Clin Orthop Relat Res (2009) 467:1577–1581
DOI 10.1007/s11999-008-0551-6

ORIGINAL ARTICLE

Obese Diabetic Patients are at Substantial Risk for Deep Infection after Primary TKA

Michelle M. Dowsey RN, BApplSc,
Peter F. M. Choong MBBS, MD, FRACS, FAOrthA

Received: 24 April 2008 / Accepted: 16 September 2008 / Published online: 8 October 2008

Abstract We conducted a prospective study of 1214 consecutive primary TKAs to compare the deep prosthetic infection rate between obese and nonobese patients during the first 12 months after surgery. We also sought to determine whether patient or surgical variables such as comorbidities, age, gender, blood transfusion, use of surgical drains, and antibiotic-impregnated cement were predictors of subsequent prosthetic infection after primary TKA. The overall prosthetic infection rate was 1.5% (n = 18). The odds for a deep prosthetic infection were greater in patients with morbid obesity (odds ratio [OR], 8.96; 95% confidence interval, 1.59–50.63) and diabetes (OR, 6.87; 95% confidence interval, 2.42–19.56). Men were more likely to have a prosthetic infection develop than women (OR, 5.93; 95% confidence interval, 1.95–18.04) and the prosthetic infection rate was lower (OR, 0.24; 95% confidence interval, 0.06–0.95) in patients when a surgical drain was used. There were no prosthetic infections in patients with diabetes who were not obese. This compares with 11 prosthetic infections in patients who were obese and diabetic and four prosthetic infections in patients who were obese but not diabetic. Morbid obesity and obesity combined with diabetes are risk factors for periprosthetic infection after TKA.
Level of Evidence: Level II, prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained.

M. M. Dowsey, P. F. M. Choong (✉)
Department of Orthopaedics, St Vincent's Hospital Melbourne, PO Box 2900, Fitzroy, 3065 Melbourne, VIC, Australia
e-mail: sarcoma@bigpond.net.au

M. M. Dowsey, P. F. M. Choong
Department of Surgery, Melbourne University, Melbourne, Australia

Introduction

Deep prosthetic infection after primary TKA is the second most common cause of early failure in patients in Australia [2]. It is the cause for 22% of revisions performed after primary surgery [2]. Rates of obesity are escalating in our general community and even more so in patients presenting for total joint arthroplasty. There is conflicting evidence regarding whether obesity is a risk factor for prosthetic infection after TKA; however in a recent review, studies with larger patient cohorts have shown a link between obesity and infection outcomes in total joint arthroplasty [6]. Our previous work established obesity was an independent risk factor for development of prosthetic infection after THA [7]. We therefore wanted to examine whether obesity was a risk factor for deep infection in the first 12 months after primary TKA in a similar cohort of patients.

We hypothesized obese patients would have higher acute periprosthetic infection after primary TKA than nonobese patients. We also sought to determine whether patient or surgical variables such as comorbidities, age, gender, blood transfusion, use of surgical drains, and antibiotic-impregnated cement were predictors of subsequent deep prosthetic infection after primary TKA.

Materials and Methods

We retrospectively analyzed prospectively collected data for all 1214 patients who underwent primary elective TKA at our institution from January 1998 to December 2005. Prosthetic joint infections were defined using the US Centers for Disease Control classifications for surgical site infections [15]. All patients who incurred an acute deep infection up to 1 year after TKA at our institution were included in the analysis (Table 1). The median age of the patients was 72 years (interquartile range, 65–77 years); 765 patients were females and 449 were males. There were 564 left and 650 right knees replaced. The median body mass index (BMI) of the group was 30.7 kg/m^2 (interquartile range, 27.1–35.3 kg/m^2). Reasons for patients undergoing TKA were osteoarthritis (n = 1114), rheumatoid arthritis (n = 95), osteonecrosis (n = 3), and trauma (n = 2). The major comorbidities were cardiovascular (n = 874), respiratory (n = 211), and diabetes mellitus (DM) (n = 206). Seventy-two percent of patients had multiple comorbidities (two or more). No patients were lost to followup during the first 12 months after their procedure, but there were 11 deaths (0.9%) during the first 12 months after index surgery. No patients were recalled explicitly for this study and all data came from the records.

