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Ninety-day Mortality in Patients Undergoing Elective Total Hip or Total Knee Arthroplasty

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Abstract

Using an institutional Joint Registry, we studied frequency, trends and predictors of mortality following elective total hip or knee arthroplasty (THA/TKA). Of the 12,727 and 12,484 patients who underwent THA and TKA respectively, all-cause mortality rates at 7-, 30- and 90-days were as follows: THA, 0.1%, 0.2% and 0.5%; TKA 0.1%, 0.2% and 0.4%, respectively. Statistically significant downward time-trend in 90-day mortality was noted after TKA ($p=0.02$), but not after THA ($p=0.41$). In multivariable-adjusted analyses of THA patients, older age, higher comorbidity index, and prior cardiac disease were significantly associated with higher 90-day mortality. In TKA patients, older age, male gender, ASA class of 3-4, and higher comorbidity index were associated with higher 90-day all-cause mortality. Optimization of disease management may reduce postoperative mortality after THA/TKA.

INTRODUCTION

Patients with treatment for refractory knee/hip arthritis pain undergo total knee arthroplasty (TKA) or total hip arthroplasty (THA). Due to an aging population and expanding indications, both procedures have become more common. It is projected that by 2030, the demand for primary TKA will grow by 6-fold to 3.48 million procedures annually, and primary THA by 174% to 572,000 procedures annually (1). THA and TKA lead to significant and impressive improvements in pain, function, and health-related quality of life (HRQoL) (2) (3). The age range for the procedures has expanded and they are being performed in both much younger and much older patients than previously (4).

Several studies have estimated mortality rates in THA and TKA cohorts. A recent systematic review of mortality after knee or hip arthroplasty revealed a combined 30-day

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postoperative mortality of 0.3% and a 90-day mortality of 0.7% (5). On the other hand, there are no studies examining time-trends in post-THA/TKA mortality, except a single study of Medicare patients in THA patients published recently (6). In this study limited to patients 65 years and older, a decrease in hospital length of stay and mortality was noted post-THA (6). However, recent studies have shown that at least one-third of all TKA/THA in the U.S. are performed in patients younger than 65 years (7), raising issues regarding generalizability of these findings. In addition, to our knowledge no data exists with regards to time-trends in post-TKA mortality.

A handful of well-designed studies have examined predictors of mortality, but they provide contradictory findings. In multivariable-adjusted analyses of patients in the National Inpatient Sample who underwent THA or TKA from 1990-2004, older age, male gender and comorbidities were associated with higher inpatient mortality (8). In contrast, in multivariable-adjusted analyses of THA patients from Medicare data from 1983-1985, older age, but not gender were significant predictors of 30-day mortality after THA (9). Univariate analyses show the same discordance in findings regarding significant predictors of post-THA/TKA mortality. In a univariate analysis of single-center study of >30,000 patients who underwent elective THA between 1969 and 1997, age >70 years, male gender and pre-existing cardiac disease were significantly associated with higher 30-day mortality (10). In another univariate analysis of 1,744 patients who underwent elective primary THA between 1998 and 2004, older age but not gender, pre-existing cardiac disease or hypertension were significantly associated with higher 90-day mortality (11). In a univariate analysis of 22,540 TKAs from a single center between 1969-1997, older age and cardiorespiratory disease were associated with higher 30-day mortality after TKA, while gender was not associated (12). In summary, it is unclear whether important demographic and clinical characteristics are associated with post-THA/TKA mortality.

The aim of this study was to use data from an existing prospective institutional total joint registry to study mortality up to 90-days after elective THA and TKA. The study objectives were to: (1) estimate 7-, 30-, and 90-day mortality rates after elective THA and TKA; (2) examine the time-trends in 90-day mortality after elective THA and TKA; and (3) assess the predictors of 90-day mortality after elective THA and TKA.

METHODS

Data Sources and Study Population

We used the data from the AA Total Joint Registry (13), a registry that collects prospective outcomes data by routinely and systematically following all patients who undergo joint replacement at AA, BB. For patients who miss their appointments, mailed questionnaires regarding outcomes and complications are requested along with radiographs. Patients not returning for follow-up and not responding to mailed letters/questionnaires are contacted by telephone call from trained, dedicated registry staff, who administers these questionnaires over the phone. The registry captures patient outcomes with particular emphasis on complications including fracture, infection, dislocation, and mortality. Mortality data (vital status and date of death) are obtained from the medical records at the AA and other medical centers, Social Security Death Index, and/or verbal report of patient's death by patient's spouse/significant other. Using AA Total Joint Registry data, several high quality studies of mortality have been published (10, 12).

