Surgical Case Order is an Independent Risk Factor for Postoperative Infection in Primary Total Knee Arthroplasty

Dengying Wu
  Wenzhou Medical College Second Affiliated Hospital: Wenzhou Medical University Second Affiliated Hospital

Chao Jia
  Wenzhou Medical University - Xueyuan Road Campus

Hongwei Lu
  Wenzhou Medical University - Xueyuan Road Campus

Shuoyi Zhou
  Wenzhou Medical University Institute of Alberta

Zheng wu
  Wenzhou Medical University Institute of Alberta

Chenglong Xie
  Wenzhou Medical University Second Affiliated Hospital

Enxing Xue (✉ xueenxing@sina.com)
  Wenzhou Medical College Second Affiliated Hospital: Wenzhou Medical University Second Affiliated Hospital

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Research Article

Abstract

Background: Total knee arthroplasty is regarded as the most effective treatment for severe knee joint problems. Surgery case order influences operative outcomes according to previous studies. This study aims to evaluate the effect of surgical case order on operative outcomes for TKA.

Methods: A retrospective study was conducted on 4,267 TKAs performed by three surgeons at our hospital from February 2008 to February 2018. Variables, such as surgical time, loss of blood, and hospitalization stay, were also recorded and analysed. Logistic regression was used to analyse every variable as a potential risk for a surgical site infection.

Results: Of the 4267 cases in this cohort, 1531 TKAs were classified as first-round cases, 1194 TKAs were second-round cases, 913 TKAs were third-round cases, 490 TKAs were fourth-round cases, and 139 were fifth-round or later cases. The mean operating time was shorter in intermediate cases (P< 0.01). Perioperative adverse events were increased in later surgical cases (P< 0.01). Later case order (OR= 1.29 [95% CI: 1.17−1.56], P<0.01) was a significant risk factor for severe arthroplasty complications. The operative time and length of stay were increased for cases performed later in the day. However, blood loss is not statistically associated with case order.

Conclusions: Surgical case order is an independent risk factor for surgical infection. Significantly increased operative time and longer LOS were noted for third-round or later TKA cases. Our results identify potentially modifiable risk factors contributing to infection rates in TKA, and cases operated on later in the day in the same room were more likely to have a higher infection risk.

Introduction

Total knee arthroplasty is associated with dramatic improvements in knee pain and knee function for those suffering from knee joint arthrosis. The procedure is among the most influential modern surgeries regarding progress in quality-adjusted life-years [1]. Total knee arthroplasty is the treatment of choice for patients with advanced degenerative joint disorder. Reliable results coupled with increasing demand have led to increased joint arthroplasty surgery [2]. The number of surgeries performed to resolve knee joint problems is rapidly increasing, extrapolating the trends in the number of arthroplasties performed during the past decade [3].

However, due to the lack of sufficient medical resources, especially surgeons and operating rooms, surgeons have to perform more surgeries in a day with numbers approaching five to six or even more. Indeed, the requirement to perform operations later in the day increases surgeon burden and fatigue. A previous study showed that fatigue impacts the surgeon's performance and surgical outcomes [4−6]. Adverse events and medical errors occur more frequently in fatigued physicians, and technical skills are also negatively influenced by surgeon fatigue.

Based on a predigestion technique and improvements in implants, five or more arthroplasty cases are planned in a single operating room each day in many large orthopaedics centres. To date, few studies have examined the influence of surgical case order on the surgical complication rate or clinical outcome of total knee joint arthroplasty, and the results have been conflicting [7–9]. In the current study, we retrospectively viewed our centre's experience to examine whether the case order influenced the perioperative outcomes of TKA.

Methods

This consecutive retrospective review comprised patients who underwent TKA at the Second Affiliated Hospital & Yuying Children's Hospital of Wenzhou Medical University from May 2008 to December 2018. A total of 4,267 patients underwent TKA at our institution, including 3574 primary TKAs (83.76%) and 693 aseptic revisions (16.24%). Patients were also included if they were undergoing inflammatory arthropathy or resection arthroplasty as well as TKA for primary osteoarthritis, developmental dysplasia, avascular osteonecrosis, and posttraumatic arthritis. Patients who underwent a previous TKA surgery of the operated joint for severe knee flexion or varus-valgus deformity, PJI, suppurative knee arthritis, or tuberculous knee arthritis or TKA surgery combined with another surgery were excluded.

Approximately 4,267 total knee arthroplasties were performed in our institution for noninfected primary and revision cases, of which the average rate for surgical site infection was 3.0% (Table 1). A patient was considered infected based on MISI guidelines for surgical site infections [10]. Case order was determined using an institutional database, with each procedure being labelled 1 to 5 depending on the number of previous cases subject to surgery in a given room. The surgery time from the when the initial incision was made to the skin was closed was recorded by the circuit nurses and calculated to the minute. The length of stay was defined as the number of calendar days from operation to discharge. Additionally, the volume of blood loss after surgery was also calculated. All cases were operated on in the same room following an aseptic surgical protocol.

