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Original Research

Higher Comorbidities are Correlated With Readmission Following Arthroplasty for Femoral Neck Fracture

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ABSTRACT

Background: A desire to control cost and improve patient outcomes following arthroplasty led to the introduction of the Center for Medicare and Medicaid Service Comprehensive Care for Joint Replacement Program. Hemi and total hip arthroplasty for femoral neck fracture has been shown to have worse outcomes than those for osteoarthritis. However, little has been studied about the effect of comorbidities on costs associated with arthroplasty for femoral neck fracture. This study investigates how the number of comorbidities influence 90-day outcomes and cost following hemi or total hip arthroplasty for displaced femoral neck fracture in patients covered by the Comprehensive Care for Joint Replacement bundle.

Methods: We reviewed all Medicare hip fracture patients undergoing hemi or total hip arthroplasty at our institution between April 2016 and November 2020. Basic demographic and perioperative information was collected. The primary outcome was hospital readmission within 90 days. The data set captured 90-day readmission to any institution, not just within our system. Secondary outcomes included 90-day reoperation and outpatient complications. Multiple logistic regression was used to examine the influence of number of comorbidities on the primary and secondary outcomes while controlling for other variables.

Results: The cohort comprised 378 patients (72% female), mean age 82 (±9) years, mean body mass index 23.4 (±4.7) kg/m^2. For every additional comorbidity, the odds of related readmission without reoperation increased by 1.261 (95% confidence interval [1.055-1.507], $P = .011$). Odds of reoperation and odds of outpatient complication did not show statistical significance with the available numbers.

Conclusions: Increasing preoperative comorbidities results in a higher odd of readmission within 90 days following arthroplasty for femoral neck fracture in this Medicare population.

Introduction

Femoral neck fracture (FNF) among the elderly in the United States is an ongoing public health concern, posing high morbidity and mortality risks to patients and economic burden to our healthcare system. Hip fractures make up a large portion of fragility fractures among the elderly. These fractures have negative impacts on patients' mental and physical health and many patients do not return to their prefracture level of function after treatment [1]. Trends on incidence have varied. Using the National Inpatient Sample, it has been shown that from 2009 to 2016, the yearly incidence of hip fracture has decreased [2] and a second analysis showed that 2003 to 2013, the incidence almost halved from 242 to 146 fractures per 100,000 adults of age 65 years and older [3]. Other groups have demonstrated that while hip fracture incidence has decreased from 2002 to 2012, from 2013 to 2015, the total number had plateaued and was higher than what was expected based on previous years [4].

Traditionally hip hemiarthroplasty (HHA) has been the treatment of choice for displaced femoral neck fractures, but in recent years, total hip arthroplasty (THA) has become more popular among US surgeons [3]. In addition to changing practices, the ways

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in which surgeons and hospital systems have been reimbursed for these procedures has also changed. In April of 2016, the Comprehensive Care for Joint Replacement model was implemented with the goal of maximizing Medicare patient outcomes following hip and knee arthroplasty in select hospitals throughout the United States. The Comprehensive Care for Joint Replacement model provided institutions with a single bundle payment for each episode of care. The bundle payment was determined by the target price set by the Center for Medicare and Medicaid Services, and institutions were incentivized to drive down costs and increase quality. This quality improvement initiative aimed make improvements by requiring hospitals to meet a certain standard with regards to patient outcomes and avoid harmful or expensive events as well as encourage interdisciplinary care coordination to maximize postoperative outcomes while minimizing costs. Importantly, these bundle payments apply not only to hip arthroplasty for primary osteoarthritis of the hip but also for arthroplasty after FNF.

It has been shown that patients that undergo HHA or THA for fracture have worse outcomes than those that undergo these surgeries for primary osteoarthritis. Longer surgical duration, length of stay, frequency of complications and need for postoperative transfusion has all been found in patients who undergo arthroplasty for fracture [5–7]. Furthermore, evidence has suggested that arthroplasty for fracture is a more expensive procedure compared to arthroplasty for osteoarthritis as the fracture patient tend to have a higher disease burden even at younger ages [8]. Currently, there is literature that demonstrates how certain patient characteristics as well as perioperative factors have a substantial influence over these patients' postoperative outcomes, including readmission, reoperation, and mortality rates [9–13]. However, an association between the number of comorbidities and episode cost has yet to be demonstrated. The purpose of this study is to investigate how the number of comorbidities influence the 90-day readmissions, reoperations, and episode cost as it compared to target cost following HHA or THA for displaced FNF in patients whose hospital admission is under the Comprehensive Care for Joint Replacement bundle within an academic tertiary care urban institution. We hypothesize that an increased number of comorbidities is associated with a higher cost following HHA or THA for displaced femoral neck fracture.

