



Extended length of stay and postoperative complications in octogenarians with hypertension following revision total knee arthroplasty



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ABSTRACT

Background: Prior studies have shown hypertensive patients to be at an increased risk of postoperative complications following various surgeries, including revision total knee arthroplasty (rTKA). However, whether these risks are compounded in octogenarian patients has not yet been well explored. The purpose of this study was to analyze whether hypertensive octogenarians, aged 80 to 89, undergoing rTKA are at an increased risk of postoperative complications relative to the younger hypertensive geriatric population aged 65 to 79.

Methods: A national database was used to collect data for all hypertensive patients who underwent rTKA from 2006 to 2018. Patients were stratified into an aged 65 to 79 cohort and an aged 80 to 89 cohort. Demographics, medical comorbidities, and postoperative complications were compared between the two cohorts. Bivariate and multivariate analyses were performed.

Results: Of the 6,599 hypertensive patients who underwent rTKA, 5,477 (83.0%) patients were in the aged 65 to 79 group and 1,122 (17.0%) patients were in the aged 80 to 89 group. Following adjustment to control for demographic and comorbidity data, relative to patients in the 65 to 79 age group, hypertensive patients who were 80–89 years old had an increased risk of unplanned reintubation (OR 3.52; $p = 0.008$), urinary tract infection (OR 2.08; $p = 0.011$), postoperative transfusion (OR 1.90; $p < 0.001$), myocardial infarction (OR 2.55; $p = 0.017$), and extended length of hospital stay (OR 1.77; $p < 0.001$).

Conclusion: Hypertensive octogenarian patients undergoing rTKA have an increased risk of an extended length of stay and other postoperative complications relative to their younger hypertensive geriatric counterparts. Orthopaedic surgeons should consider a multi-disciplinary approach to managing hypertension in these octogenarian patients prior to surgery to minimize this risk. However, even with this risk, an octogenarian age should not be used independently in evaluating if a hypertensive geriatric patient is a safe rTKA candidate.

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1. Introduction

Hypertension is the principal cause of cardiovascular disease and premature death worldwide. It is estimated to affect approximately 31% of the world's population and continues to increase in prevalence.¹ Several risk factors for developing hypertension include age, obesity, and diabetes.² Proper pharmacological and non-pharmacological management of hypertension is needed for preventing long-term cardiovascular and cerebrovascular disease.³

Importantly, patients with preoperative diastolic blood pressures of 110 mmHg or higher have been shown to be at a greater risk of numerous postoperative complications, including myocardial ischemia, arrhythmias, and renal failure.⁴ Thus, recent studies have aimed to explore the influence of hypertension on surgical outcomes in patients across various specialties.

Prior literature has shown that patients with hypertension, including those of geriatric age, tend to have worse surgical outcomes.^{2,5–13} In a study that looked at 1,266 patients with a median age of 70 years undergoing radical nephroureterectomy (RNU), hypertension was found to be associated with major complications ($p < 0.002$).¹¹ Additionally, Aronson et al. analyzed patients undergoing elective coronary artery bypass grafting (CABG) surgery

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and found that isolated systolic hypertension (SBP >140 mmHg) independently increased the risk for an adverse outcome (death, left ventricular dysfunction, renal failure or insufficiency, and CNS dysfunction).¹³ Furthermore, in patients age 85 years or older undergoing elective surgery (orthopaedic and non-orthopaedic), hypertension was found to be an independent risk factor for escalation of care in living conditions.⁹ Analogous findings in orthopaedic literature have also been found.^{14–18} In a study that looked at 46,322 patients with total knee arthroplasty (TKA) or total hip arthroplasty (THA), age over 80 years and hypertension requiring medication were two of the three most significant risk factors for postoperative cardiac complications.¹⁴ Additionally, hypertensive patients (mean age 61.3 years) with an average systolic blood pressure of 150.1 mmHg were found to have an increased risk for prolonged wound discharge following primary THA relative to normotensive patients.¹⁵

