Complications and Readmissions After Total Knee Replacement in Octogenarians and Nonagenarians

Nicholas Yohe, MD[1], August Funk, MD[1], Matthew Ciminero, MD[1], Orry Erez, MD[1], and Ahmed Saleh, MD[1]

Abstract

Introduction: From 2000 to 2010, the cohort of patients aged 85 to 94 years had the fastest growth rate increasing in size by approximately 30%. The need for total knee arthroplasty (TKA) continues to increase with a larger percentage of patients older than 80 years requiring TKA. The purpose of our study was to examine the rate and risks of 30-day complications and unplanned readmission in patients older than 80 years. **Materials and Methods:** The National Surgical Quality Improvement Project database for the years 2008 to 2014 was queried for patients older than 80 years undergoing TKA. The risks of major complications, minor complications, bleeding occurrences, unplanned readmissions, and deaths over a 30-day period were examined using univariate and multivariate analyses. **Results:** Overall, 12 026 patients were included for analysis. In all, 422 (3.5%) experienced a major complication, 2316 (19.3%) experienced a minor complication, 2074 (17.2%) had a bleeding occurrence requiring transfusion, and 566 (4.7%) experienced an unplanned readmission. Thirty-eight (0.3%) deaths were recorded. There were no significant risk factors for major complications. Patients with an American Society of Anesthesiologists (ASA) >2 (odds ratio [OR]: 1.43 [1.239-1.651]), patients older than 84 years (OR: 1.240 [1.072-1.434]), and patients receiving general anesthesia (OR: 1.191 [1.035-1.370]) had increased risks of minor complications. Patients with a body mass index >30 (OR: 0.640 [0.532-0.770]) and men (OR: 0.815 [0.706-0.941]) had reduced rates of minor complications. Increased risk of unplanned readmission occurred in patients with chronic obstructive pulmonary disease (OR: 1.694 [1.007-2.850]) and congestive heart failure (OR: 3.030 [1.121-8.192]). Increased risk of death was seen in patients with an ASA >2 (OR: 8.9 [1.144-69.82]). **Discussion/Conclusion:** Elderly patients undergoing TKA have high complication and readmission rates. Surgeons should convey these increased risk factors and rates of complications in elective TKAs to their elderly patients and work with primary care physicians to mitigate these risks.

Introduction

On average, over 600 000 total knee arthroplasties (TKAs) are performed on a yearly basis.[1] It has been estimated that the demand for this procedure will increase to 673%, roughly 3.48 million procedures, by the year 2030.[2] In terms of population expansion, during the first decade of the 21st century, Americans aged 85 to 94 years have increased nearly 30%, from 3.9 to 5.1 million.[3] As the demand for this procedure continues to rise, and people continue to live longer, there will be increased demand across all age-groups for knee replacements, including individuals aged 80 years and older.

Our area of interest involves evaluating and risk stratifying this expanding section of individuals older than 80 years who are presenting an increased demand for TKA to improve their daily quality of life and function. In general, as people age, they tend to have more medical comorbidities, take more medications, and present with higher risk for surgical procedures secondary to their baseline state of health, which can predispose them to higher incidence of postoperative complications.[4] In addition, with the advent of bundled payments, postoperative complications can substantially affect reimbursement rates for these procedures.[5-9] The purpose of this study was to evaluate patients older than 80 years undergoing

[1] Department of Orthopaedics, Maimonides Medical Center, Brooklyn, NY, USA

Corresponding Author:
Nicholas Yohe, Department of Orthopaedics, Maimonides Medical Center, 927 49th Street, Brooklyn, NY, USA.
Email: nyohe@maimonidesmed.org

elective TKA and determine risk factors for morbidity and mortality postoperatively.

Materials and Methods

A retrospective review of the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) database for the years 2008 to 2014 was performed for this study. The NSQIP is comprised of data collected from multiple hospitals across the United States. The NSQIP database has been utilized for numerous orthopedic studies and has proven to be highly reliable with an interobserver disagreement of only 1.6%.[8] Data collected and included for analysis include demographic data, medical comorbidities, procedures performed, functional status, complications, readmissions, and mortality over the initial 30-day postoperative period.

