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ORIGINAL ARTICLE • HIP - FRACTURES

Incidence, risk factors and clinical impact of postoperative delirium following open reduction and internal fixation (ORIF) for hip fractures: an analysis of 7859 patients from the ACS-NSQIP hip fracture procedure targeted database

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Abstract

Objective Delirium is one of the most common acute psychiatric disturbances taking place in patients, particularly elderly, following hip fractures. Using a validated national surgical database, we sought to define the incidence, risk factors and clinical impact associated with the occurrence of delirium following open reduction and internal fixation (ORIF) for hip fracture.

Methods The 2016 American College of Surgeons—National Surgical Quality Improvement Program (ACS-NSQIP) Hip Fracture Targeted Procedure file—was retrieved and merged with the ACS-NSQIP 2016 file. A total of 7859 patients were finally included in the study.

Results A total of 2177 (27.7%) patients experienced an episode of delirium following the procedure. Adjusted analysis showed an increasing age ≥ 65 years ($p < 0.001$), partially dependent functional health status prior to surgery ($p = 0.001$), bleeding disorder ($p = 0.012$), preoperative dementia ($p < 0.001$), preoperative delirium ($p < 0.001$), being bed-ridden postoperatively ($p < 0.001$), no weight bearing as tolerated on first postoperative day ($p < 0.001$), an ASA grade > II ($p < 0.001$), non-emergency case ($p = 0.010$) and a prolonged length of stay > 3 days ($p < 0.001$). In addition, Black or African-American ethnicity had a lower odds of developing postoperative delirium ($p = 0.020$) as compared to Whites. Moreover, postoperative delirium was significantly associated with non-home discharge disposition ($p < 0.001$), higher odds of 30-day readmissions ($p < 0.001$) and 30-day mortality ($p < 0.001$).

Conclusion This study identifies several risk factors associated with the occurrence of postoperative delirium in patients undergoing ORIF for hip fracture. Surgeons can utilize these data to risk stratify and consequently tailor an appropriate preoperative and postoperative care protocol to prevent the occurrence of delirium.

Keywords Delirium · Hip fracture · ORIF delirium · NSQIP · Open reduction internal fixation

Introduction

Hip fractures are the second most common fragility fracture in the elderly [1], and many hip fracture patients experience significant complications [2, 3] and high risk of mortality within 1 year of fracture [4–6]. In particular, delirium is the most common complication for hospitalized hip fracture patients with incidences ranging from 9.5 to 62% [7–10]. Delirium, defined as an "acute confusional state," encompasses several key features, which include disturbance in attention and cognition, fluctuating course of symptoms, the inability to explain disturbances by preexisting cognitive disorders and clinical evidence that disturbance is caused by a medical condition, substance intoxication/withdrawal or medication side effect

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[11]. Delirium can lead to serious disturbances in cognition, which can be distressing and an alarming experience for patients and family members [12, 13]. Although potentially life threatening, early recognition and prevention strategies can lower the risk of delirium in patients [14]. Apart from predisposing to increased morbidity and mortality, occurrence of delirium is also a poor prognostic sign in terms of postoperative functional outcomes following hip fracture [15]. Previous studies have acknowledged various predictors such as prior dementia, age, male gender, preoperative albumin, number of comorbidities and operative time to be associated with a higher risk of developing delirium [16–19].

While the risk of delirium after hip fracture surgery has been explored, the current ability to appropriately risk stratify is limited by the way hip fracture subjects have been studied as a whole without considering the type of procedure performed. A common strategy for evaluation of complications after hip fracture surgeries is to group all "hip fracture patients" together, regardless of the type of surgery that they had performed for treatment. However, not all hip fracture surgeries are the same in terms of length of time for surgery, degree of complexity of the case and expected recovery time, mobility expectations and other precautions that need to be taken into account (such as anterior or posterior hip precautions to prevent dislocation for arthroplasty surgeries). Expected hospital course and complication risk profile can be very different for closed reduction percutaneous pinning of a hip fracture compared to a total hip arthroplasty performed for a displaced femoral neck fracture in an elderly patient. Grouping "hip fracture" so generally can lead to ascribing a care protocol that may not really be meaningful or relevant to the procedure performed nor appropriately predict postoperative complications or mortality.

