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ORIGINAL ARTICLE

ANALYSIS OF RISK FACTORS FOR PREOPERATIVE DELIRIUM FOLLOWING GERIATRIC HIP FRACTURE AND ITS RELATIONSHIP WITH MORTALITY: A RETROSPECTIVE COHORT STUDY

ABSTRACT

Introduction: Although postoperative delirium in patients with hip fractures has been extensively studied, preoperative delirium has rarely been examined. We investigated the risk factors for developing preoperative delirium in patients with hip fracture and their relation to mortality.

Materials and Method: We retrospectively reviewed the records of 316 patients who underwent hip fracture surgery. Preoperative delirium was defined according to the Diagnostic and Statistical Manual-5 criteria, and the time of onset of delirium (0-24 hours) was recorded. We evaluated patient demographics, medical conditions, laboratory results, movement patterns, and death rates.

Results: Preoperative delirium occurred in 16.5% of the patients. Most patients who experienced delirium developed symptoms during the first six hours of hospitalization. The preoperative delirium group showed lower serum albumin levels (3.2 ± 0.5 vs 3.6 ± 0.6 g/dL, $p < 0.001$), lower prognostic nutritional index values (31.2 ± 6.8 vs 36.1 ± 7.5 , $p < 0.001$) and elevated creatine kinase levels (168 vs 92 U/L, $p < 0.001$). Alzheimer's/dementia (odds ratio: 5.43), creatine kinase levels above 100 U/L (odds ratio: 3.65), albumin levels below 3.5 g/dL (odds ratio: 3.12), prognostic nutritional index values under 35 (odds ratio: 2.78) and dependent mobilization (odds ratio: 2.18) were independent risk factors. The multivariate logistic regression model showed suitable discrimination power through its area under curve value of 0.687 which fell within a 95% confidence interval of 0.599 to 0.774 while achieving sensitivity at 65.8% and specificity at 61.2% and accuracy at 61.7%. The preoperative delirium group experienced a 36.5% one-year mortality rate, which was significantly higher than the 18.2% mortality rate in the non-delirium group ($p = 0.001$).

Conclusion: The risk factors for preoperative delirium include low albumin levels, low prognostic nutritional index values, elevated creatine kinase, dependent mobilization, and neurocognitive impairment. The presence of preoperative delirium leads to an extended postoperative delirium duration and elevated patient mortality rates. The research results require analysis based on the study design which used a single center to collect retrospective data and the difficulties of detecting delirium through medical records analysis.

Keywords: Delirium; Hip Fractures; Mortality; Creatine Kinase; Nutrition Assessment.

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INTRODUCTION

Hip fractures are the leading and most dangerous musculoskeletal injuries in the elderly population. The aging population worldwide has led to a fast-growing number of hip fracture cases and it is predicted that the 1.7 million cases in 1990 will become 6.3 million by 2050 (1). Most hip fractures (95%) occur in people aged sixty and above and 90% stem from falls (2,3). The death rate of patients with hip fracture is between 15% and 30% during the first year of recovery, and most patients fail to regain their previous level of functionality (4). Loss of independent walking ability affects 40% of the patients, while 60% require assistance with their daily tasks (5).

Delirium is the most prevalent postoperative complication among elderly patients. The development of postoperative delirium affects 20-50% of older patients with hip fracture, leading to longer hospital stays, elevated healthcare expenses and higher death rates (6, 7). Postoperative delirium has received extensive attention, but preoperative delirium has been investigated less so. Preoperative delirium creates challenges for surgical readiness and produces poor results during postoperative care.

The literature has identified elements which affect recovery, but how these impact preoperative delirium development is not clear (3). Meta-analyses of patients across all age groups have failed to identify distinct risk factors which affect preoperative delirium in elderly patients undergoing surgery (1). Research on how nutritional status, laboratory results (including enzymes indicating muscle damage), and mobilization abilities affect the development of preoperative delirium is lacking.

We investigated how preoperative nutritional status, laboratory results, and mobilization abilities determine preoperative delirium in elderly patients with hip fracture, while studying how preoperative delirium affects postoperative delirium duration and survival rates during the first year. Our research

aimed to detect early warning signs of preoperative delirium in patients with hip fractures aged above sixty-five years, establish the predictive value of markers, and determine preoperative delirium timing effects on surgical results and one-year survival rates.

MATERIALS AND METHOD

Study Design and Population

We analyzed 316 elderly patients who underwent hip fracture surgery at our orthopedics and trauma clinic between January 2020 and December 2023. This study aimed to identify preoperative delirium risk indicators and study their relationships with death rates.

The study included patients who met four specific criteria: (1) age > 65 years; (2) hip fracture diagnosis limited to femoral neck or intertrochanteric fractures; (3) surgical intervention; and (4) at least 12 months of follow-up. Patients with pathological fractures, multiple trauma, acetabular fractures, previous hip surgery, or incomplete data were excluded.

