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Death after Total Hip Arthroplasty in Patients with Compensated Heart Failure: Retrospective Cohort Study

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Abstract

Total hip arthroplasty (THA) is the preferred treatment for femoral neck fracture when functional longevity is expected, but congestive heart failure (CHF) is a risk factor for mortality. The hypothesis of this study is that mortality risk increases with disease severity, influencing the choice between total and hemiarthroplasty. This study queried the National Surgical Quality Improvement database for patients treated for an acute, closed, intracapsular femoral neck fracture, identifying 4486 THA and 34 282 hemiarthroplasty recipients. Subjects were stratified by preoperative risk factors, New York Heart Association categories of mild, moderate, and severe CHF, and odds of death within 30 days. The 30-day postoperative mortality rates for total and hemiarthroplasty were 2.1% (n = 95) and 5.4% (n = 1857), respectively. The 30-day postoperative mortality of patients undergoing THA with mild CHF was 14.3%, and moderate CHF was 21.4%., and for patients undergoing hemiarthroplasty with mild CHF was 11.4%, moderate CHF was 13.9%, and severe CHF was 18.4%. Mild (adjusted odds ratio [AOR] 1.63, 95% Confidence Interval [CI] 1.24-2.14), moderate (AOR 2.21, CI 1.49-3.30), and severe (AOR 2.89, CI 1.41-5.93) CHF was associated with death within 30 days of hemiarthroplasty. Mild (AOR 5.37, 95% CI 2.16-13.38) and moderate (AOR 12.00, CI 3.42-42.17) CHF was associated with death within 30 days of THA. Patients with CHF had increased mortality after THA for acute femoral neck fracture, suggesting it is not a modifiable risk factor. Hemiarthroplasty is a reasonable choice with CHF given evidence of unfavorable survival.

Abbreviations

AOR = Adjusted Odds Ratio
CHF = congestive heart failure
NICE = National Institute for Health and Care Excellence
NSQIP = National Surgery Quality Improvement Program
THA = total hip arthroplasty

Introduction

In North America, an estimated 140 000 patients annually sustain an acute femoral neck fracture.[1-3] Treatment options include internal fixation and hip arthroplasty depending on patient factors such as age, fracture morphology, functional status, and pre-operative medical comorbidities. Hip arthroplasty allows for swift mobilization while mitigating concern for fixation failure, osteonecrosis, or nonunion among osteoporotic elderly patients when compared to internal fixation.[4-9]

Despite advances in perioperative medical care and surgical technique, the mortality after a femoral neck fracture remains high at 20% within 1 year postoperatively.[10,11] This is partially attributed to the elevated incidence of severe medical comorbidities in this population such as renal disease, pulmonary disease, dementia and congestive heart failure (CHF).[4,11] Given the elevated post-operative mortality rates, hemiarthroplasty remains the overwhelming arthroplasty treatment option in this population owing to equivalent 2-year quality-of-life metrics, lower dislocation rate, less blood loss, initial lower complication rate, and surgical morbidity when compared to total hip arthroplasty (THA).[12-14] THA is indicated for patients with favorable long-term survival given the clinical and functional longevity of THA when compared to hemiarthroplasty after the first 2 years after surgery, and gives the benefit of avoidance of secondary conversion surgery in the subset of patients who experience persistent groin pain after hemiarthroplasty.[4,12,14-17]

Given that several years of post-operative survival are necessary to materialize the benefit of THA when compared to hemiarthroplasty, the National Institute for Health and Care Excellence (NICE) guidelines provide a framework for choosing between these treatment options to maximize appropriate resource utilization and minimize patient morbidity.[18] However, the NICE guidelines are broad and thus patients with seemingly benign but physiologically severe medical comorbidities remain eligible for THA.[18] One such example of this comorbidity type is compensated CHF. CHF can be diagnosed both based on objective measures such as ejection fraction evaluated by echocardiography, and clinical characteristics outlined in the Framingham criteria (including pulmonary edema, cardiomegaly, hepatojugular reflux, jugular venous distention, orthopnea, peripheral edema, and exertional dyspnea, among others).[19] CHF is present in 6-20% of patients undergoing treatment for a hip fracture.[20] Prior studies cite CHF as a risk factor for mortality following arthroplasty for femoral neck fracture.[20] However, these studies do not delineate the effect of compensation with CHF on mortality in this subpopulation. While decompensated CHF is generally treated with hemiarthroplasty, compensated CHF may be asymptomatic and thus be eligible for THA under the NICE guidelines.[18] This is despite the 3-fold increase in mortality with compensated CHF in the general population.[21] This study sought to determine the effect of heart failure compensation on the 30-day case-specific mortality rate following THA after an acute femoral neck fracture. The authors hypothesized that the impact of CHF on mortality after THA would be dependent on CHF severity.