With delirium associated with increased morbidity [20, 21], mortality [22–24] and increased healthcare costs [25], there is an impending need for clinicians to identify risk factors for delirium early in the care of older patients in order to better medically optimize these high-risk patients and prevent the occurrence of delirium. With prior studies limited to relatively smaller sample sizes and assuming homogeneity of procedures for hip fracture, when in reality the procedures are quite different, we sought to utilize a large national surgical database to identify predictors associated with an increased risk of developing postoperative delirium following open reduction and internal fixation (ORIF) for hip fracture.

Materials and methods

Data collection

The American College of Surgeons—National Surgical Quality Improvement Program (ACS-NSQIP) database collects more than 150 surgical variables up to 30 days following operations from more than 500 hospitals across the USA. The data are collated by trained surgical and clinical reviewers with audit reports showing an inter-reviewer disagreement rate of below 2% [26]. In 2016, the ACS-NSQIP released a Targeted Procedure Hip Fracture file which consisted of additional geriatric-relevant variables for hip fracture cases treated with open reduction and internal fixation (ORIF) (CPT-27236, CPT-27244, CPT-27245) that were collected from a total of 117 clinical sites [27]. The Targeted Procedure file was merged with the ACS-NSQIP 2016 database file. The data were filtered to remove surgeries being done for fractures that resulted from malignancies. This was done to ensure that only procedures being performed for fractures were included in the study. A total of 7859 patients were included in the final cohort for analysis.

Baseline demographics and preoperative clinical characteristics

Patient demographics that were a part of the study included age, gender, body mass index (BMI; kg/m^2), ethnicity (White, African-American or Black, American Indian or Alaska Native, Native Hawaiian or Pacific Islander and Unknown/Not reported), comorbidities, transfer status (acute care hospital/inpatient, home, nursing home/chronic care facility, outside emergency department/ED, other location and unknown), admission status (inpatient/outpatient), emergency case (yes or no), American Society of Anesthesiologists (ASA) Class, quarter of admission, time from admission to operation (days), total operative time (minutes) and total hospital length of stay (days). Thirty-day readmissions, a non-home discharge destination and 30-day mortality were also assessed as part of postoperative clinical outcomes. Cases with missing data for the above variables were removed from analysis to prevent confounding.

Relevant preoperative laboratory values were also retrieved to assess any significant associations between abnormal preoperative laboratory findings and the occurrence of delirium. These included preoperative serum sodium (Na), albumin (Alb), creatinine (Cr) and white blood cell count (WBC). The variables were dichotomized with regard to normal and abnormal laboratory parameters to allow for adjustment during logistic regression. Hyponatremia was defined as serum sodium < 135 mEq/L; increased creatinine was defined as > 1.2 mg/dL; increased WBC was defined as > 11,000/μL, hypoalbuminemia (Alb < 3.5 g/dL), and a low hematocrit (Hct) < 36%.

Targeted file-specific variables

The Targeted Procedure file collects geriatric and hip fracture-specific variables which include—preoperative dementia/

cognitive function, preoperative delirium, preoperative use of bone protection medications, preoperative use of mobility aids, medical co-management during stay, use of a standardized hip fracture care program, type/location of fracture (displaced/undisplaced femoral neck fracture (FNF), intertrochanteric, subtrochanteric, other) and weight bearing as tolerated begun on the first postoperative day. Postoperative delirium is defined using a method previously utilized in medicine, intensive care and surgical literature [28]. Trained clinical reviewers carry out a detailed chart-based review for the presence of postoperative delirium anytime within the 30-day period. In addition, they also carry out a medical record review for phrases or words relevant to delirium which included—"delirium, confusion, sundowning, somnolent, crying out, inattentive, disorientation, incoherent, hallucinating, restlessness or combative." It can also be described as "metabolic encephalopathy, acute confusional state, acute organic mental disorder and acute organic brain syndrome." In addition, delirium recorded whether the patient was currently taking medications designed for delirium. Specific details regarding the recording of the variable by NSQIP clinical reviewers are made available elsewhere [27].