Definition and Assessment of Preoperative Delirium

Preoperative delirium was defined as an acute state of confusion that developed after hospital admission and prior to surgery. Diagnoses were made according to the Diagnostic and Statistical Manual (DSM)-5 criteria with psychiatric consultation and confirmed using the Confusion Assessment Method (CAM). Preoperative delirium developed in 52 patients (16.5%). The time of onset of delirium was the time elapsed until the development of post-fracture delirium and was categorized into five groups: (1) 0-6 h (n=28, 53.8%), (2) 6-12 h (n=15, 28.8%), (3) 12-24 h (n=9, 17.3%), (4) 24-48 h (n=0, 0%), and (5) >48 h (n=0, 0%).

Postoperative delirium was defined as delirium that began within the first 72 h after surgery or continued from preoperative delirium.

Postoperative delirium was detected in 40 patients (12.7%); 32 of these developed in patients with preoperative delirium (61.5%), and eight developed in patients without preoperative delirium (3.0%).

Clinical Assessment Parameters

Patient information was collected through demographic and clinical assessments, including age, sex, fracture location, American Society of Anesthesiologists (ASA) score, and pretrauma mobility level. Patient mobility was categorized as independent walking without help, assisted walking with a cane or walker, or wheelchair-dependent or bedridden status.

Patient comorbidities including hypertension, diabetes mellitus, coronary artery disease, heart failure, Alzheimer's disease (AD), dementia, chronic obstructive pulmonary disease, and chronic renal failure were documented. The diagnosis of AD and dementia was verified through consultations with neurology and psychiatry specialists. The total disease count was equal to the sum of all recorded comorbidities.

Laboratory test results from the first 24 h before surgery were documented, including hemoglobin, albumin, total protein, urea, creatinine, lymphocyte count, creatine kinase (CK), and fasting blood glucose (FBG). The prognostic nutritional index (PNI) calculation used the formula [serum albumin (g/dL) \times 10 + total lymphocyte count (/mm³) \times 0.005]. CK levels were evaluated for the first time in relation to preoperative delirium, and a threshold value of 100 U/L, determined by receiver operating characteristic (ROC) analysis, was used.

Surgical and Hospital Parameters

The time to surgery (days), type of anesthesia (general/spinal), duration of surgery (min), intraoperative blood loss (mL), transfusion requirement (none/1-2 units/>2 units of red blood cell suspension), intensive care unit (ICU) stay

duration, and total hospital stay duration were recorded. Surgery duration was categorized using a threshold value of 70 min. Intraoperative blood loss was categorized using a threshold value of 90 mL.

Follow-up and Mortality Assessment

Patients were evaluated at four time points after discharge: 1, 3, 6, and 12 months. Patients who did not attend outpatient clinic follow-ups were contacted via phone. Researchers confirmed patient deaths by checking hospital records and the national death reporting system.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics (version 27.0; IBM Corp., Armonk, NY, USA). Normal distribution was assessed using the Kolmogorov–Smirnov test. Mean \pm standard deviation was used for normally distributed data, median [25th–75th percentile] for non-normally distributed data, and number (%) for categorical data.

Independent samples t-tests or Mann–Whitney U tests were used to compare continuous variables between patients with and without preoperative delirium, while chi-square tests or Fisher's exact tests were used to analyze categorical variables. For the analysis of the time of onset of preoperative delirium, comparisons were made between five time groups (0–6 h, 6–12 h, 12–24 h, 24–48 h, >48 h). The Kruskal–Wallis test and analysis of variance were used for continuous variable intergroup analyses, whereas the chi-square test was used to analyze categorical variables. Due to the absence of patients in the 24–48 h and >48 h groups, these groups were represented by a "0" value in the statistical analysis.

Univariate and multivariate logistic regression analyses were performed to determine the independent risk factors that contributed to preoperative delirium. Variables with $p < 0.20$ in the univariate analysis were included in the multivariate



model. A backward-stepwise method was used. Model fit was assessed using Nagelkerke R^2 and the Hosmer–Lemeshow test. The final model achieved discriminative results through calculations of sensitivity and specificity and accuracy and PPV and NPV and AUC with 95% confidence intervals. Cut-off values were established through ROC analysis and existing medical literature by using age ≥ 80 y, albumin < 3.5 g/dL, PNI < 35 , CK > 100 U/L, pre-trauma dependent mobilization, surgery duration > 70 min, and intraoperative blood loss > 90 mL.

The effect of preoperative delirium on postoperative delirium persistence was evaluated using the chi-square test. Patients who developed delirium after 24 h were not included in the analysis.

The preoperative delirium effect on mortality was determined using risk ratio (RR) calculations. Fisher's exact test was used to evaluate differences in mortality rates between the study groups. The research used a $p < 0.05$ threshold to determine statistical significance for all data analyses.

Ethical Approval

This study was approved by the Ethics Committee of Trakya University Faculty of Medicine. (Approval Date: 22/09/2025, Number: 2025/396). Patient consent was not required owing to the retrospective design of the study. The data were analyzed anonymously. This study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

Study Population Characteristics

The study involved 316 elderly patients with hip fractures, with an average age of 81.5 y, 68.4% females, and with 56.3% of the participants aged ≥ 80 years. Intertrochanteric fractures occurred twice as often as femoral neck fractures (65.2% vs. 34.8%). Most patients needed help in walking before their injury (55.4%), 29.7% had maintained their ability to

walk independently, and 14.9% required complete care (Table 1).