Obesity was defined according to the US Centers for Disease Control guidelines [3]. A BMI less than 30 kg/m^2 was classified as nonobese, 30 kg/m^2 to 39 kg/m^2 as obese, and 40 kg/m^2 or greater as morbidly obese. Of the 1214 patients who underwent TKA, 59% were either obese (n = 592) or morbidly obese (n = 123). Substantially more women (63% [n = 498]) were obese or morbidly obese than men (48% [n = 217]). The number of patients with multiple comorbidities was similar between groups: obese, 73% (n = 431); morbidly obese, 77% (n = 95); and nonobese, 70% (n = 349). The median age at the time of surgery was younger ($p < 0.001$) for the obese and morbidly obese groups than for the nonobese group (71 years [interquartile range, 64–76 years] and 67 years [interquartile range, 62–73 years] versus 74 years [interquartile range, 68–78 years], respectively) (Table 2).

TKAs were performed in a positive-pressure operating room. Patients received perioperative prophylactic antibiotics, which consisted of 1 g intravenous cefazolin on induction and continued for 24 hours after the procedure. When a preexisting allergy to cephalosporins was identified, prophylaxis was substituted with 1 g vancomycin twice a day for 24 hours with the first dose administered on induction. The dosage and timing of antibiotic prophylaxis were as per protocol in all 18 patients diagnosed with deep infection, with one of the 18 patients receiving vancomycin. All patients had a urinary catheter inserted in the operating room just before surgery, which remained in situ for 48 hours. Gentamicin was given just before insertion and removal of the urinary catheter. Regional anesthesia was used in 1083 patients and general anesthesia in 131 patients. A totally cemented prosthesis was used in all patients. Antibiotic-impregnated cement was introduced at

Table 1. Cases of deep infection

Patient	Age (years)	Gender	BMI (kg/m^2)	Time to infection	Organism	Outcome
1	75	Female	49	7 months	MRSA	Died of disease
2	77	Male	32	5 months	Staphylococcus aureus	Removed, not revised
3	60	Male	31	6 days	Coagulase-negative Staphylococcus	Washout and retained
4	58	Male	24	7 weeks	Peptostreptococcus magnus	Washout and retained
5	80	Male	30	6 months	Staphylococcus aureus	Washout and retained
6	81	Male	32	3 months	MRSA	Amputation†
7	67	Female	46	2 weeks	Enterococcus faecalis/ Corynebacterium	Washout and retained
8	75	Female	42	3 weeks	MRSA	Washout and retained
9	73	Female	38	3 weeks	MRSA	Washout and retained
10	52	Male	39	3 months	MRSA	Washout and retained
11	67	Male	30	6 months	Staphylococcus aureus	Washout and retained
12	81	Male	24	3 weeks	No organism growth	Washout and retained
13	61	Female	40	5 weeks	MRSA	Died of disease*
14	77	Male	33	6 weeks	Coagulase-negative Staphylococcus	Washout and retained
15	70	Female	31	4 weeks	MRSA	Washout and retained
16	49	Male	23	7 months	Staphylococcus aureus	Staged revision
17	77	Male	30	5 months	Staphylococcus aureus	Washout and retained
18	75	Male	26	8 months	Staphylococcus lugdunensis	Washout and retained

* Refused surgical treatment; †treated at another institution; BMI = body mass index; MRSA = methicillin-resistant Staphylococcus aureus.

Table 2. Patient demographics

Variable	Nonobese (n = 499)	Obese (n = 592)	Morbidly obese (n = 123)	p Value
Age (years)*	74 (68–78)	71 (64–76)	67 (62–73)	< 0.001
Gender (male:female)	232:267	202:390	15:108	< 0.001
BMI (kg/m^2)*	26 (24–28)	33 (31–36)	42 (41–46)	

* Values expressed as medians, with interquartile ranges in parentheses; BMI = body mass index.

our institution in March 2002 and was used in 621 patients. In the majority of patients (n = 1165), a medial parapatellar approach was used; 44 patients underwent surgery through a midvastus approach and five underwent surgery through a lateral parapatellar approach. No cases of infection occurred using the latter two approaches.

Postoperative care for all patients was standardized through the use of a clinical pathway for TKA introduced at our institution in 1995 [8]. Low-pressure suction drains were used in 1109 patients and remained in situ for 24 to 48 hours. The median postoperative hemoglobin level was 102 g/dL (interquartile range, 90–112 g/dL), and 300 patients received an allogeneic blood transfusion postoperatively. Autologous blood transfusions were not used during the study.

