Is Arthroplasty Immediately After an Infected Case a Risk Factor for Infection?

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Abstract

Background It is common practice in many centers to avoid performing a clean case in a room in which an infected procedure has just taken place. No studies of which we are aware speak to the necessity of this precaution.

Questions/purposes The purposes of this study were to identify (1) the risk of infection in a group of patients who underwent arthroplasties performed immediately after a first-stage arthroplasty for joint infection; and (2) the risk of superficial and deep infections in these patients compared with a matched group of patients who underwent arthroplasties not performed after an infected surgery.

Methods Eighty-three patients (85 arthroplasties) who underwent arthroplasties (primary or revision) immediately after patients with known infections underwent surgery in the same operating room (OR) were analyzed for 12 months after surgery to determine the incidence of infection. They were matched for demographic factors and surgery type with

a control group of 321 patients (354 arthroplasties) who underwent surgery in an OR that had not just been used for surgery involving patients with infections. We compared the risk of superficial and deep infections between the groups.

Results Patients in the study group were not more likely to have infections develop than those in the control group. One patient in the study group (1.17%) and three in the control group (0.84%) had deep infections develop; the infection in the patient in the study group was caused by a different organism than that of the patient with an infection whose surgery preceded in the OR. Two superficial infections (2.35%) were detected in the study group and 17 (4.8%) were detected in the control group.

Conclusions With the numbers available, we found that a deep infection was not more likely to occur in a patient without an infection after an arthroplasty that followed surgery on a patient with an infection than in one who had surgery after a clean case. Although sample size was a potential issue in this study, the results may serve as hypothesis generating for future studies.

Level of Evidence Level III, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

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Introduction

Joint arthroplasty is one of the most common and successful operations in orthopaedics, and infection remains the most morbid and costly associated complication [7, 15, 19, 29]. Infection also is reported to be one of the most common indications for revision [3, 4]. Numerous factors influence the risk of infection after arthroplasty, including factors relating to the patient, the surgical environment, and the surgeon [8, 11, 18, 22, 34].

Appropriate use of perioperative antibiotics, using meticulous sterile technique, and minimizing the number of personnel in the operating room (OR) decrease the risk of infection [11, 12, 19, 20]. In addition, a common practice has been to avoid performing a noninfected (clean) surgical case immediately after performing surgery on a patient with an infection (infected case) in the same OR on the same day. In theory, doing so could be a risk factor for infection in the subsequent clean case [13]. For this reason, arthroplasties involving infected cases often are scheduled at the end of the day. Although such policies may be reasonable, there may be reasons in high-volume revision arthroplasty centers that make such scheduling difficult. For instance, patients with diabetes who are insulin-dependent often are better served by having their surgery early in the day [15]. In addition, following this rule often requires the most difficult case of the day to be the last case of the day. Finally, and most importantly, there is little evidence to support this approach.

We sought to assess the risk of infection in noninfected hip and knee arthroplasty cases performed in ORs immediately after patients known to have deep infections were operated on in the same room, and to compare the risk of infection with a control group of patients who had surgery in ORs that were not just used to treat patients with infections.

Patients and Methods

We retrospectively analyzed OR schedules for arthroplasties performed at one tertiary institution from January 2007 to June 2011. All consecutive cases scheduled as the first stage of two-stage revision knee or hip arthroplasties were identified. To verify that there had not been a change in the order of the cases or the actual type of the surgeries, we cross-referenced the OR database and surgeon's office schedules.

We included patients in the study if the surgery was a first-stage revision (irrigation, débridement, and removal of an infected prosthesis), which was followed by an arthroplasty (primary or revision) on a patient without infection and the surgeries had been performed in the same OR on the same day. The control group was composed of primary and revision TKAs and THAs done during the same period but not preceded by infected cases. These were matched to the study group for sex, age, and type of surgery. There were no policies in place at the host institution regarding clean cases following infected or potentially infected cases in the OR.

