.31

The main antimicrobial used for nasal staphylococcal eradication is mupirocin. Mupirocin, an antibiotic based on a chemical produced by the bacteria *Pseudomonas fluorescens*, has been used for this purpose since the 1980s when it was shown to be effective at eradicating *staphylococcus aureus* bacteria.32 Subsequent studies have found that mupirocin and preoperative antimicrobial prophylaxis does in fact reduce surgical site infection, and in cases where it does not, a lack of power was thought to be the cause of non-significant findings.28,33,34 Decolonization begins before admission through ascertaining a patient’s colonization status. In addition to mupirocin, chlorhexidine is utilized to combat extra nasal skin pathogen sites.35,36

Despite evidence that mupirocin can be used to reduce *Staphylococcus aureus* infections and post-surgical infec-
colonization. Nasal povidone-iodine has been proven to reduce staphylococcal colonization since the 1990s due to widespread use of mupirocin in other areas of medicine. Manufacturers are responding to this change with new antimicrobials. 3M Company, in 2010, released povidone-iodine for nasal staphylococcal colonization. Nasal povidone-iodine has been proven to be effective in eradicating both MSSA and MRSA. Some research has even indicated that povidone-iodine in some situations can be superior to mupirocin. One study found that patients may face financial difficulty with mupirocin due to cost.

Bosco and coworkers highlighted that multiple intraoperative interventions are effective at reducing surgical site infections following total knee arthroplasty, including the use of powderless gloves, optimal operating room air quality, and antibiotic laden cement in high risk patients. As highlighted by Bosco and coworkers, postoperative strategies for reduction of infection rates include wound drainage observation, the use of antibiotic cement, powderless gloves, and povidone-iodine.

Blood Management

An evidenced based universally applied protocol for the management of blood loss after TKA is essential to minimizing the risk of SSI. The use of allogeneic blood transfusions is associated with increased length of stay and induces immunomodulation that can lead to increased risk for infection at the surgical site. Talbot and colleagues reported a 3.2-fold increase of post-sternotomy infection among transfused patients compared with those who were not transfused. Bower and associates reported infections following cardiac surgery in almost twice as many as multiple transfused patients compared with similar non-transfused patients. In a study of 12,000 patients undergoing total hip or knee replacements, Friedman and colleagues reported that those patients who received allogeneic blood transfusion had a significantly greater rate of wound inflammation or infection compared to those who received autologous blood transfusion or no blood transfusion. Additionally, they reported that the rates of any infection, lower or upper respiratory tract and lung infection, were significantly increased in their patient population. Thus, it is clear that allogeneic blood transfusion is associated with an increased risk of SSI.

We must understand the risks of not transfusing patients in order to make informed decisions as to the risk-benefit ratio of blood transfusion. An essential component of this decision is determining the hemoglobin threshold at which postoperative red-cell transfusion is indicated. Carson and coworkers conducted a multicenter, randomized controlled trial analyzing the outcomes of patients who sustained hip fracture surgery. They randomized the cohort into two groups: 1. those who received transfusions for a hemoglobin level of 10 grams per deciliter (Liberal group) and 2. those who received transfusions for a hemoglobin level of less than 8 grams per deciliter or who had symptoms of anemia (more restrictive group). The primary outcomes were death or an inability to walk across a room without human assistance on 60-day follow-up. They found no difference in the functional outcomes or mortality rates between the groups. They concluded that the more restrictive transfusion policy was safe in patients undergoing hip fracture surgery. Thus, for asymptomatic patients with a hemoglobin of 8 grams per deciliter or greater, the increased risk of SSI associated with allogeneic blood transfusion is not offset by any benefit in outcomes.

Conclusions

Appropriate strategies along the continuum of care must be implemented in order to reduce SSIs. Preoperatively this includes patient risk modification as well as appropriate methods of antibiotic prophylaxis and S. aureus decolonization. Postoperative strategies include wound drainage observation, the use of antibiotic cement, powderless gloves, and povidone-iodine use as well as blood management. This review highlights the need to understand the individual patient’s complication and readmission profile and how they occur over the continuum of care.

Disclosure Statement

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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