We reviewed the medical records for all patients in this group, including inpatient data, discharge summaries, and all outpatient followup notes. Data collected included patient demographics, comorbidities, operative time, length of stay, discharge destination, complications, and readmissions that occurred within the first 12 months of the index surgery. Once data collection was complete, patients were separated into obese and nonobese groups according to their BMI classification as described previously.

Differences in infection rates between obese and nonobese patients were determined using the chi square test. Multiple logistic regression was performed to determine whether any comorbidities commonly linked with obesity (cardiovascular disease or diabetes) might be associated with an increased risk of periprosthetic infection and whether patient (gender, etiology, or smoking) and surgical factors (transfusion, drain tube, or antibiotic-impregnated cement) influenced infection rates. The OR and 95% confidence intervals were tabled for each variable tested. Comorbidities associated with an increased rate of prosthetic infection were further analyzed in combination with obesity using a chi square test. Data were maintained and analyzed using Microsoft® Excel® (Microsoft Corp, Redmond, WA) and SigmaStat® for Windows® Version 3.0.1 (SPSS Inc, Chicago, IL).

Results

We observed a periprosthetic infection in 18 of the 1214 patients (1.5%). The infection rate tended to be higher ($p = 0.111$) in obese patients (1.7% [n = 10]) and morbidly obese patients (3.3% [n = 4]), compared with nonobese patients (0.8% [n = 4]) in the univariate model. However, in the multivariate analysis the odds for a prosthetic infection developing during the first 12 months after primary TKA in obese patients was 2.2 (95% confidence interval [CI] 0.64–8.14; $p = 0.201$) and for morbidly obese patients, 8.96 (95% confidence interval [CI], 1.59–50.63; $p = 0.013$) (Table 3).

Table 3. Variables tested against prosthetic infection

Individual variable	Odds ratio	95% CI	p Value
Cardiovascular disease	1.92	0.40–9.19	0.413
Diabetes mellitus	6.87	2.42–19.56	< 0.001
Respiratory	0.89	0.22–3.51	0.864
Smoking	2.31	0.44–12.14	0.323
Obese (BMI 30–39 kg/m^2)*	2.29	0.64–8.14	0.201
Morbidly obese (BMI $\geq$ 40 kg/m^2)*	8.96	1.59–50.63	0.013
Rheumatoid arthritis	3.81	0.82–17.76	0.088
Transfusion	2.54	0.87–7.43	0.086
Drain tube	0.24	0.06–0.95	0.042
Antibiotic cement	1.05	0.35–3.11	0.934
Gender (male)	5.93	1.95–18.04	0.002
Age 65–74 years†	0.86	0.19–3.86	0.845
Age $\geq$ 75 years†	2.21	0.58–8.50	0.247

* Compared with nonobese group (BMI < 30 kg/m^2); †compared with age < 65 years; CI = confidence interval; BMI = body mass index.

Table 4. Incidence of diabetes and obesity in patients with prosthetic infection (n = 18)

Diabetes	Nonobese	Obese	Morbidly obese	p Value
Yes	0	7	4	0.010
No	3	4	0	

Only DM among the comorbidities was associated with an increased prosthetic infection rate. The prosthetic infection rate for patients with DM was 6.87 times (95% CI, 2.42–19.56; $p < 0.001$) that of patients without DM. Periprosthetic infections were more common when diabetes was associated with obesity (Table 4).

Of all remaining variables (respiratory disease, smoking, rheumatoid arthritis, transfusion, drain tube, antibiotic cement, gender and age group) tested, only gender and use of a surgical drain predicted deep prosthetic infection. The rate of prosthetic infection for men was 5.93 times (95% CI, 1.95–18.04; $p = 0.002$) that of women. The prosthetic infection rate was less (OR, 0.24; 95% CI, 0.06–0.95; $p = 0.042$) in patients when a postsurgical drain was used.

Discussion

The rationale of our study was to determine if obesity was an independent risk factor for development of a deep prosthetic infection in TKA, an association we previously observed with THA [7]. We were surprised by the paucity of studies which report specifically on the incidence of acute periprosthetic infection for obese patients after primary TKA and even fewer that review the combined effect of comorbidities with obesity [1, 16, 17, 19, 25]. In the current study, we also analyzed other patient and surgical variables also reported to correlate with prosthetic infection.

