Mortality After Total Knee and Total Hip Arthroplasty in a Large Integrated Health Care System

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ABSTRACT

Context: The number of excess deaths associated with elective total joint arthroplasty in the US is not well understood.

Objective: To evaluate one-year postoperative mortality among patients with elective primary and revision arthroplasty procedures of the hip and knee.

Design: A retrospective analysis was conducted of hip and knee arthroplasties performed in 2010. Procedure type, procedure volume, patient age and sex, and mortality were obtained from an institutional total joint replacement registry. An integrated health care system population was the sampling frame for the study subjects and was the reference group for the study.

Main Outcome Measures: Standardized 1-year mortality ratios (SMRs) and 95% confidence intervals (CIs) were calculated.

Results: A total of 10,163 primary total knee arthroplasties (TKAs), 4963 primary total hip arthroplasties (THAs), 606 revision TKAs, and 496 revision THAs were evaluated. Patients undergoing primary THA (SMR = 0.6, 95% CI = 0.4-0.7) and TKA (SMR = 0.4, 95% CI = 0.3-0.5) had lower odds of mortality than expected. Patients with revision TKA had higher-than-expected mortality odds (SMR = 1.8, 95% CI = 1.1-2.5), whereas patients with revision THA (SMR = 0.9, 95% CI = 0.4-1.5) did not have higher-than-expected odds of mortality.

Conclusion: Understanding excess mortality after joint surgery allows clinicians to evaluate current practices and to determine whether certain groups are at higher-than-expected mortality risk after surgery.

INTRODUCTION

The number of excess deaths associated with elective total joint arthroplasty surgeries in the US is not well understood. Studies estimating risk of death after total knee arthroplasty (TKA) and total hip arthroplasty (THA) in the US use Medicare data, which are limited to patients aged 65 years and older. The ability to evaluate large representative cohorts of patients with arthroplasty procedures for hip and knee joints (either elective or revision) that are not of Medicare age has been limited, and estimates of the excess deaths associated with these procedures remain either unclarified or unstudied.

Conflicting information exists regarding excess mortality in primary hip and knee arthroplasty. Although several studies have estimated a lower-than-expected mortality rate in elective primary THA and TKA because of the selection of patients for surgery,[1-7] other investigators[8-10] report an increased mortality rate for this subgroup of patients. A reported association between excess mortality and the indications for arthroplasty has been suggested as a possible explanation for some of the excess deaths in subgroups of patients.[11] In addition, excess mortality of patients after primary THA and TKA procedures can vary by age, sex, and time since the procedure.[2,5,8,12] Regarding excess mortality after revision THA and TKA, even less is known, but in studies using Medicare data, an increased risk of death after revision THA,[4] but not after revision TKA,[1] has been reported.

We sought to investigate the one-year postoperative mortality of patients who underwent elective joint arthroplasty in a large integrated health care system. Specifically, we evaluated the postoperative excess mortality among patients who underwent primary and revision elective arthroplasty of the hip and knee.

METHODS

Study Design, Sample, Data Collection

A retrospective analysis was conducted of all procedures performed in 2010, and registered by the Kaiser Permanente (KP) Total Joint Replacement Registry from the Southern and Northern California Regions.[13,14] An integrated health care system, KP covers more than 8.2 million people in the Regions included in the study and is mostly sociodemographically representative of the areas it covers.[15-17] The registry identified the elective primary and revision TKA and THA cases in the year studied. Detailed information on the data collection procedures, coverage, and participation of the registries has been previously published.[13]

Whether the procedure was primary or revision, the number of procedures, age, sex, and one-year mortality of patients were obtained from the registry. One-year postoperative mortality was the end point of the study and is prospectively monitored by the registry.

Reference Group

The reference population used for the study was the membership population of the KP integrated health care system for 2010 (Table 1). Data on the membership and mortality for the entire cohort were obtained from an administrative database

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within the organization, which monitors the institution's membership and service utilization.

Statistical Analysis

Sex- and age-specific volumes as well as one-year mortality rates for each of the procedure groups (ie, primary THA, revision THA, primary TKA, revision TKA) were summarized. For the reference population, the end-of-year membership was used as the denominator, and mortality rate was calculated from the number of deaths in 2010 divided by the number of members in the end-of-year membership estimates. Expected deaths were calculated by multiplying the reference population death rate of each category by the number of cases for a specific procedure group. Standardized mortality ratios (SMRs, observed deaths/expected deaths) and 95% confidence intervals (CIs) were calculated. Excess deaths were calculated from the difference of observed and expected deaths. All results are presented for the overall group by procedure type, by age groups, and by sex. Analyses were performed using SAS software (Version 9.2, SAS Institute, Cary, NC).