Incidence and Risk Factors of Pre-operative Delirium

Pre-operative delirium affected 52 patients (16.5%). The patients who developed delirium were older than those without delirium (84.2 y vs 81.0 y) and made up 71.2% of patients aged 80 and above ($p=0.012$). The delirium group showed higher ASA scores than the non-delirium group ($p=0.008$); however, no sex differences were observed between the groups. The delirium group had twice as many patients with ASA score 4 as the

non-delirium group (30.8% vs. 17.0%). The pre-trauma mobility assessment showed that dependent patients had a significantly higher risk of developing delirium, whereas independent walkers had lower delirium rates (Table 1).

Comorbidity Profile

Neurocognitive disorders were strongly linked to preoperative delirium development. Alzheimer's disease or dementia was found 46.2% of patients in the delirium group, and only 10.6% of the non-delirium group ($p < 0.001$). The delirium group had a significantly higher total disease burden than the non-delirium group (2.8 vs 2.1, $p=0.008$) (Table 1).

Laboratory Parameters

Patients with delirium had lower hemoglobin, albumin, total protein, and lymphocyte levels. The PNI results were significantly lower in those with delirium compared to those without (31.2 vs 36.1, $p < 0.001$), indicating that malnutrition is a factor in the development of delirium. The delirium group showed elevated urea and creatinine levels, and CK levels were twice those in the non-delirium group (168 vs. 92 U/L, $p < 0.001$). The FBG levels in patients with delirium were higher than in those without (178.5 mg/dL vs. 148.3 mg/dL, $p=0.007$) (Table 1).

Table 1. Patient Characteristics, Laboratory Parameters, and Preoperative Delirium Relationship

Parameter	All Patients (n=316)	Pre-op Delirium (+) (n=52)	Pre-op Delirium (-) (n=264)	p-value
DEMOGRAPHIC AND CLINICAL CHARACTERISTICS				
Age (years)	81.5 ± 7.2	84.2 ± 6.8	81.0 ± 7.2	0.003 ^b
Age groups				0.012 ^c
<80 years	138 (43.7%)	15 (28.8%)	123 (46.6%)	
≥80 years	178 (56.3%)	37 (71.2%)	141 (53.4%)	
Gender				0.485 ^c
Male	100 (31.6%)	18 (34.6%)	82 (31.1%)	
Female	216 (68.4%)	34 (65.4%)	182 (68.9%)	
Fracture Type				0.627 ^c
Femoral neck	110 (34.8%)	17 (32.7%)	93 (35.2%)	
Intertrochanteric	206 (65.2%)	35 (67.3%)	171 (64.8%)	
ASA Score				0.008 ^c
ASA 2	123 (38.9%)	12 (23.1%)	111 (42.0%)	
ASA 3	132 (41.8%)	24 (46.2%)	108 (40.9%)	
ASA 4	61 (19.3%)	16 (30.8%)	45 (17.0%)	
Pre-Trauma Mobilization				<0.001 ^c
Independent	94 (29.7%)	8 (15.4%)	86 (32.6%)	
Supported	175 (55.4%)	30 (57.7%)	145 (54.9%)	
Dependent	47 (14.9%)	14 (26.9%)	33 (12.5%)	
Comorbidities				
Hypertension	181 (57.3%)	33 (63.5%)	148 (56.1%)	0.320 ^c
Diabetes	111 (35.1%)	21 (40.4%)	90 (34.1%)	0.382 ^c
Coronary Artery Disease	73 (23.1%)	15 (28.8%)	58 (22.0%)	0.278 ^c
Heart Failure	57 (18.0%)	13 (25.0%)	44 (16.7%)	0.151 ^c
Alzheimer's	28 (8.9%)	12 (23.1%)	16 (6.1%)	<0.001 ^e
Dementia	31 (9.8%)	14 (26.9%)	17 (6.4%)	<0.001 ^e
Alzheimer's or Dementia	52 (16.5%)	24 (46.2%)	28 (10.6%)	<0.001 ^c
COPD	51 (16.1%)	11 (21.2%)	40 (15.2%)	0.277 ^c
Chronic Kidney Disease	41 (13.0%)	10 (19.2%)	31 (11.7%)	0.137 ^c
Total Number of Diseases ^a	2.2 ± 1.8	2.8 ± 1.9	2.1 ± 1.7	0.008 ^b
LABORATORY PARAMETERS				
Hemoglobin (g/dL) ^a	11.5 ± 1.9	11.0 ± 1.8	11.6 ± 1.9	0.038 ^b
Albumin (g/dL) ^a	3.5 ± 0.6	3.2 ± 0.5	3.6 ± 0.6	<0.001 ^b
Total Protein (g/dL) ^a	6.3 ± 0.8	6.0 ± 0.7	6.4 ± 0.8	0.001 ^b
Urea (mg/dL) ^f	47.0 [37–62]	56.0 [43–72]	45.0 [36–59]	0.002 ^d
Creatinine (mg/dL) ^f	0.9 [0.8–1.2]	1.1 [0.9–1.4]	0.9 [0.7–1.1]	0.008 ^d
Lymphocytes (10 ³ /μL) ^a	1.4 ± 0.7	1.2 ± 0.6	1.5 ± 0.7	0.004 ^b
PNI ^a	35.3 ± 7.6	31.2 ± 6.8	36.1 ± 7.5	<0.001 ^b
CK (U/L)* ^f	101 [62–178]	168 [112–284]	92 [58–156]	<0.001 ^d
FBG (mg/dL) ^a	153.3 ± 74.3	178.5 ± 82.4	148.3 ± 71.8	0.007 ^b