Our study has several limitations. Prosthetic infections were limited to those that occurred during the first 12 months after index surgery; this enables us to report infection rates for a cohort with followup for all study patients which strengthens our findings. Patient comorbidities tested were limited to those commonly associated with postsurgical complications, although numerous other comorbid conditions (eg, renal failure, hypothyroidism, diverticulosis) related to the development of prosthetic infection have been identified. However these comorbidities tend to lose importance when included in a multivariate analysis [20]. Postoperative care of patients was standardized through clinical pathway protocols; however, some differences in surgical technique were identified. Antibiotic-impregnated cement was not used at our institution until 2002 and closed suction drains were not used by all surgeons in this study. These variables were addressed in our regression analysis.

Our major finding was the risk of a deep prosthetic infection after primary TKA was greater in morbidly obese patients compared with nonobese patients. This finding was specific to our morbidly obese group and we did not observe a major difference comparing obese with nonobese patients. This contrasts with results of our previous study on THA, which showed a higher incidence of deep prosthetic infection in obese and morbidly obese patients [7]. We were surprised by this finding and can only speculate regarding why any level of obesity was a risk factor for infection in THA but only morbid obesity was a risk factor in TKA. One possible explanation is the greater amount of adipose tissue encountered at the hip during THA than at the knee during TKA. In this regard, it is known poor vascularity of adipose tissue has been linked with infection after abdominal surgery in obese patients [5, 10, 24]. We could find no other study reporting on deep prosthetic infection with a comparable number of morbidly obese patients. A recent prospective study on 1509 TKAs by Chesney et al. [4] reported a higher odds for infection in morbidly obese patients but their finding was not significant and this may be the result of fewer numbers in their morbidly obese group (n = 34). One other series with a similar cohort comparing patients with a BMI greater than 35 kg/m^2 with patients with a BMI 35 kg/m^2 or less also reported a higher infection rate in their obese group, 1.1% versus 0.3%, noting superficial and deep infection were combined in their analysis [17].

We noted a higher odds for prosthetic infection in patients with DM confirming previous reports. Prosthetic infection rates between 5.5 and 7% in diabetic patients undergoing TKA have been recorded [9, 13, 26]. However, we also noted there were no prosthetic infections in patients with DM who had a BMI less than 30 kg/m^2. This compares with 11 prosthetic infections in patients with DM who were obese. The influence of obesity in patients with DM undergoing TKA may be related to the influence of obesity on diabetic control [12, 14, 23]. Obesity is associated with poor diabetic control and hyperglycemia and is an independent risk factor for nosocomial infections in patients undergoing major cardiovascular or abdominal surgery [21]. We did not assess for diabetic control as part of this study and therefore only can raise this point as a point of interest. Only one previous study has reported on the combined effect of obesity and DM on complication rates in patients undergoing joint arthroplasty [11]. Jain et al. [11] reported a higher odds for a postoperative complication in obese patients with DM undergoing total joint arthroplasty than in patients with DM alone.

We identified two other patient and surgical variables associated with deep prosthetic infection. The odds for a prosthetic infection were greater in men and yet obesity is more predominant among women presenting for TKA than for men [11, 17]. We also observed a lower odds for prosthetic infection in patients undergoing TKA when a postoperative drain was used. This contrasts with the pooled results from a meta-analysis on the use of closed suction drainage in total joint arthroplasty, which reported no major difference in the deep infection rate with or without the use of closed suction drainage [18]. The difference in findings may be attributable to the cohort size for the individual studies pooled in this meta-analysis. None of the nine studies included in that meta-analysis reported a difference in prosthetic infection rates with or without the use of a drain following TKA. All were comparatively small (range, 32–138 cases) with only one exception. One study involved 275 cases and also reported no difference in infection rates with or without the use of a drain; however, there was no evidence of patient followup beyond the inpatient stay in this review [22].

We reported an overall periprosthetic infection rate of 1.5% in a series of 1214 primary TKAs. We found morbid obesity was associated with an odds for a prosthetic infection nine times that of nonobese patients and prosthetic infection occurred predominantly in patients who were obese and diabetic. These results were in contrast to our findings for THA, which determined obesity was a risk factor for periprosthetic infection independent of major comorbidities [7]. The differences in outcomes in these two studies raise questions regarding whether the impact of obesity on infection rates after joint arthroplasty is a direct or systemic one and additional research is required in this area. Given a majority of patients presenting for TKA are currently obese and this has a negative impact on outcomes, developing treatment protocols for obese patients should be considered to minimize the risk of infection.

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