Inclusion Criteria

Patients were included for analysis in this study if they were older than 80 years and had a TKA as determined by the Current Procedural Terminology code 27447. Patients who underwent a TKA for conditions such as acute trauma, infection, or malignancy as identified by *International Classification of Diseases* (ICD) Ninth Revision, or ICD, 10th Revision codes were excluded.

Outcome data of interest for this study were analyzed, including mortality, major complications, minor complications, bleeding occurrences, and unplanned readmission. A major complication was defined by the authors as deep wound infection, wound dehiscence, cerebral vascular accident, pulmonary embolism, failure to wean intubation, unplanned reintubation, cardiac arrest, myocardial infarction, sepsis, and unplanned reoperation. A minor complication was defined by the authors as superficial wound infection, acute renal failure, deep venous thrombosis (DVT), peripheral neurological deficit, bleeding occurrence(s) requiring transfusion, and pneumonia.

Multivariate logistic regression models were utilized to determine and analyze factors that placed patients at risk of developing these adverse outcomes over the initial 30 postoperative days. The NSQIP database stratifies patients older than 89 years into a "90+" age-group, and therefore the elderly patient cohort was divided into patients aged 80 to 84 years and 85 years and older for the analysis. The patient cohort was stratified with demographic data, including gender, race, and ethnicity. Variables analyzed using multivariate logistic regression models resulting in odds ratios (ORs) included admission source, body mass index (BMI), functional status prior to surgery, history of chronic obstructive pulmonary disease (COPD), history of congestive heart failure (CHF), and type of anesthesia. Operative variables included operative time and American Society of Anesthesiologists (ASA) classification.

Results

A total of 12 026 patients older than 80 years undergoing TKA between 2008 and 2014 were identified and included for the

Table 1. Patient Demographics.

Demographic and Surgical Data	Number of Patients (%)
Total number of patients	12 026
Age	
80-84	8533 (70.95)
85+	3493 (29.05)
Gender	
Male	4243 (35.36)
Female	7758 (64.64)
Race	
White	9558 (79.48)
Nonwhite	2168 (18.03)
Ethnicity	
Hispanic	547 (4.55)
Non-Hispanic	11 479 (95.45)

analysis. Demographic data are presented in Table 1. There were 422 (3.5%) patients with reported major complications. There were 2316 (19.3%) patients with reported minor complications. There were 2074 (17.2%) patients with reported bleeding occurrences. There were 566 (4.7%) patients with reported incidents of unplanned readmissions. There were 38 (0.3%) reported patient deaths. The overall complication and mortality data are presented in Table 2.

Multivariate logistic regression models were used to determine risk factors and ORs for patients older than 80 years undergoing primary TKAs. There were no significant risk factors for major complications. There were a total of 422 patients who experienced 554 major complications. The breakdown of major complications is presented in Table 3.

For minor complications, Hispanic patients were at a lower risk than non-Hispanic patients (OR: 0.643 [95% confidence interval, CI: 0.451-0.918]). Male patients were at a lower risk than female patients (OR: 0.815 [95% CI: 0.706-0.941]). Patients with a BMI >30 were at lower risk compared to those with a normal BMI (OR: 0.640 [95% CI: 0.532-0.770]).

Patients older than 84 years were at a higher risk of minor complications compared to those aged 80 to 84 years (OR: 1.240 [95% CI: 1.072-1.434]). Patients receiving general anesthesia were at higher risk compared to those receiving spinal anesthesia (OR: 1.191 [95% CI: 1.035-1.370]). Patients with an ASA classification >2 were at increased risk for minor complications (OR: 1.430 [95% CI: 1.239-1.651]). The breakdown of minor complications is presented in Table 4.