Statistical analysis

The overall incidence rate of postoperative delirium was calculated using descriptive statistics. The study population was divided into two cohorts: (1) those who developed postoperative delirium after surgery and (2) the "control" group—those who did not develop postoperative delirium after surgery. Unadjusted analysis using Pearson Chi-square tests was run to assess for any significant association between preoperative, intra-operative factors and the occurrence of postoperative delirium. For data with missing variables (e.g., laboratory parameters), the "missing indicator" variable method was used to adjust for missing data in univariate logistic regression. A similar method has been utilized by studies involving the NSQIP in the past as literature has shown that data missing from NSQIP does not occur at random [29, 30]. All variables with a p value < 0.05 were then entered into a multivariate logistic regression model and adjusted for each other. For assessing the clinical impact of postoperative delirium on postoperative outcomes such as 30-day readmissions, non-home discharge and 30-day mortality, we ran a backward elimination logistic model while adjusting for all baseline clinical characteristics and preoperative laboratory parameters. The area under curve (AUC) was calculated to assess the predictive probability of the logistic models.

Results

Baseline clinical characteristics of the study population

A total of 7859 patients were included in the study. Most patients were female ($N = 5504$; 70.0%) and in the age group of 80–89 years ($N = 3154$; 40.1%). White ethnicity comprised majority of the study population ($N = 6019$; 76.5%). A total of 2177 (27.7%) patients experienced an episode of delirium during hospitalization following surgery. All baseline demographics and clinical characteristics of the study population are shown in Table 1.

Predictors of postoperative delirium

Following unadjusted analysis using Pearson Chi-square tests (Table 2) and univariate logistic regression for preoperative laboratory parameters with missing data (Table 3), all variables with a p value < 0.05 were entered into a multivariate logistic regression model (Table 4). After adjustment, an age ≥ 65 years ($p < 0.001$), partially dependent functional health status prior to surgery (OR 1.29 [95% CI 1.11–1.51]; $p = 0.001$), bleeding disorder (OR 1.21 [95% CI 1.04–1.41]; $p = 0.012$), preoperative dementia (OR 2.37 [95% CI 2.06–2.72]; $p < 0.001$), preoperative delirium (OR 10.01 [95% CI 8.26–12.14]; $p < 0.001$), being bed-ridden postoperatively (OR 1.48 [95% CI 1.22–1.79]; $p < 0.001$), no weight bearing as tolerated on first postoperative day (OR 1.33 [95% CI 2.05–2.71]; $p < 0.001$), an ASA grade > II (OR 1.29 [95% CI 1.07–1.57]; $p < 0.001$), non-emergency case (OR 1.20 [95% CI 1.04–1.57]; $p = 0.010$), a prolonged length of stay > 3 days ($p < 0.001$) and a time from admission to surgery of less than 1 day (OR 1.66 [95% CI 1.43–1.93]; $p < 0.001$) were found to be significantly associated with a higher risk of developing postoperative delirium. In addition, Black or African-American ethnicity had a lower odds of developing postoperative delirium (OR 0.63 [0.43–0.93]; $p = 0.020$) as compared to Whites. The model had good predictive probability with an area under curve (AUC) = 0.803 [95% CI 0.79–0.81].

Clinical impact of postoperative delirium on discharge disposition, 30-day readmissions and 30-day mortality

A total of 6859 (87.3%) patients had a non-home discharge following ORIF for hip fracture. 30-day readmission and 30-day mortality rates were 8.5% and 5.2%, respectively. Majority of the 30-day readmissions were medical in nature and included pneumonia (6.7%), sepsis/

