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Surgical Site Infection After Total Knee Arthroplasty: Risk Factors in Patients With Timely Administration of Systemic Prophylactic Antibiotics

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ABSTRACT

Background: Surgical site infection (SSI) after total knee arthroplasty (TKA) is a catastrophic complication. Administration of prophylactic antibiotics within 60 minutes before surgery is a well-established strategy to prevent SSI. The study is aimed to identify the risk factors for SSI regarding primary TKA in patients with timely administration of systemic prophylactic antibiotics.
Methods: A retrospective review of patients with primary TKA between 2009 and 2013 was conducted. Patients who had prophylactic antibiotics administered after skin incision or >60 minutes before skin incision were excluded.
Results: Of the 3152 patients enrolled, the incidence of SSI and deep-implant SSI was 1.52% and 0.79%, respectively. Charlson Comorbidity Index ≥3 was an independent risk factor for both SSI (odds ratio [OR], 2.34; 95% confidence interval [CI], 1.24-4.44, $P = .01$) and deep-implant SSI (OR, 3.46; 95% CI, 1.52-7.91, $P < .01$). Optimal dose of systemic antibiotics adjusted by patients' body weight for prophylaxis (OR, 0.29; 95% CI, 0.17-0.62, $P < .01$) and using antibiotic-laden bone cement (OR, 0.33; 95% CI, 0.17-0.64, $P < .01$) were significant protective factors for SSI. Meanwhile, using antibiotic-laden bone cement (OR, 0.31; 95% CI, 0.13-0.76, $P = .01$) also significantly decreased the risk of deep-implant SSI.
Conclusion: Our findings highlight the importance of appropriate dosage of prophylactic antibiotics and use of antibiotic-laden cement in preventing SSI after primary TKA. For prevention of deep-implant SSI, using antibiotic-laden bone cement seems to be an advisable strategy.

Total knee arthroplasty (TKA) is one of the most successful surgical procedures for the treatment of end-stage arthritis of the knee [1]. Despite advances in surgical techniques and infection control practices, surgical site infection (SSI) after TKA remains a catastrophic complication. Among the SSI, deep-implant SSI is associated with long-term knee pain, functional disability, and mortality, in particular. Removal of prostheses and staged revision surgeries are usually required to treat the patients with deep-implant SSI.

As the rate of SSI after total joint arthroplasty continues to rise [2], the attempts to curb this trend rely on identifying the risk factors and improving prevention strategies. Known risk factors for SSI are related to the environment, surgeon, and patient [3-6]. Therein, however, debate continues about which contributing factors are impactful and are amenable to intervention (eg, antimicrobial prophylaxis) [7]. Among them, the timing of prophylactic antibiotics administration is well established as one of the most important factors in SSI prevention [7,8]. The effectiveness of

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prophylactic antibiotics administered shortly before skin incision to inhibit or eliminate microbial contamination during the procedure was established in the 1960s, and it has been recommended in current guidelines for surgical prophylaxis [8-10]. Despite the general consensus of this fundamental surgical prophylaxis, wide ranges of variations in the timing of perioperative antibiotic administration with suboptimal compliance have been reported [10,11]. Furthermore, inconsistent recommendations exist in the published guidelines [8, 9,11-13]. The American Academy of Orthopedic Surgeons [8] and the US advisory statement [9] recommend that prophylactic antibiotics be completely infused within 60 minutes before surgery and discontinued within 24 hours postoperatively. However, European guidelines recommend that the first dose of prophylaxis be administered as shortly as 30 minutes before the incision [11,12]. Data regarding the optimal timing of antibiotic prophylaxis and its effectiveness in TKA are limited and inconsistent [8,10,13,14].

Administration of prophylaxis within 60 minutes before skin incision has been advocated in our institute. This hospital-based retrospective study aimed to evaluate the clinical effectiveness of administration of prophylactic antibiotics shortly within 30 minutes before surgery and identify the other risk factors for SSI regarding primary TKA in patients with timely administration of systemic prophylactic antibiotics. The clinical impact of using antibiotic-laden bone cement was also examined.

Materials and Methods

Patients and Study Design

This is a retrospective study of patients undergoing TKA between January 2009 and December 2013 at a 2700-bed primary-care and tertiary referral medical center. The study was conducted with a waiver of patient consent but approved by the Institution Review Board of the hospital.

