Article

Predictors of Mobility and Frailty Outcomes in Older Patients Living with Dementia Undergoing Hip Fracture Surgery: A Retrospective Observational Cohort Study

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ABSTRACT

Older adults with dementia are at increased risk of hip fracture requiring surgery and poor postoperative outcomes. However, less is known about how dementia severity affects short-term recovery, including mobility and frailty during hospitalization. We conducted a retrospective cohort study of patients aged ≥ 75 years with dementia undergoing hip fracture surgery. Mobility and frailty at discharge were analyzed using multivariable ordered logistic regression models adjusting for age, sex, Charlson Comorbidity Index, baseline mobility, baseline frailty, and postoperative delirium. Among 265 patients, mobility data were available for 254 patients, of which 75.6% had lower mobility at discharge. Among patients with complete frailty data (n = 247), 63.6% had higher frailty scores at discharge. Increasing dementia severity was strongly associated with worse mobility and higher frailty. Compared with mild dementia, moderate dementia was associated with higher odds of worse mobility (odds ratio (OR) 3.09, 95% confidence intervals (CI) 1.46–6.59), and severe dementia with substantially higher odds (9.05, 3.06–26.75). Baseline mobility was also independently associated with discharge mobility, with higher odds among those requiring a gait aid (2.30, 1.25–4.22) and those who were assist-dependent or non-ambulatory (6.34, 2.45–16.38). For frailty, postoperative delirium (2.37, 1.32–4.28), higher baseline frailty (2.68 per point increase, 1.61–4.47), and increasing dementia severity (moderate: 5.03, 2.18–11.61; severe: 6.59, 2.15–20.21) were independently associated with higher frailty at discharge. Dementia severity and baseline function are important factors in discharge planning and rehabilitation, while delirium prevention may mitigate frailty worsening during hospitalization after hip surgery.

KEYWORDS: geriatrics; dementia; surgery; frailty; postoperative mobility; postoperative delirium

ABBREVIATIONS

OR, odds ratio; CI, confidence interval; CCI, Charlson Comorbidity Index; VIF, variance inflation factor; SD, standard deviation

INTRODUCTION

Dementia has been recognized as a growing public health concern, especially with an aging population. In 2050, it is estimated that 131.5 million people globally will have some form of dementia [1]. Dementia is characterized by progressive cognitive decline and functional impairment, with severity ranging from mild to severe.

Hip fractures are some of the most common but serious injuries among older adults. Compared to the general population, people with dementia are almost three times more likely to fall and fracture their hip [2–4]. Following hip fracture surgery, patients with dementia have higher rates of complications, including breathing difficulties, cardiac events, or urologic complications [5,6]. They are also more likely to be discharged to a long-term care home [7], experience functional decline [8], and die within the first year after surgery [9].

Most studies examining the relationship between dementia and hip fracture surgery have treated dementia as a binary variable (present or not) [6,10,11] and have typically focused on discharge location [8] or mortality rates [9,11,12]. However, less is known about how dementia severity affects acute in-hospital recovery outcomes, specifically mobility at discharge and frailty at discharge. Some prior studies have examined functional recovery outcomes in patients with cognitive impairment following hip fracture surgery, including overall mobility, walking ability, and physical performance measures such as grip strength [8,13,14]. While some prior studies have used grip strength as a proxy for frailty, grip strength primarily reflects physical frailty and does not capture the multidimensional cognitive and functional domains incorporated with the Clinical Frailty Scale (CFS) [15,16]. Additionally, while frailty is known to be a relevant predictor of recovery after surgery [17,18], most studies assess frailty at baseline or examine change over months to years, with little research evaluating acute in-hospital changes in frailty, especially in dementia patients [19,20]. Understanding the individual contributions of dementia severity and baseline mobility to short-term recovery outcomes is crucial. Although related, mobility and frailty capture different aspects of postoperative recovery. Frailty is a multidimensional state of physiological vulnerability [21], whereas mobility represents a specific domain of physical function [22]. Clarifying these predictors may inform individualized care planning, rehabilitation programs, and discharge decisions for patients with dementia.

The objective of this study was to evaluate predictors of mobility and frailty at discharge among older adults with dementia undergoing hip fracture surgery. We hypothesized that greater dementia severity would be independently associated with worse mobility at discharge and higher frailty at discharge.

