Risk factors associated with periprosthetic joint infection after total elbow arthroplasty

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Abstract

Background: For patients undergoing total elbow arthroplasty (TEA), the present study aimed to investigate: (i) what risk factors are associated with periprosthetic elbow infection; (ii) what is the incidence of infection after TEA; and (iii) what is the acuity with which these infections present?

Methods: The Statewide Planning and Research Cooperative System database was used to identify all patients who underwent TEA between 2003 and 2012 in New York State. Admissions for prosthetic joint infection (PJI) were identified using ICD-9 (International Classification of Diseases, Ninth Revision, Clinical Modification) diagnosis code 996.66. Multivariate analysis was used to determine risk factors that were independently prognostic for PJI.

Results: Significant risk factors for PJI included hypothyroidism [odds ratio (OR) = 2.04; $p = 0.045$], tobacco use disorder (OR = 3.39; $p = 0.003$) and rheumatoid arthritis (OR = 3.31; $p < 0.001$). Among the 1452 patients in the study period who underwent TEA, 3.7% ($n = 54$) were admitted postoperatively for PJI. There were 30 (56%) early infections, 17 (31%) delayed infections and seven (13%) late infections.

Conclusions: Pre-operative optimization of thyroid function, smoking cessation and management of rheumatoid disease may be considered in surgical candidates for TEA. The results of the present study add prognostic data to the literature that may be helpful with patient selection and risk profile analysis.

Level of evidence: Level III: prognostic study

Keywords

arthroplasty, elbow, infection, hypothyroidism, rheumatoid arthritis, smoking

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Introduction

Prosthetic joint infection (PJI) after total elbow arthroplasty (TEA) is a rare but devastating complication that often requires additional surgery and prolonged antibiotic therapy. By contrast to the literature regarding hip, knee and shoulder PJI, there have been limited reports on factors predisposing patients to prosthetic elbow infections,¹ with the majority of data drawn from small case series.^{2–4} Reported risk factors have included a history of multiple prior elbow procedures,^{5,6} early wound complications or drainage,^{5,7} previous infection,⁵ smoking,⁸ obesity⁹ and rheumatoid arthritis.¹⁰ Although hypothyroidism was recently identified as an important predictor for PJI after hip and

knee replacement,¹¹ this has not previously been demonstrated in the elbow.

Large-scale database and registry studies related to TEA do exist in the published literature, although they

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are not always capable of tracking long-term complication rates. For example, the Nationwide Inpatient Sample database has generated useful data relating to the index TEA hospitalization but does not record outcomes beyond the initial hospital stay.^{12,13} Other registry studies have reported long-term survivorship with revision surgery for infection as an endpoint but lack supplementary information to help further describe specific infection characteristics.^{14,15} One example is the Norwegian registry, which reported a very low infection rate of less than 1% but discussed that the database only tracked deep infections leading to removal of prosthetic parts and not infections in which the hardware remained implanted.¹⁵ Perhaps one of the most detailed databases for examining long term complications related to orthopaedic procedures is the New York Statewide Planning and Research Cooperative System (SPARCS). Gay et al.¹⁰ recently utilized this database to evaluate changes in indications over time as well as complications related to TEA. They reported a 3.1% infection rate within 90 days and an all-cause revision rate of 6.4% during the study period, although they did not further analyze the infection cases.¹⁰

Given the limited data available to adequately counsel patients about risk factors and properly select surgical candidates for TEA, we used a large multihospital, statewide healthcare database to identify demographic risk factors for postoperative PJI. We aimed to investigate: (i) what risk factors are associated with periprosthetic elbow infection; (ii) what is the incidence of infection after TEA; and (iii) what is the acuity with which these infections present?

Materials and methods

Database

The New York SPARCS is a comprehensive healthcare data reporting system established by the New York State Department of Health (<https://www.health.ny.gov/statistics/sparcs>). This database contains a census of all hospital admissions performed in the state of New York annually. Each record includes data on patient demographics, medical diagnoses and surgical procedures. Hospital admissions utilize ICD-9 (International Classification of Diseases, Ninth Revision, Clinical Modification) codes for both diagnoses and procedures. The database includes a unique encrypted identification code for each patient, which allows researchers to track patients across multiple encounters. Our version of the database did not contain any patient identifiers or protected health information and therefore the present study was given an exemption from further institutional review.

TEA cases

The present study cohort consisted of 1452 patients who underwent a primary TEA in New York between 1 January 2003 and 30 September 2012. We initially identified the 1512 patient records with an ICD-9 procedure code for TEA (81.84) during this period. We then excluded eight patient records with an unspecified identification code and six patient records with an unspecified date of surgery. For the 1498 remaining patient records, we only considered the first TEA admission for each of the 1452 patients and excluded the remaining 46 records.