One hundred twenty-one cases with infected arthroplasties had been performed as the first case of the day. Of the 114 operations that followed in the ORs, 100 were clean

cases. After excluding 12 nonarthroplasties, two TKA liner exchanges, and one case of a patient who did not reach a minimum followup of 12 months, 85 noninfected arthroplasties (83 patients) remained for inclusion in the study. The patients in the study group underwent 28 primary THAs, five revision THAs, 38 primary TKAs, and 14 revision TKAs. All patients had been operated on immediately after a patient with an infection and had at least 12 months followup. Of the 84 preceding infected cases (a simultaneous bilateral TKA was performed after one infected case), there were 69 (82%) positive cultures, 11 (13%) diagnosed with infection based on pus discharge from the wound, and four (5%) with combined high markers of inflammation and high intraoperative polymorphonuclear (PMN) cell count. The infecting organisms included *Staphylococcus aureus* in 22 (including six methicillin-resistant), coagulase-negative *Staphylococcus* species in 21, *Streptococcus* species in 10, *Enterococcus* species in six (including two vancomycin-resistant), *Pseudomonas aeruginosa* and mixed Gram-negative bacilli each in three, *Klebsiella pneumoniae*, *Escherichia coli*, *Enterobacter cloacae*, and *Corynebacterium striatum* each in one. Followup data were available for 77 patients (79 cases); data also were available for six patients (six cases) with a variable period between the time of the patient's discharge from the hospital and 12 months after that when the patients were seen again. The control group consisted of 321 patients (354 arthroplasties) (Table 1).

For all patients in the study and control groups, we reviewed the immediate postoperative course, which usually consisted of 3 to 5 days of inpatient care and the first 12 months of followup, which is the time that joint infections could be reasonably attributed to contamination at the time of surgery [32, 33]. We recorded wound problems including prolonged wound discharge, cellulitis, stitch abscess, and deep infection.

The diagnosis of deep infection was based on generally accepted criteria. The joint was considered to have a deep infection if (1) the patient presented with a sinus communicating with the joint; (2) purulence was found intraoperatively; (3) at least two preoperative or intraoperative positive cultures with the same organism were obtained; or (4) high inflammatory serum markers were associated with an abnormal intraoperative PMN cell count [30]. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were the routine markers measured when infection was suspected. Cutoff points for abnormal ESR and CRP in our institution are 30 mm/hour and 10 mg/L, respectively [26]. More than 10 PMNs per high-power field was considered elevated [6]. Diagnoses of cellulitis and stitch abscess were based on the clinical judgment of the surgeon as recorded in the chart. Prolonged discharge was diagnosed when the wound drainage had not stopped by the time the patient was discharged from the hospital (usually

Table 1. Demographic and categorical information of the groups

Group	Sex (male/female)	Age (years)	ASA score	BMI (kg/m ²)	Primary TKA	Primary THA	Revision TKA	Revision THA
Study group	32/53	64.5	2.56	31.8	38	28	14	5
Control group	143/210	66	2.53	31.4	170	111	48	25
p value	0.617	0.241	0.691	0.580	0.226	0.106	0.137	0.800

ASA = American Society of Anesthesiologists.

3 to 4 days postoperatively during the period of this study). The causative organisms for the superficial infections were not available in the medical data because these infections generally are treated empirically with broad-spectrum, oral antibiotics without wound swabs for culture. It has been shown that cultures of the skin or discharging fluids have very low specificity for detecting the actual infecting organism [7, 9]. We included wound-healing problems because of the evidence in the literature indicating that they may predispose to deep joint infection [5, 27, 28, 31]. In cases of deep infection, microbiologic reports were extracted and for the patients in the study group, culture data were compared with data of the infecting organism of the preceding case.

The health statuses of the patients in the study and control groups were compared using the American Society of Anesthesiologists (ASA) score as an indicator [24]. Moreover, BMI as a potential independent risk factor for infection was calculated and compared between the groups [14]; patients with a BMI greater than 40 kg/m² were considered morbidly obese.

