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ORIGINAL RESEARCH

Impact of Heart Failure on Hip Fracture Outcomes: A Population-Based Study

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BACKGROUND: Hip fracture and heart failure are becoming more prevalent conditions in hospitalized patients. Despite differences in postoperative outcomes from other intermediate risk procedures, guidelines classify hip fracture repair as an intermediate risk operation.

OBJECTIVE: This population-based study sought to examine the prevalence and incidence of heart failure in hip fracture patients.

DESIGN, SETTING, AND PATIENTS: We conducted a population-based historical cohort study of 1116 Olmsted County, MN residents undergoing 1212 hip surgeries from 1988 through 2002. Data were obtained through medical record review. Heart failure was defined by Framingham criteria.

RESULTS: The prevalence of preoperative heart failure in our study population was 27% (327 of 1212 cases). Those with preoperative heart failure demonstrated longer lengths of stay, were more often discharged to a skilled facility, and had higher inpatient mortality rates. Rates of postoperative heart failure were 6.7% at 7 days and 21.3% at 1 year. Postoperative heart failure was more common among those with preoperative heart failure (HR 3.0), and those with preoperative heart failure demonstrated higher postoperative mortality rates. Men had a higher risk of postoperative mortality compared to women. Overall survival was lowest among those with both preoperative and postoperative heart failure.

CONCLUSIONS: Heart failure represents a common and serious perioperative condition in hip fracture patients. Hip fracture patients with and without heart failure carry higher postoperative risk than guidelines may suggest. Future work must focus on the perioperative management of hip fracture patients with and without heart failure to mitigate postoperative morbidity. *Journal of Hospital Medicine* 2011;6:507–512. © 2011 Society of Hospital Medicine

As the population ages, hip fractures and heart failure increase in prevalence.[1,2] Heart failure prevalence is also increasing in hospitalized patients.[3] Indeed, hospitalizations involving heart failure as an active issue tripled in the last 30 years.[4] Heart failure has been associated with an increased risk for hip fracture,[5,6] and previous studies report a 6%–20% prevalence of preoperative heart failure in hip fracture patients.[7–10] While exacerbation of heart failure increases the mortality risk in patients admitted for hip fractures,[8] the incidence of new heart failure, as well as the preoperative factors that predict postoperative heart failure in this patient population remain unclear.

American College of Cardiology/American Heart Association (ACC/AHA) perioperative guidelines identify orthopedic surgeries, including hip fracture repair, as ''intermediate risk'' procedures.[11] Compared to other intermediate risk operations, however, postoperative outcomes following hip fracture repair differ significantly.[12–16] Overall mortality in hip fracture patients has been reported at 29% at one year,[8] with the excess mortality from hip fracture alone at nearly 20%.[10,13] However, the exact factors that contribute to this excess mortality, particularly with regard to heart failure, remain unclear.

To examine the preoperative prevalence, subsequent incidence, and predictors of heart failure in patients undergoing hip fracture repair operations, this study used an established, population-based database to compare the postoperative consequences in hip fracture repair patients with and without preexisting heart failure. We hypothesized that preoperative heart failure worsens postoperative outcomes in hip fracture patients.

METHODS

Case Ascertainment

Following approval by the Institutional Review Boards of Mayo Clinic and the Olmsted Medical Center, we used the Rochester Epidemiology Project (REP) to identify the patients for this study. The REP is a population-based medical records linkage system that records all diagnoses, surgical procedures, laboratory data, and death information from hospital, emergency room, outpatient, and nursing home care in the community.[17]

All Olmsted County, Minnesota, residents who sustained a hip fracture and underwent surgical repair