Material and methods

Patient population and data collection

This institutional review board–approved, single hospital system investigation is a retrospective cohort study. All Medicare patients who presented to 1 of 4 hospitals within our hospital system between April 2016 and November 2020 with a femoral neck fracture and underwent HHA or THA were considered for inclusion. These patients were identified by querying the enterprise administrative and billing data, and clinical data were collected retrospectively.

Data collected included basic demographic data such as sex, age, body mass index, and comorbidities as well as perioperative factors including American Society of Anesthesiologist (ASA) classification, preoperative anemia as defined within our hospital system (<12.6 for men, <11.2 for women), time from admission to surgery, cemented vs press-fit femoral instrumentation, surgical approach, need for a transfusion, and inpatient complications. Body mass index was described in 6 categories: (I) <18.5, (II) 18.5-24.9, (III) 25.0-29.9, (IV) 30.0-34.9, (V) 35.0-39.9, (VI) >40. Comorbidities were described in total number. For consistency, comorbidities were collected from the preanesthesia evaluation note as the anesthesia team would conduct a thorough chart review and patient interview to determine ASA classification and risk. All listed conditions were included in the total number of comorbidities as these were included in the patient's preanesthesia assessment.

The primary outcome was a hospital readmission within 90 days of index surgery. Our data set captured any readmission within 90 days. We examined readmissions without reoperation separately from reoperation. Secondary outcomes included reoperation for any reason and outpatient complications. Outpatient complications were classified as medical concerns that presented in the first 90 days following surgery that required medical attention via either an outpatient visit or the emergency department but did not result in a hospitalization. These included dislocations that were closed reduced in the emergency room, cellulitis or urinary tract infections that were treated with antibiotics, falls/syncope, pain control issues, and deep vein thrombosis. Readmissions, reoperations, and complications were identified through chart review of hospital visits and follow-up visits. Additionally, we collected information on the cost of the first 90 days following surgery and compared this to our institutional target price for this procedure which was $52,492.

Analysis

We applied a multiple logistic regression analysis to examine the odds of the primary and secondary outcomes while controlling for age, body mass index, gender, THA/HHA, femoral implant fixation type, ASA score, surgical complexity – complicated vs uncomplicated decided upon the time of presentation of the patient at the hospital, hospital at which surgery occurred, preoperative anemia, time to surgery, operative time, length of stay, surgical approach, occurrence of inpatient complication, transfusion, and discharge disposition – home vs subacute rehabilitation. The models were evaluated using the Nagelkerke's R squared value with a value of approximately 0.130 indicating medium effect size. Continuous variables were compared using student's *t*-test and categorical variables using chi-squared analysis. All statistical analyses were performed using Excel (Microsoft, Redmond, WA) and SPSS (IBM Armonk, NY).

Results

Five hundred six patients met inclusion criteria. One hundred eight patients were excluded for missing data (21.3%), leaving 378 for final analysis. A majority of patients underwent HHA 281 (74%) vs 97 who underwent THA (26%). The characteristics of the entire

Table 1
Patient demographics.

Demographic information	All patients 378 (%)
Age	81.7 ± 8.8
Female (%)	273 (72)
Body mass index	
I (<18.5)	45 (12)
II (18.6-24.9)	207 (55)
III (25-29.9)	86 (22)
IV (30.0-34.9)	30 (8)
V (35.0-39.9)	8 (2)
VI (>40)	2 (<1)
ASA class	
I	3 (<1)
II	102 (27)
III	249 (66)
IV	24 (6)
Preoperative anemia	205 (54)

This table demonstrates the patient demographical information for the entire cohort.

cohort can be seen in Tables 1 and 2. The number of comorbidities can be seen in Table 3 and the types of comorbidities can be seen in Table 4. The occurrence of adverse outcomes in the entire cohort is seen in Table 5. Table 6 illustrates the reasons for outpatient complications and Table 7 the reasons for readmission.