In summary, these aforementioned studies have shown that hypertensive geriatric and non-geriatric patients undergoing THA, TKA, and other surgeries are at an increased risk for post-operative morbidity.^{14–18} However, several of these studies are severely limited in that they did not stratify by age within the geriatric population (65 years and older).^{14–18} There are many physiologic and functional differences that exist within this cohort that need to be considered as they may influence risks and outcomes. Such differences in risk for post-operative morbidity and mortality between octogenarians and their younger geriatric counterparts has been demonstrated in many prior studies.^{5,19–23} Gray et al. also examined the risk of complications in octogenarians using 19,585 patients who underwent open reduction internal fixation (ORIF) for ankle fractures. The authors found that patients aged 80 years and above had a higher risk of wound complications, pulmonary complications, and renal complications within 30-days compared to their younger counterparts following ORIF for ankle fractures.²⁴ Therefore, it is critical to explore potential differences in post-operative morbidity and mortality within the hypertensive geriatric population following various orthopaedic surgeries, such as revision TKA (rTKA). Thus, the purpose of this study was to analyze whether there are any differences in risk for thirty-day morbidity and mortality following rTKA in hypertensive octogenarians (aged 80–89 years) compared to their younger hypertensive geriatric counterparts (aged 65–79 years).

2. Methods

From the years 2006–2018, data were collected through the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database for this retrospective study. This database has been well-described in the existing literature.^{6,7,25–27}

Patients who underwent rTKA were identified using Current Procedural Terminology codes 27486 and 27487. In order to analyze a homogenous cohort of patients, only aseptic revision cases were included in the analysis by excluding cases with a primary diagnosis of prosthetic joint infection by International Classification Diseases (ICD)-9 and ICD-10 codes. Only patients with a diagnosis of hypertension were included in the analysis. In this database, hypertension was defined as a blood pressure of 140/90 mmHg or above with the use of an antihypertensive medication within 30 days prior to the operation.²⁸ Patients were excluded if they had missing baseline data, including their sex, race, or American Society of Anesthesiologists (ASA) score. Patients were also excluded if their age was <65 or if they presented with disseminated cancer. Patients were further excluded if they had other procedures performed during their visit for rTKA. Two patient cohorts were stratified in this study: patients who were 65–79 years old and

patients who were 80–89 years old.

Collected data regarding patients' demographics, clinical characteristics, and comorbidities are shown in [Tables 1 and 2](#). The thirty-day outcomes assessed in this study are shown in [Table 3](#). Based on previous studies, extended length of hospital stay was defined as more than 3 days.^{29,30} To conduct statistical analyses, IBM SPSS 28 (SPSS Inc., Armonk, NY) software was used. Data on patient demographics, comorbidities, and complications were analyzed between the two different age cohorts using bivariate analyses. Pearson's Chi-squared test and one-way analysis of variance were utilized where appropriate. To control for confounding variables, demographics and comorbidities were included in the multivariate analyses for p-values < 0.20.^{31,32} Multivariable logistic regression analyses were performed to identify the independent risk factors for postoperative complications. In this study, a p-value of <0.05 was statistically significant.

3. Results

3.1. Demographics

In total, 6,599 hypertensive patients who underwent rTKA were included in the analysis after applying the exclusion criteria. 5,477 (83.0%) hypertensive patients were in the aged 65 to 79 group and 1,122 (17.0%) hypertensive patients were in the aged 80 to 89 cohort. Relative to patients aged 65 to 79, those with hypertension who were 80–89 years old were more likely to have a lower body mass index (30.3 vs 33.8 kg/m²; $p < 0.001$) and have an ASA class of IV (7.1% vs 4.2%; $p < 0.001$). Hypertensive patients aged 65 to 79 were more likely to be Black (12.7% vs 9.0%; $p = 0.002$) ([Table 1](#)).