MATERIALS AND METHODS

Study Design and Population

We conducted a retrospective observational cohort study using chart review. We included patients 75 years or older with a diagnosis of dementia admitted with hip fracture to the QEII Health Sciences Centre, a Canadian urban academic quaternary care hospital, between 2012 January 1, and 2017 December 31. Hip fracture cases were identified using diagnostic codes for hip fracture, femoral neck fracture and intertrochanteric fracture as the reason for admission and further filtered by age (≥75). Dementia diagnoses were identified within this group using diagnostic codes retrieved from reported past medical history that included dementia and Alzheimer's disease. Recognizing the potential for under-capturing dementia in the health record, we also included diagnostic codes for cognitive impairment. Chart review was conducted by a senior general internal medicine subspecialty resident to confirm a diagnosis of dementia by reviewing the admission note, listed past medical history, and functional and cognitive assessment forms. In cases where cognitive impairment was the listed medical diagnosis, when it was clear that the patient had progressive functional impairment due to cognitive impairment, we considered this to be congruent with a diagnosis of dementia. Patients were excluded if they had a listed diagnosis of cognitive impairment for reasons other than dementia (i.e., developmental delay, traumatic brain injury) or if there was no proof in the electronic health record that cognitive impairment mapped to progressive functional impairment. Patients who did not receive surgery during admission for hip fracture were excluded. Baseline (pre-fracture) mobility and frailty were obtained from admission documentation in the medical record, as well as clinician, physiotherapy, and occupational therapy documentation describing pre-hospitalization status.

Exposure

The exposure of interest, dementia severity, was captured through chart review. This study did not retrospectively establish new dementia diagnoses; rather, patients were identified using documented dementia or cognitive impairment diagnoses within the electronic health record. We categorized dementia severity as mild, moderate, or severe/very severe using the functional assessment staging (FAST) scale [23]. In cases where dementia severity was not identified in the listed past medical history, we considered the highest level of functional impairment that was clearly not associated with physical disease or disability to inform the stage of dementia. Using the FAST scale, mild dementia is associated with mild functional impairment (i.e., dependency for instrumental activities of daily living (IADLs)), moderate dementia is associated with moderate functional impairment (i.e., requiring assistance with basic activities of daily living (BADLs)), and severe/very severe dementia is associated with severe functional impairment (i.e., dependency for BADLs). We logged cases where functional impairment was unknown as dementia of unknown stage. In cases of uncertainty, clinical details were discussed with the supervising investigator, a specialist in General Internal Medicine and frailty care (author NS).

Outcomes

The primary outcome examined was mobility at discharge. We recorded both "baseline" mobility (pre-fracture information extracted from the admission note) and discharge mobility (postoperative mobility assessment extracted from the last physiotherapy note). We categorized mobility using a functional scale based on the hierarchical assessment of balance and mobility, identifying four levels: independent, independent with gait aid, assist-dependent, and non-ambulatory [24]. Mobility was treated as an ordinal outcome, with higher values indicating worse mobility. Each mobility category was assigned a value (1 = independent, 2 = independent with gait aid, 3 = assist-dependent, and 4 = non-ambulatory). The secondary outcome was frailty at discharge. This was assessed using the Clinical Frailty Scale (CFS) at baseline (pre-admission) and at discharge [25]. Patients were classified as living with mild (CFS 5), moderate (CFS 6) or severe/very severe frailty (CFS 7 and 8). As this cohort had dementia, and dementia staging correlates to frailty stage, there were no patients with CFS 1–4 levels of frailty. For patients with non-dementia-related illness contributing to functional impairment, their frailty stage was mapped to the greatest degree of functional impairment experienced. The CFS is a scale that ranges from 1–8, with higher numbers indicating higher frailty [26].