Patient characteristics, such as age, sex, height, and weight, were collected from the database. Body mass index (BMI) was calculated based on height and weight. Perioperative details of total operative time and intraoperative and postoperative complications within 30 days were also noted. Patient demographic characteristics were compared between surgical case groups in Table 1. No statistically significant differences in demographics were noted between groups. Patients were clinically followed up for a minimum of three months for evaluation of surgical site infection.

Values are generally expressed as the mean and standard deviation (mean ± SD). Proportions were compared using the Chi square test. Between-group comparisons for operative time, blood loss, and length of the hospital were analysed by two-sided one-way ANOVA. Logistic regression was used to estimate each variable as a potential independent risk factor for the presence of adverse events based on the following variables: surgical case order, age, sex, BMI, joint (hip or knee), and surgeon. The significance threshold was defined as 0.05.

Result

Of the 4267 joints (4267 patients) subject to total knee joint arthroplasty and met the inclusion criteria for this study, 1531 joints were classified as first-round cases, 1194 arthroplasties were second-round cases, 913 joints were third-round cases, 490 procedures were fourth-round, and 139 patients were fifth-round or later cases. Surgeries were performed by a total of five surgeons. The average duration of TKA was 92.69 ± 9.35 min. The overall risk of arthroplasty infection was 3.28%. The average blood loss for the cohort was 180.21 ± 6.30 ml. The average length of stay (LOS) was 5.3 ± 2.2 days.

Table 2 presents the perioperative results stratified by case order. The overall mean operative time was shorter for cases that were performed later in the day (96.0 vs. 88.0 vs. 82.4 vs. 89.5 vs. 97.3 minutes, P < 0.01). A statistically significant difference in arthroplasty complications were noted between groups (2.16% vs. 2.26% vs. 3.29% vs. 3.67% vs. 5.04%, P = 0.6993). Significant differences in the incidences of expenses and LOS were noted among these groups. The fifth-round cases exhibited an increased incidence of arthroplasty infection and longer LOS than the other fourth groups. The most frequent adverse complication was surgical site infection.

Logistic regression was selected to analyse the risk factors for arthroplastic surgical sites (Table 3). When controlling for specific demographic factors, later case order (OR = 1.40 [95% CI: 1.22−1.61], P < 0.01) was a significant risk factor for arthroplastic infection. Additionally, age (OR, 1.11; 95% CI, 1.15−1.48; P < 0.01) and BMI (OR, 1.05; 95% CI, 0.98−1.12; P < .001) were associated with an increased risk for surgical site infection. Sex (OR, 1.21; 95% CI, 0.92−1.59; P = .059) was not a significant risk factor for TKA infection.

Discussion

In this study, we found that cases undergoing TKA operations later in the day were associated with increased risk of arthroplasty infection rates, decreased surgical time (before the fourth case), reduced blood loss, and longer hospital stays. With similar patient characteristics between groups, our results illustrate differences in infection rates based on surgery case order among operations performed on the same day.

Surgical time continually decreased among the first one-third of operations. Significantly increased operative time was noted for the fifth-round TKA with an approximately eight-minute increase compared with fourth-round cases and a thirteen-minute increase compared with third-round cases. This finding suggests that fatigue might play a role. These results indicate that the effects of practice before surgery and surgeon fatigue during in the day. Studies have shown that a good command of psychomotor skills and cognitive performance before a sport could improve surgical performance [11]. It has been demonstrated that performing preoperative warm-up exercises for approximately 15 minutes with simple surgical tasks lead to a substantial increase in surgical skill proficiency [12]. A few studies found that surgeon fatigue increased throughout the operative day, causing an increase in the time required to

complete surgeries [9, 13–14]. A study by Willis-Owen et al. suggested that a longer duration of surgery for TKA led to an increased infection rate [15]. The main reason for the increased infection rates may be more prolonged operative site exposure to the air. A total of 115 infections, a main adverse event, were found in our research [16]. In our study, cases performed later during the day had a higher risk of infection (2.16% in the first round, 2.26% in second, 3.29% in third, 3.67% in fourth, 5.04% in fifth), demonstrating the effect of surgical case order on the risk of subsequent periprosthetic joint infection. However, a study conducted by Chen et al. suggested that TKA cases operated later in the day do not exhibit an increased risk of infection [17].