Table 1 Characteristics of the study population

Baseline demographics	Number	Percentage (%)
Age (years)		
< 65	776	9.9
65–79	2164	27.6
80–89	3154	40.1
≥ 90	1765	22.5
Gender		
Male	2355	30.0
Female	5504	70.0
Body mass index/BMI (kg/m^2)		
< 25.0	4418	56.2
25.0–29.0	2189	27.8
30.0–35.0	841	10.7
> 35.0	411	5.2
Ethnicity		
White	6019	76.5
Black or African-American	231	2.9
Asian	142	1.8
American Indian or Alaska Native	10	0.1
Native Hawaiian or Pacific Islander	5	0.1
Unknown/Not Reported	1452	18.5
Comorbids		
Insulin-dependent diabetes mellitus (IDDM)	638	8.1
Non-insulin dependent diabetes mellitus (NIDDM)	823	10.5
Smoker within past year	905	11.5
Dyspnea at rest	87	1.1
Dyspnea at moderate exertion	522	6.6
Function health status—totally dependent	198	2.5
Function health status—partially dependent	1437	18.3
Ventilator dependent	16	0.2
History of severe COPD	875	11.1
Ascites	27	0.3
Congestive heart failure (CHF) in 30 days before surgery	311	4.0
Hypertension (HTN) requiring medication	5270	67.1
Preoperative dialysis	164	2.1
Disseminated cancer	125	1.6
Chronic steroid use	436	5.5
Open wound/wound infection	312	4.0
Bleeding disorders	1371	17.4
Transfusion of at least one unit of packed RBCs within 72 h	386	4.9
Prior history of sepsis	46	0.6
Prior history of septic shock	5	0.1
Prior history of SIRS	738	9.4
> 10% weight loss in last 6 months	118	1.5
Acute renal failure (ARF)	39	0.5
Other hip-specific factors		
Preoperative dementia	2173	27.6
Preoperative delirium	896	11.4
Pre-fracture bone protection medication use	2182	27.8
Use of mobility aid		
Yes	4190	53.3
Unknown	279	3.6

Table 1 (continued)

Baseline demographics	Number	Percentage (%)
Medical co-management during stay		
Complete	6160	78.4
Partial	965	12.3
None	734	9.3
Standardized hip fracture care program		
Yes	3950	50.3
No	3909	49.7
Weight bearing as tolerated (WBAT) on postoperative day 1		
Yes	5280	67.2
Not applicable/bed-ridden or other medical issues	741	9.4
No	1838	23.4
Type/location of fracture		
Femoral Neck Fx (Subcapital, Garden Type 1 and 2)—undisplaced	702	8.9
Femoral Neck Fx (Subcapital, Garden Type 3 and 4)—displaced	2237	28.5
Intertrochanteric	4249	54.1
Subtrochanteric	471	6.0
Other/cannot be determined	200	2.6
Type of anesthesia		
General (GA)	5775	73.5
Other(MAC/Regional/Epidural/Spinal)	2084	26.5
ASA class		
I	52	0.7
II	1324	16.8
III	4935	62.8
IV	1540	19.6
V	8	0.1
Admission status		
Inpatient	7837	99.7
Outpatient	22	0.3
Transferred from		
Home	5943	75.6
Acute care hospital (inpatient)	326	4.1
Nursing home/chronic care facility	800	10.2
Outside ED	692	8.8
Other	83	1.1
Unknown	15	0.2
Quarter of admission		
Jan–March	1983	25.2
April–June	1860	23.7
July–Sept	1880	23.9
Oct–Dec	2136	27.2
Time from admission to operation (days)		
≤ 1 day	6078	77.3
> 1 day	1781	22.7
Total operative time (mins)		
0–60	4395	55.9
> 60	3464	44.1
Total hospital length of stay (days)		
0–3	1622	20.6
4–6	3824	48.7
> 6	2413	30.7