Predictors

Model covariates were selected a priori based on their clinical relevance and availability in the dataset. They included age [27,28], sex [29,30], CCI [31,32], dementia severity [33], postoperative delirium [34], baseline frailty score [35], and baseline mobility [36]. These variables were chosen as they represent key demographic, comorbidity, and functional status factors that are known to influence postoperative recovery in older adults with hip fractures. This approach was chosen over data-driven variable selection to reduce the risk of overfitting the model and to ensure the inclusion of clinically important covariates, regardless of statistical significance. CCI scores were calculated retrospectively from documented comorbidities listed in the electronic health record using the ICD-10 diagnosis codes. Comorbidities were identified and weighted according to the original Charlson criteria [37] using the updated mapping algorithms [38]. Scores were further adjusted for age by adding one point for every decade over 40 years [39]. We recorded postoperative delirium as a binary variable. It was identified through retrospective review of physician and nursing documentation. In the absence of standardized screening during the study period, delirium was considered present when explicitly documented by the treating clinical team. Preoperative delirium was not systematically captured and was therefore not included in the analysis.

Statistical Analysis

We used descriptive statistics to summarize baseline demographic and clinical characteristics, stratified by sex. Continuous variables were reported as means with standard deviations, and categorical variables as frequencies with percentages. We then looked at changes in mobility and frailty from baseline to discharge by reporting the median and interquartile range (IQR). These changes were further assessed statistically using the Wilcoxon signed-rank test due to the ordinal nature of these variables. The median length of stay for patients in the cohort was also reported to provide additional clinical context.

Regression Analysis

We constructed two multivariable ordered logistic regression models. Model 1 examined predictors of mobility at discharge, and Model 2 examined predictors of frailty at discharge. Covariates for both models were selected a priori based on clinical relevance and are described above. Patients with missing covariate or outcome data were excluded from multivariable analyses using complete case analysis. The categories for mobility before admission had to be combined for the regression. This is because one of the groups did not have enough observations to be able to run the regression; specifically, assist-dependent and non-ambulatory categories were combined.

Model Assumptions

Assumptions for ordered logistic regression were assessed prior to model interpretation. The proportional odds assumption was evaluated using generalized ordered logistic regression with autofit constraints (gologit2). Multicollinearity was assessed using variance inflation factors (VIFs). Linearity of continuous predictors on the logit scale was evaluated using restricted cubic spline models for age and CCI. No evidence of problematic multicollinearity or clinically meaningful nonlinearity was identified. Odds ratios with 95% confidence intervals were reported, with statistical significance set at $p < 0.05$. All statistical analyses were conducted using Stata version 18.0.

RESULTS

Cohort Characteristics

The study included 265 patients aged 75 years and older with dementia who were admitted to the hospital for hip fracture surgery. Baseline demographic and clinical characteristics stratified by sex are presented descriptively in Table 1. The mean age was 86.8 years (SD 5.4) for females and 85.7 years (SD 5.7) for males. Males had a higher mean CCI (4.1) compared to females (2.7). Severe dementia was seen in 39.0% of females and 34.3% of males. Most patients underwent hemiarthroplasty (81.5% of females, 80.0% of males), and almost half of the patients were living in long-term care homes before admission to the hospital.

Table 1. Baseline demographics of hip surgery patients stratified by sex (n = 265).

	Male (n = 70)	**Female (n = 195)**
Age, mean (SD)	85.7 (5.7)	86.8 (5.4)
CCI, mean (SD)	4.1 (2.6)	2.7 (2.1)
Pre-admission frailty, mean (SD)	6.2 (0.83)	6.2 (0.91)
Dementia severity, n (%)		
Mild	25 (35.7%)	50 (25.6%)
Moderate	21 (30.0%)	67 (34.4%)
Severe	24 (34.3%)	76 (39.0%)
Unknown	0 (0.0%)	2 (1.0%)
Surgery type, n (%)		
ORIF/IM nail	12 (17.1%)	33 (16.9%)
Hemiarthroplasty	56 (80.0%)	159 (81.5%)
Total hip arthroplasty	1 (1.4%)	2 (1.0%)
Unknown	1 (1.4%)	1 (0.51%)
Pre-residence, n (%)		
Independently living at home	11 (15.7%)	14 (7.2%)
Independently living in apartment	7 (10.0%)	13 (6.7%)
House with care	6 (8.6%)	27 (13.9%)
Apartment with care	4 (5.7%)	12 (6.2%)
Assisted living	9 (12.9%)	31 (15.9%)
Nursing home	33 (47.1%)	96 (49.2%)
Unknown	0 (0.0%)	2 (1.0%)
Mobility before admission, n (%)		
Independent	29 (41.4%)	53 (27.2%)
Independent with gait aid	33 (47.1%)	110 (56.4%)
Assist	2 (2.9%)	14 (7.2%)
Non-ambulatory	5 (7.1%)	18 (9.2%)
Unknown	1 (1.4%)	0 (0.0%)

Notes: CCI = Charlson Comorbidity Index; SD = standard deviation. CCI data were missing for 3 patients, 1 female and 2 males. Pre-admission frailty scores were missing for 6 patients, all female.