Patients aged 85 and older were at an increased risk of bleeding occurrences requiring transfusion (OR: 1.234 [95% CI: 1.062-1.434]). Patients with an ASA classification > 2 were at increased risk of experiencing a bleeding occurrence requiring transfusion (OR: 1.401 [95% CI: 1.208-1.626]). Patients under general anesthesia had higher rates of bleeding occurrences requiring transfusion (OR: 1.204 [95% CI: 1.041-1.393]). Male patients had a reduced risk of bleeding occurrences requiring transfusion (OR: 0.788 [95% CI: 0.679-0.915]). Hispanic patients had a lower risk of bleeding occurrences requiring transfusion (OR: 0.685 [95% CI:

Table 2. Overall Complications, Readmission, and Death.

Variable	Major Complication Odds Ratio/95% CI	Minor Complication Odds Ratio/95% CI	Bleeding Occurrence Odds Ratio/95% CI	Unplanned Readmission Odds Ratio/95% CI	Death Odds Ratio/95% CI
Age					
81-84	Reference group	Reference group	Reference group	Reference group	Reference group
85+	1.111 [0.809-1.526]	1.240 [1.072-1.434]*	1.234 [1.062-1.434]*	1.068 [0.787-1.451]	1.268 [0.504-3.191]
Gender					
Female	Reference group	Reference group	Reference group	Reference group	Reference group
Male	1.123 [0.830-1.520]	0.815 [0.706-0.941]*	0.788 [0.679-0.915]*	1.050 [0.784-1.405]	1.445 [0.605-3.451]
Ethnicity					
Non-Hispanic	Reference group	Reference group	Reference group	Reference group	Reference group
Hispanic	0.513 [0.208-1.262]	0.643 [0.451-0.918]*	0.685 [0.476-0.986]*	0.413 [0.151-1.131]	1.045 [0.137-7.946]
BMI					
Underweight (<18.5)	3.213 [1.081-9.546]	0.741 [0.361-1.522]	0.698 [0.331-1.474]	0.839 [0.109-6.468]	Insufficient data
Normal (≥18.5 and <25.0)	Reference group	Reference group	Reference group	Reference group	Reference group
Overweight (≤25.0 and <30.0)	2.267 [0.837-1.919]	0.859 [0.724-1.019]	0.822 [0.690-0.980]*	1.091 [0.756-1.576]	2.112 [0.451-9.879]
Obese (≥30.0)	1.376 [0.898-2.109]	0.640 [0.532-0.770]*	0.597 [0.493-0.723]*	0.877 [0.590-1.302]	2.785 [0.598-12.972]
ASA class					
ASA1/2	Reference group	Reference group	Reference group	Reference group	Reference group
ASA3/4/5	1.238 [0.903-1.698]	1.430 [1.239-1.651]*	1.401 [1.208-1.626]*	1.547 [1.135-2.110]*	6.105 [1.420-26.256]*
Anesthesia					
Spinal anesthesia	Reference group	Reference group	Reference group	Reference group	Reference group
General anesthesia	0.961 [0.712-1.297]	1.191 [1.035-1.370]*	1.204 [1.041-1.393]*	0.939 [0.704-1.253]	0.685 [0.289-1.622]
Functional status					
Independent	Reference group	Reference group	Reference group	Reference group	Reference group
Partially/totally dependent	2.951 [0.870-10.013]	1.765 [0.812-3.836]	1.746 [0.786-3.882]	3.231 [1.212-8.613]*	8.937 [1.144-69.815]*
COPD					
No	Reference group	Reference group	Reference group	Reference group	Reference group
Yes	1.090 [0.579-2.052]	1.107 [0.816-1.502]	1.071 [0.779-1.474]	1.694 [1.007-2.850]*	1.449 [0.331-6.349]
CHF					
No	Reference group	Reference group	Reference group	Reference group	Reference group
Yes	2.725 [0.808-9.196]	1.565 [0.719-3.404]	1.792 [0.823-3.904]	3.030 [1.121-8.192]*	Insufficient data

Abbreviations: ASA, American Society of Anesthesiologists Classification; BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease.
*These are the abbreviations for the variables in the chart.

Table 3. Major Complications.