The time period of interest for this study was from 1/1/1994 to 5/31/2008. This recent observation period was chosen to update the literature with more recent estimates of mortality. We chose a 14-year period of study to have enough mortality events to allow study of predictors and time-trends in mortality.

Study Outcome

The study outcome of interest was mortality within 90-days of the index elective THA or TKA (primary or revision). We excluded patients who underwent THA with hip fracture as the underlying diagnosis, since these constitute non-elective THA and mortality risk is expected to be higher in these patients. Since it may be argued that despite rigorous follow-up of all patients, some patients may be lost to follow-up, we compared the mortality rates from our study to the recently published mortality rates in a subset of these THA/TKA patients who resided in the Olmsted County (14), obtained by merging joint registry data with BB Epidemiology Project, a population-based study (15). More than 90% of the Olmsted County residents are examined at AA health care system over a 3-year period (15).

Predictors of Outcomes

In separate univariate analyses for THA and TKA, we examined whether the following variables were associated with 90-day all-cause mortality: (1) Age, in five year increments; (2) Gender; (3) Prior cardiac events (myocardial infarction, congestive heart failure, or arrhythmia), coded as yes/no; (4) Prior thromboembolic event (deep venous thrombosis or pulmonary embolism), coded as yes/no; (5) Body mass index, for each 5-unit increase (values over 80 and under 10 were set to missing); (6) Comorbidity assessed by Deyo-Charlson index, per 1-point increase; (7) American Society of Anesthesiologist (ASA) score; and (8) primary versus revision surgery. The Deyo-Charlson index is a validated comorbidity assessment consisting of a weighted sum of 17 comorbidities (including cardiac, pulmonary, renal, hepatic disease, diabetes, cancer, HIV, etc.), where a higher score indicates more comorbidity (16). The ASA score is a validated measure of peri- and post-operative outcomes, categorized as class I-II vs. III-IV (17). As reported previously, ASA class and Deyo-Charlson index have low correlation (<0.35) in this cohort and therefore there is no concern of collinearity by including both in the models. Only predictors statistically significant in univariate models ($p<0.05$) were entered into backward selection multivariable logistic regression models.

Statistical Analyses

Summary statistics were computed for the cohort as mean (standard deviation) or number (percentage). Logistic regression was used for univariate and multivariable-adjusted analyses 90-day all-cause mortality, using the variables listed above. We used backward selection method for multivariable logistic regression, allowing variables associated with p -value <0.05 in univariate models to enter the model. We calculated odds ratios (and 95% confidence intervals). Time-trends in mortality was examined at three increments for the entire study period (1994-2008) using a linear regression with the independent variable being the year of orthopedic surgery, divided into five study periods of 3-year duration. A p -value < 0.05 was considered statistically significant. All analyses were performed using SAS 9.2 by SAS Institute Inc., Cary, NC, USA.

RESULTS

Study Cohort and its characteristics

The study population initially consisted of 12,727 patients with elective THA and 12,484 with elective TKA, after exclusion of 2,077 patients with hip fracture. The characteristics of patients who underwent elective THA and TKA were as follows, respectively: mean age was 64 and 68 years, 49% and 44% were male, and the underlying diagnosis was osteoarthritis in 63% and 77%, respectively (**Table 1**).

Post-operative mortality (7-, 30- and 90-day)

Of 12,727 patients, 58 (0.5%) in the elective THA cohort died within the 90-day of their arthroplasty; similarly, 52/12,484 patients (0.4%) in TKA cohort died within 90-days. Ninety day all-cause mortality was much higher in patients with hip fracture who underwent non-elective THA (194/2,077 or 9.3%), who were excluded from all analyses.

In the THA cohort, 7- and 30-day all-cause mortality rates were 0.1% (12/12,727) and 0.2% (31/12,727) respectively. In patients with TKA, 7- and 30-day all-cause mortality rates were 0.1% (13/12,484) and 0.2% (28/12,484), respectively.

Time Trends in 90-day all-cause Mortality

We did not observe any statistically significant time-trend in 90-day all-cause mortality in patients who underwent THA ($p=0.41$) (**Figure 1A**). The 90-day mortality rates post-THA in the five periods were as follows: 1994-96, 0.62% (95% CI: 0.36, 1.01); 1997-99, 0.46% (95% CI: 0.24, 0.81); 2000-02, 0.34% (95% CI: 0.16, 0.65); 2003-05, 0.41% (95% CI: 0.21, 0.74); and 2006-08, 0.44% (95% CI: 0.21, 0.82). There was a significant decrease in mortality over the study period in patients who underwent elective TKA ($p=0.02$) (**Figure 1B**). The 90-day mortality rates in the five time periods post-TKA were as follows: 1994-96, 0.62% (95% CI: 0.34, 1.03); 1997-99, 0.51% (95% CI: 0.25, 0.91); 2000-02, 0.33% (95% CI: 0.14, 0.65); 2003-05, 0.36% (95% CI: 0.18, 0.65); and 2006-08, 0.31% (95% CI: 0.13, 0.60).