The average age of the cohort was 81.7 ± 8.8 years, range 48-102 years. A majority of the patients were female (72%), presented with preoperative anemia (54%), had an ASA class of III or higher (72%), had 3-5 comorbidities, underwent surgery through a posterior approach (59%) with cemented components (63%), and were discharged to a subacute rehabilitation facility (88%). Additionally, 83% of patients underwent surgery within 48 hours of surgery, the average length of surgery was 127 ± 48 minutes, range 14-387 minutes, and average postoperative length of stay was 5 ± 3.2 days.

Odds of being above the institutional target price

When controlling for the various predictors, the odds of being above the target price compared to below it for an increasing number of comorbidities was not significant, odds ratio (OR) 1.046 (95% confidence interval [CI] = [0.941-1.162], P = .403). The Nagelkerke R squared for this model was 0.082.

Odds of reoperation

When controlling for the various predictors, the odds of a reoperation for each additional comorbidity was not significant, OR 1.031 (95% CI = [0.818-1.300], P = .794). The Nagelkerke R squared for this model was 0.194. The reasons for reoperation included 4 for dislocation/instability, 6 for fracture (5 periprosthetic and 1 of the contralateral greater trochanter following fall), and 4 for infection.

Odds of readmission

When controlling for the various predictors, the odds of a readmission for each additional comorbidity was significant, OR 1.261 (95% CI = [1.055-1.5070], P = .011). This indicates that for every additional comorbidity, there is a 26% increase in the odds that a patient will be readmitted, and this result is statically significant. The Nagelkerke R squared for this model was 0.157.

Odds of outpatient complication

When controlling for the various predictors, the odds of an outpatient complication for each additional comorbidity was not significant, OR 1.095 (95% CI= [0.867-1.382], P = .447). The Nagelkerke R squared for this model was 0.120.

Table 2
Perioperative characteristics.

Variable	All patients 378 (%)
Time to surgery (≤48 h)	313 (83)
Operative time (in min)	126 ± 48
Approach	
Anterior	56 (14)
Posterior	322 (86)
THA	97 (26)
HHA	281 (74)
Fixation	
Cemented	239 (63)
Transfusion	79 (21)
Inpatient complication	36 (10)
Length of stay (in d)	5 ± 3.2
Discharge	
SNF	334 (88)

This demonstrates the peri-operative characteristics of the entire cohort.
HHA, hip hemiarthroplasty; THA, total hip arthroplasty.

Table 3
Comorbidities.

Number of Comorbidities	All patients 378 (%)
0	8 (2)
1	29 (8)
2	25 (7)
3	74 (20)
4	73 (19)
5	62 (16)
6	32 (8)
7	27 (7)
8	24 (6)
9	9 (2)
10	11 (3)
11	1 (>1)
12	2 (1)
13	0
14	1 (>1)

This table demonstrates the distribution of the number of comorbidities in the cohort.

Discussion

We found a significant association between readmission rates following arthroplasty for femoral neck fractures and the number of comorbidities patients had preoperatively, while controlling for several patient and perioperative factors. Our data show a 26% increase in the odds of a readmission for each additional comorbidity a patient has within this data set. Similar trends were not seen when examining whether an episode cost exceeded the target price, required reoperation, and occurrence of an outpatient complication.