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from 1988 through 2002 were evaluated. Patients with more than one hip fracture during the study period (96 occurrences) were censored from the data analysis at the time of the subsequent hip fracture and then included as new cases. The complete enumeration of hip fracture episodes managed in the 3 Olmsted County hospital facilities (Mayo Clinic's Saint Mary's and Rochester Methodist Hospitals, and the Olmsted Medical Center Hospital) occurred in 3 phases: First, all hospitalizations with the surgical procedure (International Statistical Classification of Diseases, 9th Revision [ICD-9]) codes 79.15 (reduction, fracture, femur, closed with internal fixation), 79.25 (reduction, fracture, femur, open, without internal fixation), 79.35 (reduction, fracture, femur, open with internal fixation), 79.95 (operation, unspecified bone injury, femur), 80.05 (arthrotomy for removal of hip prosthesis), 80.15 (arthrotomy, other, hip), 80.95 (excision, hip joint), 81.21 (arthrodesis, hip), 81.40 (repair hip, not elsewhere classified), 81.51 (total hip replacement), 81.52 (partial hip replacement), and 81.53 (revision hip replacement) were identified. Second, through review of the original inpatient and outpatient medical records, we confirmed that a fracture was associated with the index hospitalization. Finally, radiology reports of each index hospitalization verified the presence and exact anatomical location of each fracture. Of those with fractures on admission x-rays, only patients with a proximal femur (femoral neck or intertrochanteric) fracture as the primary indication for the surgery were included in the study. Surgical report or radiographic evidence of hip fracture was available for all patients. Secondary fractures due to a specific pathological lesion (eg, malignancy) or high-energy trauma (by convention, motor vehicle accidents or falls from significant heights) were excluded. Only patients who had provided an authorization to review their medical records for research were ultimately included in the study cohort.[18] Medical records were searched manually, if indicated.

Criteria for Heart Failure and Death

Preoperative heart failure was based on clinical documentation of heart failure in a patient's medical record prior to the time of the hip fracture repair. Postoperative heart failure, including acute exacerbations, was defined according to Framingham criteria.[19] Framingham criteria included clinical evidence of increased central venous pressure, pulmonary edema, an S3 gallop, radiographic pulmonary edema, and response to diuresis. Heart failure was not graded on clinical severity (ie, New York Heart Association classification). We did not distinguish between systolic and diastolic heart failure. Mortality was defined as death from any cause within the first year following hip fracture repair. Deaths were identified either through REP resources or the National Death Index.

Statistical Methods

Continuous variables are presented as mean ± standard deviation and categorical variables as a number (percent). Two-sample *t* tests or Wilcoxon rank sum tests were used to test for significant differences in continuous variables. Chi-square or Fisher's exact tests were used for categorical variables. Rates of postoperative outcomes were calculated using the Kaplan–Meier method for the overall group and for those with and without preoperative heart failure. A landmark survival curve was used to evaluate postoperative mortality among patients who experienced heart failure in the first 7 postoperative days versus those who did not. Patients who died or underwent another hip operation within the first 7 postoperative days were excluded from this analysis. Univariate Cox proportional hazards models were used to evaluate the predictors of postoperative heart failure and mortality. Patients who died or experienced a second hip surgery within 1 year of their first were censored at that time. Any subsequent hip fracture repair was treated as a new case. To account for the inclusion of multiple hip fracture repairs for a given patient, the Cox proportional hazards model included a robust variance estimator. This provided an accurate calculation of the standard error in the presence of within-subject correlation.[20] Statistical tests were two-sided, and *P* values were considered significant if less than 0.05. Statistical analyses were performed using SAS (version 9.1.3, SAS Institute, Cary, NC).

RESULTS

From among 1327 potential hip fracture repairs, we excluded 115 cases involving multiple injuries or operations (19), pathological fractures (20), in-hospital fractures (3), or an operation >72 hours after the initial fracture (5). Three patients under 65 years of age were also excluded, as were cases with missing information (9) or cases managed nonoperatively (56). The final analysis included 1212 surgical cases in 1116 subjects. No subjects were lost to surveillance for 1 year following their hip fracture repair.