Risk Factors for 90-day all-cause mortality after THA and TKA

The univariate correlates of 90-day mortality after THA (**Table 2**) and TKA (**Table 3**) are shown in the respective tables. In multivariable-adjusted analyses of patients with THA, older age, higher Deyo-Charlson comorbidity index, and prior history of cardiac events were significantly associated with higher 90-day mortality in the THA cohort (**Table 2**).

In multivariable-adjusted analyses in patients who underwent TKA, older age, male gender, ASA class of 3-4, and higher Deyo-Charlson comorbidity index were associated with higher 90-day all-cause mortality (**Table 3**).

DISCUSSION

In this study, we estimated 7-, 30- and 90-day all cause mortality in a large cohort of Total Joint Registry patients who were followed prospectively for complications including mortality. The risk of postoperative mortality was low. We found a significant downward time-trend in 90-day mortality after elective TKA, but not after elective THA. Several risk factors for all-cause 90-day post-arthroplasty mortality in patients were identified. Cardiac disease (but not thromboembolic disease) was a risk factor for 90-day mortality in patients who underwent elective THA, and higher preoperative comorbidity increased the risk of 90-day mortality after both procedures, elective THA or elective TKA. Several study findings in the current study are novel and deserve further discussion. One of the limitations of previous studies was the examination of different mortality end-points (in-hospital vs. 30-day vs. 7-day), with very few studies providing data for mortality assessment at various time-points after TKA/THA. Better knowledge of mortality risk may allow risk stratification of patients and better informed consent, since both TKA and THA are elective surgeries and mortality is an unexpected outcome. Studies with large sample sizes that assess predictors of mortality using multivariable-adjusted analyses to adjust for confounding, such as this study, add to the current knowledge in this area.

A novel finding in this study was a significant downward trend in mortality after TKA over a 14-year period from 1994-2008. To our knowledge, there are no studies that have examined this in a representative sample of patients undergoing TKA. Although suspected, whether this is occurring in concert with an increasing patient comorbidity is unknown. No significant time-trends were noted in mortality after THA, although the rates in the latter years were closer to 0.4% compared to 0.6% in the earliest period, 1994-96. This observation in conjunction with previous finding of decreasing mortality from 1969-1997 post-THA (12), indicates that post-THA mortality that decreased over last four decades, may have stabilized in the last decade. Several potential explanations exist for declining mortality rates in patients undergoing **TKA**. Improved pathways for preventing complications with close patient monitoring, institution of pre-operative cardiac work-up and optimization for elective surgeries and early detection and treatment of key complications such as pneumonia and myocardial infarction are likely reasons for decreasing mortality over time, despite increasing age and comorbidity of patients undergoing these procedures. For example, a 33% reduction in 90-day mortality in TKA group from 0.62% in 1994-96 to 0.44% in 2006-08 seems clinically meaningful relative risk reduction. Due to the low risk of mortality after these elective procedures, this risk reduction translates into 2 fewer patient deaths per 1000 procedures. Considering that TKA and THA are elective procedures, we think that even a small absolute risk reduction in mortality as noted here is clinically relevant and meaningful.

In THA patients, we found that pre-existing cardiac disease, but not thromboembolic disease, independently predicted a higher 90-day all-cause mortality rate in multivariable-adjusted model. The odds of 90-day mortality in patients with cardiac disease were three times higher than those without pre-existing cardiac disease. Conflicting evidence exists with regards to association of preexisting cardiac disease with post-arthroplasty mortality with one study reporting this association (10) and the other study finding no such association (11). These published studies of predictors of mortality after THA/TKA have several limitations. The negative study has a small sample size <2,000 patients and may have been underpowered to detect this association (11). In addition, previous data are from univariate analyses only and did not control for important covariates and confounders, which makes estimates potentially biased due to residual confounding. One study examined mortality only during the inpatient stay (8) and one study was limited to older age groups (≥ 65 years for Medicare) (9). Two studies provided data only up to 1997 (10, 12). Most studies used data that were based on claims data, which are not collected primarily for clinical or research use (8-9). Sample sizes were much larger in our study (>12,000) and previous positive study using univariate analyses (>30,000) (10). Our study advances the scientific knowledge in the area by confirming this positive finding from a previous univariate analysis and performing more rigorous analyses in a large study sample. The lack of significant association of previous thromboembolic disease with 90-day mortality post-THA is an interesting finding. Surgeons are often concerned with mortality risk associated with thromboembolism and cardiac disease in patients undergoing THA. While our study was not designed to and does not answer the question regarding relative contributions of cardiac and thromboembolic complications to 90-day mortality, it provides insights into relative importance of history of these two important conditions to 90-day mortality.