In the present study, our findings indicated that surgical cases performed later in the day were associated with increased complication rates, which is similar to the findings of some previous studies in other fields. A significant increase in arthroplasty-related complications was observed in patients when surgeons had performed three or more procedures during a day. The surgeon's accumulated fatigue was considered the primary reason for this adverse event and may cause worse operative outcomes. However, different results have been reported in other surgical fields regarding the effects of surgeon fatigue on clinical outcomes [18]. Previous research indicated that surgery started later in the day may increase the risk of intraoperative complications for THA [9]. Other studies reported that sleep deprivation in attending surgeons does not lead to higher mortality or complications [19–20]. Similarly, Govindarajan et al. found that the incidence of elective daytime procedure complications was similar regardless of whether the physician had provided medical services the previous night [21].

One shortcoming of our study is its retrospective nature. This is vitally important given that fatigue resistance varies among surgeons. For further analysis, it is necessary to assess each of the level of fatigue in each surgeon. Moreover, operating room staff were shift changes not analysed in our study because there were different levels of surgeons associated with these cases and itinerant and instrumental nurses, which undoubtedly affected the efficiency and surgical outcome. Importantly, two potential factors can also contribute to the infection rate, which was not analysed in the present study. One factor is bacterial transmission. A study found that contaminant build-up during the first case is carried over and amplified during subsequent cases [22].

Another element must be considered as a contributor to infectious risk, as it has two sides when practised correctly. Specifically, it is proper sterilization of medical instruments. However, if any sterilization process goes wrong, there is undoubtedly an effect on adequate sterilization of the medical equipment. Previous literature has shown that cases using flash sterilization have a higher rate of infection than those using standard sterilization methods [23].

Despite these limitations, the study has several significant advantages. Our study analysed data generated from a single medical centre over ten years based on five dedicated and high-volume surgeons (200–400 TKAs per year). Additionally, the cohort size and event statistics also provide this study with adequate power to demonstrate clinical significance. To our knowledge, this is a relatively comprehensive

study to assess the impact of surgical case sequence on perioperative outcomes for TKA patients. Future studies may help to illuminate whether these effects translate to other noteworthy clinical consequences.

Conclusion

We found that surgical case order was an independent risk factor for adverse complications in TKA, and cases that were operated on later in the day exhibited an increased risk for developing an infection. Significantly increased operative time and longer LOS were noted for fourth-round or later TKA cases. In short, all of our study findings indicate that repeated surgeries during the day lead to surgeon fatigue, which affects the surgical outcomes and increases the infection rate. However, further studies on surgeon fatigue are necessary to completely understand this critical factor given that surgeons face challenges associated with the increased surgical volume.

Abbreviations

TKA, Total knee arthroplasty

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Ethics Committee of the Second Affiliated Hospital and Yuying Children's Hospital of Wenzhou Medical University.

Consent for publication

Not applicable

Availability of data and materials

The dataset analysed during the current study is available from the corresponding author on reasonable request.

Competing interests

The authors declare no that they have no competing interests.

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Authors' contributions

XueZhong Gao and Dengying Wu analysed and interpreted the data and made major contributions in writing the manuscript. Chao Jia and Hongwei Lu analysed and interpreted the data and revised the manuscript. Chenglong Xie interpreted the data and provided supervision in this study. Enxing Xue provided administrative support and revised the manuscript. All authors read and approved the final manuscript.

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Tables

Table 1: Patient Demographics

Type of Surgery	Total knee Arthroplasty (N=4267)
Gender	
Male	1605
Femal	2662
Age (mean ± standard deviation), y	61.36±11.30
BMI (mean ± standard deviation), kg/m^2	27.58±3.19
Surgical time (mean ± standard deviation), min	90.15±18.41
Periprosthetic Joint infection, %	3

BMI, body mass index.

Table 2: Peri-operative details

Variable	Case 1	Case 2	Case 3	Case 4	Case 5	P value
Number	1531	1194	913	490	139	< 0.01*
Operating time (min)	96.01±16.95	87.98±17.11	82.42±20.66	89.54±17.11	97.29±6.62	< 0.01*
Blood drop	181.14±5.42	180.23±4.64	180.15±6.77	179.96±6.43	179.57±8.24	< 0.01*
Infection rate	2.16%	2.26%	3.29%	3.67%	5.04%	< 0.01*
LOS (days)	4.9±1.8	5.1± 2.3	5.4± 2.2	5.4± 2.0	5.7±2.5	< 0.01*

LOS: length of stay

Table 3: Factors affecting the risk of systematic adverse events after TKA (adjusted odds ratios for confounders from a logistic regression analysis)

Factors	Odds ratio	95% CI	P value
Surgical case order	1.29	1.17−1.56	P<0.01
Age	1.21	1.15−1.48	P<0.01
BMI	1.05	0.98−1.12	P<0.01
Gender	1.21	0.92−1.59	P=0.059

BMI: body mass index