Major Complication	Number of Major Complications (%)
Deep SSI	14 (2.52)
Organ/space infection	11 (1.99)
Wound dehiscence	17 (3.07)
Reintubation	33 (5.96)
PE	97 (17.51)
Failure to wean intubation	12 (2.17)
CVA	26 (4.69)
Cardiac arrest	16 (2.89)
MI	67 (12.09)
Sepsis/septic shock	67 (12.09)
Reoperation/return to OR	194 (35.02)

Abbreviations: CVA, cerebral vascular accident; MI, myocardial infarction; OR, operating room; PE, pulmonary embolism; SSI, surgical site infection.

Table 4. Minor Complications.

Minor Complication	Number of Minor Complications (%)
Superficial SSI	68 (2.85)
Pneumonia	85 (3.56)
Renal failure	11 (0.46)
PNI	3 (0.13)
DVT	155 (6.49)
Bleeding occurrence	2066 (86.52)

Abbreviations: DVT, deep vein thrombosis; PNI, peripheral nerve injury; SSI, surgical site infection.

0.476-0.986]). Overweight patients (BMI 25-29.9) and obese patients (BMI >30) had lower rates of bleeding occurrences requiring transfusion (OR: 0.822 [95% CI: 0.690-0.980], OR: 0.597 [95% CI: 0.493-0.723], respectively).

Patients who were partially/completely dependent on others to assist with activities of daily living (ADLs) prior to surgery were at an increased risk for unplanned readmission (OR: 3.231 [95% CI: 1.212-8.613]). Patients with COPD were at increased risk for unplanned readmission (OR: 1.694 [95% CI,

Table 5. Length of Stay.

Variable	Length of Stay (Days)	P Value
Age		
81-84	3.62	.346
85+	3.84	
Gender		
Female	3.64	.0048*
Male	3.73	
Ethnicity		
Non-Hispanic	3.51	.1645
Hispanic	3.37	
BMI		
Underweight (<18.5)	3.92	.5181
Normal (≥18.5 and <25.0)	3.63	
Overweight (≥25.0 and <30.0)	3.62	.5392
Obese (≥30.0)	3.73	.0268*
Functional status		
Independent	3.64	<.001*
Partially/totally dependent	4.19	
COPD		
No	3.65	<.0001*
Yes	4.10	
CHF		
No	3.66	<.0001*
Yes	5.17	
Complications		
No	3.45	
Minor	4.03	<.0001*
Major	6.43	<.0001*

Abbreviations: BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.
*These are the abbreviations for the variables in the chart.

Table 6. Discharge Destination.

Variable	Odds of Being Discharged to Rehab Odds Ratio/95% CI
Age	
80-84	0.532 [0.459-0.617]*
Gender	
Male	0.542 [0.482-0.609]*
Ethnicity	
Non-Hispanic	0.901 [0.694-1.170]
BMI	
Underweight (<18.5)	0.434 [0.182-1.035]
Overweight (≥25.0 and <30.0)	1.157 [1.001-1.338]*
Obese (≥30.0)	1.634 [1.404-1.902]*
Functional status	
Independent	0.393 [0.267-0.577]*
COPD	
Yes	1.647 [1.242-2.183]*
CHF	
Yes	1.465 [0.548-3.921]
Complication	
Minor	2.065 [1.745-2.444]*
Major	1.315 [0.927-1.866]

Abbreviations: BMI, body mass index; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease.
*These are the abbreviations for the variables in the chart.

1.007-2.850]). Patients with CHF had increased risk of unplanned readmission following surgery (OR: 3.030 [95% CI: 1.121-8.192]). Patients with an ASA group over 2 had an increased risk for unplanned readmission (OR: 1.547 [95% CI, 1.135-2.11]).

Patients dependent for ADLs were at increased risk for postoperative mortality (OR: 8.937 [95% CI, 1.144-69.815]), and patients with an ASA group >2 were also at increased risk for death within 30 days postoperatively (OR: 6.105 [95% CI: 1.420-26.256]).