*^a Mean ± Standard Deviation; ^b Independent samples t-test; ^c Chi-square test; ^d Mann-Whitney U test; ^e Fisher's exact test; ^f Median [25th–75th percentile]. Novel finding in literature. PNI: Prognostic Nutritional Index; CK: Creatine Kinase; FBG: Fasting Blood Glucose; COPD: Chronic Obstructive Pulmonary Disease; ASA: American Society of Anesthesiologists.



Table 2. Preoperative Delirium Onset Time Analysis

Time of Delirium Onset	n (%)	Median Age	ASA ≥3 (%)	Albumin (g/dL) ^a	Alzheimer/Dementia (%)	12-month Mortality (%)
0-6 hours	28 (53.8%)	85.2	23 (82.1%)	3.1 ± 0.5	15 (53.6%)	12 (42.9%)
6-12 hours	15 (28.8%)	83.8	11 (73.3%)	3.3 ± 0.4	6 (40.0%)	5 (33.3%)
12-24 hours	9 (17.3%)	82.4	6 (66.7%)	3.4 ± 0.5	3 (33.3%)	2 (22.2%)
24-48 hours	0 (0.0%)	-	-	-	-	-
>48 hours	0 (0.0%)	-	-	-	-	-
p-value	-	0.238 ^g	0.412 ^c	0.084 ^g	0.382 ^c	0.287 ^c

^a Mean ± Standard Deviation; ^c Chi-square test; ^g ANOVA test (Kruskal-Wallis test for median age). Note: Analysis of the time of onset of post-fracture delirium in 52 patients who developed preoperative delirium

Temporal Patterns of Delirium Onset

All 52 patients who developed preoperative delirium presented with symptoms within the first 24 h following their fracture. The majority of patients (53.8%) developed delirium during the first 6 h after fracture, followed by 28.8% between 6–12 h, and 17.3% between 12–24 h. No patients developed delirium after 24 h (Table 2). The median age of the patients showed a non-significant decrease as delirium onset was delayed ($p=0.238$). Patients who experienced delirium earlier in their hospital stay had higher ASA scores, lower albumin levels, and higher incidence of AD and dementia, although the differences were not statistically significant. The 12-month mortality rates demonstrated a non-significant pattern of increased risk for patients who developed delirium in the first 6 h compared with those who developed delirium between 12–24 h (42.9% vs. 22.2%) ($p=0.287$) (Table 2).

Postoperative Delirium Continuity

Forty patients (12.7%) developed postoperative delirium, with most continuing from pre-operative delirium. A majority (61.5%) of patients with preoperative delirium maintained their condition after surgery, but only 3.0% of patients without preoperative delirium developed postoperative delirium ($p<0.001$). Analysis of duration showed that patients with preoperative delirium maintained

their condition longer and experienced more frequent postoperative delirium episodes. Patients who developed delirium within the first 6 h of preoperative care had a 71.4% chance of showing postoperative delirium, whereas patients who developed delirium between 6-12 h had a 53.3% chance, and those who developed it between 12-24 h had a 44.4% chance ($p=0.048$). The absence of patients who developed preoperative delirium after 24 h demonstrates that the first 24 h post-fracture plays a vital role in the development of delirium (Table 3).

Surgical and Hospital Parameters

Patients who showed preoperative delirium needed to wait longer for their surgery compared to those without delirium (median, 6 days vs. 4 days, $p<0.001$). The delirium group received blood transfusions at a higher rate (69.2% vs. 55.7%, $p=0.028$), and required twice as many blood transfusions exceeding two units compared (23.1% vs. 13.3%). The delirium group spent longer periods in the ICU and had longer hospital stays (Table 4).