3.2. Comorbidities

Compared to hypertensive patients in the aged 65 to 79 cohort, patients who were aged 80 to 89 were more likely to have comorbidities, such as bleeding disorders (7.8% vs 5.3%; $p = 0.001$), preoperative transfusion requirement (2.1% vs 0.5%; $p < 0.001$), and have dyspnea on moderate exertion (10.5% vs 7.7%; $p = 0.004$). Hypertensive patients who were aged 65 to 79 were more likely to be smokers (5.2% vs 1.9%; $p < 0.001$), diabetics (29.0% vs 22.6%; $p < 0.001$), and have an independent functional status (96.2% vs 90.8%; $p < 0.001$) ([Table 2](#)). There were no differences in mean operative time for patients in the aged 65 to 79 cohort compared to patients in the aged 80 to 89 group (134.1 vs. 131.4 min; $p = 0.194$).

3.3. Complications

On bivariate analysis of complications following rTKA in hypertensive patients, patients who were aged 80 to 89 were more likely to develop unplanned reintubation (0.9% vs 0.2%; $p < 0.001$), urinary tract infections (UTIs) (1.7% vs 0.9%; $p = 0.023$), post-operative transfusion requirement (20.1% vs 9.5%; $p < 0.001$), deep vein thrombosis (1.5% vs 0.7%; $p = 0.006$), myocardial infarction (1.2% vs 0.3%; $p < 0.001$), extended hospital length of stay of more than 3 days (37.0% vs 23.2%; $p < 0.001$), and mortality (1.1% vs 0.3%; $p < 0.001$) compared to patients aged 65 to 79 ([Table 3](#)).

Following adjustment on multivariate logistic regression analysis, hypertensive patients who were 80–89 years old had an increased risk of unplanned reintubation (OR 3.52; 95% CI 1.39 to 8.93; $p = 0.008$), UTIs (OR 2.08; 95% CI 1.18 to 3.64; $p = 0.011$), postoperative transfusion (OR 1.90; 95% CI 1.57 to 2.29; $p < 0.001$), myocardial infarction (OR 2.55; 95% CI 1.18 to 5.49; $p = 0.017$), and extended length of stay greater than 3 days (OR 1.77; 95% CI 1.53 to 2.05; $p < 0.001$) ([Table 4](#)).

Table 1
Demographics and clinical characteristics among hypertensive patients undergoing revision total knee arthroplasty.

Demographics	65–79 years old (N = 5,477)	80–89 years old (N = 1,122)	P-Value
Age ^a (year)	71.18 ± 4.21	83.08 ± 2.56	< 0.001 ^c
Sex ^b			0.602 ^d
Male	2,228 (40.7)	447 (39.8)	
Female	3,249 (59.3)	675 (60.2)	
Race ^b			0.002 ^d
White	4,406 (80.4)	936 (83.4)	
Black	693 (12.7)	101 (9.0)	
Hispanic	277 (5.1)	53 (4.7)	
Indian	13 (0.2)	2 (0.2)	
Asian	66 (1.2)	25 (2.2)	
Hawaiian	22 (0.4)	5 (0.4)	
BMI ^a (kg/m ²)	33.79 ± 6.61	30.34 ± 5.93	< 0.001 ^c
ASA Classification ^b			< 0.001 ^d
ASA I	8 (0.1)	0 (0.0)	
ASA II	1,656 (30.2)	236 (21.0)	
ASA III	3,580 (65.4)	806 (71.8)	
ASA IV	232 (4.2)	80 (7.1)	
ASA V	1 (0.0)	0 (0.0)	

Bolding equals significance p < 0.05.

BMI, body mass index; ASA, American Society of Anesthesiologists.

^a The values represent the mean and the standard deviation.

^b The values represent the number of patients, with the percentage indicated in parentheses.

^c Analysis of variance.

^d Pearson's chi-squared test.

Table 2
Comorbidities among hypertensive patients undergoing revision total knee arthroplasty.