Methods

A query of the National Surgical Quality Improvement Program (NSQIP) database from 2015-2018 for patients receiving a THA (current procedural terminology [CPT] code: 27130) or hemiarthroplasty (CPT code: 27236 and 27125) for an acute, closed, non-oncologic intracapsular femoral neck fracture (International Classification of Diseases, Tenth Revision [ICD10] code: S72.0xA or ICD9 code: 820.0-2) was performed. Independent analyses were run for the hemiarthroplasty and THA cohorts. Patients were initially stratified based on the presence or absence of pre-operative risk factors and the odds of death within 30-days of a hemiarthroplasty or THA for a femoral neck fracture. CHF was further classified into 3 categories based on the New York Heart Association criteria: mild (diagnosis of heart failure without dyspnea on exertion; compensated CHF), moderate (diagnosis of heart failure with moderate dyspnea on exertion; exertional CHF), and severe (heart failure with dyspnea at rest; decompensated CHF).[21] There were only 3 patients diagnosed with severe CHF so they were excluded from the THA cohort and analysis. Univariate analysis identified significant preoperative risk factors ($P<.10$) for inclusion in a multivariate logistic regression. Significance in the multivariate logistic regression was defined as $P<.003$ for hemiarthroplasty and $P<.004$ for THA after a Bonferroni correction for 16 hemiarthroplasty-associated and 14 THA-associated risk factors related to mortality on the prior univariate analysis.

Continuous variables were reported as mean and standard deviation, with comparisons conducted in univariate analysis via two-sided *t*-tests or analysis of variance. Categorical variables were reported as number and percent, with comparisons conducted in univariate analysis via chi-square tests. Results from multivariate logistic regression analysis were reported as adjusted odds ratio (AOR) and the 95% confidence interval (CI) not encompassing 1. All statistical computing was performed using Stata Release 15 (StataCorp LLC, College Station, TX).

Results

In the group of patients who received a total hip arthroplasty, the mean BMI was 25.7 kg/m^2, 69.1% were female, and the mean age was 72.3 years (**Table 1**). In the group of patients who received a hemiarthroplasty, the mean BMI was 24.7 kg/m^2, 67.9% were female, and the mean age was 80.3 (**Table 2**).

The 30-day mortality for a patient receiving a THA for femoral neck fracture without CHF was 1.8% (n=80). The presence of mild CHF increased the absolute risk of 30-day mortality to 14.3% (n=9) after THA for femoral neck fracture. The presence of moderate CHF increased the absolute risk to 21.4% (n=6). The 30-day mortality for a patient receiving a hemiarthroplasty for femoral neck fracture without CHF was 5.1% (n=1693). The absolute risk of 30-day mortality increased to 11.4% (n=106) with mild CHF, 13.9% (n=44) with moderate CHF, and 18.4% (n = 14) with severe CHF. A comparison of the mortality rates between patients who underwent total hip arthroplasty for femoral neck fracture with CHF versus patients without CHF, adjusted for BMI, sex, age, partial or total dependence for activities of daily living, COPD, insulin use, hypertension, dialysis dependence, pre-operative blood transfusion, pre-operative albumin level, and pre-operative hematocrit found that any level of CHF significantly increases the risk of 30-day mortality. When compared to the mortality of patients without CHF receiving THA for an acute femoral neck fracture, there was a severity dependent association with CHF (mild: adjusted odds ratio [AOR] 5.4, 95% confidence interval [CI] 2.2 - 13.4; moderate: AOR 12.0, CI 3.4 - 42.2; **Table 3**). THA for an acute femoral neck fracture had a number needed to harm (the number of patients receiving a treatment needed for one patient to experience the adverse outcome) of 8 for mild CHF and 5 for moderate CHF.