Mortality Analysis

The presence of preoperative delirium was associated with elevated mortality rates during all observation periods. The delirium group

Table 3. Relationship Between Preoperative and Postoperative Delirium and Temporal Analysis

A. Relationship Between Pre-Operative and Post-Operative Delirium			
	Pre-Operative Delirium (+) (n=52)	Pre-Operative Delirium (-) (n=264)	p value
Post-op Delirium Development			<0.001 ^c
Present	32 (61.5%)	8 (3.0%)	
Absent	20 (38.5%)	256 (97.0%)	
Post-Operative Delirium Total	40 patients (12.7%)		
Post-Operative Delirium Duration			<0.001 ^c
No Post-Operative Delirium	20 (38.5%)	256 (97.0%)	
1–3 days	10 (19.2%)	5 (1.9%)	
4–7 days	15 (28.8%)	2 (0.8%)	
>7 days	7 (13.5%)	1 (0.4%)	
B. Temporal Relationship Between Pre-Operative Delirium Duration and Post-Operative Delirium Persistence			
Pre-Operative Delirium Duration	Total (n)	Post-Operative Delirium Persisting n (%)	Post-Operative Delirium Not Persisting n (%)
0–6 hours	28	20 (71.4%)	8 (28.6%)
6–12 hours	15	8 (53.3%)	7 (46.7%)
12–24 hours	9	4 (44.4%)	5 (55.6%)
24–48 hours	0	0 (0.0%)	0 (0.0%)
>48 hours	0	0 (0.0%)	0 (0.0%)
Total	52	32 (61.5%)	20 (38.5%)

^c Chi-square test. ^a Post-Operative delirium developed in a total of 40 patients (32 patients with pre-operative delirium continued to have it + 8 patients without pre-operative delirium developed it newly).

Table 4. Surgical and Hospital Parameters

Parameter	Pre-Operative Delirium (+) (n=52)	Pre-Operative Delirium (-) (n=264)	p value
Time Until Surgery (days) ^f	6.0 [4-9]	4.0 [3-6]	<0.001 ^d
Type of Anesthesia			0.834 ^c
General	44 (84.6%)	225 (85.2%)	
Spinal	8 (15.4%)	39 (14.8%)	
Transfusion Requirement			0.028 ^c
None	16 (30.8%)	117 (44.3%)	
1-2 Units	24 (46.2%)	112 (42.4%)	
>2 Units	12 (23.1%)	35 (13.3%)	
ICU Length of Stay (days) ^f	2.0 [1-4]	1.0 [0-2]	<0.001 ^d
Total Hospital Stay (days) ^f	15.0 [12-20]	10.0 [8-13]	<0.001 ^d

^c Chi-square test; ^d Mann-Whitney U test; ^f Median [25th-75th percentile]



experienced first-month mortality at a rate that exceeded that of the non-delirium group by more than four times. The risk ratio for death decreased with time but remained higher than twice that of the non-delirium group rate throughout the 12-month study. The delirium group had a 36.5% mortality rate at the end of 12 months, whereas the non-delirium group had an 18.2% mortality rate.

Independent Risk Factors

The multivariate logistic regression model revealed distinct factors that independently predicted preoperative delirium development. The presence of AD or dementia was the most significant risk factor, increasing the risk of

delirium by 5.43 times (OR: 5.43, 95% CI: 2.61-11.29). The second most important independent risk factor for delirium was elevated CK levels, with values above 100 U/L increasing the risk by 3.6 times. Low albumin levels and reduced PNI values also contributed to an increased delirium risk. The risk of delirium doubled when patients had dependent mobility before their trauma. Age and ASA score maintained their significance in the univariate analysis but lost significance in the multivariate analysis. The risk factors used in the model accounted for 35% of the total variance in delirium, as shown in Figure 1.

The final multivariate logistic regression model showed it could predict preoperative delirium with