Comorbidities ^b	65–79 years old (N = 5,477)	80–89 years old (N = 1,122)	P-Value ^a
COPD	316 (5.8)	80 (7.1)	0.080
CHF	55 (1.0)	17 (1.5)	0.133
Renal failure	3 (0.1)	2 (0.2)	0.171
Dialysis	25 (0.5)	4 (0.4)	0.645
Steroid use	249 (4.5)	52 (4.6)	0.897
Weight loss	13 (0.2)	6 (0.5)	0.090
Bleeding disorder	289 (5.3)	87 (7.8)	0.001
Smoker	285 (5.2)	21 (1.9)	< 0.001
Preoperative transfusion	25 (0.5)	24 (2.1)	< 0.001
Functional status			< 0.001
Independent	5,244 (96.2)	1,010 (90.8)	
Partially dependent	198 (3.6)	94 (8.5)	
Totally dependent	11 (0.2)	8 (0.7)	
DM status			< 0.001
No DM	3,888 (71.0)	869 (77.5)	
Noninsulin-dependent DM	1,119 (20.4)	170 (15.2)	
Insulin-dependent DM	470 (8.6)	83 (7.4)	
Dyspnea			0.004
No dyspnea	5,038 (92.0)	1,002 (89.3)	
Moderate exertion	420 (7.7)	118 (10.5)	
At rest	19 (0.3)	2 (0.2)	
Anesthesia type			0.559
General	3,344 (61.1)	664 (59.2)	
Neuraxial	1,466 (26.8)	330 (29.4)	
Regional	117 (2.1)	26 (2.3)	
MAC	537 (9.8)	100 (8.9)	

Bolding equals significance p < 0.05.

COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; DM, diabetes mellitus; MAC, monitored anesthetic care.

^a Pearson's chi-squared test.

^b The values represent the number of patients, with the percentage indicated in parentheses.

3.4. Hypertension vs. No hypertension

A subset analysis was done comparing patients aged 80–89 with hypertension to patients aged 80–89 without hypertension to assess whether non-hypertensive patients had more favorable outcomes. Our results showed that there were no differences in postoperative complications or length of stay between those with and those without hypertension in this age group (Table 5).

4. Discussion

Hypertensive patients have been shown to have an increased risk of complications, longer length of hospital stay, and mortality following various surgeries compared to their non-hypertensive counterparts.^{8,11,12,14–18} However, whether or not these risks disproportionately affect octogenarians compared to younger geriatric patients following rTKA has not yet been studied. After controlling for demographics and comorbidities, this study showed

Table 3
Bivariate analysis of postoperative complications of hypertensive patients following revision total knee arthroplasty.

30-Day Outcomes ^b	65–79 years old (N = 5,477)	80–89 years old (N = 1,122)	P-Value ^a
Operative Complications			
Superficial Surgical Site Infection	22 (0.4)	7 (0.6)	0.305
Deep Surgical Site Infection	27 (0.5)	6 (0.5)	0.857
Organ Space Infection	51 (0.9)	9 (0.8)	0.678
Wound Dehiscence	20 (0.4)	8 (0.7)	0.102
Non-Operative Complications			
Pneumonia	29 (0.5)	9 (0.8)	0.272
Unplanned Reintubation	13 (0.2)	10 (0.9)	< 0.001
Pulmonary Embolism	28 (0.5)	6 (0.5)	0.920
Renal Insufficiency	14 (0.3)	3 (0.3)	0.944
Urinary Tract Infection	51 (0.9)	19 (1.7)	0.023
Postoperative Transfusion	518 (9.5)	226 (20.1)	< 0.001
Deep Vein Thrombosis	38 (0.7)	17 (1.5)	0.006
Myocardial Infarction	19 (0.3)	13 (1.2)	< 0.001
Sepsis	40 (0.7)	11 (1.0)	0.384
Extended Length of Stay (>3 days)	1,272 (23.2)	415 (37.0)	< 0.001
Readmission	295 (7.2)	67 (8.0)	0.419
Reoperation	189 (3.5)	40 (3.6)	0.849
Death	18 (0.3)	12 (1.1)	< 0.001

Bolding equals significance $p < 0.05$.