Current literature supports that patients with femoral neck fractures and high preoperative illness burden are at increased risk for poor outcomes following surgery. Li et al [9] found that the older male patients with a high comorbidity burden in their population had a statically significant lower survival rate postoperatively. Other studies have focused on how the presence of certain preoperative factors influences postoperative outcomes of these patient. Patients with Parkinson's disease have been shown to have a higher likelihood of dislocation, readmission and revision following treatment of femoral neck fracture [10,14]. Another group found that patients with renal disease who are dialysis dependent not only have an increased odds of mortality but also increased odds of requiring a postoperative transfusion [11]. Erivan et al [12] demonstrated that there was an association between the a patient's place of residence before and after fracture with those living at care homes or in-hospital settings having an increased risk of mortality than those coming from home, and an increased mortality when discharged to care facilities compared to those going home. Subsequent fracture occurrence is also a common event that has been examined. Bogoch et al [15] found that in the 2 years following femoral neck fracture, up to 9% of patients have at least one other fragility fracture and this occurs on average within 9 months of the original femoral neck fracture. In many of these studies, authors acknowledge that the influence on morbidity and mortality are likely multifactorial with confounding effects from various preoperative factors. As such, many studies have controlled for multiple variables at once including demographic factors, hospital stay length, place of residence before and after the fracture, characteristics of the fracture, time from the fracture to surgery, and in some cases, multiple comorbidities. We controlled for similar variables in our analysis for similar reasons.

Table 4
The categories of comorbidities and frequency of each category in the cohort.

Comorbidity	THA	HHA
Arrhythmia	16	67
Arthritis	4	11
Asthma	8	14
Bleeding/Clotting disorder	8	15
Coronary artery disease	12	49
Cancer	18	59
Cardiac	4	7
Chronic kidney disease	8	22
Cirrhosis	0	2
COPD	3	16
CVA/TIA	4	38
Diabetes	14	42
Endocrine	4	12
Electrolyte imbalance	2	5
ETOH/Substance abuse	2	7
Gait disorder	2	2
Gastrointestinal	9	34
Gout/Pseudogout	2	8
Genitourinary	6	23
GERD	19	25
Hearing loss	2	5
Hematology	7	17
Hyperlipidemia	31	100
Hypertension	52	169
Pulmonary hypertension	2	9
Cardiomyopathy/Heart failure	12	30
Hypothyroidism	16	47
Infectious	6	10
ICH/SDH	0	6
Malnutrition	6	11
Memory/Cognition	6	48
Migraine	1	5
Mood/Psychiatric	17	48
Musculoskeletal	3	7
Neurological	3	12
Neuropathy	3	4
Osteopenia/Osteoporosis	11	32
Parkinson	4	18
Pulmonary	10	25
Renal	2	10
Rheumatologic/Immune	5	14
Recent fracture	1	2
Seizure	0	4
Sleep disorder	0	5
Spinal pathology	7	14
Vascular disease	7	19
Valvular disease	5	21
Vertigo/Dizziness	3	5
Vision/Ophthalmology	6	22

For further clarification of the categories please see Appendix Table 1.
HHA, hip hemiarthroplasty; THA, total hip arthroplasty.

This study included femoral neck fracture patients who underwent both HHA and THA and was controlled for in our analysis using multivariable logistic regression. THA has been gaining popularity as a treatment option for these fractures over the last 2 decades. Between 1999 and 2009, the was an over 10-fold increase in the use of THA for fracture [16]. This is relevant to the discussion of healthcare costs and the bundle payments as some studies have shown that THA for femoral neck fracture is more expensive than HHA and more expensive than THA for osteoarthritis due to higher complication, readmission, and reoperation rates [3,6,17,18]. These findings have prompted discussions about whether reimbursement for these surgeries should be under that same payment program as THA for osteoarthritis, should be conducted in a risk-stratified fashion, or should be excluded from the current payment models, and remain an important point to be addressed by healthcare institutions and payers. While our analysis did not find a statistically significant difference in the odds of surpassing the target price based on increasing number of comorbidities, our findings with regards to increased readmission provide evidence that risk stratification should be considered. Interesting, Maceroli et al [19] found that when THA was performed for fracture at high-volume arthroplasty centers in New York State there was a lower mortality rate at 30 days and 1 year compared to lower-volume centers in the state, without any difference in reoperation rates. Given the high number of primary hip arthroplasties done at our hospital, this may play a role in explaining the lack of significant differences we found at 90 days postoperatively.

This study is not without limitations. First, our sample size of 378 patients is much lower than the numbers provided by larger database studies. However, because all of our patients were within our hospital system, the data we could collect were much more granular than those available in large data sets. Additionally, our patients were treated at separate hospitals within the same enterprise and by several different surgeons with various postoperative protocols. While we did attempt to control for some of this variation in our analysis, controlling by institution, this variation also gives our study generalizability to other urban tertiary care centers. A third limitation of this study is related to the ways in which the preoperative comorbidities were documented in the electronic medical record. We used preoperative documentation of these comorbidities created during the anchor admission. This documentation did not include, and so our study did not account for, illness severity such as stage of chronic kidney disease or congestive heart failure, HgA1C levels for

Table 5
Adverse outcomes.