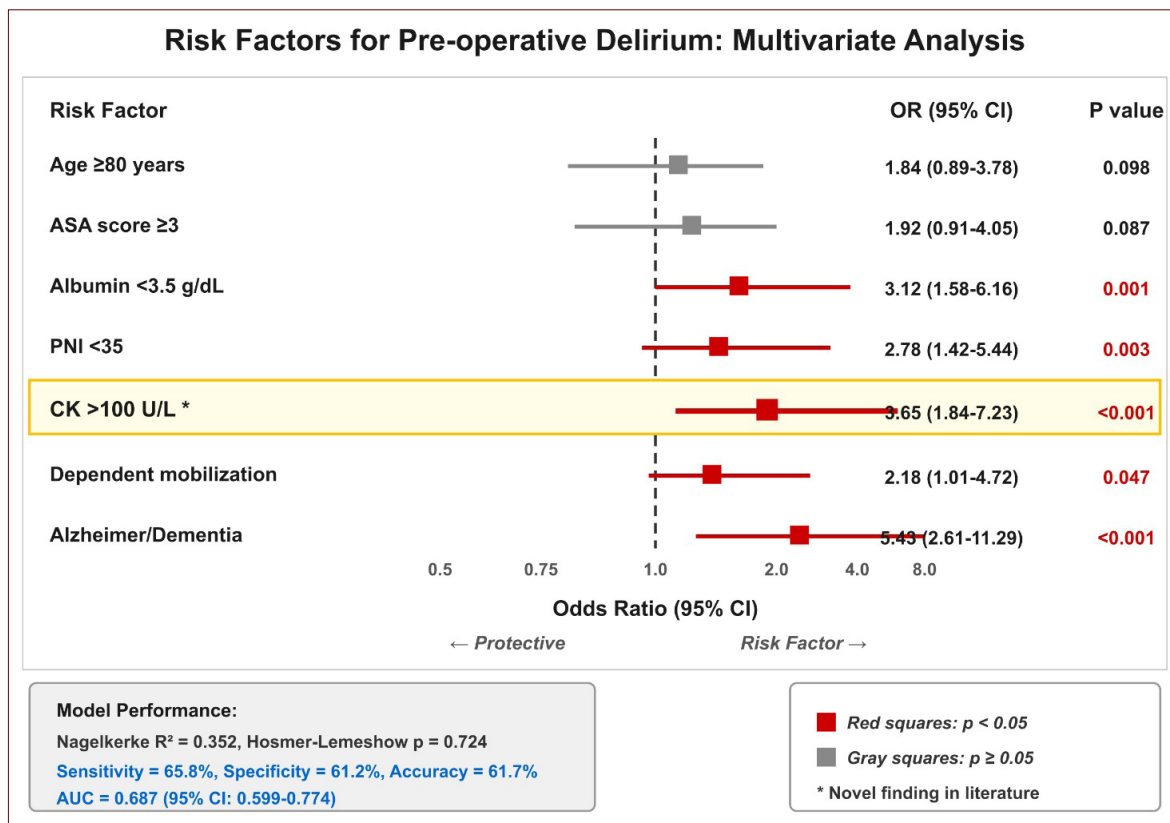


Figure 1. Forest plot of risk factors for preoperative delirium. Multivariate logistic regression analysis showing odds ratios with 95% confidence intervals. CK: creatine kinase, PNI: Prognostic Nutritional Index, ASA: American Society of Anesthesiologists, CI: confidence interval, OR: odds ratio.

a moderate level of accuracy. The model produced results which included 65.8% sensitivity and 61.2% specificity and 61.7% overall accuracy. The model achieved a 18.8% positive predictive value (PPV) and a 92.9% negative predictive value (NPV) which showed its strong ability to predict patients who would not develop delirium. The receiver operating characteristic curve area under the curve (AUC) measured 0.687 with a 95% confidence interval ranging from 0.599 to 0.774 which shows the model achieved acceptable discrimination ability. Model fit was adequate with Nagelkerke $R^2 = 0.352$ and Hosmer-Lemeshow goodness-of-fit test $p = 0.724$ (Table 5, Figure 1, Figure 2).

Table 5. Performance Measures of the Multivariate Logistic Regression Model for Preoperative Delirium Prediction

Performance Measure	Value	95% CI
Sensitivity	65.8%	56.2 – 75.4%
Specificity	61.2%	55.3 – 67.1%
Accuracy	61.7%	56.3 – 67.1%
Positive Predictive Value (PPV)	18.8%	12.4 – 25.2%
Negative Predictive Value (NPV)	92.9%	89.2 – 96.6%
Area Under ROC Curve (AUC)	0.687	0.599 – 0.774
Nagelkerke R^2	0.352	–
Hosmer-Lemeshow p-value	0.724	–

ROC: Receiver Operating Characteristic; CI: Confidence Interval; PPV: Positive Predictive Value; NPV: Negative Predictive Value.