RESULTS

There were 10,163 primary TKAs, 4963 primary THAs, 606 revision TKAs, and 496 revision THAs performed in 2010. Table 2 reports the overall, sex-specific, and age-specific number of procedures; mortality rate; and number of excess deaths among primary and revision groups. Elective primary TKA (0.9%) and THA (1.1%) had the lowest 1-year mortality rates.

For elective primary THA (SMR = 0.6, 95% CI = 0.4-0.7) and TKA (SMR = 0.4, 95% CI = 0.3-0.5), patients had significantly lower odds of 1-year mortality than expected. Patients who underwent revision TKA procedures had age-adjusted mortality odds that were higher than expected (SMR = 1.8, 95% CI = 1.1-2.5). Patients undergoing revision THA (SMR = 0.9, 95% CI = 0.4-1.5) did not have significantly higher odds of mortality within 1 year compared with the expected (Table 3).

Differences in sex and age group SMRs were observed in some of the studied groups (see Table 3; Figures 1 and 2). In elective THAs, mortality was lower than expected for both men and women in patients who were aged 75 years and older. In elective TKAs, patients older than age 65 years had lower-than-expected mortality for both sexes. In revision TKA, a higher-than-expected mortality rate was observed in men aged 65 to 74 years (SMR = 5.0, 95% CI = 1.0-9.0) and aged 75 to 84 years (SMR = 3.8, 95% CI = 1.3-6.2), whereas no differences were observed in women.

DISCUSSION

In this study, we found that patients undergoing revision TKA had a higher-than-expected mortality within one year of their surgery. Conversely, patients undergoing elective primary arthroplasty had a lower-than-expected mortality at one year postoperatively, whereas those undergoing revision THA did not have a significantly different mortality risk than the reference population of this study. This lower-than-expected mortality in these groups could be explained by patient selection for surgery, or increased medical contact during the perioperative period that resulted in identification of acute medical issues or better management of chronic conditions.

Lower-than-expected 1-year mortality was observed in patients undergoing elective primary THA compared with the reference population. The SMR of 0.6 (40% lower-than-expected risk of mortality) is consistent with several studies on large cohorts of patients.[2-4,6,7] To our knowledge, only one single-center study from the United Kingdom reported a higher-than-expected mortality rate in patients undergoing primary THA, and the authors suggest the higher proportion of patients undergoing procedures for reasons other than osteoarthritis as the likely reason for these findings.[8] In our cohort, the lower-than-expected mortality rate is probably caused by patient selection (a type of "healthy patient" effect, in which those not healthy have a lower chance of having the procedure) but could also be partially attributed to better management of comorbidities before the surgery, or to the benefits of having the procedure. Because some studies have reported a continuous lower risk of mortality for years after hip arthroplasty procedures,[2,3,5,7] compared with the general population, it is possible having the procedure also affects the life expectancy of these patients.

Conversely, the observed 1-year mortality rate for revision THA procedures was not

Table 1. 2010 Kaiser Permanente California (Southern and Northern Regions) membership, deaths, and death rates per 100,000 members by age groups

	Total			Females			Males		
Age, y	Number	Deaths	Death rate	Number	Deaths	Death rate	Number	Deaths	Death rate
0-1	136,103	325	238.8	66,350	54	81.4	69,734	64	91.8
1-4	244,764	43	17.6	119,048	13	10.9	125,697	24	19.1
5-14	905,751	103	11.4	443,286	39	8.8	462,402	52	11.2
15-24	878,984	541	61.5	442,627	121	27.3	436,239	247	56.6
25-34	804,613	584	72.6	431,928	143	33.1	372,624	276	74.1
35-44	901,831	1141	126.5	468,888	359	76.6	432,880	502	116.0
45-54	1,005,457	2965	294.9	522,320	964	184.6	483,036	1349	279.3
55-64	881,361	5840	662.6	466,609	2043	437.8	414,476	2938	708.8
65-74	487,842	7738	1586.2	260,782	3154	1209.4	226,932	3865	1703.2
75-84	263,765	11,483	4353.5	146,608	5217	3558.5	117,077	5549	4739.6
≥ 85	94,796	12,485	13,170.4	60,159	6701	11,138.8	34,595	4880	14,106.1
All ages	660,5271	43,250	654.8	3,428,605	18,808	548.6	3,175,692	19,746	621.8