Changes in Mobility and Frailty

Postoperative delirium occurred in 110 of 261 patients (42.1%) with available data (4 missing), with a higher proportion among males (54.3%) than females (36.9%). Data for mobility change were available for 254 patients. Overall, 192 of 254 patients (75.6%) experienced a decline in mobility after surgery. The median change in mobility from baseline to discharge was 1 point (IQR 0–2). Paired analysis using the Wilcoxon signed-rank test showed a significant decrease in mobility between baseline and discharge status ($z = 13.13$, $p < 0.001$). Among 247 patients with complete frailty data, 157 (63.6%) had higher frailty scores at discharge compared with baseline. This difference was statistically significant ($z = 12.09$, $p < 0.001$). The median change in frailty score was 1 point (IQR 0–1). Median length of stay was 11 days (IQR 6–32), range 1–330 days. Of 265 patients, 243 were included in the mobility model, and 242 were included in the frailty model after the exclusion of cases with missing covariates or outcome data.

Predictors of Mobility at Discharge

To assess predictors of mobility at discharge, we conducted a multivariable ordered logistic regression adjusting for age, sex, comorbidities, delirium, dementia severity, baseline frailty, and baseline mobility (Table 2). The overall model was statistically significant (LR $\chi^2(9) = 77.6$, $p < 0.001$).

Increasing dementia severity was independently associated with higher odds of worse mobility at discharge. Compared to patients with mild dementia, those with moderate dementia had three times the odds of worse discharge mobility (odds ratio (OR) 3.09, 95% confidence intervals (CI) 1.45–6.59, $p = 0.003$). Those with severe dementia had over nine times higher odds (9.05, 3.06–26.75, $p < 0.001$). Postoperative delirium was not significantly associated with worsened discharge mobility (1.47, 0.82–2.64, $p = 0.193$).

Baseline mobility was independently associated with mobility at discharge. Compared with patients who were independently mobile before admission, those requiring a gait aid had twice the odds of worse discharge mobility (2.30, 1.25–4.22, $p = 0.007$), and those who were assist-dependent or non-ambulatory had six times higher odds (6.34, 2.45–16.38, $p < 0.001$).

Age (0.99, 0.94–1.04, $p = 0.734$), male sex (1.81, 0.96–3.39, $p = 0.065$), CCI (1.09 per point increase, 0.97–1.23, $p = 0.165$), and baseline frailty score (1.14, 0.71–1.84, $p = 0.578$) were not independently associated with discharge mobility. There was no evidence of multicollinearity among included variables (max VIF 3.83). The proportional odds assumption was satisfied based on the global Wald test from the partial proportional odds model (Wald $\chi^2(8) = 9.60$, $p = 0.295$). Restricted cubic spline analyses demonstrated no evidence of clinically meaningful nonlinear associations for age or CCI. Dementia severity and baseline mobility showed the strongest independent associations with discharge mobility (Table 2).

Table 2. Multivariable ordered logistic regression examining factors that predict mobility at discharge (n = 243).

	Odds Ratio	95% Confidence Interval	p-Value
Age	0.99	0.94–1.04	0.734
Male sex	1.81	0.96–3.39	0.065
CCI (per point increase)	1.09	0.97–1.23	0.165
Postoperative delirium	1.47	0.82–2.64	0.193
Frailty before admission	1.14	0.71–1.84	0.578
Dementia severity			
Moderate dementia	**3.09**	**1.45–6.59**	**0.003**
Severe dementia	**9.05**	**3.06–26.75**	**<0.001**
Mobility before admission			
Independent with gait aid	**2.30**	**1.25–4.22**	**0.007**
Assist/non-ambulatory	**6.34**	**2.45–16.38**	**<0.001**

Notes: OR = odds ratio; CI = confidence interval; CCI = Charlson Comorbidity Index. Reference categories: female sex, mild dementia, and independent mobility. Bold values indicate statistical significance ($p < 0.05$).