The cleaning policy in the OR of our hospital is a routine one using diluted 7% chlorhexidine. The cleaning procedure is performed between two successive cases and consists of removing waste and soiled linen, sanitizing nondisposable equipment that is in contact with patients and horizontal surfaces such as the floor, spot cleaning of vertical surfaces such as the walls, and damp dusting of overhead lights. A terminal cleaning procedure is done at the end of the day, when no additional cases are anticipated for the remainder of the day in that room. Terminal cleaning adds sanitizing of the walls, exterior surface of equipment, and flooding the floor with a disinfectant followed by scrubbing. Terminal cleaning is not performed after an infected case that is not the last case of the day.

We did not use ultraviolet radiation, body exhaust systems, and laminar airflow at the study sites during the period of study.

Our surgical-site preparation protocol consists of two stages. In the first stage, the patient's limb is washed using sterile scrub brushes presoaked in 4% chlorhexidine gluconate. After drying the skin with a sterile towel, prepping the whole lower limb is performed using 10% povidone-iodine solution followed by sterile draping of the limb using

standard techniques. All patients in both groups received preoperative prophylactic intravenous antibiotics, consisting of intravenous cefazolin 2 g and gentamicin 80 mg, unless otherwise indicated.

Statistical analysis was performed with an unpaired t-test to compare demographic details. Categorical parameters were assessed with chi-square and Fisher's exact tests. Comparisons between the groups were assessed with unpaired single-sided tests under the assumption that the study group could only do substantially worse but not substantially better than the control group. A significant p value was deemed to be 0.05. A post hoc power analysis was calculated; with the numbers available, our study was powered at 80% to detect a significant ($p < 0.05$) difference between an infection risk of 5.5% in the study group and 0.8% in the control group.

Results

None of the 83 patients (85 cases) in the study group had a deep infection with the same bacterium develop as the previously infected patient who underwent surgery in the same OR. There was one deep infection (1.17%) following a primary TKA, diagnosed 18 weeks after surgery and treated by a two-stage revision. The infecting organism was *Streptococcus viridans*. The preceding infected case at the time of the index surgery had been a hip infected by *Staphylococcus aureus*. Microbiologic identifications of both infections were verified by multiple cultures.

There were histories of prolonged discharge in two cases (2.35%) and two superficial infections that presented as cellulitis (2.35%). All were treated empirically with oral antibiotics for 5 to 10 days and regular wound care, and all resolved without further sequelae.

Three deep infections (0.84%) developed in the control group at 5 weeks, 8 months, and 11 months after surgery. These patients all had primary TKAs. There were 17 superficial infections (4.8%) and four cases of prolonged discharge (1.13%) in this group, all of which were treated empirically with oral antibiotics for 5 to 10 days and regular wound care, and all infections resolved without further sequelae.

Table 2. Outcomes and their statistical significance

Group	Total number of surgeries	Deep infection	Cellulitis	Stitch abscess	Superficial infections	Prolonged discharge
Study group	85	1 (1.17%)	2 (2.35%)	0	2 (2.35%)	2 (2.35%)
Control group	354	3 (0.84%)	12 (3.3%)	5 (1.4%)	17 (4.8%)	4 (1.13%)
p value		0.498	NA	NA	NA	0.242

NA = not applicable; when the rate of an event in the control group was more than the rate in the study group, statistical comparison was not performed.

With the numbers available, statistical analysis did not show a significant difference in the rate of either superficial ($p = 0.751$) or deep infections ($p = 0.498$) between the two groups (Table 2). In addition, the rate of prolonged discharge was not significantly different between the groups ($p = 0.242$).

ASA score and BMI were available for all patients and they were not different between the groups. The mean ASA score was 2.56 (range, 1–4) for the study group and 2.53 for the control group (range, 1–4; $p = 0.691$). Average BMI was 32 kg/m² (range, 18–58 kg/m²) for the study group and 31 (range, 15–67 kg/m²) for the control group ($p = 0.58$). Nine patients (10.5%) in the study group and 36 (10.1%) in the control group were morbidly obese ($p = 0.844$).