Complications	All patients 378 (%)
Reoperations	14 (4)
Readmission (excluding reoperation)	31 (8)
Outpatient complication	18 (5)

This table demonstrates the frequency of adverse outcomes. Reasons for outpatient complication and readmission can be seen in Tables 6 and 7, respectively.

Table 6
The frequency of 90-day postoperative outpatient complications.

Outpatient complication	THA	HHA
Cardiac	1	1
Dislocation	0	4
DVT/PE	0	2
Genitourinary	0	1
Infection	2	2
Pain control	0	2
Pressure ulcer	1	2

For further clarification of the complications please see Appendix Table 3.
DVT, deep vein thrombosis; HHA, hip hemiarthroplasty; PE, pulmonary embolism; THA, total hip arthroplasty.

Table 7
The frequency of 90-day postoperative readmission reasons.

Reason for admission	THA	HHA
Cardiac	0	4
DVT/PE	0	2
Gastrointestinal	2	4
Infection	1	7
Pressure ulcer	0	4
Other	0	7

DVT, deep vein thrombosis; HHA, hip hemiarthroplasty; PE, pulmonary embolism; THA, total hip arthroplasty.

diabetes, an active vs remission stages of malignancy. Finally, while we found that the total number of comorbidities leads to a significant increase in the odds of a readmission, we predict that the type of comorbidities is likely more impactful on the odds of readmission and possibly on the odds of other adverse outcomes. While the current literature discusses how certain preoperative factors can influence postoperative outcomes, there is a paucity of information describing the impact of comorbidities and cost. This study aims to address this. It is out of the scope of our investigation to examine specific comorbidities as we do not have a large enough sample size.

The strengths of this study include the generalizability of our conclusions due to hospital and surgeon variety as previously discussed. Additionally, the sample size was modest but distributed over 4 years allowing us to include various surgical and postoperative protocols in our sample. Second, we were able to collect a significant amount of data for each patient, and thus account for many patients specific and perioperative variables. This granularity is not available with large database studies which already exist in the current body of literature on this topic.

Conclusions

While being above the target cost for the first 90 days following arthroplasty for femoral neck fracture was not found to be associated with increasing number of preoperative comorbidities, this study demonstrates that Medicare patients with higher number of comorbidities had an increased odds of 90-day readmission following arthroplasty for FNF. Although not found in this data set, increased readmissions may have significant economic consequences and warrant further investigation. This study is an important addition to the current body of literature as it provides additional insight into the challenges of caring for medically complex patients with FNFs at tertiary centers. Center for Medicare and Medicaid Services, surgeon advocates, and national bodies must continue to advocate for adequate compensation and innovative compensation models in order to keep these large safety net institutions solvent and provide access to care for the sickest patients while continuing to provide high quality of care and control costs.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101494.

CRediT authorship contribution statement

Anastasia Gazgalis: Writing – original draft, Formal analysis, Data curation. **Shawn Simmons:** Data curation. **Mary Doucet:** Data curation. **Prakash Gorroochurn:** Formal analysis. **H. John Cooper:** Writing – review & editing, Conceptualization. **Carl L. Herndon:** Writing – review & editing, Conceptualization.

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Appendix Table 1
Provides a complete list of comorbidities of this study cohort.