The average length of stay (LOS) for female patients was 3.64 days versus 3.73 days for male patients (P = .0048). The average LOS for patients older than 85 years was 3.84 days versus 3.62 days for those younger than 85 years (P = .3466). The average LOS for those with no complications was 3.45 days. Those who experienced a major complication had an average stay of 6.43 days, those with a minor complication stayed 4.03 days, and these values were significant (P < .001). Patients without COPD stayed in the hospital for 3.64 days versus 4.10 days for those with COPD and this was significant (P < .001). Patients without a history of CHF stayed in the hospital for 3.66 days versus 5.17 days for those with CHF and this was significant (P < .001). Patients who were functionally independent stayed in the

hospital for 3.64 days versus 4.19 days (P < .001). These data are presented in Table 5.

Males had a lower risk of being discharged to a rehabilitation facility versus females (OR: 0.542 [95% CI: 0.482-0.609]). Patients' aged 80 to 85 years had a lower risk of being discharged to a rehabilitation facility versus older patients (OR: 0.532 [95% CI: 0.459-0.617]). Patients who experienced a minor complication had a higher rate of being discharged to a rehabilitation facility (OR: 2.065 [95% CI: 1.745-2.444]). Those patients experiencing a major complication trended toward a higher rate of discharge to a rehabilitation facility, but this did not reach significance (OR: 1.315 [95% CI, 0.927-1.866]). Obese and overweight patients had a higher rate of being discharged to a rehabilitation facility (OR: 1.634 [95% CI, 1.404-1.902] and OR: 1.157 [95% CI, 1.001-1.338], respectively). A history of COPD increased patient's chances of being discharged to a rehabilitation facility postoperatively (OR: 1.647 [95% CI, 1.242-2.183]). These results are presented in Table 6.

Discussion

Previous studies have shown that elderly patients do not experience any increase in age-related complications; however, many of these patients have significant medical comorbidities that predispose them to postoperative complications.[4] Our review of the NSQIP database showed that patients aged 85 years and older were at increased risk of minor complications compared to those aged 80 to 84 years. Patients undergoing procedures under general anesthesia were at an increased

risk of experiencing minor complications, consistent with previous studies demonstrating a higher risk of complications with general anesthesia.[10]

Male patients were at reduced risk of experiencing a minor complication or bleeding occurrence in the present study. This stands in contrast to previous studies showing higher rates of wound infections and overall complication rates in men and no differences in inpatient complications between men and women.[11,12] Further studies are necessary to elucidate why elderly males experience reduced rates of minor complications and bleeding occurrences in contrast to previous studies.[11,12]

The effect of BMI on outcomes in TKA has been debated in the literature. A recent meta-analysis performed by Si et al showed a higher rate of infection, superficial infection, and DVT in patients with BMI >30.[13] Our sample of 12 026 elderly patients showed, however, that BMI >30 reduced the odds of a patient experiencing a minor complication such as DVT or superficial wound infection.[13] Consistent with this meta-analysis, BMI did not have an effect on reoperation or deep infections. Overweight (BMI 25-25.9) and obese (BMI 30+) patients had reduced risks of bleeding occurrences requiring a transfusion compared to the normal BMI cohort, consistent with previously published studies.[14-18]

Unplanned readmission within the first 30 days is a costly complication, especially as the new Medicare bundled payment system will not reimburse hospitals for readmissions within the first 30 days.[5,6] Patients with a functional status other than totally independent for ADLs prior to surgery experienced a 3-fold increase in the risk of unplanned readmission in our study. Pugley et al found a 1.78 OR of patients with a dependent functional status having an adverse outcome when undergoing TKA; however, there was no difference in the rate of patients experiencing readmission based on functional status[7] This difference could be attributed to their study looking at patients across all age-groups and only analyzing the year 2011 from the NSQIP database.[7] One recent study showed that preoperative functional mobility affected inpatient recovery of activities after TKA.[19-21] The COPD, CHF, and an ASA classification >2 also increase the odds of a patient older than 80 years experiencing an unplanned readmission following elective TKA.[7] Surgeons should work closely with patients' treatment teams and geriatricians to help optimize patients with these conditions prior to surgery.

