Prolonged Operative Time Correlates with Increased Infection Rate After Total Knee Arthroplasty

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Abstract Risk stratification has proven to be a useful tool in surgical site infection prevention. The duration of the surgical procedure has been recommended for use in surgical site infection (SSI) risk stratification (Infect Control Hosp Epidemiol 20:247–248, 1999). A retrospective analysis of 6489 patients who underwent total knee replacement (TKR) between 1993 and 1999 assessed the association between the duration of the surgical procedure and the risk of postoperative infection. One hundred thirteen infected patients were matched with 236 controls, and nominal variables were statistically processed. Patients without infections ($n = 236$) had surgery durations of 94 ± 28 min, and patients with infection ($n = 104$) had durations of 127 ± 45 min ($p < 0.001$). Operation time has positive correlations with weight ($r = 0.3$, $p < 0.001$), body mass index ($r = 0.3$, $p < 0.001$), and the total number of comorbidities ($r = 0.2$, $p < 0.001$; $n = 340$). The results confirm that the duration of the surgical procedure can be used as a risk predictor for SSI in TKR.

Key words TKA infection · SSI risk stratification · duration of surgery

Introduction

Total knee replacement (TKR) surgery involves substantial exposure, tissue dissection in a superficial joint with rather poor soft tissue coverage, and the implantation of a large amount of foreign material. Primary wound healing is of paramount importance to the total joint surgeon, as development of deep wound infection is a dreaded complication after TKR surgery.

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surgical procedure has been recommended for use in SSI risk stratification [5]. This study, a retrospective analysis of patients who underwent TKR, assessed the association between the duration of the surgical procedure and the risk of postoperative infection and its possible value as a risk predictor.

Methods

Medical records from 1993 to 1999 were reviewed. The search resulted in 6489 total knee arthroplasty procedure records, from which 113 procedures were infected. Each patient with an infected TKA was matched to two controls. In total, 353 patients (113 infections and 236 controls) were matched by age, gender, and the same month/year of operation.

All data were transferred from Excel database to SPSS version 10 for analysis. The distribution of each variable was analyzed using univariate analysis. The association of each variable with the outcome and duration of surgery was assessed using the appropriate bivariate analysis, t test, Mann–Whitney test, or chi-squared analysis. Fisher's exact test was used where the expected cell contents were less than five. All variables associated with duration of surgery were processed through forward stepwise regression analysis. Several models were examined as many of the associated predictors showed strong interassociation.

Results

Age showed weak inverse correlation with duration of surgery ($r = -0.14$, $p = 0.012$). Surgery time diminished with increasing patient age. Patient height did not correlate with duration of surgery ($r = 0.02$, $p = 0.7$). Weight correlated positively with duration ($r = 0.3$, $p < 0.001$) as did body mass index (BMI; $r = 0.3$, $p < 0.001$). The heavier patient has a longer operative time.

The results for the nominal variables are shown in Table 1. With regard to the operated side, having both sides done differs from either of the single sides ($p < 0.001$ for

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Table 1 Association of surgical time with nominal data

Variable value	N	Mean duration (min)	SD	p value
Female	208	102	37	0.6
Male	130	105	38	
No diabetes	307	103	37	0.4
Diabetes	31	109	42	
Not obese	230	100	35	0.007
Obese	108	111	40	
No prior open surgery	284	99	36	<0.001
Prior open surgery	54	124	38	
No prior arthroscopy	278	104	37	0.5
Prior arthroscopy	60	101	38	
No vascular disease	242	105	39	0.4
Vascular disease	96	100	34	
Adequate nutrition	329	103	37	0.8
Poor nutrition	9	101	44	
Primary TKR	322	101	35	0.001
Revision	18	150	52	
No chronic renal failure	331	103	37	0.4
Chronic renal failure	6	116	30	
Right side	164	99	34	<0.001
Left side	153	101	35	
Both	23	148	45	0.003
OA	262	101	36	
RA	46	105	41	
Posttrauma	19	131	37	
Prior sepsis	3	89	6	
Avascular necrosis	5	77	48	
Other	5	134	13	

OA, osteoarthritis; RA, rheumatoid arthritis.

each). Thus, having both sides done increases the operation time. Those with a diagnosis of osteoarthritis ($p = 0.01$) or avascular necrosis ($p = 0.049$) have shorter operation times than posttraumatic subjects. The frequency of other diagnoses is too low to show statistically significant effects. Patients with no other comorbidities had operation times of 93 ± 28 min ($n = 236$), whereas patients with other comorbidities had operation times of 127 ± 45 min ($n = 104$; $p < 0.001$). The correlation between the duration of surgery and the total number of comorbidities was statistically significant ($r = 0.2$, $p < 0.001$; $n = 340$).