Table 1 summarizes the baseline characteristics of the study population. The overall prevalence of preoperative heart failure was 27.0% (327 of 1212). Those with preoperative heart failure were older, heavier, more likely male and white, and less likely to live independently preoperatively. They were also more likely to suffer from preexisting cardiovascular comorbidities.

Table 1 also summarizes the main outcome characteristics of the study population. Those with preoperative heart failure had longer mean lengths of stay (LOS), were more often discharged to a skilled facility, and demonstrated higher inpatient mortality rates.

Table 2 summarizes the outcomes associated with preoperative heart failure. The overall rate of postoperative heart failure was 6.7% within 7 postoperative days and 21.3% within 1 postoperative year.

TABLE 1. Baseline Characteristics and Outcomes Among Olmsted County, Minnesota, Residents Undergoing Hip Fracture Repair, 1988–2002, by Preoperative Heart Failure Status

	All (N = 1,212)‡	HF (N = 327)‡	No HF (N = 885)‡	*P* Value*
Demographics				
Mean age (years) (SD)	84.2 (7.44)	85.5 (6.54)	83.7 (7.70)	0.0010[1]
Male gender	237 (19.6)	76 (23.2)	161 (18.2)	0.0491[2]
Mean BMI (kg/m^2)† (SD)	23.3 (4.97)	24.1 (5.68)	23.0 (4.65)	0.0123[1]
White	1,204 (99.3)	322 (98.5)	882 (99.7)	0.0371[3]
Preoperative living situation				
Nursing facility	468 (38.6)	144 (44)	324 (36.6)	0.0184[2]
Home	744 (61.4)	183 (56)	561 (63.4)	0.0519[2]
Preoperative ambulatory status†				
Dependent	149 (12.3)	50 (15.3)	99 (11.2)	
Independent	1,061 (87.7)	276 (84.7)	785 (88.8)	
Medical history				
Hypertension	705 (58.2)	226 (69.1)	479 (54.1)	<0.0001[2]
Diabetes mellitus	143 (11.8)	63 (19.3)	80 (9)	<0.0001[2]
Cerebrovascular disease	331 (27.3)	129 (39.4)	202 (22.8)	<0.0001[2]
Peripheral vascular disease	195 (16.1)	80 (24.5)	115 (13)	<0.0001[2]
Coronary artery disease	464 (38.3)	237 (72.5)	227 (25.6)	<0.0001[2]
Atrial fibrillation/flutter	254 (21)	133 (40.7)	121 (13.7)	<0.0001[2]
Complete heart block	18 (1.5)	9 (2.8)	9 (1)	0.0337[3]
Pacer at time of admission	32 (2.6)	16 (4.9)	16 (1.8)	0.0029[2]
Chronic obstructive pulmonary disease	196 (16.2)	78 (23.9)	118 (13.3)	<0.0001[2]
Liver disease	15 (1.2)	7 (2.1)	8 (0.9)	0.1375[3]
Chronic renal insufficiency§	131 (10.8)	61 (18.7)	70 (7.9)	<0.0001[2]
Mean length of hospitalization (days) (SD)	10.0 (7.57)	11.1 (8.82)	9.6 (7.01)	0.0010[1]
Discharge disposition†				0.0019[2]
Home	150 (12.4)	26 (8.0)	124 (14.0)	
Skilled nursing facility	1,004 (82.9)	278 (85.0)	726 (82.1)	
Dead	57 (4.7)	23 (7.0)	34 (3.9)	

Abbreviations: BMI, body mass index; HF, heart failure; SD, standard deviation.
**P* values for those with, vs without, preoperative heart failure ([1]Rank sum, [2]Chi-square, [3]Fisher's exact). †BMI data were missing for 15 cases, preoperative ambulatory status was missing for 2 cases, and discharge disposition was missing for 1 case. ‡All values are N (%) unless otherwise noted. §Chronic renal insufficiency was defined as a creatinine >2.0 mg/dL.