Outcomes

Using the patient identification code, we retrospectively followed patients from the date of their TEA. We identified patients who were admitted postoperatively for a PJI (ICD-9 diagnosis 996.66) and compared the date of the TEA with the date of hospital admission to calculate the number of days between the initial TEA surgery and the PJI. Infections were stratified into early (<3 months), delayed (3 months to 24 months) or late (>24 months).

Demographic covariates

Demographic variables for each admission, including age (in years), sex (male, female), race (white, nonwhite) and year of admission (2003 to 2012), were extracted. A composite comorbidity score was calculated using the Charlson and Deyo scoring method for ICD-9 coding.¹⁶ We also used ICD-9 codes to determine common individual comorbidities including diabetes mellitus (diagnosis 250), hypertension (diagnosis 401.9), tobacco use disorder (diagnosis 305.1), hypothyroidism (diagnosis 244.9) and rheumatoid arthritis (diagnosis 714.0).

Statistical analysis

We used frequency tables to calculate the incidence of PJI among patients undergoing TEA. Frequency tables were also used to describe the details of patient presentation and management during admission for PJI. We used frequency tables and means with 95% confidence intervals (CI) to describe the demographics of the study cohort. Simple logistic regression was used for each variable to determine the significance of each demographic variable as an independent predictor of PJI following TEA. Backwards stepwise regression modelling was then used for each outcome to build a single, comprehensive risk factor model of the significant predictors. Risk was defined by the odds ratio (OR) and 95% CI of PJI.

Table 1. Incidence of periprosthetic joint infection following total elbow arthroplasty.

	Incidence (%)
Any	3.72
Early (<3 months)	2.07
Delayed (3 months to 24 months)	1.17
Late (>24 months)	0.48

All statistical analyses were performed using SAS, version 9.4 (SAS Institute Inc., Cary, NC, USA). $p < 0.05$ (two-tailed) was considered statistically significant.

Results

Patients admitted for PJI had an older mean age (62 years versus 60 years), were more likely to be female (78% versus 70%), more likely to be white (80% versus 71%), had a higher mean Deyo score (0.96 versus 0.73 points), were more likely to have rheumatoid arthritis (37% versus 16%), more likely to have diabetes mellitus (22% versus 15%), more likely to have hypertension (44% versus 41%), more likely to have tobacco use disorder (15% versus 5%) and more likely to have hypothyroidism (20% versus 11%) (Table 1). The unadjusted univariate regressions for each variable are shown in Table 2. In the composite regression model, significant risk factors for PJI included rheumatoid arthritis (OR = 3.31; 95% CI = 1.85 to 5.90; $p < 0.001$), tobacco use disorder (OR = 3.39; 95% CI = 1.52 to 7.56; $p = 0.003$) and hypothyroidism (OR = 2.04; 95% CI = 1.02 to 4.08; $p = 0.045$) (Table 3).

Among the 1452 patients who underwent TEA, 54 (3.72%) were admitted postoperatively for periprosthetic infection.

There were 30 (56%) early infections, 17 (31%) delayed infections and seven (13%) late infections. The incidence was 2.1% for early infection, 1.2% for delayed infection and 0.5% for late infection.

Discussion

The risk factors and epidemiology of periprosthetic elbow infection are poorly understood. Using a large, statewide sample of patients who underwent TEA over a 10-year period, we evaluated the risk factors of postoperative PJI. We found that rheumatoid arthritis, tobacco use and hypothyroidism were independent predictors for PJI.

The present study has several limitations that should be acknowledged. A common limitation of large

Table 2. Demographics of patients undergoing total elbow arthroplasty according to diagnosis of periprosthetic joint infection, univariate analysis.

	Frequency		Regression (univariate)	
	No PJI	PJI	OR*	p
Mean age (years)	60	62	1.01	0.248
Sex (%)				
Male	30	22	1.00	–
Female	79	78	1.51	0.217
Race (%)				
White	71	80	1.00	–
Nonwhite	29	20	0.63	0.180
Mean Deyo score	0.73	0.96	1.14	0.162
Rheumatoid arthritis (%)				
No	84	63	1.00	–
Yes	16	37	3.2	<0.001
Diabetes mellitus (%)				
No	85	78	1.00	–
Yes	15	22	1.63	0.148
Hypertension (%)				
No	59	56	1.00	–
Yes	41	44	1.14	0.643
Tobacco use disorder (%)				
No	95	85	1.00	–
Yes	5	15	3.03	0.006
Hypothyroidism (%)				
No	89	80	1.00	–
Yes	11	20	2.11	0.032

PJI, periprosthetic joint infection; OR, odds ratio; CI, confidence interval.