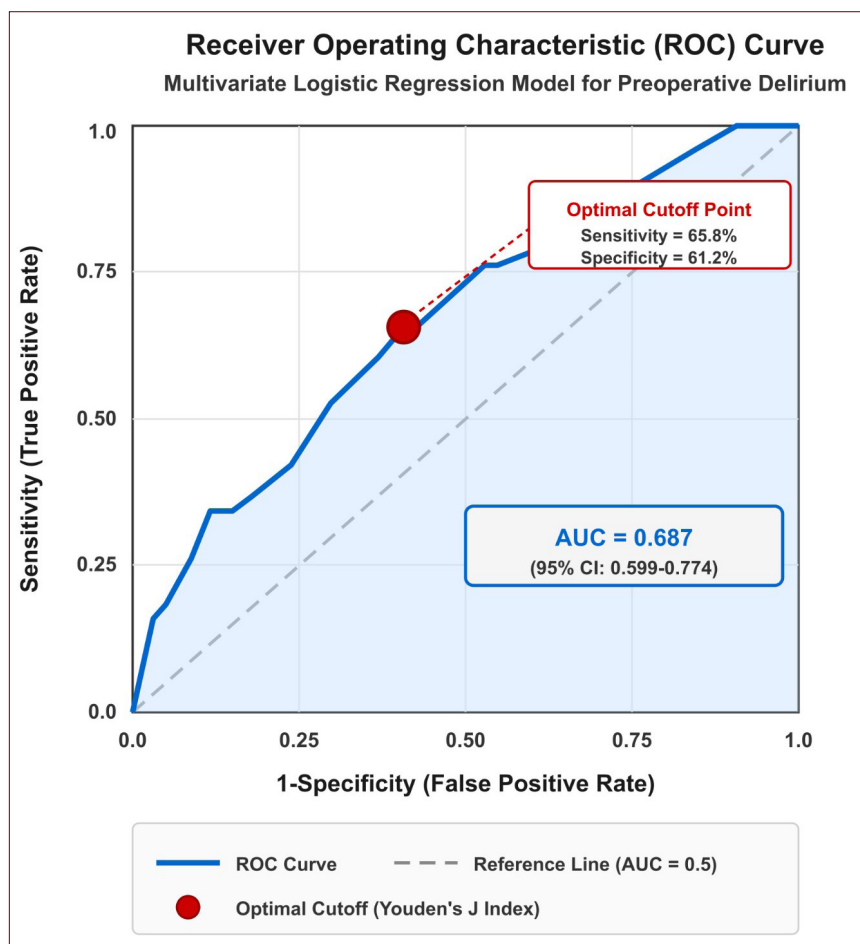


Figure 2. Receiver Operating Characteristic (ROC) curve for the multivariate logistic regression model predicting preoperative delirium. The diagonal dashed line represents the performance of a random classifier (AUC = 0.5). The red dot indicates the optimal cutoff point determined by Youden's J index (sensitivity = 65.8%, specificity = 61.2%). The area under the curve (AUC) was 0.687 (95% CI: 0.599-0.774), indicating acceptable discriminative performance



DISCUSSION

This study examined the factors that increase the risk of preoperative delirium and their impact on survival rates among elderly patients with hip fractures. There has been extensive research on postoperative delirium, whereas preoperative delirium remains poorly understood. The research revealed that preoperative delirium occurred in 16.5% of the patients. The most significant risk factors for preoperative delirium included AD/dementia (odds ratio [OR]: 5.43), elevated CK level (OR: 3.65), low albumin level (OR: 3.12), low PNI (OR: 2.78), and dependent mobilization (OR: 2.18). The one-year mortality rate of the patients who experienced preoperative delirium was 36.5%; however, the mortality rate of the control group was 18.2%.

Our study found for the first time that elevated CK levels were associated with preoperative delirium. A CK level >100 U/L increased the risk of delirium by 3.65 times. The preoperative delirium patients showed a median CK value of 168 U/L, whereas the non-delirium group had a median CK value of 92 U/L. The significant difference between these values indicates that muscle damage and post-fracture immobilization may be responsible for the development of delirium. Muscle breakdown, indicated by elevated CK levels, results in systemic inflammation and metabolic disturbances. The breakdown of muscle tissue produces myoglobin and other substances that affect the blood-brain barrier and create neuroinflammatory conditions. Pain and discomfort due to muscle injuries create conditions that increase the risk of delirium. The results suggest that CK measurement should become a standard procedure during the initial treatment period of hip fracture because patients with elevated values require intensive observation.

Preoperative delirium development occurred during the first 24 h of hospital stay, according to our study results. The first 6 h after the fracture resulted in preoperative delirium development

in 53.8% of the 52 patients who experienced this condition. The postoperative delirium persistence rate was 71.4% among patients who experienced early delirium (within 6 h) but decreased to 44.4% among those who developed delirium between 12–24 h. Patients who experienced early delirium had poorer treatment outcomes. Patients with hip fractures experience the highest risk of developing delirium during the first day after surgery, followed by a gradual decrease in risk throughout the subsequent days (8). The patients who developed early delirium showed three distinct risk factors: they were older (85.2 y vs. 82.4 y), had more severe ASA scores (82.1% vs. 66.7%) and showed higher rates of AD/dementia (53.6% vs. 33.3%). Patients who experienced early delirium showed higher mortality rates at the twelve-month mark (42.9% vs. 22.2%). The initial period following a fracture represents a crucial time for patient observation because patients who experience delirium during this time require enhanced monitoring.

Our study demonstrated the direct impact of nutritional factors on preoperative delirium development. The PNI value was 31.2 ± 6.8 in the preoperative delirium group and 36.1 ± 7.5 in the non-delirium group ($p < 0.001$). The fact that PNI <35 increases the risk of delirium by 2.78 times is consistent with a previous report (9). Xu and Luo's finding of a threshold value of PNI <45.45 in patients with femoral neck fractures may reflect population differences (10). Our lower threshold value can be explained by the advanced age and high comorbidity burden in our patient group. Dong et al. demonstrated that preoperative malnutrition elevates delirium risk by 3.04 times during non-cardiac surgical procedures, which aligns with the high-risk nature of hip fracture surgery (11).

This study supports the established connection between low albumin levels and higher preoperative delirium risk. Albumin levels below 3.5 g/dL in our study resulted in a 3.12 times higher risk of

preoperative delirium which exceeded the 2.99 times risk increase found by Wang et al. (12). Wang et al. demonstrated that a albumin level decrease of 1 g/L increases delirium risk by 11%, showing a direct relationship between albumin levels and delirium risk. Our research verifies the established relationship between albumin levels and delirium risk, while confirming that albumin serves as a vital threshold indicator. The patients with preoperative delirium had an average albumin level of 3.2 ± 0.5 g/dL while the non-delirium group had an average of 3.6 ± 0.6 g/dL. The difference in albumin levels indicates that this protein serves as both a nutritional marker and an indicator of metabolic stress and inflammation. Research has shown that patients with body mass index values below 18.5 kg/m² have a 1.686 times higher risk of mortality (13). Chen et al. established that hemoglobin levels (OR=1.95) function as independent factors that increase delirium risk (8).