Table 2 Univariate analysis of factors using Chi-square analysis

Variable	Delirium	No delirium	*p* value
Age(years)			**< 0.001**
< 65	72 (3.3%)	704 (12.4%)	
65–79	443 (20.3%)	1721 (30.3%)	
80–89	1000 (45.9%)	2154 (37.9%)	
≥ 90	662 (30.4%)	1103 (19.4%)	
Gender			0.596
Male	662 (30.4%)	1693 (29.8%)	
Female	1515 (69.6%)	3989 (70.2%)	
Body mass index/BMI (kg/m^2)			**< 0.001**
< 25.0	1331 (61.1%)	3087 (54.3%)	
25.0–29.0	567 (26.0%)	1622 (28.5%)	
30.0–35.0	197 (9.0%)	644 (11.3%)	
> 35.0	82 (3.8%)	329 (5.8%)	
Ethnicity			**0.008**
White	1709 (78.5%)	4310 (75.9%)	
Black or African–American	49 (2.3%)	182 (3.2%)	
Asian	30 (1.4%)	112 (2.0%)	
American Indian or Alaska Native	0	10 (0.2%)	
Native Hawaiian or Pacific Islander	0	5 (0.1%)	
Unknown/not reported	389 (17.9%)	1063 (18.7%)	
Comorbids			
Diabetes			0.223
IDDM	177 (8.1%)	616 (10.8%)	
NIDDM	207 (9.5%)	461 (8.1%)	
No	1793 (82.4%)	4605 (81%)	**< 0.001**
Smoker within past year	191 (8.8%)	713 (12.5%)	<0.001
Dyspnea			0.101
At rest	30 (1.4%)	57 (1.0%)	
Moderate exertion	160 (7.3%)	362 (6.4%)	
No	1987 (91.3%)	5263 (92.6%)	
Functional health status			**< 0.001**
Totally dependent	93 (4.3%)	105 (1.8%)	
Partially dependent	657 (30.2%)	780 (13.7%)	
Unknown	25 (1.1%)	36 (0.6%)	
Independent	1402 (64.4%)	4761 (83.8%)	
Ventilator dependent	7 (0.3%)	9 (0.2%)	0.151
History of severe COPD	272 (12.5%)	603 (10.6%)	**0.018**
Ascites	10 (0.5%)	17 (0.3%)	0.278
Congestive heart failure (CHF) within last 30 days	108 (5.0%)	203 (3.6%)	**0.005**
Hypertension (HTN) requiring medication	1537 (70.6%)	3733 (65.7%)	**< 0.001**
Preoperative dialysis	48 (2.2%)	116 (2.0%)	0.650
Disseminated cancer	21 (1.0%)	104 (1.8%)	**0.006**
Chronic steroid use	108 (5.0%)	328 (5.8%)	0.160
Open wound/wound infection	114 (5.2%)	198 (3.5%)	**< 0.001**
Bleeding disorders	448 (20.6%)	923 (16.2%)	**< 0.001**
Transfusion of at least one unit of packed RBCs < 72 h	117 (5.4%)	269 (4.7%)	0.240
Systemic sepsis			**< 0.001**
Prior history of sepsis	19 (0.9%)	27 (0.5%)	
Prior history of septic shock	2 (0.1%)	3 (0.1%)	
Prior history of SIRS	280 (12.9%)	458 (8.1%)	
> 10% weight loss in last 6 months	45 (2.1%)	73 (1.3%)	**0.011**

Table 2 (continued)

Variable	Delirium	No delirium	*p* value
Acute renal failure (ARF)	13 (0.6%)	26 (0.5%)	0.431
Other hip specific factors			
Preoperative dementia	1135 (52.1%)	1038 (18.3%)	**< 0.001**
Preoperative delirium	724 (33.3%)	172 (3.0%)	**< 0.001**
Pre-fracture bone protection medication use	685 (31.5%)	1497 (26.3%)	**< 0.001**
Preoperative use of mobility aid			**< 0.001**
Yes	1434 (65.9%)	2756 (48.5%)	
Unknown	94 (4.3%)	2741 (48.2%)	
No	649 (29.8%)	185 (3.3%)	
Medical co-management during stay			**< 0.001**
Complete	1768 (81.2%)	4392 (77.3%)	
Partial	276 (12.7%)	689 (12.1%)	
None	133 (6.1%)	601 (10.6%)	
Standardized hip fracture care program			0.608
Yes	1084 (49.8%)	2866 (50.4%)	
No	1093 (50.2%)	2816 (49.6%)	
Weight bearing as tolerated (WBAT) on postoperative day 1			**< 0.001**
Yes	1238 (56.9%)	4042 (71.1%)	
Not applicable/bed-ridden or other medical issues	317 (14.6%)	424 (7.5%)	
No	622 (28.6%)	1216 (21.4%)	
Type/location of fracture			**0.001**
Femoral Neck Fx (Subcapital, Garden Type 1 and 2)—undisplaced	166 (7.6%)	536 (9.4%)	
Femoral Neck Fx (Subcapital, Garden Type 3 and 4)—displaced	662 (30.4%)	1575 (27.7%)	
Intertrochanteric	1193 (54.8%)	3056 (53.8%)	
Subtrochanteric	102 (4.7%)	369 (6.5%)	
Other/Cannot be determined	54 (2.5%)	146 (2.6%)	
Type of anesthesia			0.579
General (GA)	1590 (73.0%)	4185 (73.7%)	
Other (MAC/regional/epidural/spinal)	587 (27.0%)	1497 (26.3%)	
ASA class			**< 0.001**
≤ II	194 (8.9%)	1182 (20.8%)	
> II	1983 (91.1%)	4500 (79.2%)	
Emergency case			**0.013**
Yes	581 (26.7%)	1678 (29.5%)	
No	1596 (73.3%)	4004 (70.5%)	
Admission status			0.318
Inpatient	2173 (99.8%)	5664 (99.7%)	
Outpatient	4 (0.2%)	18 (0.3%)	
Transferred from			**< 0.001**
Home	1486 (68.3%)	4457 (78.4%)	
Acute care hospital (inpatient)	86 (4.0%)	240 (4.2%)	
Nursing home/chronic care facility	368 (16.9%)	432 (7.6%)	
Outside ED	209 (9.6%)	483 (8.5%)	
Other	27 (1.2%)	56 (1.0%)	
Unknown	1 (0%)	14 (0.2%)	
Quarter of admission			0.337
Jan–March	563 (25.9%)	1420 (25.0%)	
April–June	505 (23.2%)	1355 (23.8%)	
July–Sept	542 (24.9%)	1338 (23.5%)	
Oct–Dec	567 (26.0%)	1569 (27.6%)	