different from expected. The nonsignificant SMR is consistent with the mortality rate reported by a large Norwegian cohort of patients[5] and by a smaller US series of patients.[18] However, our nonsignificant mortality ratio is different from other large US cohorts, in which one study found a lower-than-expected mortality rate and one found a higher rate.[4,6] Our estimates could be different from these studies for several reasons. First, there were different periods evaluated; both other studies evaluated 90 days, and this study evaluates 1 year. Second, the sampling frames of the studies differed, in that one was a nationally representative sample, the other was a high-volume single center, and the current study was a large multicenter sample from one US geographic region. Finally, the sample sizes evaluated varied; one study evaluated more than 13,000 patents, the other evaluated a little over 1200, and ours had 496 cases.[4,6]

The lower-than-expected mortality rate in patients undergoing elective primary TKA reported in the current study is similar to that of other large studies.[1,19-21] In 4 studies of Scandinavian and American samples, the reported lower-than-expected rate of deaths of patients undergoing primary TKA ranged from 3% to 51%, depending on the time parameter and subgroup of patients. Another smaller study in England and Wales reported

Table 2. Overall and sex-specific number of procedures for elective primary procedures and revisions, deaths, and excess deaths within one year of procedure by age group, 2010

	Total cases			Females		Males	
Procedure type by age, y	No.	Deaths, no. (%)	Excess deaths, no.	Deaths, no. (%)	Excess deaths, no.	Deaths, no. (%)	Excess deaths, no.
Total hip arthroplasty, primary, elective							
15-24	14	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
25-34	49	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
35-44	125	0 (0.0)	-0.2	0 (0.0)	0.0	0 (0.0)	-0.1
45-54	601	3 (0.5)	1.2	0 (0.0)	-0.5	3 (1.0)	2.1
55-64	1477	11 (0.7)	1.2	2 (0.3)	-1.5	9 (1.3)	4.2
65-74	1497	13 (0.9)	-10.7	7 (0.8)	-4.1	6 (1.0)	-3.8
75-84	1044	23 (2.2)	-22.5	14 (2.1)	-10.1	9 (2.5)	-8.3
≥ 85	156	7 (4.5)	-13.5	6 (5.6)	-5.9	1 (2.0)	-5.9
Total	4963	57 (1.1)	-44.5	29 (1.0)	-22.1	28 (1.3)	-11.8
Total hip arthroplasty, revision							
25-34	4	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
35-44	14	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
45-54	66	0 (0.0)	-0.2	0 (0.0)	-0.1	0 (0.0)	-0.1
55-64	139	2 (1.4)	1.1	0 (0.0)	-0.4	2 (3.5)	1.6
65-74	128	3 (2.3)	1.0	3 (3.8)	2.0	0 (0.0)	-0.8
75-84	120	3 (2.3)	-2.2	1 (1.5)	-1.4	2 (3.8)	-0.5
≥ 85 years	25	3 (2.5)	-0.3	2 (11.8)	0.1	1 (12.5)	-0.1
Total	496	11 (2.2)	-0.6	6 (2.0)	0.2	5 (2.5)	0.1
Total knee arthroplasty, primary, elective							
25-34	7	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
35-44	62	0 (0.0)	-0.1	0 (0.0)	0.0	0 (0.0)	0.0
45-54	765	1 (0.1)	-1.3	0 (0.0)	-0.9	1 (0.3)	0.2
55-64	3145	11 (0.3)	-9.8	6 (0.3)	-2.4	5 (0.4)	-3.7
65-74	3706	24 (0.6)	-34.8	11 (0.5)	-16.6	13 (0.9)	-11.2
75-84	2189	46 (2.1)	-49.3	17 (1.2)	-31.8	29 (3.5)	-9.8
≥ 85	289	11 (3.8)	-27.1	3 (1.6)	-17.7	8 (7.8)	-6.5
Total	10,163	93 (0.9)	-122.4	37 (0.6)	-69.4	56 (1.4)	-31.0
Total knee arthroplasty, revision							
35-44	4	0 (0.0)	0.0	0 (0.0)	0.0	0 (0.0)	0.0
45-54	62	1 (1.6)	0.8	1 (3.2)	0.9	0 (0.0)	-0.1
55-64	200	3 (1.5)	1.7	0 (0.0)	-0.5	3 (3.3)	2.3
65-74	182	8 (4.4)	5.1	2 (1.8)	0.7	6 (8.2)	4.8
75-84	120	12 (10.0)	6.8	3 (4.3)	0.5	9 (17.6)	6.6
≥ 85	38	2 (5.3)	-3.0	1 (6.7)	-0.7	1 (4.3)	-2.2
Total	606	26 (4.3)	11.4	7 (2.1)	0.9	19 (7.0)	11.4