Patients with ASA scores above 3 had 2.38 times more risk of developing preoperative delirium according to univariate analysis however, this association became non-significant in multivariate analysis. The study by Arshi et al. established ASA score as a risk factor for postoperative delirium with an OR of 1.20; our higher OR might stem from our focus on preoperative delirium (14). A study found that patients with ASA scores ≥ 3 experienced a 2.01 times higher risk of developing delirium during major orthopedic surgeries (15), and 54.6% of patients with dementia developed delirium (16). In our study, the presence of AD/dementia increased the risk of preoperative delirium 5.43 times indicating that neurocognitive disorders are a leading cause of preoperative delirium. Visual and auditory impairments also strongly contribute to delirium development (8).

The duration of postoperative delirium exceeded 7 d in 13.5% of the patients who had preoperative delirium, but only 0.4% of the patients without preoperative delirium experienced this outcome.

The results demonstrated that preoperative delirium led to both extended postoperative delirium and more severe delirium symptoms.

The median time to surgery was 6 d in the preoperative delirium group and 4 d in the non-delirium groups, respectively ($p < 0.001$). Delays in surgical procedures may stem from the challenges faced by healthcare providers when identifying and treating preoperative delirium. A study showed that surgical timing did not affect 30-d mortality; however, our research established that extended preoperative delays lead to preoperative delirium (17). The survival outcomes of patients who underwent surgery within 2 d after injury were superior to those who required > 2 d (13). The preoperative delirium group required blood transfusions at a higher rate than did the non-delirium group (69.2% vs. 55.7%, $p = 0.028$). Lee et al. demonstrated that blood transfusions increased the risk of developing postoperative delirium by 2.53 times (18).

This study examined how preoperative delirium affects patient survival at different time points. The delirium group experienced a 9.6% mortality rate during the first month, compared to only 2.3% in the non-delirium group (RR: 4.23). Mortality rates were 36.5% and 18.2%, respectively, when tracked for 12 months (RR: 2.11). A Turkish study reported a one-year overall mortality rate of 29.49%, which exceeds the 22% rate observed in our study (19). Gottschalk et al. found no significant link between postoperative delirium and mortality, but our study established a strong connection between preoperative delirium and mortality. Preoperative delirium appears to be a more dangerous clinical condition than postoperative delirium based on these findings.

The final multivariate logistic regression model showed average discrimination power through its ability to predict preoperative delirium with 65.8% sensitivity and 61.2% specificity and 61.7% overall accuracy. The ROC curve area reached 0.687 (95%



CI: 0.599-0.774) which showed that the model had acceptable ability to distinguish between groups. This research has some limitations. This was a retrospective, single center study, which may limit generalizability of the findings.

Our findings indicate that standard tests for CK, albumin, and PNI should be performed during preoperative assessments. The risk level for patients increased when their CK levels exceeded 100 U/L, albumin levels were below 3.5 g/dL or PNI levels were below 35. The monitoring of patients with a history of AD or dementia and need-assisted mobilization should be intensified. The development of delirium during the first 6 h after a fracture makes patients more likely to experience ongoing postoperative delirium. Future research should study CK as a potential cause of delirium through prospective investigation. Preoperative nutritional strategies should be evaluated to establish their effectiveness in reducing the occurrence of delirium.

CONCLUSION

Preoperative delirium is a significant complication affecting 16.5% of elderly hip fracture patients, with all cases developing within the first 24 hours post-fracture. Elevated CK levels >100 U/L (OR: 3.65), AD/dementia (OR: 5.43), low albumin <3.5 g/dL (OR: 3.12), PNI <35 (OR: 2.78), and dependent mobilization (OR: 2.18) were independent risk factors. Preoperative delirium was associated with persistent postoperative delirium (61.5%) and increased one-year mortality (36.5% vs. 18.2%). The prediction model demonstrated acceptable discriminative ability (AUC: 0.687, 95% CI: 0.599-0.774).

This study has limitations inherent to its retrospective, single-center observational design, which restrict causal inference and external validity. Preoperative delirium was identified through medical record review using DSM-5 criteria rather than prospective standardized screening,

increasing the risk of misclassification, particularly of hypoactive delirium. Although multivariable analyses were performed, residual confounding is likely, as key factors such as frailty, pain severity, medication exposure, inflammatory markers, fracture complexity, and environmental contributors were not systematically captured. Laboratory-based nutritional indices and creatine kinase levels may have reflected acute physiological stress rather than baseline status. While preoperative delirium was associated with increased one-year mortality, the observational design precludes conclusions regarding causality.

Future multicenter, prospective studies using validated delirium assessment tools and comprehensive geriatric variables are needed to clarify mechanisms and to evaluate whether targeted prevention strategies can improve outcomes and survival in older adults with hip fractures.

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