TABLE 2. Association of Preoperative Heart Failure With Postoperative Outcomes Among Olmsted County, Minnesota, Residents Undergoing Hip Fracture Repair, 1988–2002

	Preoperative Heart Failure (Subjects)				
Outcome	All (N = 1212)	No (N = 885)	Yes (N = 327)	Risk ratio* (95% CI)	*P* Value
Heart failure exacerbation within seven postoperative days†	6.7% (5.4, 8.3)	4.8% (3.5, 6.5)	12.1% (8.7, 16.2)	2.72 (1.72, 4.31)	<0.0001
One-year postoperative heart failure exacerbation‡	21.3% (18.8, 23.7)	15.0% (12.5, 17.4)	39.3% (33.3, 44.9)	3.00 (2.32, 3.87)	<0.0001
One-year postoperative mortality‡	24.5% (22.0, 26.9)	19.8% (17.1, 22.4)	37.2% (31.6, 42.3)	2.11 (1.67, 2.67)	<0.0001
One-year postoperative mortality or heart failure exacerbation‡	36.5% (33.7, 39.2)	29.7% (26.6, 32.6)	55.0% (49.3, 60.2)	2.28 (1.88, 2.76)	<0.0001

Abbreviations: CI, confidence interval.
* Risk ratio for those with vs without preoperative heart failure. Odds ratios were calculated using logistic regression for the outcome of heart failure exacerbation within seven postoperative days; hazard ratios were calculated using Cox proportional hazards models for each of the one-year outcomes. †Excluded 26 cases in which a patient died in hospital without postoperative heart failure. ‡One-year rates were estimated using the Kaplan–Meier method.

Postoperative heart failure was significantly more common among those with preoperative heart failure (hazard ratio [HR], 3.0; 95% confidence interval [CI], 2.3 to 3.9; $P < 0.001$). Among those without preoperative heart failure, rates of postoperative incident heart failure were 4.8% at 7 days and 15.0% at 1 year. Compared to patients without preoperative heart failure, those with preoperative heart failure demonstrated higher one year mortality rates and higher rates of postoperative heart failure at 7 days and 1 year.

Figure 1 displays the outcomes to 1 year of surveillance. Rates of postoperative heart failure and postoperative mortality were consistently higher among those with, versus without, preoperative heart failure. Figure 2 displays similar data stratified by gender. Postoperative heart failure rates did not differ significantly between genders (HR, 1.0; 95% CI, 0.8 to 1.4), but postoperative mortality rates were significantly higher among males than females (HR, 1.9; 95% CI, 1.5 to 2.5; $P < 0.001$).

Figure 3 displays survival rates to 1 year based on the occurrence of incident or recurrent heart failure within the first 7 postoperative days. Survival rates were lowest among patients with recurrent heart failure in the first 7 postoperative days and highest

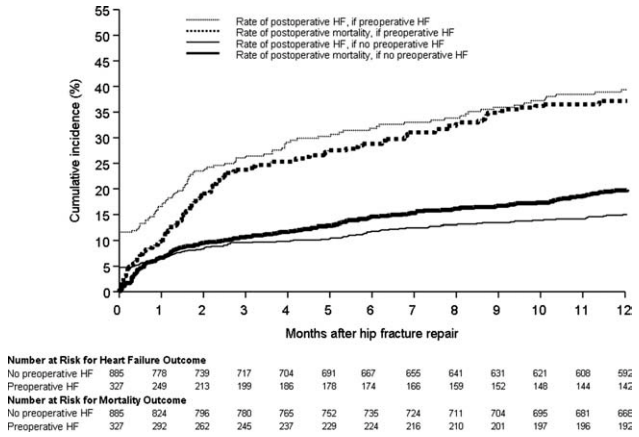

FIG. 1. Cumulative incidence of postoperative outcomes among Olmsted County, Minnesota, residents undergoing hip fracture repair, 1988–2002, by preoperative heart failure status. **Abbreviations:** HF, heart failure.