Table 2 (continued)

Variable	Delirium	No delirium	*p* value
Time from admission to operation (days)			**0.001**
≤ 1 day	1629 (74.8%)	4449 (78.3%)	
> 1 day	548 (25.2%)	1233 (21.7%)	
Total operative time (mins)			**0.035**
0–60	1259 (57.8%)	3136 (55.2%)	
> 60	918 (42.2%)	2546 (44.8%)	
Total hospital length of stay (days)			**< 0.001**
0–3	274 (12.6%)	1348 (23.7%)	
4–6	975 (44.8%)	2849 (50.1%)	
> 6	928 (42.6%)	1485 (26.1%)	

Table 3 Univariate analysis of variables, associated with postoperative delirium, with missing values using logistic regression analysis

Preoperative laboratories	Odds ratio (95% CI)	*p* value
Hyponatremia (Na < 135.0)		
No	Ref	–
Yes	0.90 (0.79–1.03)	0.133
Missing	0.40 (0.17–0.960	**0.039**
Hematocrit		
> 36	Ref	–
< 36	1.06 (0.96–1.18)	0.223
Missing	0.50 (0.19–1.3)	0.155
Creatinine		
≤ 1.2	Ref	–
> 1.2	1.21 (1.07–1.37)	**0.002**
Missing	0.43 (0.18–1.01)	0.053
Hypalbuminemia (Alb < 3.5)		
No	Ref	–
Yes	1.32 (1.17–1.49)	**< 0.001**
Missing	0.94 (0.83–1.06)	0.283
Increased WBC (> 10)		
No	Ref	–
Yes	1.2 (1.09–1.33)	**< 0.001**
Missing	0.74 (0.37–1.49)	0.401

septic shock (4.9%), urinary tract infection/UTI (2.2%) and stroke (2.1%). Readmissions due to surgical site infections (superficial/deep/organ-space) accounted for 2.7% of the readmissions. After adjusting for baseline clinical characteristic and preoperative laboratory values in a backward elimination logistic regression model, postoperative delirium was associated with a higher odds of non-home discharge disposition (OR 1.79 [95% CI 1.42–2.25]; $p < 0.001$), 30-day readmissions (OR 1.80 [95% CI 1.52–2.14]; $p < 0.001$) and 30-day mortality (OR 2.04 [95% CI 1.61–2.59]; $p < 0.001$) in patients with hip fractures that were surgically treated with ORIF (Table 5).

Discussion

The current study utilizes a large national surgical database to identify several preoperative, intra-operative and postoperative factors significantly associated with the occurrence of postoperative delirium in patients undergoing ORIF for hip fracture. Moreover, the study demonstrates that postoperative delirium is associated with higher odds of having a non-home discharge and is also associated with a higher risk of 30-day readmissions and 30-day mortality. With costs of delirium being attributed up to $64,421/case and an overall national burden of delirium amounting up to $152 billion USD/year [25, 31], preoperative identification of patients at a higher risk of developing delirium postoperatively can allow doctors to incorporate a multi-disciplinary care pathway to prevent the occurrence of this complication. We found increasing age and partially dependent functional health status to be associated with a higher risk of postoperative delirium. This finding is in line with findings from past surgical literature [32]. While we utilized geriatric age groups (e.g., ≥ 65 years of age), a recent systematic review by Smith et al. concluded that there was moderate evidence of nearly a two times greater probability of postoperative delirium in patients aged 80 years or older undergoing surgery for hip fracture [33]. Similarly, increasing age was also found to be a significant predictor in another prospective study by Lee et al. on 425 patients undergoing acute hip fracture repair [16]. A plausible explanation is that gradual neurodegeneration takes place with age, which can render patients to delirium especially when "stressed" as in the scenario of major trauma and/or surgery [34].