Comorbidity	Description
Arrhythmia	Atrial fibrillation, atrial flutter, bradycardic rhythms, and unspecified rhythms
Arthritis	Osteoarthritis and rheumatoid
Bleeding/Clotting disorder	Antiphospholipid syndrome, anti-cardiolipin antibody, factor V Leiden, prior deep venous thromboses,
Cancer	Breast, lymphomas, leukemias, prostate, and sarcoma, active or in remission
Cardiac	Anatomic abnormalities, chronic hypotension, dysautonomia, Lyme myocarditis, orthostatic hypotension, postural tachycardia syndrome (POTS)
Endocrine	Adrenal insufficiency, empty sella syndrome, hyperparathyroidism, hyperthyroid, syndrome of inappropriate antidiuretic hormone (SIADH), thyroid nodules/ multinodular goiter
Electrolyte imbalance	Hypernatremia, hyponatremia,
ETOH/Substance abuse	Substance abuse includes current use and in treatment on methadone
Gastrointestinal	Achalasia, bleeding, Crohn's, cholelithiasis, constipation, diverticulitis, gastric bypass, gastritis, esophageal stricture, hiatal hernia, hepatitis C, irritable bowel syndrome, liver transplant, lymphocytic colitis, peptic ulcer disease, small bowel obstruction, unspecified colonic masses
Genitourinary	Benign prostatic hyperplasia, fibroids, neurogenic bladder, and incontinence
Hematology	Anemias, monoclonal gammopathy of undetermined significance (MGUS), thrombocytopenia
Infectious	Bacterial infections include osteomyelitis, human immunodeficiency virus (HIV), recent or concurrent pneumonias, recurrent or concurrent UTIs
Memory/ Cognition	Altered mental status, dementia, and developmental delay
Mood/Psychiatric	Anxiety, depression, and multiple psychiatric illness include schizophrenia and bipolar
Musculoskeletal	Avascular necrosis of the femoral head, costochondritis, chronic lower back pain without a spinal pathology, chronic lymphedema, lateral epicondylitis, leg length discrepancies secondary to polio, prior joint arthroplasty <3 mo, prior joint arthroplasty with infection, rotator cuff injuries, sciatica pain
Neurological	Aneurysms, aphasia, bell's palsy, fibromyalgia, progressive supranuclear palsy, meningiomas, schwannomas, tremors, temporal contusions
Neuropathy	Diabetic and idiopathic pathologies
Pulmonary	Bronchiectasis, emphysema, nasal polyps, obstructive sleep apnea, pleural effusion, pulmonary fibrosis, prior pulmonary embolism, sinusitis, tracheomalacia, tracheostomy excludes asthma, chronic obstructive pulmonary disorder, pulmonary hypertension
Renal	Acute kidney injury, hydronephrosis, nephrolithiasis, nephrotic syndrome, renal mass, renal transplant, single kidney
Rheumatologic/ Immune	Allergic rhinitis, dermatographia, genetic immunodeficiency syndromes including IgA deficiency, myasthenia gravis, pericarditis, polymyalgia rheumatica, psoriasis, systemic lupus erythematosus, scleroderma, sjogren's, temporal arteritis, vitiligo
Spinal pathology	Cervical or lumbar disc disease, kyphosis, compression fractures, sciatica pain, scoliosis, spinal stenosis
Vascular disease	Aortic and abdominal aneurysms and peripheral vascular disease
Valvular disease	Any disorder of a heart valve with and without treatment
Vision loss	Cataracts, dry eye, glaucoma, macular degeneration

Appendix Table 2
Demonstrates a complete list of the outpatient complications.

Outpatient complication	Description
Cardiac	Arrhythmia (1), syncope (1)
Dislocation	Dislocation requiring closed reduction, no admission (4)
DVT/PE	Deep vein thrombosis (1), pulmonary embolism (1)
Genitourinary	Urinary retention requiring prolonged Foley (1)
Infection	Cellulitis (1), urinary tract infection (1)
Pain control	Pain requiring ED visit: exacerbation of acute on chronic back pain (1), surgical site (2)
Pressure ulcer	Heel (1), sacral decubitus (1), unspecified foot ulceration (1)

Appendix Table 3
Demonstrates all the reasons for readmission.

Reason for admission	Description
Cardiac	Arrhythmia which required treatment (1), CHF exacerbation (2), uncontrolled hypertension with chest pain (1)
DVT/PE	Deep vein thrombosis (2)
Gastrointestinal	Gastrointestinal bleed on anticoagulation (4), small bowel obstruction (2)
Infection	Pneumonia (3), urinary tract infection (5)
Pressure Ulcer	Pressure ulcers requiring debridement and/or intravenous antibiotics (4)
Other	Altered mental status (1), anemia (2), failure to thrive and admitted to hospice (1), fall without injury (1), fall with injury (1), hyperkalemia (1)