The association of higher comorbidity with 90-day post-THA mortality confirms previous noted association of higher comorbidities with in-hospital mortality in patients undergoing elective THA or TKA using the National Inpatient Sample (18), and extends this to 90-day mortality. In TKA patients, higher comorbidity was significantly associated with 90-day mortality similar to that noted in a univariate analysis of 22,540 TKAs between 1969-1997 (12). These findings underscore the importance of assessing and optimizing comorbidity management in elderly patients with multiple comorbid conditions. This is intuitive to

surgeons and anesthesiologists, who likely take this into account while consenting patients and managing them post-operatively. A higher pre-operative comorbidity may lead to higher peri-operative complication and subsequent mortality risk. These patients should receive extra attention and closer monitoring to avoid rare fatalities after elective THA.

Our 90-day mortality of 0.5% for elective THA and 0.4% for elective TKA is similar to the previously reported range of 30-90 mortality of 0.3%-0.7% for elective THA (10, 19-21) and 30-day mortality of 0.2% following elective TKA (12). Further, comparing these mortality rates to previously reported 7-, 30- and 90-day mortality rates for the subset of these patients who were Olmsted County residents, our estimates were within 0.1-0.2% of previously reported 0.1%, 0.3% and 0.7% for THA and 0.1%, 0.3% and 0.4% for TKA (14). This finding provides support to our statement that mortality is followed-up very closely in our large patient cohort prospectively by rigorous and systematic follow-up and confirms the robustness of these estimates. These findings are consistent with the fact that mortality is rare after elective THA or TKA. Our 90-day mortality of 9.2% for non-elective THA for patients with hip fracture seems plausible based on 30-day mortality of 6% in this cohort in an earlier study (9).

Our finding that ASA class of III-IV increased the risk of 90-day mortality 5-times compared to class I-II, confirms similar associations of ASA with in-hospital mortality after elective THA or TKA (22) and 3-5 year mortality after elective THA (11). ASA is a validated measure of peri- and post-operative morbidity and complications (17, 23), and has been validated as a risk for complications in several studies of arthroplasty (24-25). Association of older age with higher 90-day mortality after THA and TKA is in agreement with similar findings from other studies (8-12), and is not surprising. The association of male gender with higher mortality post-TKA extends a previous finding of a non-statistical association ($p=0.052$) with higher 30-day mortality in a single-center study (12).

The study findings must be interpreted considering the study strengths and limitations. We studied a large number of patients (>12,000 each for THA and TKA), examined several important factors previously not examined regarding their association with 90-day mortality (body mass index, Deyo-Charlson comorbidity score, and prior history of thromboembolism), and used robust analyses.

Our study has several limitations. This was a retrospective review of prospectively collected data as a part of Total Joint Registry, and despite our attempts to include several potentially important variables, residual confounding is possible. Generalizability may be a challenge, since this is a single-center study and resources and systems can vary by the type of practice. Despite a large sample size, very few patients in the elective THA or TKA died, which makes our study liable to type II error, i.e., missing an important association due to lack of power. We believe that an even larger sample of patients is needed to validate these associations and to further explore other predictors of mortality. **Also, even though mortality** was assessed from multiple sources including social security death index and active surveillance to reduce the likelihood of under-reporting, some under-reporting is possible and therefore these estimates may be somewhat conservative. No validation studies assessing the completeness of capture of mortality have been performed in AA total joint registry.

In conclusion, we performed a study estimating the 90-day all-cause mortality rates following elective THA and TKA. We found important downward time-trends in 90-day mortality after TKA. We identified important demographic and clinical risk factors for 90-day mortality after THA/TKA. Findings from this study are a resource for providers to discuss mortality risk depending on patient demographics or presence of cardiac disease and

other comorbidity. Future studies should explore whether use of certain interventions, including pre-operative comorbidity management and optimization with emphasis on cardiac comorbidity, can reduce post-operative mortality.