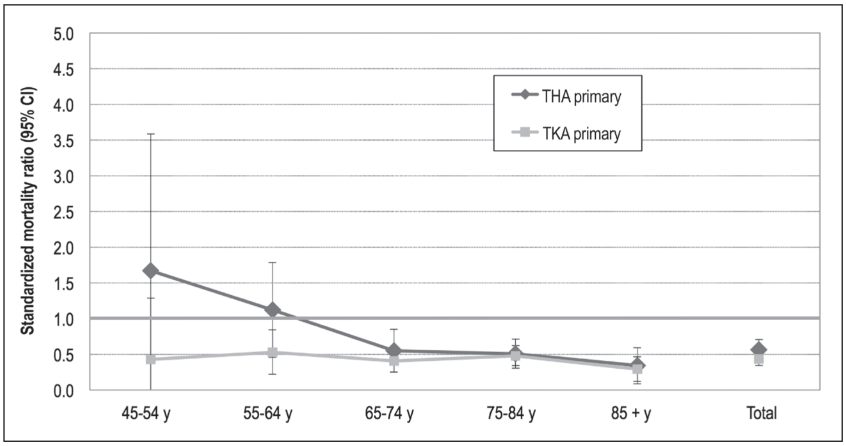

Figure 1. Standardized mortality ratios for patients who underwent primary total knee arthroplasty (TKA) and total hip arthroplasty (THA), by age group.
CI = confidence interval.

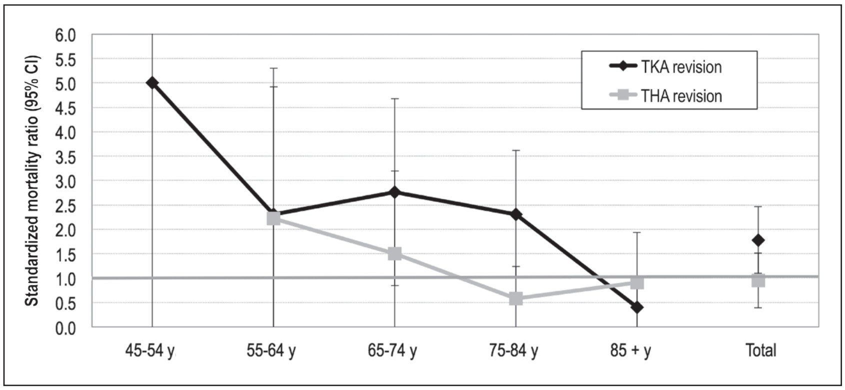

Figure 2. Standardized mortality ratios for patients who underwent revision total knee arthroplasty (TKA) and total hip arthroplasty (THA), by age group.
CI = confidence interval.

lower-than-expected mortality as well for primary TKA, but probably because of the smaller sample sizes these numbers were not significantly different from the overall population mortality used as the reference.[12] In our study, we not only found that patients had a death rate 60% (SMR = 0.4) lower than expected, but we also found an even stronger effect for women compared with men and for older patients compared with younger patients, which again is comparable to what other studies have reported.[12,19,20] Two studies have reported patients who underwent TKA to be at a higher risk of mortality than expected when the comparison group used was different from the general population[9] and when only long-term survival of the cohort was evaluated.[10]

In the patients who had revision TKA, a higher-than-expected mortality risk compared with the general population (SMR = 1.8) was observed. This is different from Medicare cohort data (SMR = 0.9)[1] and findings of a Danish (SMR = 0.9) study,[20] which reported on revision TKA cohorts. It is possible that the younger age of the patients in our study cohort, and consistently higher-than-expected mortality rates in younger patients with arthroplasty, could explain this difference between our study findings and the ones reported by the other studies. Although our study did not evaluate patient comorbidities, it is likely that these younger patients have more comorbidities. It

Table 3. Sex-specific standardized mortality ratio (SMR) and 95% confidence intervals (CI) by procedure type and age group, 2010