^a Pearson's chi-squared test.

^b The values represent the number of patients, with the percentage indicated in parentheses.

Table 4
Multivariate analysis of postoperative complications of hypertensive patients following revision total knee arthroplasty.

80–89 years old (versus 65–79 years old) 30-Day Outcomes	Odds Ratio	95% CI	P-Value	
Unplanned Reintubation	3.523	1.391	8.925	0.008
Urinary Tract Infection	2.075	1.182	3.640	0.011
Postoperative Transfusion	1.898	1.572	2.292	< 0.001
Deep Vein Thrombosis	1.819	0.976	3.391	0.060
Myocardial Infarction	2.548	1.182	5.493	0.017
Extended Length of Stay (>3 days)	1.771	1.527	2.054	< 0.001
Death	1.568	0.673	3.653	0.297

Bolding equals significance $p < 0.05$.

CI, confidence interval.

Table 5
Bivariate analysis of postoperative complications of 80–89 Years old patients following revision total knee arthroplasty.

30-Day Outcomes ^b	No Hypertension (N = 283)	Hypertension (N = 1,122)	P-Value ^a
Operative Complications			
Superficial Surgical Site Infection	3 (1.1)	7 (0.6)	0.435
Deep Surgical Site Infection	0 (0.0)	6 (0.5)	0.218
Organ Space Infection	1 (0.4)	9 (0.8)	0.422
Wound Dehiscence	1 (0.4)	8 (0.7)	0.498
Non-Operative Complications			
Pneumonia	2 (0.7)	9 (0.8)	0.871
Unplanned Reintubation	0 (0.0)	10 (0.9)	0.111
Pulmonary Embolism	2 (0.7)	6 (0.5)	0.731
Renal Insufficiency	0 (0.0)	3 (0.3)	0.384
Urinary Tract Infection	5 (1.8)	19 (1.7)	0.932
Postoperative Transfusion	47 (16.6)	226 (20.1)	0.179
Deep Vein Thrombosis	3 (1.1)	17 (1.5)	0.564
Myocardial Infarction	1 (0.4)	13 (1.2)	0.223
Sepsis	3 (1.1)	11 (1.0)	0.904
Extended Length of Stay (>3 days)	100 (35.3)	415 (37.0)	0.606
Readmission	10 (5.0)	67 (8.0)	0.149
Reoperation	6 (2.1)	40 (3.6)	0.222
Death	1 (0.4)	12 (1.1)	0.261

Bolding equals significance $p < 0.05$.

^a Pearson's chi-squared test.

^b The values represent the number of patients, with the percentage indicated in parentheses.

for the first time that hypertensive octogenarian patients undergoing rTKA have an increased risk of extended length of stay and other postoperative complications relative to their younger

hypertensive geriatric counterparts.

This study's finding of an increased risk of postoperative complications and prolonged hospital stay following rTKA for

hypertensive octogenarians is consistent with prior orthopaedic literature exploring the influence of hypertension on post-surgical outcomes. Schick et al. found that a history of hypertension was an independent risk factor for any complication as well as major morbidity or mortality following ORIF for distal radius fractures.¹⁶ Likewise, hypertension was found to be an independent risk factor for developing a postoperative complication or requiring an inpatient stay following THA in a study of 34,416 Medicare-aged patients with a mean age of 73 years.¹⁷ Furthermore, Dy et al. showed that hypertension is an independent risk factor for myocardial infarction following THA and TKA.¹⁸ Importantly, studies have also shown that postoperative complications disproportionately affect older patients as opposed to their younger counterparts. For example, in a study looking at 886 patients undergoing ORIFs for closed, non-polytraumatic, non-pilon ankle fractures, risk for postoperative infection among older patients above 50 years with hypertension (RR = 3.52, $p = 0.004$) was greater than the risk for younger patients (RR = 2.46, $p = 0.017$).¹⁰ As seen with these prior studies, although the impact of hypertension on postoperative complications of older patients undergoing surgery is well documented, there is a limited literature about whether this risk increases for octogenarians relative to their younger geriatric counterparts.