The preoperative diagnosis for TKA was advanced arthritis of knee joint resulting from osteoarthritis, rheumatoid arthritis, and posttraumatic arthritis. Patients undergoing TKA with one of the following conditions were excluded: (1) previous diagnosis for septic arthritis on the operated knee joint; (2) incomplete chart records; (3) preoperative antibiotic therapy for other infectious diseases, for example, urinary tract infection; (4) bilateral TKA in the same surgery; (5) revision TKA, unicompartmental, and conversion procedures (conversions from partial to TKA); (6) duration of follow-up <1 year; and (7) systemic prophylactic antibiotics administered after skin incision or >60 minutes before surgery.

The infection control measurements in our institution were conducted based on the recommendation of the current guidelines for control of SSI [9,15]. Patients with a weight <80 kg undergoing joint arthroplasty received a single-dose prophylactic antibiotic with 1 g of cefazolin within 60 minutes before skin incision at the induction of anesthesia, followed by 3 additional doses of cefazolin in the following 24 hours at the end of the surgery. A single-dose of 2 g cefazolin was considered to be optimal for patients with a weight >80 kg. Vancomycin or clindamycin was prescribed instead if the patient had a history of allergy to cephalosporins, and the dosage was given based on the patient's weight [15]. The surgical limb was prepared in a povidone-iodine alcoholic solution or chlorhexidine in cases of allergy to iodine, and the surgical site was covered with 3M Ioban 2 Antimicrobial Incise Drape. A pneumatic tourniquet was inflated during the procedure and deflated when the wound was closed or if the duration of tourniquet exceeded 120 minutes. All surgeons routinely used double gloves. The potential risk factors for acquiring SSI were categorized as patient and procedural variables. Patient variables included sex, age, body mass index, comorbid diseases, American Society of Anesthesiologists score, and Charlson Comorbidity Index (CCI) [16] as a measurement of general physical status. Procedural variables were wound classification, duration of surgery of more than the 75th percentile, and antimicrobial prophylaxis strategies.

The variables of the antimicrobial prophylaxis strategy were measured at the time of surgery, including the choice of antibiotic, dose, timing of administration of the first dose and subsequent doses, use of antibiotic-laden bone cement for prosthetic fixation, and antibiotic irrigation during operation. The antibiotic-laden bone cement was prepared in 2 ways. One was adding and stirring the antibiotic powder (such as cefazolin, vancomycin, and cefuroxime) into the powdered bone cement by hand in the operating room before the addition of the liquid monomer. The other way of preparation simply mixed the liquid monomer to the powdered cement that was commercially premixed with antibiotics (such as Palacos G [0.5 g gentamicin] or Simplex P [1-g tobramycin]). Timing of administration of systemic prophylactic antibiotics was divided into 2 categories: within 30 minutes and >30 minutes but within 60 minutes before surgery. The duration of systemic prophylactic antibiotics after the surgery was also divided into 2 categories: within 24 hours and >24 hours.

Outcome Assessment

The dependent outcome variable of this study was the occurrence of SSI after TKA. All patients developing an SSI were identified using the criteria of the US Centers for Disease Control and Prevention [17]. SSIs after TKA were categorized as superficial infection (involving skin or subcutaneous tissue) that occurred within 30 days after the index surgery or as deep-implant infection (involving fascia, muscle, and periprosthetic joint space) that developed within 1 year after the index surgery.

Statistical Analysis

Patients were divided into infection and noninfection groups. The Student's t test or the Mann-Whitney U test was used for comparison of continuous variables, and the chi-square test or Fisher's exact test was used for comparison of dichotomous variables when analyzing the differences between the 2 groups of patients. Variables with a P value <.1 were entered into a logistic regression model to determine the independent factor(s) for SSI or deep-implant SSI. A P value of <.05 was considered to be statistically significant. Statistical analysis was performed using SAS, version 9.1.3 (SAS Institute).

Results

During the 5-year study period, a total of 3275 patients underwent primary TKA at this hospital. Patients excluded from the study included those with previous diagnosis of septic arthritis on the operated knee joint before the TKA (n = 6), incomplete medical records (26), preoperative antibiotic therapy for other infectious diseases (75), bilateral TKA in the same surgery (1), duration of follow-up <1 year (3), and preoperative antibiotics administered after incision or >60 minutes before surgery (12; Fig. 1).

Of the 3152 patients included in the analysis, 22% were male, with an average age (mean ± standard deviation [SD]) of 69.7 ± 7.8 years. The American Society of Anesthesiologists score was ≥3 for 35% of the patients. The duration of the surgery (mean ± SD) was 109.4 ± 22.4 minutes, and the in-hospital stay (mean ± SD) was 6.3 ± 1.4 days. All patients received prophylactic antibiotics (cefazolin [n = 3099] and clindamycin [n = 53]). All the prostheses were fixed with bone cement. Antibiotic-laden bone cement was used in 89%