	Elective, primary, SMR (95% CI)			Revision, SMR (95% CI)		
Procedure type by age, y	Overall	Females	Males	Overall	Females	Males
Total hip arthroplasty						
45-54	1.7 (0.0-3.6)	NA	3.3 (0.0-7.1)	NA	NA	NA
55-64	1.1 (0.5-1.8)	0.6 (0.0-1.4)	1.9 (0.7-3.1)	2.2 (0.0-5.3)	NA	5.0 (0.0-11.9)
65-74	0.6 (0.3-0.8)	0.6 (0.2-1.1)	0.6 (0.1-1.1)	1.5 (0.0-3.2)	3.0 (0.0-6.4)	NA
75-84	0.5 (0.3-0.7)	0.6 (0.3-0.9)	0.5 (0.2-0.9)	0.6 (0.0-1.2)	0.4 (0.0-1.2)	0.8 (0.0-1.9)
≥ 85	0.3 (0.1-0.6)	0.5 (0.1-0.9)	0.1 (0.0-0.4)	0.9 (0.0-1.9)	1.1 (0.0-2.5)	0.9 (0.0-2.7)
Total	0.6 (0.4-0.7)	0.6 (0.4-0.8)	0.7 (0.4-1.0)	0.9 (0.4-1.5)	1.0 (0.2-1.9)	1.0 (0.1-1.9)
Total knee arthroplasty						
45-54	0.4 (0.0-1.3)	NA	0.7 (0.0-2.0)	5.0 (0.0-14.8)	10.0 (0.0-29.6)	NA
55-64	0.5 (0.2-0.8)	0.7 (0.1-1.3)	0.6 (0.1-1.1)	2.3 (0.0-4.9)	NA	4.3 (0.0-9.1)
65-74	0.4 (0.2-0.6)	0.4 (0.2-0.6)	0.5 (0.2-0.8)	2.8 (0.8-4.7)	1.5 (0.0-3.7)	5.0 (1.0-9.0)
75-84	0.5 (0.3-0.6)	0.3 (0.2-0.5)	0.7 (0.5-1.0)	2.3 (1.0-3.6)	1.2 (0.0-2.6)	3.8 (1.3-6.2)
≥ 85	0.3 (0.1-0.5)	0.1 (0.0-0.3)	0.6 (0.2-0.9)	0.4 (0.0-1.0)	0.6 (0.0-1.7)	0.3 (0.0-0.9)
Total	0.4 (0.3-0.5)	0.3 (0.2-0.5)	0.6 (0.5-0.8)	1.8 (1.1-2.5)	1.0 (0.3-2.0)	(1.4-3.6)

NA = not available because no events occurred in these strata.

is also possible that because revision arthroplasties are not always elective, such as revisions for infection, fractures, or severe loss of function, these patients were not selected for surgery as the elective primary cohorts were.

A general trend toward lower SMR in older patient groups was also observed in all groups. This supports the hypothesis that patient selection is associated with this observed difference in mortality in patients who are undergoing joint arthroplasty and the general population. Younger patients are known to have poorer surgical outcomes than older patients,[22,23] but the reasons for these poorer outcomes can be many. It is possible that their greater activity puts more strain on their joints and therefore leads to poorer outcomes, but it is also very likely that these are the heavier patients with greater comorbidities that put them at a higher risk of complications and therefore mortality after surgery.

The limitations of this study include our inability to evaluate cause-specific mortality and therefore to investigate the reasons for death in the procedures we found to have a higher-than-expected mortality. This study also only evaluated a short-term postarthroplasty period (1 year), limiting its ability to comment on the long-term impact of the procedures and mortality. Because of the limited samples available for the revision arthroplasty groups, the estimates of SMR provided have significant uncertainty (ie, wide CIs) and therefore should be interpreted with care. Furthermore, we did not evaluate how the indication for surgery and comorbidity profiles of our patients could affect excess mortality after surgery.

The strengths of this study include the large sample size of patients undergoing primary arthroplasty, the generalizability of the sample to the larger California population, and the captive comparable group used as the reference group.

CONCLUSION

This study confirms that patients undergoing primary elective lower limb arthroplasty have lower-than-expected mortality within one year of their procedure, whereas those undergoing revision TKA have a higher-than-expected mortality. Understanding how joint arthroplasty and their indications affect a patient's life expectancy is important when considering this procedure, counseling patients, and preparing for both the preoperative and postoperative care of these patients. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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