Several studies have reported on mortality rates in elderly patients undergoing TKAs, but results have been mixed. In a study using a retrospective Canadian database, Kreder et al showed that octogenarians had an in-hospital mortality rate of 1.54%, conflicting without reported results of 0.3% over a 30-day postoperative period.[22] The smaller sample size (2104 vs 12 026) may have played a role in this higher reported rate of patient mortality.[22] Joshi et al in a review of 110 primary TKAs in octogenarians showed a survivorship of 99.4% at 5 years, closer to our reported mortality rate of 0.3%.[23] Belmar et al performed 15 primary TKAs in patients older than 90 years with no reported patient deaths postoperatively; however, this small sample size may bias the results.[4] Our reported mortality rate of 0.3% in patients older than 80 years aligns with previous

studies, showing an overall 30-day mortality rate of 0.2% for all patients undergoing primary TKA.[24] However, physicians should convey the increased odds of mortality for patients with a dependent functional status or ASA >2 (OR 8.937 and 6.105, respectively) prior to elective TKAs.

Length of stay after total joint replacement has historically been high for elderly patients undergoing joint replacements with studies ranging from 5 to 7 days.[25] Our results showed no significant difference in LOS between patients aged 80 to 84 and those older than 85 years; however, women tended to leave the hospital 0.1 days sooner than men. Patients with COPD and CHF stayed in the hospital longer, possibly due to complications of surgery or their comorbid conditions. Limitations of this database are that a cause of the increased LOS is not available to the authors, and it is not inclusive of all cases, unlike other databases.

Despite the fact that discharge destination was added to the database in 2011, a large number of patients still included for analysis allow for meaningful interpretation of this data. With the advent of bundled payments from the Affordable Care Act, a new philosophy on payments for TKA was created.[26] By sending more patients home after TKA, this has the potential to save money without sacrificing patient care or outcomes.[26] Our results show that patients older than 85 years, females, overweight patients, dependent patients, and COPD increase the risk of going to a rehabilitation facility after elective TKA. This should be taken into consideration when orthopedists are planning TKAs in these patients and appropriate postoperative plans should be coordinated.

In our study, Hispanic patients had lower risks of minor complications and bleeding occurrences than non-Hispanic patients. This stands in contrast to other studies that showed Hispanic patients had higher rates of infections after TKA.[27] Our study differs in that all patients were older than 80 years, however, and this could affect the relationship between race and outcomes. Further analysis of the effects of race in elderly patients undergoing TKA is needed.

There were several strengths to our current study. First, the large patient sample of over 12 026 people undergoing elective TKA allows for powerful analysis. This allows for a comprehensive analysis of patients older than 80 years undergoing elective TKA. Another strength of this study is the reliability of the NSQIP database with only 1.6% interobserver disagreement.[8] Finally, the NSQIP database allows for a comprehensive review of a multitude of patient outcomes and risk factors, allowing for in-depth analysis of various conditions and outcomes related to the elderly population undergoing elective TKA.

There are several limitations of the current study. First, the NSQIP database is a retrospective review of patients undergoing elective TKA. Another potential disadvantage of this study is that the NSQIP database only captures adverse outcomes and readmissions over the initial postoperative 30 days. Conceivably, the elderly population could experience adverse outcomes or readmission rates at a higher incidence after the initial postoperative 30 days and should

be examined in a future study. Finally, discharge destination was added as a category in 2011, thereby eliminating 1645 patients from analysis of this variable.

Conclusions

Octogenarians and nonagenarians undergoing elective TKAs experience relatively high rates of complications; however, most of these complications are minor. Patients who are functionally dependent for ADLs and those who have COPD or CHF are much more likely to experience an unplanned readmission and therefore orthopedists should be aware of these high-risk factors when assessing these patients for surgery. Additionally, overweight and obese patients experience lower complication rates and should not be excluded from surgical consideration based solely on BMI. It is possible that many of these increased risks may be mitigated if surgeons participate in shared decision-making with patients and their primary care physicians prior to surgical intervention.

Authors' Note

Declaration of Conflicting Interests

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