A comparison of the mortality rates between patients who underwent hemiarthroplasty after femoral neck fracture with CHF versus patients without CHF, adjusted for BMI, sex, age, partial or total dependence for activities of daily living, COPD, resting or exertional dyspnea, insulin use, tobacco use, hypertension, dialysis dependence, pre-operative blood transfusion, pre-operative albumin level and pre-operative hematocrit found that any level of CHF significantly increases the risk of 30-day mortality. When compared to the mortality of patients without CHF receiving a hemiarthroplasty for an acute femoral neck fracture, there was a severity dependent association with CHF (mild: AOR 1.6, CI 1.2 - 2.1; moderate: AOR 2.2, CI 1.5 - 3.3; severe: AOR 2.9, CI 1.4 - 5.9; **Table 3**). Hemiarthroplasty for an acute femoral neck fracture had a number needed to harm of 16 for mild CHF, 11 for moderate CHF, and 8 for severe CHF.

There was no statistically significant difference in 30-day postoperative mortality rates in patients with mild CHF who received hemiarthroplasty or THA (P=.54), or moderate CHF (P=.27) (**Table 4**).

Discussion

Prior studies have advocated for hemiarthroplasty in patients with an acute femoral neck fractures who also have medical comorbidities such as neurocognitive deficit, dialysis-dependence, and severe cardiopulmonary disease given the elevated postoperative morbidity and mortality risks associated with these preoperative characteristics.[3] Based on existing treatment paradigms, an acute femoral neck fracture in the setting of decompensated CHF is a clear indication for hemiarthroplasty. In comparison, with appropriate medical treatment, compensated CHF patients often

Table 1. Demographic Characteristics of Patients Undergoing Total Hip Arthroplasty for a Displaced Femoral Neck Fracture Stratified by Survival 30-days Post-operatively, National Surgery Quality Improvement Program Database 2015-2018

Variable	Whole Population (n=4486)	Surviving at 30-days (n=4391)	Mortality at 30-days (n=95)	*P*-value
Body Mass Index (kg/m^2)[a]	25.7 ± 5.6	25.7 ± 5.6	23.8 ± 6.4	.001
Sex (female)	3098 (69.1%)	3049 (67.9%)	49 (1.1%)	<.001
Age (years)	72.3 ± 11.2	72.1 ± 11.2	81.5 ± 8.7	<.001
Activities of Daily Living[a]				
Partial Dependence	323 (7.2%)	303 (6.7%)	20 (0.4%)	<.001
Total Dependence	52 (1.2%)	48 (1.1%)	4 (0.1%)	<.001
Chronic Obstructive Lung Disease	367 (8.2%)	349 (7.8%)	18 (0.4%)	.001
Dyspnea				
with Exertion	164 (3.7%)	159 (3.5%)	5 (0.1%)	.55
with Rest	21 (0.5%)	20 (0.4%)	1 (0.0%)	.55
Insulin Use	308 (6.9%)	296 (6.6%)	12 (0.3%)	.050
Tobacco Use	732 (16.3%)	3669 (81.8%)	85 (1.9%)	.159
Congestive Heart Failure				
Mild	63 (1.4%)	54 (1.2%)	9 (0.2%)	<.001
Moderate	28 (0.6%)	22 (0.5%)	6 (0.1%)	<.001
Hypertension	2601 (57.9%)	2537 (56.5%)	64 (1.4%)	.074
Dialysis Dependence	57 (1.3%)	52 (1.2%)	5 (0.1%)	.007
Pre-operative Transfusion	82 (1.8%)	76 (1.7%)	6 (0.1%)	.007
Pre-operative Albumin (g/d)[a]	3.6 ± 0.6	3.6 ± 0.6	3.1 ± 0.6	<.001
Pre-operative Hematocrit (%)	35.9 ± 14.2	35.9 ± 14.2	35.4 ± 14.7	.087

[a]Missing variables: Body mass index analyses excluded 251 patients with missing data; Activities of daily living analyses excluded 19 patients with missing data; Pre-operative albumin analyses excluded 1645 patients with missing data