Preoperative cognitive dysfunction has been shown to significantly have an impact on postoperative delirium in previous studies [35–38]. Moreover, patients who experienced preoperative delirium with hip fracture treatment have poor functional outcomes at discharge and 6 months following hip fracture repair [10]. Similarly, a systematic review and meta-analysis from more than 32 studies concluded that patients with a preoperative diagnosis of dementia were

Table 4 Multivariate logistic regression analysis showing significant predictors following adjustment for significant variables from Tables 2 and 3

Variables	Odds ratio (95% CI)	*p* value
Age(years)		
< 65	Ref	–
65–79	1.84 (1.36–2.47)	**< 0.001**
80–89	2.55 (1.89–3.43)	**< 0.001**
≥ 90	2.75 (2.01–3.76)	**< 0.001**
Ethnicity		
White	Ref	
Black or African–American	0.63 (0.43–0.93)	**0.020**
Asian	0.96 (0.60–1.53)	0.867
American Indian or Alaska Native	0	0.999
Native Hawaiian or Pacific Islander	0	0.999
Unknown/not reported	0.87 (0.71–1.08)	0.200
Function health status		
Totally dependent	1.00 (0.701–1.42)	0.994
Partially dependent	1.29 (1.11–1.51)	**0.001**
Unknown	0.98 (0.52–1.85)	0.942
Independent	Ref	–
Bleeding disorders		
No	Ref	–
Yes	1.21 (1.04–1.41)	**0.012**
Preoperative dementia		
No	Ref	–
Yes	2.37 (2.06–2.72)	**< 0.001**
Preoperative delirium		
No	Ref	–
Yes	10.01 (8.26–12.14)	**< 0.001**
WBAT on POD#1		
Yes	Ref	–
N/A (Bed-ridden/other medical)	1.48 (1.22–1.79)	**< 0.001**
No	1.33 (2.05–2.71)	**< 0.001**
ASA grade		
≤ II	Ref	–
> II	1.29 (1.07–1.57)	**0.008**
Emergency case		
Yes	Ref	–
No	1.20 (1.04–1.57)	**0.010**
Length of stay (days)		
0–3 days	Ref	–
4–6 days	1.63 (1.37–1.95)	**< 0.001**
> 6 days	3.30 (2.72–4.02)	**< 0.001**
Time from admission to operation (days)		
≤ 1 day	1.66 (1.43–1.93)	**< 0.001**
> 1 day	Ref	**–**

The model had an area under curve: 0.803 (95% CI 0.79–0.81) showing a very good predictive probability

associated with a sixfold greater probability of developing postoperative delirium [33].

Our results showed that an African-American ethnicity was associated with a lower risk of developing postoperative delirium. This is in contrast with previous literature reporting no relation between ethnicity and occurrences of delirium in intensive care units in elderly patients [39]. They did, however, find that younger African-American patients aged 18–49 were at lower risk of developing incident delirium as compared to Caucasians of the same age. Currently, the literature is limited on racial disparities and occurrences of delirium. Future large-scale studies might yield a more affirmative answer to this question.

Contrary to a recent systematic review showing no relation between time to surgery and occurrence of delirium [33], we found that a time to surgery within 1 day to be associated with a higher risk of postoperative delirium. Given the current limitation of the ACS-NSQIP database not holding time to surgery in hours, it is difficult to comment on the clinical significance of this finding. It is plausible that a patient who may have been admitted in the evening but ends up having surgery after midnight, but within 24 h, may have had that time period recorded as a single day spent in the hospital. Secondly, a significant proportion of patients presenting to acute care with hip fractures are often very debilitated, with regard to dehydration and nutritional status [40], which are known predictors of postoperative delirium [41]. The medical optimization of these comorbidities may often get over-looked in the rush to ensure a surgery taking place within 24–48 h, thus predisposing the patient to higher odds of developing postoperative delirium [42]. The current Targeted Procedure database does not hold details regarding details of nutritional status which may play an important role in implicating the findings.