*Simple unadjusted univariate logistic regression for each variable calculating the risk of PJI.

database studies, including this one, is that variability among hospital coding practices may have led to undocumented cases of PJI. Furthermore, ICD-9 coding cannot account for type of TEA implant,

Table 3. Significant risk factors for periprosthetic joint infection following total elbow arthroplasty.

	OR (95% CI)*	P
Rheumatoid arthritis	3.31 (1.85 to 5.90)	<0.001
Tobacco use disorder	3.39 (1.52 to 7.56)	0.003
Hypothyroidism	2.04 (1.02 to 4.08)	0.045

OR, odds ratio; CI, confidence interval.

*Stepwise regression model with all predictors

severity of the infection, physical examination findings, laboratory data including erythrocyte sedimentation rate, C-reactive protein, white blood cell or arthrocentesis, as well as postoperative functional outcomes. Furthermore, the definition of periprosthetic joint infection can vary widely, as has been demonstrated in shoulder arthroplasty literature.¹⁷ As a result of the frequent 'stealth' nature of upper extremity PJI, it may be advisable to simply report 'culture-positive' revisions, accompanied by a description of the number of cultures taken and the number positive.¹⁸

We identified rheumatoid arthritis, tobacco use, and hypothyroidism as significant independent risk factors for PJI. Gay et al.¹⁰ also identified a statistically significant increase in PJI rate in patients with rheumatoid arthritis compared to other patients in the first 90 postoperative days. By contrast, Cook et al.¹² found that the rate of perioperative complications were nearly equivalent for patients with and without rheumatoid arthritis. These findings suggest that the increased risk of complications in patients with rheumatoid arthritis may manifest more on a long-term basis compared to the perioperative period. Smoking has also previously been demonstrated to be a risk factor for prosthetic elbow infection.⁸ To our knowledge, no other studies have specifically examined hypothyroidism related to infections in TEA. However, a recent study of hip and knee arthroplasty demonstrated greater than a two-fold increase in the rate of PJI in patients with hypothyroidism.¹¹ Patients undergoing foot and ankle surgery have also been noted to have an increased risk of wound complications associated with thyroxine supplementation.¹⁹ Although the direct mechanism for this is unknown, there has been increasing understanding of the role of thyroid function in the immune system. A study of healthy adults demonstrated associations between thyroid hormone levels and natural killer-like T cells, interleukin-6 expression and lymphocyte expression.²⁰

The overall incidence of postoperative PJI in the present study was 3.7%. This is comparable to most other

studies, which report an incidence ranging between 1% and 11%.^{2,14,15} A prior study utilized the SPARCS database to examine PJI in elbow replacement and reported a 90-day postoperative infection rate of 3.1%, although long-term infection rates were not investigated.¹⁰ Our slightly higher overall reported rate of infection was likely a result of the capture of all cases coded as PJI, including delayed and late infections, rather than using only revision operative codes as indicators of infection.^{14,15,21} Additionally, shoulder arthroplasty literature has indicated that the presence of PJI as a result of indolent organisms such as *Propionibacterium acnes* is common in the upper extremity.^{22–24} Although there are no studies related to this phenomenon specific to TEA, many revision cases for aseptic loosening may in fact be indolent prosthetic joint infections that were missed.

A substantial number of the infections reported in this series (44%) occurred in the delayed or chronic stage (>3 months postoperatively). This is similar to the results reported in a large single-centre study of 358 TEA procedures, in which 51% of infections presented at greater than 3 months postoperatively.²⁵ This indicates the difficulty in adequately capturing infection rates with short-term follow-up; analysis of 90-day postoperative outcomes is clearly not sufficient.

Conclusions

In summary, hypothyroidism was identified as a risk factor for postoperative infection after TEA. Given the prevalence of thyroid disease and the relative ease of screening with pre-operative laboratory testing, further study is warranted to determine the health benefits and cost-efficacy of pre-operative thyroid optimization. Smoking and rheumatoid arthritis were also identified as independent predictors. Based on our findings, pre-operative management of rheumatoid disease, optimization of thyroid function and smoking cessation should be considered in all surgical candidates for TEA.

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Ethical review and patient consent

This article does not contain any studies with human participants or animals performed by any of the authors.

Level of evidence

Level III: prognostic study

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