show no outward clinical signs of their diagnosis.[22] Additionally, since CHF can be diagnosed clinically based on the presence of the criteria outlined in the Framingham study, or through the use of echocardiography to evaluate heart function by measuring ejection fraction, many patients can also be identified in early stages of heart failure when their symptoms are silent due to compensation despite the presence of the disease.[22] Despite the diagnosis of CHF, more advanced diagnostic work-up such as echocardiogram in this population often reveals minimal cardiac disease, and as a result these patients are often evaluated as being "medically optimized" for surgery.[8,18,23] Bohsali et al recently evaluated peri-operative outcomes following arthroplasty for a femoral neck fracture among patients with CHF; however, the study stratified severity of CHF based upon ejection fraction (preserved or unpreserved) as opposed to New York Heart Association criteria.[24] Though perioperative CHF is often evaluated based on echocardiographic results of ejection fraction, the New York Heart Association classification includes an ordinal scale of clinical status not encompassed with ejection fraction stratification alone making it more applicable to surgical screening.[25] The New York Heart Association classification of CHF severity is an independent predictor of CHF outcomes regardless of ejection fraction.[24-26] Prior studies also aggregated CHF into a single diagnosis despite the vast differences in the outcomes of compensated versus decompensated heart failure.[20,21,27] The decision-making algorithm for hemiarthroplasty versus THA is complex and the NICE guidelines are one method of guiding the surgeon to the most appropriate treatment option.[16] Data from studies investigating the long-term outcome of THA and hemiarthroplasty surgeries suggests the quality-of-life outcomes are equivalent between hemiarthroplasty and THA even up to 4-years after surgery.[28] Thus, a hemiarthroplasty may perform acceptably well for the lifetime of the compensated CHF patient. Additionally, if necessary, staged conversion to a THA is a well-tolerated procedure with excellent long-term outcomes.[29]

These findings indicate that there is a significantly increased risk of perioperative mortality after THA in patients with CHF of any severity. This effect included a dose response association, but even in mild CHF, the absolute risk was relatively large at an 8-fold increase when compared to patients without CHF (14.3% compared to 1.8%). The number needed to harm in this scenario was also low at 8. This effect can be reasonably considered to be clinically significant when weighing the risks and benefits of THA in this population.

Table 2. Demographic Characteristics for Patients Undergoing Hip Hemiarthroplasty for Displaced Femoral Neck Fracture Stratified by Survival 30-days Post-Operatively, National Surgery Quality Improvement Program Database 2015-2018

Variable	Whole Population (n=34282)	Surviving at 30-days (n=32425)	Mortality at 30-days (n=1857)	*P*-value
Body Mass Index (kg/m^2)†	24.7 (+/-5.2)	24.7 (+/-5.2)	23.6 (+/-5.1)	<.001
Female sex	23263 (67.9%)	22231 (64.8%)	1032 (3.0%)	<.001
Age (years)	80.3 (+/-10.1)	80.1 (+/-10.2)	84.6 (+/-7.3)	<.001
Functional Status				
Partial Dependence	6507 (18.9%)	5882 (17.2%)	625 (1.8%)	<.001
Total Dependence	1326 (3.9%)	1136 (3.3%)	190 (0.5%)	<.001
Chronic Obstructive Lung Disease	3619 (10.5%)	3298 (9.6%)	321 (0.9%)	<.001
Dyspnea				
with Exertion	1842 (5.4%)	1690 (4.9%)	152 (0.4%)	<.001
with Rest	304 (0.9%)	264 (0.8%)	40 (0.1%)	<.001
Insulin Use	2359 (6.9%)	2211 (6.4%)	148 (0.4%)	.004
Tobacco Use	3765 (10.9%)	3612 (10.5%)	153 (0.4%)	<.001
Congestive Heart Failure				
Mild	929 (2.7%)	823 (2.4%)	106 (0.3%)	<.001
Moderate	316 (0.9%)	272 (0.8%)	44 (0.1%)	<.001
Severe	76 (0.2%)	62 (0.2%)	14 (0.0%)	<.001
Hypertension	22594 (65.9%)	21306 (62.1%)	1288 (3.8%)	.001
Dialysis Dependence	629 (1.8%)	565 (1.6%)	64 (0.2%)	<.001
Preoperative Transfusion	787 (2.3%)	701 (2.0%)	86 (0.2%)	<.001
Preoperative Albumin (g/d)†	3.5 (+/-0.5)	3.5 (+/-0.5)	3.3(+/-0.6)	<.001
Preoperative Hematocrit (%)	35.6 (+/-11.6)	35.6 (+/-0.1)	34.9 (+/-0.3)	.018

Table 3. Multivariate Adjusted Odds of 30-day Mortality Stratified by Heart Failure Severity and Type of Arthroplasty, National Surgery Quality Improvement Program Database 2015-2018

Stratification	Adjusted Odds Ratio[a]	95% Confidence Interval	*P*-value
Total Hip Arthroplasty			
Mild Heart Failure	5.4	2.2-13.4	<.001
Moderate Heart Failure	12.0	3.4-42.2	<.001
Hemiarthroplasty			
Mild Heart Failure	1.6	1.2-2.1	<.001
Moderate Heart Failure	2.2	1.5-3.3	<.001
Severe Heart Failure	2.9	1.4-5.9	<.001