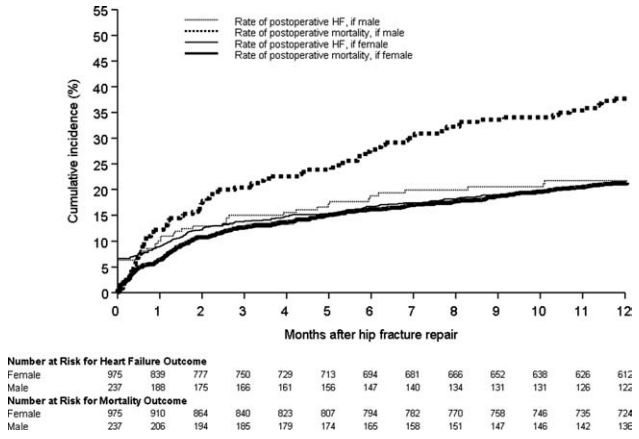

FIG. 2. Cumulative incidence of postoperative outcomes among Olmsted County, Minnesota, residents undergoing hip fracture repair, 1988–2002, by gender. **Abbreviations:** HF, heart failure.

among those with no preoperative or postoperative heart failure. Subjects with incident heart failure in the first postoperative week, and those with preoperative heart failure who did not suffer a recurrence, demonstrated intermediate survival rates ($P < 0.001$ for trend across all four groups).

DISCUSSION

This population-based study found that heart failure represents a highly prevalent condition in elderly patients undergoing hip fracture repairs. It demonstrates that those with preoperative heart failure typically suffer from more cardiovascular comorbidities and carry a higher risk of postoperative heart failure and postoperative mortality.

While many studies have focused on the epidemiology of hip fractures,[21] population-based data on cardiac complications following hip fracture repair are significantly less common. The ACC/AHA preoperative cardiac evaluation guidelines classify orthopedic procedures, including hip fracture repair, as "intermediate risk."[11] Consequently, some may assume that all orthopedic patients will have a mortality rate less than 5%. Indeed, the 30-day postoperative mortality rate published from our institution's Total Joint Registry was 0.6% following elective total hip arthroplasty.[22] However, the present study demonstrates that current ACC/AHA preoperative cardiac evaluation guidelines may not apply to the population of frail patients undergoing hip fracture repair. Particularly among those who experience new heart failure within the first seven days following surgery, outcomes are substantially worse than the ACC/AHA perioperative guidelines may suggest.[11]

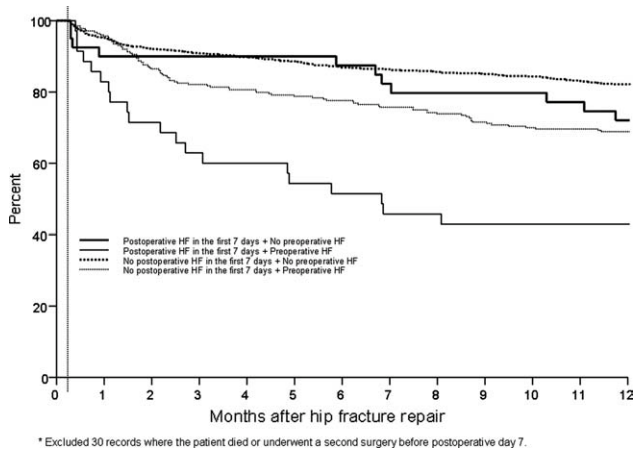

FIG. 3. Landmark survival curve to outcome of survival, by heart failure status; excluded 30 records where the patient died or underwent a second surgery before postoperative day 7. **Abbreviations:** HF, heart failure.