Predictors of Frailty at Discharge

In Table 3, the fully adjusted multivariable ordered logistic regression model (n = 242) revealed that postoperative delirium was independently associated with higher frailty at discharge (2.37, 1.32–4.28, p = 0.004). Higher baseline frailty was also associated with greater frailty at discharge (2.68 per one-point increase, 1.61–4.47, p < 0.001).

Dementia severity remained strongly associated with frailty at discharge despite adjustment for baseline frailty. Compared to patients with mild dementia, those with moderate dementia had increased odds of higher frailty at discharge (5.03, 2.18–11.61, p < 0.001), as did those with severe dementia (6.59, 2.15–20.21, p = 0.001).

Age, sex, and pre-admission mobility with a gait aid were not independently associated with higher frailty at discharge. Patients who were assist-dependent or non-ambulatory prior to admission showed a trend toward increased odds of higher frailty at discharge, although this did not reach statistical significance (2.23, 0.99–5.04, p = 0.054). Charlson Comorbidity Index was not significantly associated with higher frailty at discharge, though there was a trend toward increased odds (1.13 per point increase, 0.99–1.28, p = 0.062). Model diagnostics demonstrated no evidence of problematic multicollinearity (max VIF 3.87). The proportional odds assumption was supported by the global Wald test from the partial proportional odds model ($\chi^2(12) = 6.45$, p = 0.892). Restricted cubic spline analyses showed no evidence of nonlinear associations for age or CCI, thus both variables were kept as continuous predictors in the final model.

Table 3. Multivariable ordered logistic regression examining predictors of frailty at discharge (n = 242).

	Odds Ratio	95% Confidence Interval	p-Value
Age	0.98	0.93–1.03	0.478
Male sex	1.39	0.77–2.50	0.277
CCI (per point increase)	1.13	0.99–1.28	0.062
Postoperative delirium	**2.37**	**1.32–4.28**	**0.004**
Frailty before admission	**2.68**	**1.61–4.47**	**<0.001**
Dementia severity			
Moderate dementia	**5.03**	**2.18–11.61**	**<0.001**
Severe dementia	**6.59**	**2.15–20.21**	**0.001**
Mobility before admission			
Independent with gait aid	1.61	0.86–3.01	0.134
Assist/non-ambulatory	2.23	0.99–5.04	0.054

Notes: OR = odds ratio; CI = confidence interval; CCI = Charlson Comorbidity Index. Reference categories: female sex, mild dementia, and independent mobility. Bold values indicate statistical significance ($p < 0.05$).

DISCUSSION

This study identified predictors independently associated with worse mobility and higher frailty at discharge among patients with dementia undergoing hip fracture surgery. Predictors of mobility and frailty at discharge differed across outcomes, although some overlapping patterns were observed.

The level of cognitive impairment was a strong independent predictor of mobility at discharge. Patients with moderate dementia had three times the odds of having worse mobility at discharge, and those with severe dementia had more than nine times the odds, after adjusting for age, comorbidities, delirium, baseline frailty, and mobility before admission. Although dementia has been associated with worse outcomes after hip surgery, prior studies have examined dementia as a binary outcome and focused on mortality or the institutions to which patients are discharged [6,7,10]. The findings from our study demonstrate that levels of dementia severity are strongly associated with short-term mobility outcomes. This relationship likely reflects differences in movement coordination, ability to participate in rehabilitation, communication abilities, and overall neurological function. Patients with advanced dementia may have limited ability to participate in early mobilization, which is critical for recovery after hip surgery.

In the general hip fracture population, approximately 40–60% of patients recover their baseline level of mobility within the first year, meaning nearly half do not return to baseline function [40,41]. In contrast, in our cohort of patients living with dementia, approximately 75% had already experienced a decline in mobility at discharge. This suggests a substantially worse early functional trajectory in this population. These findings highlight the need for targeted perioperative and rehabilitation strategies to support functional recovery in patients with dementia.