A sum of risks was calculated from five modalities considered as a risk factor: having a revision, having both sides done, the existence of any comorbidities, morbid obesity, and any prior open surgery. This produced a discrete scale from 0 to 5. The diagnoses were also reclassified and combined to three groups: prior sepsis or avascular necrosis, osteoarthritis or rheumatoid arthritis, and all other diagnoses. This will be referred to as the revised DX. The actual observed scores ranged from 0 to 3. No subjects had scores higher than 3. The results are shown in Table 2. The duration of the operation increased as the number of risks increased, and this linear trend is statistically significant ($p < 0.001$). However, variances are large.

In a stepwise linear regression, the risks and BMI together explain 24% of the variance. The weight cubed is the best fit of several weight functions applied to the data.

In a stepwise linear regression, the risks and weight cubed together explain 25% of the variance. The largest amount of variance (31%) is explained by BMI, side (unilateral vs. bilateral), whether the patient had prior operation or not, whether the patient is morbidly obese or not, and primary/revised TKR. This includes the weight twice both as BMI and in the obese function. Removing five outliers increases the explained variance to 32%, with predictors risk summation, weight, morbid obesity, prior open surgery, and the revised DX.

Patients without infections ($n = 236$) had surgery durations of 94 ± 28 min. Patients with infection ($n = 104$) had durations of 127 ± 45 min ($p < 0.001$). This duration (127 min) can be interpreted as the critical duration of surgery in the perspective of increased infection risk. The predictors of infection have been discussed in a paper by Peersman et al. [7]. The duration of surgery is a predictor of infection, together with side of operation, morbid obesity, reclassified diagnosis, and BMI. If the cutoff value is set at 0.25, 72% of the cases are correctly assigned, 168 of 236 uninfected, and 73 of 101 infected. Adding other variables such as surgeon did not improve the prediction.

Nonlinear modeling was applied to the data, but prediction of either duration or infection was inferior to the models described above.

None of the models predict 50% or more of the variance. It is surprising that in predicting the infection rate, duration is joined by variables such as morbid obesity and diagnosis, which are independently associated with duration. This suggests a nonlinear association and the possibility of an underlying factor not measured in the current study.

Discussion

Surveillance of SSI with feedback of appropriate data to surgeons has proven to be an important component of strategies to reduce SSI risk [5].

Three categories of variables are established as reliable predictors of SSI risk: (1) those that estimate the intrinsic degree of microbial contamination of the surgical site, (2) those that measure the duration of an operation, and (3) those that serve as markers for host susceptibility [5]. The three most accepted schemes for classifying the degree of intrinsic microbial contamination of a surgical site were developed by the 1964 NAS/NRC Cooperative Research Study and modified in 1982 by CDC, the SENIC project, and the NNIS risk index. The SENIC project and the NNIS index both include duration of the surgical pro-

Table 2 Duration of surgical operating time and sum of risks

Sum of risks score	N	Mean duration	SD	p compared to 0 risks
0	177	92	29	0.001
1	130	106	35	
2	33	151	43	
3	3	159	45	0.003

cedure as an important issue and possible risk factor for the risk of development of SSI [5].

Risk stratification has proven to be a useful tool in SSI prevention. An epidemiologically correct collection of data seems of paramount importance. The accuracy of recording the duration of operation (i.e., time from skin incision to skin closure) has not been studied yet.

Hip and knee replacements are established as a golden standard in the treatment of osteoarthritis. In literature, one can find several reports on complications caused by these arthroplasty procedures. Complications predominantly include vessel and nerve damage, periprosthetic fractures, wound infection, wound bleeding, prosthetic dislocation, thromboembolism, and cardiac and pulmonary complications; these also sometimes lead to death [2, 3, 8, 9].

In a study of De Thomasson et al. [2], the authors concluded that the patient's age and general health status are important factors in relation to complications. The same conclusion was drawn by Strehle et al. [9]: a higher age and a high ASA score lead to a higher risk for perioperative complications.

To our knowledge, recent literature that highlights the important role of operation duration on the perioperative complication rate is sparse. A study by Kessler et al. [4] investigated the impact of patient- and procedure-related parameters on the complication rate following revision total hip arthroplasty. Duration of the revision operation appeared as a predictive parameter for perioperative morbidity in revision total hip arthroplasty [4]. This finding is confirmed in a review study by Saleh et al. [8]. In their study, operation duration emerges as an independent intraoperative risk factor for superficial SSI in total knee and hip arthroplasty procedures, with a high association of superficial SSI to deep wound infection [7]. The key to further improvement of the predictive power of logistic regression models for prediction of SSI rates might well be the inclusion of a larger number of procedure-specific variables [1].

This current review shows that not only patient-specific and procedure-dependent factors are responsible for perioperative morbidity and complications. Duration of the operative procedure also has a definite influence, especially regarding postoperative infection of implants.

Conclusion

The current study confirms the importance of the duration of the surgical procedure as a risk factor for SSI. Duration of the procedure can be used to predict infection.

There may be no adequate discrimination for all types of operations, but in total knee surgery, the duration of the procedure is one of the key factors in the development of postoperative infection.

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