[a]Odds ratio adjusted for body mass index, sex, age, functional status, chronic obstructive lung disease, dyspnea, insulin use, tobacco use, hypertension, dialysis dependence, pre-operative transfusion, pre-operative albumin, and pre-operative hematocrit

There was also a similar dose-response association with mortality for patients undergoing hemiarthroplasty with CHF. In comparison to patients who underwent THA, however, the effect was reduced after hemiarthroplasty owing to the higher baseline peri-operative mortality rates in the hemiarthroplasty population. The impact on perioperative mortality after hemiarthroplasty was approximately double for mild or moderate CHF and triple for severe CHF, all of which were less than the 8-fold increase seen with mild CHF in THA patients. Cullen et al found the 1-year post-operative odds of death to be double when comparing those with and without CHF, which approximates the mortality seen in this hemiarthroplasty population.[21] This reflects an expected trend which is corroborated by the findings of this study, since hemiarthroplasty is generally indicated for patients with other severe medical comorbidities, in addition to CHF. When stratifying these populations, the data in this study demonstrates that combining compen-

Table 4. Comparative Statistics for 30-day Post-Operative Mortality Rates With Mild or Moderate CHF in Hemiarthroplasty Versus Total Hip Arthroplasty Patients, National Surgery Quality Improvement Program Database 2015-2018

Stratification	Surviving within 30 days	Dead within 30 days	*P*-value
Mild Heart Failure			
Total Hip Arthroplasty	54 (85.7%)	9 (14.3%)	.54
Hemiarthroplasty	823 (88.6%)	106 (11.4%)	
Moderate Heart Failure			
Total Hip Arthroplasty	22 (78.6%)	6 (21.4%)	.27
Hemiarthroplasty	272 (86.1%)	44 (13.9%)	

sated and decompensated CHF into a single diagnosis underestimates the mortality estimate of mild or moderate heart failure in the femoral neck fracture receiving a THA. The findings of this study did not demonstrate a statistically significant difference in 30-day mortality for THA compared to hemiarthroplasty in patients with CHF, which reflects the clinical implications of CHF on mortality risk. The patient population with CHF is clinically more like the baseline population of hemiarthroplasty patients who are indicated for hemiarthroplasty due to the presence of underlying medical comorbidities.

Compensated CHF is not a modifiable risk factor in the setting of either hemiarthoplasty or THA. Patients with mild CHF have significantly elevated 30-day post-operative mortality. As mentioned above, when compensated CHF is appropriately treated, it is often asymptomatic, and may even show minimal signs of disease with advanced diagnostic testing such as echocardiography.[8,18,22,23] When considering this alongside these findings that suggest that the mortality risk associated with CHF in patients undergoing hip arthroplasty is not modifiable, it appears that surgical teams may be able to rely on functional clinical status when risk stratifying for preoperative planning purposes, without warranting an echocardiogram. This offers the advantage of streamlining the process of pre-operative preparation by relying on clinical history, and preventing operative delays that may be incurred by pursuing additional diagnostic workup.

Limitations

The limitations to this study include the inherent inability to report causality due to the retrospective nature of the analysis. Additionally, the observations, while profound, are limited to 30-day post-operative mortality, and longer follow-up is necessary to further characterize the details of this relationship but suggest that this is the most optimistic view of the relationship between arthroplasty and CHF in the setting of an acute femoral neck facture. The lifetime association between CHF and mortality suggests the associations would increase with longer follow-up.[30] Though NSQIP is widely employed to report arthroplasty outcomes, it is subject to coding and data entry errors. However, interobserver reliability is reported to be greater than 98%.[31]

Conclusion

Patients with mild, compensated, CHF are often clinically asymptomatic and remain eligible under NICE guidelines to undergo THA following a femoral neck fracture. CHF is an independent risk factor for early postoperative mortality when arthroplasty is used to treat an acute femoral neck fractures with a number needed to harm of 8 in mild CHF patients receiving THA. CHF is a progressive disease, and although this study was limited in analysis to 30-days postoperatively due to the nature of the NSQIP database, the results indicate that even within that relatively short timeline, there was a high risk of mortality which significantly increased odds of death. Hemiarthroplasty and total hip arthroplasty are likely to be functionally equivalent for the expected lifetime of a patient with CHF, while hemiarthroplasty reduces a number of known surgical risks including increased anesthesia time, blood loss, and risk of requiring a blood transfusion.

Hence, the presence of CHF, regardless of compensation, should be considered as an appropriate indication for choosing hemiarthroplasty.

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