However, there are several orthopaedic studies that are in contrary to this study's findings of an increased risk for postoperative complications in hypertensive octogenarians. In a systematic review and meta-analysis that examined 1,651 fractures managed by ORIF, hypertension was not found to significantly increase the risk of wound complications ($p > 0.05$).³³ Likewise, a history of hypertension was not found to increase postoperative mortality in a study of patients undergoing primary elective THA (majority of patients age 65 years or older).³⁴ A study that looked at thirty-day postoperative complications and mortality in unilateral TKA patients (mean age of 67 years) found that while hypertension was the most common medical comorbidity (70.0%), it was not an independent predictor of major or minor local or systemic complications.³⁵ Despite the findings from these aforementioned studies being in contrast to this study's results, none are in direct disagreement with this study's finding of hypertensive octogenarians having an increased risk of postoperative complications and a longer length of stay following rTKA relative to younger geriatric patients.

The increased length of stay risk in hypertensive octogenarians found in this study may partly be due to poor wound healing in these patients. Good cardiovascular health is essential for effective wound healing following surgery. Common cardiovascular risk factors, including hypertension, adversely affect the endothelium through various mechanisms including an increased production of reactive oxygen species, leading to poor wound healing.³⁶ It is possible that with increasing age among the geriatric population, blood pressures are not being managed as optimally due to personal, social, and biological factors, thereby worsening their cardiovascular health and thus wound healing capacities. In addition, there tends to be a greater incidence of other comorbidities not found in the NSQIP database with increasing age, which may exacerbate the effect of hypertension on wound healing and postoperative health.³⁷

As is the case with other studies, this study is not without limitations. Using the large NSQIP database creates numerous inherent limitations. Miscoding or omission of data points, including procedural codes or complications, is known to occur in large databases despite attempts at quality control. In addition, this study only considered 30-day postoperative complications and mortality. The utilization of a longer period, such as 60 days or 180 days, could reveal other significant differences in postoperative

complications, readmission rates, or mortality in the octogenarian cohort relative to their younger geriatric counterparts. As a result, we may be underestimating the true rates. Future studies should consider longer periods when evaluating postoperative complications and mortality. Another limitation is that the NSQIP database does not report on the use of tourniquets, therefore we are unable to evaluate its impact on wound healing, deep vein thrombosis, and postoperative blood transfusion. Future studies should examine how the use of tourniquets can impact postoperative complications. A further potential limitation of this study is that the degree of elevated blood pressure was not considered, as variations in risk may exist based on stage of hypertension. Future studies should focus on evaluating the different stages of hypertension and its impact on postoperative complications. Moreover, only hypertensive patients on antihypertensive medication were included in the study. Uncontrolled hypertension in octogenarians might lead to more prominent postoperative complications relative to their younger geriatric patients and thus needs to be further studied. Despite these limitations, this study is the first retrospective study with a large sample size to analyze whether or not hypertensive octogenarians undergoing rTKA are at an increased risk of thirty-day postoperative morbidity and mortality.

5. Conclusion

Octogenarians with hypertension are at an increased risk for postoperative complications and a longer length of stay following rTKA relative to their younger hypertensive geriatric patients. Further research examining the possible reasons for this increased risk is needed to improve patient outcomes and reduce healthcare costs. Additionally, future research should explore these risks within the hypertensive geriatric cohort for other orthopaedic procedures as well. It is important for orthopaedic surgeons to be aware of these risks to assist in decision making for surgical management and so that they can better educate their patients of these risks. However, even with this risk, an octogenarian age should not be used independently in evaluating if a hypertensive geriatric patient is a safe rTKA candidate.

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Not applicable

Code availability

Not applicable.

Financial interests

The authors declare they have no financial interests.

Ethics approval

Institutional review board approval was not required for this study as all data is de-identified and public.

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Declaration of competing interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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