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Figure 1A. Time trends in 90-day mortality in patients with elective THA (n=12,787; Figure 1A) and elective TKA (n=12,484; Figure 1B)

There was no significant time-trend in the 90-day mortality after elective THA over the study's observation period ($p=0.41$).

Figure 1B. Time trends in 90-day mortality in patients with elective THA (n=12,787; Figure 1A) and elective TKA (n=12,484; Figure 1B)

There was statistically significant decrease in the 90-day mortality after elective TKA over the study's observation period ($p=0.02$).

Table 1

Clinical Characteristics of the Study Population

	THA (n=12,727 patients)	TKA (n=12,484 patients)
Age (years) ₁	64.4 ± 14.3	67.8 ± 11.0
Male/Female	6,169 (48.5%)	5,525 (44.3%)
Primary/Revision	9,455 (74.3%)	10,303 (82.5%)
% Bilateral ^a	389 (3.1%)	1,566 (12.5%)
% Cemented or hybrid	11,941 (93.8%)	12,050 (96.5%)
Operative Diagnosis		
Osteoarthritis	8,068 (63.4%)	9,649 (77.3%)
Rheumatoid arthritis	209 (1.6%)	309 (2.5%)
Other ^b	4,450 (35.0%)	2,526 (20.2%)
Body Mass Index ^c	28.8 ± 6.0	31.1 ± 6.3
ASA Class		
I-II	7,447 (58.5%)	6,892 (55.3%)
III-IV	5,261 (41.3%)	5,578 (44.7%)
Deyo-Charlson Index ^d	1.2 ± 2.1	1.4 ± 2.2

THA, Total hip arthroplasty; TKA, Total knee arthroplasty; SD, standard deviation; ASA, American Society of Anesthesiologist

^aBilateral indicates the number (percent) of patients who underwent bilateral knee or bilateral hip surgeries within 90-days of the index surgery and includes simultaneous bilateral and staged bilateral surgeries;

^bOther category includes Avascular necrosis, and failure due to previous surgery;

^cBody Mass Index data were available starting in 1988;

^dDeyo-Charlson Index data were available starting in 1994.

Table 2Univariate and Multivariable-adjusted^a predictors of 90-day mortality after Total Hip Arthroplasty

	Univariate		Multivariable-adjusted ^a	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age (per 5-year increase)	1.4 (1.2, 1.5)	<0.001	1.2 (1.1, 1.4)	<0.001
Male (ref, female)	1.2 (0.7, 2.0)	0.53		
ASA class III-IV (ref, I-II)	3.6 (2.0, 6.5)	<.001	NS	
Deyo-Charlson index (per 1-pt increase)	1.3 (1.2, 1.3)	<.001	1.2 (1.1, 1.3)	<0.001
BMI (per 5-pt increase)	0.8 (0.6, 1.1)	0.11		
Prior Thromboembolic event (ref, no)	1.7 (0.6, 4.8)	0.3		
Prior cardiac event (ref, no)	5.6 (3.3, 9.4)	<0.001	3.0 (1.7, 5.4)	<0.001
Primary (ref, revision)	1.3 (0.7, 2.5)	0.42		

OR, odds ratio; CI, confidence interval; NS, not significant; ref, reference

^a Multivariable backward selection logistic regression models included all variables that were significant in univariate analyses with p<0.05 and retained only the variables that were significant with p<0.05

Table 3Univariate and Multivariable-adjusted^a predictors of 90-day mortality after Total Knee Arthroplasty

	Univariate		Multivariable-adjusted ^a	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age (per 5-year increase)	1.6 (1.3, 1.9)	<0.001	1.6 (1.2, 1.7)	<0.001
Male (ref, female)	2.4 (1.3, 4.3)	0.004	1.9 (1.1, 3.5)	0.03
ASA class III-IV (ref, I-II)	8.7 (3.7, 20.6)	<0.001	5.5 (2.3, 13.2)	<0.001
Deyo-Charlson index (per 1-pt increase)	1.3 (1.2, 1.3)	<0.001	1.2 (1.1, 1.3)	<0.001
BMI (per 5-pt increase)	0.8 (0.6, 1.1)	0.13		
Prior Thromboembolic event (ref, no)	1.1 (0.3, 3.4)	0.91		
Prior cardiac event (ref, no)	2.3 (1.3, 4.1)	0.005	NS	
Primary (ref, revision)	0.7 (0.4, 1.5)	0.4		

OR, odds ratio; CI, confidence interval; NS, not significant

^a Multivariable backward selection logistic regression models included all variables that were significant in univariate analyses with $p < 0.05$ and retained only the variables that were significant with $p < 0.05$