For frailty, both postoperative delirium and dementia severity were strong independent predictors of worse outcomes at discharge. Patients who developed delirium had more than twice the odds of higher frailty at discharge, independent of baseline frailty. In addition, dementia severity demonstrated a strong, graded association with frailty. Patients with moderate and severe dementia had approximately five to six times the odds of greater frailty compared to those with mild dementia. Baseline frailty was also a strong predictor, reinforcing the additive and progressive nature of vulnerability in this population. These findings suggest that both chronic vulnerability (dementia severity and baseline frailty) and acute in-hospital complications, such as delirium, contribute to higher frailty during hospitalization. This aligns with the concept of the frailty cycle, where baseline frailty increases when a patient undergoes an acute health crisis despite receiving the standard of care. Understanding the frailty cycle is of particular importance when care planning in the context of dementia, a driver of progressive frailty [42]. Delirium may contribute to higher frailty through mechanisms such as systemic inflammation [43] or a higher incidence of postoperative complications [44], thereby limiting recovery [45].

The difference in the role of predictors across outcomes is clinically relevant. Dementia severity appears to be a key determinant of both mobility and frailty outcomes, whereas delirium plays an important role as an acute, potentially modifiable factor influencing frailty. This suggests that while underlying cognitive impairment reflects baseline vulnerability, delirium may represent a target for intervention to mitigate in-hospital decline.

Limitations

This study has several limitations. First, as this was a retrospective chart review, there is the possibility of misclassification and incomplete documentation. Baseline mobility and frailty relied on retrospective documentation in the medical record and may have been subject to incomplete or inconsistent reporting. Dementia severity was retrospectively classified using chart documentation and FAST criteria rather than a prospective standardized cognitive assessment, which may have resulted in some misclassification. Because delirium was also identified retrospectively from clinical documentation rather than standardized screening tools, postoperative delirium may have been under-recognized. Further, since dementia severity and frailty both incorporate functional dependence, there may be conceptual overlap between the exposure and outcome measures. The study uses data from 2012–2017 based on data availability. This may limit the current relevance of the findings, as clinical practice and perioperative care have continued to evolve since that period. Since this was a single-centre study at a Canadian hospital, the generalizability of the results may be limited for other healthcare systems with different patient populations, rehabilitation protocols, discharge processes or cultural contexts. Further, since a complete case analysis was used, bias may have been introduced if data were not missing at random. The sample size was also small within the dementia severity subgroups, therefore potentially limiting the statistical power for some predictors and subgroup comparisons. Outcomes were also limited to mobility and frailty at discharge. Longer-term outcomes were not assessed. As such, the findings reflect short-term recovery. Lastly, while the proportional odds assumption was not violated in the ordered logistic regression, merging the mobility categories due to small sample sizes may have decreased the detail of our results.

CONCLUSIONS

Among older adults with dementia undergoing hip fracture surgery, mobility decline and higher frailty were common. Dementia severity was a strong independent predictor of discharge mobility, demonstrating a progressive relationship across levels of cognitive impairment. Dementia severity and postoperative delirium were both independently associated with higher frailty at discharge, highlighting the contribution of both baseline vulnerability and acute in-hospital factors. These findings underscore the importance of considering dementia severity in informed surgical consent discussions, shared decision-making, and rehabilitation planning. These findings also identify delirium prevention as a potential strategy to mitigate vulnerability during hospital admission for hip fracture.

ETHICAL STATEMENT

Ethics Approval

The study was approved by the Ethics Committee of Nova Scotia Health (file number: 1024169 and 2019 January 15). Patient consent was waived due to the retrospective nature of the chart review. A waiver of consent was submitted and approved by the research ethics board.

Declaration of Helsinki STROBE Reporting Guideline

This study adhered to the Helsinki Declaration. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) reporting guideline was followed.

DATA AVAILABILITY

The dataset of the study is available from the authors upon reasonable request.

AUTHOR CONTRIBUTIONS

Conceptualization, AN, SK, JL, DBM, and NS; Methodology, AN and NS; Formal Analysis, AN, SK, and NS; Writing—Original Draft Preparation, AN, SK, JL, DBM, and NS; Writing—Review & Editing, AN, SK, JL, DBM, and NS; Supervision, NS.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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