The finding of postoperative delirium significantly affecting 30-day readmissions is similar to recent literature about delirium after spine surgery [43]. This is particularly important as doctors can utilize these data to emphasize the need for postoperative medical optimization and careful coordination during transitions of care [44] to prevent occurrence of complications that may predispose patients to developing readmissions.

Introduction of multi-disciplinary ortho-geriatric care pathways can be an effective way of reducing rates and length of postoperative delirium [45]. Oberai et al. conducted a detailed systematic review investigating the impact of multi-intervention programs on postoperative outcomes after hip fractures and concluded that following pooled analysis, use of a multi-component intervention involving regular geriatrician checkups, control of environment stimuli, avoidance of poly-pharmacy, monitoring of nutrition and electrolyte balance, avoidance of poly-pharmacy and regular mobility, effectively reduced the odds of developing

Table 5 Multivariate logistic regression assessing the clinical impact of postoperative delirium non-home discharge disposition and 30-day readmissions, after adjusting for all clinical characteristics in Tables 2 and 3

Variables	Odds ratio (95% CI)	*p* value	Area under curve (AUC) [95% CI]
Non-home discharge destination	1.79 [1.42–2.25]	**< 0.001**	0.83 [0.81–0.84]
30-day readmissions	1.80 [1.52–2.14]	**< 0.001**	0.69 [0.67–0.71]
30-day mortality	2.04 [1.61–2.59]	**< 0.001**	0.83 [0.81–0.85]

postoperative delirium [46]. In addition to the use of postoperative care pathways, given the variable presentations of delirium, we propose that detailed surveillance of high-risk patients in the acute postoperative period can also be an effective way for identifying occurrences of delirium early on.

There are several limitations to the study. First, the ACS-NSQIP Targeted Hip fracture database does not give details regarding the severity of delirious episodes. Second, the time from surgery to episode of delirium is not recorded in the database which may be useful in assessing whether any prior in-hospital complications may play a role in the occurrence of this complication. Third, it does contain data with regard to the number and types of medications used before and after surgery as well as whether the patient was in the intensive care setting at the time of the occurrence of the episode, the former being particularly useful as poly-pharmacy has been known to play a major role in occurrence of delirium [47]. Fourth, though the length of stay was found to be significantly associated with occurrence of delirium, it is difficult to establish a causal relationship to see whether the prolonged stay was a risk factor to delirium or whether the episode of delirium itself resulted in the prolonged length of stay. Incorporation of the time to postoperative delirium occurrence in future datasets may be an effective way to establish causality for certain variables such as length of stay and readmissions. The ACS-NSQIP Targeted Hip Fracture records data from only a few hospitals and the results may not be generalized to the national population. Finally, the NSQIP records surgical outcomes data up to 30 days post-surgery. There may be a significant number of complications which may be occurring well beyond the 30-day period, in which future studies can aim to capture by designing prospective databases with longer follow-up periods.

Conclusion

Delirium is a challenging, but common, complication for hip fracture patients. Although recognized as a frequent complication, it is often difficult to fully risk stratify and implement prevention strategies with our current understanding of hip fracture surgery techniques. Previous reports have evaluated the risk of delirium for a collection of hip fracture treatments which may mislead delirium risk as hip fracture surgery techniques can vary considerably in terms of complexity, blood loss, morbidity and postoperative guidelines. The current study focused on the risks of delirium following open reduction internal fixation of hip fractures. Using a relatively larger sample size from multiple hospitals, this study effectively identifies numerous predictors associated with the occurrence of delirium in hip fracture patients treated with open reduction internal fixation (ORIF). Doctors can utilize these data to better filter for high-risk patients preoperatively and place them on a multi-specialty care pathway to prevent the occurrence of the grave complication of delirium and subsequently cut costs of care related to the complications and readmissions that may occur for hip fracture patients.

Compliance with ethical standards

Conflict of interest Author Khan has received research grants from Spinal Kinetics. Authors Malik, Phieffer, Quatman and Ly all declare that they have no conflicts of interest. The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS-NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors. Since data were derived from a de-identified database, it was exempt from Institutional Review Board (IRB) approval.

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