Preoperative heart failure has been associated with adverse risk for postoperative mortality after hip fracture.[9,10,12] However, these studies did not report heart failure as a complication of hip fracture repair. A prospective cohort study of 2448 hip fracture patients at an academic hospital in Great Britain found a 5% rate of inpatient heart failure as a postoperative complication.[23] The hazard ratio for one-year mortality was 11.3 with postoperative heart failure.[23] However, the British study did not distinguish heart failure from other cardiovascular diseases as a preoperative comorbidity or stratify the risk for postoperative mortality by preoperative heart failure status.[23] Our findings add to previous literature by measuring heart failure as a specific complication of hip fracture repair and examining the association of preoperative heart failure with postoperative heart failure and mortality.

Length of stay after hip fracture repair varies in the literature, but previous work has not clearly associated heart failure with length of hospitalization in the setting of hip fracture repair.[24,25] Our study found a significantly higher mean length of stay among those with preoperative heart failure. This adds to previous work by delineating an association between heart failure and increased length of stay after hip fracture repair.

We found a higher rate of postoperative mortality among men compared to women. Rates of postoperative heart failure, however, were more similar (Figure 2). Previous studies have found a consistently higher

mortality rate among men versus women after hip fracture.[9,23,25–29] Possible explanations for these findings include the overall increased burden of cardiovascular disease among men, lower treatment rates of osteoporosis in men,[30] and increased susceptibility to other postoperative complications, such as infection.[25]

The findings of this study carry important clinical implications for the perioperative care of hip fracture patients with, or at risk for, heart failure. They suggest that current risk stratification guidelines classifying orthopedic operations as ''intermediate risk'' procedures do not reflect the high risk for morbidity that hip fracture patients face.[11] The association of heart failure with adverse outcomes implies the need for heightened surveillance in the perioperative period, particularly with regard to volume status and medication reconciliation. Hip fracture patients and their families must be counseled about the ramifications of perioperative heart failure, including higher rates of postoperative heart failure, longer hospitalizations, and ultimate mortality.

This research carries several limitations and remains subject to biases inherent in retrospective cohort studies. The reported effects of heart failure on outcomes after hip fracture repair may be due to confounding from age, functional status, and other comorbidities. We attempted to minimize sampling bias through complete enumeration of hip fracture surgeries among Olmsted County residents. Completeness of follow-up (100% at one year) was possible given the availability of documentation of all inpatient and outpatient medical care in the community.[17] We used objectively defined outcomes to minimize measurement bias. Applicability to a more diverse population may be limited because >95% of the research population was from a single, predominantly white community. However, prior studies have documented that hip fracture incidence rates[31] and socioeconomic factors[17] in Olmsted County are similar to those for other white residents of the United States. Heart failure rates were determined clinically according to the Framingham criteria. However, the Framingham criteria may inappropriately diagnose individuals with heart failure[32] and falsely elevate the prevalence of heart failure as a preoperative comorbidity or postoperative complication.

The statistical analysis included patients counted multiple times if they underwent subsequent hip fracture repair during the study period. Including these patients may inaccurately inflate event rates or contribute to incorrect estimates of standard error. However, we felt it was appropriate to include recurrent hip fracture repair cases in the analysis because they represent a clinically distinct patient from both a medical and functional perspective. We used a robust variance estimator in the Cox proportional hazards models to provide an accurate calculation of the standard error given the possibility for correlation within subjects.[20] Finally, the proportion of these patients was low (94 of 1116 unique patients; 8.4%).

Future work must involve further risk stratification and therapeutic interventions in perioperative hip fracture patients. A more robust analysis of heart failure, with differentiation between systolic and diastolic dysfunction, may facilitate risk stratification. Assessment of compliance with standard preoperative heart failure medications and the impact of heightened clinical vigilance may enlighten means to improve postoperative outcomes. Studies on risk stratification and therapeutic interventions may then inform policy regarding length of stay and reimbursement in hip fracture patients.

CONCLUSION

In summary, our population-based findings reveal that heart failure represents a prevalent and serious comorbidity in patients undergoing hip fracture repair. Clinicians caring for perioperative hip fracture patients must pay particular attention to risk for, and implications of, new or recurrent heart failure.

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