Discussion

Infection is the most common indication for revision knee arthroplasty in the United States [3]. Airborne bacteria may originate from breathing, skin, or clothes of the operating staff, improper air conditioning devices, contaminated equipment or surfaces, and other sources [1, 2, 13, 25]. Efforts have been made to decrease the bacteria concentration of OR air; however, it is important to verify the effectiveness of protocols and procedures put in place to reduce the risk of infection. One common practice has been assuming that an OR is not suitable for a clean case after an infected case was done in that same room earlier during the same day. The premise for this precaution is that the organisms originating from the infected wound may remain viable in the OR and that they could cause infection in subsequent patients treated in the same room [16]. If this were shown to be true, a full terminal cleaning would be necessary before performing another arthroplasty in the same room or, in practical terms, the infected case would need to be performed as the last case of the day. This adds cost and inflexibility to the system and may not be ideal for certain patients, perhaps including patients with diabetes who might fare better having surgery earlier in the day. With the numbers available, our study did not find any

evidence that performing a clean case immediately after an infected case in the same OR increased the risk of infection in the clean case that followed.

This study has several important limitations. First, the power analysis used in the study is a post hoc analysis based on the number of cases available in the study group (85 cases, 83 patients). Powered at 80% to detect a difference (with a $p < 0.05$), we calculated we could detect a 5.5% infection rate in the study group compared with 0.8% in the control group, a nearly sevenfold difference. To detect a 2% infection rate, the study group would need 1200 patients and to detect a 1.6% infection rate (twice that of the control group), we would need 2300 patients in the study group. Even so, our data may be hypothesis generating for future studies, and may help form a larger study group in a future meta-analysis. Second, the patients were followed for 1 year postoperatively; this may not be sufficient to detect some low-grade, indolent infections. Third, the patients in the two groups were not specifically matched for some comorbidities like diabetes mellitus, smoking, and peripheral vascular disease that are known risk factors for infection. In addition, as a result of the lack of a uniform definition for superficial wound infection and prolonged discharge, some inaccuracy in diagnosis of these entities is possible. Some of the superficial infections might have been missed in the six patients (six cases) who did not return for followup during the early postoperative period. In addition, no microbiologic reports were available on superficial infections. The diversity of the predisposing factors for surgical site infection, many of which were not controllable by the authors might have represented confounding variables here. However, variables such as ASA class and BMI, in particular, were slightly higher in the control group and so did not likely represent confounding variables here [5, 29].

To the best of our knowledge, there is only one study on the infection rate of arthroplasties performed after infected cases, which showed one deep infection in a TKA among 35 joint arthroplasties that were done after infected cases [23]. The causative organism was found to be *Propionibacterium acnes* in that case and in the preceding infected case. Considering the rarity of *Propionibacterium acnes* as a cause of joint infection, Namdari et al. concluded that the infection in the second case most probably had been

induced by cross contamination from the first case and encouraged precaution in performing an arthroplasty after an infected case [23]. Superficial infections were not assessed. The discrepancy of the findings of their study in comparison to ours can be explained in several ways. The first is the possibility that our study was not adequately powered; our study had sufficient sample size to have 80% power to detect a difference in infection risk of 5.5% versus 0.8%, meaning that if the difference were smaller than that, our study might have failed to identify it. Second, differences in cleaning or sterilizing policies of the two centers may have caused this disparity. Namdari et al. [23] described the use of vertical laminar flow in their operating room in an effort to decrease the infection rate [10, 17]. Some studies have reported a paradoxical increase in the rate of infection associated with laminar airflow that has been attributed to recirculation of the seeding bacteria to the air and subsequently the wound [4, 21]. This factor may be another contributor to the discrepancy between the results of the current study with the Namdari's study.

Our study has several unique strengths, including a large number of patients and the use of a matched control group. The similar health status for the two groups was verified using the ASA score. In addition, considering the simple cleaning and sterilizing protocol used in our OR, results of this study can be extrapolated reliably to most arthroplasty centers.

We did not find an increased risk of infection in patients whose arthroplasties followed procedures on patients with infections performed in the same room. Although our study included several hundred patients, a study of several thousand would be needed to detect small but potentially clinically relevant differences; our study can be considered hypothesis generating for such a study.

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