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Risk Factor Analysis and Prediction Model Construction for Postoperative Delirium in Elderly Patients with Hip Fracture

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Abstract: *Objective:* To analyze the independent risk factors for postoperative delirium (POD) in elderly patients with hip fracture and construct and validate a risk prediction model. *Methods:* A total of 134 elderly patients with hip fractures aged over 60 years old who underwent elective surgical treatment in the hospital from September 2022 to September 2023 were selected as the study subjects. The occurrence of POD was evaluated using the Confusion Assessment Method (CAM) scale from 1 to 5 days after surgery, and the patients were divided into the POD group (n = 35) and the non-POD group (n = 95) based on the diagnosis. General information was compared between the two groups, and logistic regression analysis was used to investigate the independent risk factors for POD and construct a nomogram model. The predictive value of the nomogram model for POD was tested by drawing a Receiver Operating Characteristic (ROC) curve. *Results:* There were significant differences in age, comorbid diabetes, comorbid stroke, preoperative albumin, and intraoperative blood loss between the two groups ($P < 0.05$). Multivariate logistic regression analysis revealed that increasing age, comorbid diabetes, comorbid stroke, and low preoperative albumin levels were independent risk factors for POD. The ROC curve showed that the AUC of the nomogram model for predicting POD in elderly patients with hip fracture was 0.896 (95% CI: 0.841–0.951, $P < 0.001$), with specificity, sensitivity, and Youden's index of 0.989, 0.907, and 0.893, respectively. *Conclusion:* Increasing age, comorbid diabetes, history of stroke, and preoperative hypoalbuminemia are independent risk factors for POD in elderly patients with hip fracture. The nomogram prediction model constructed based on these risk factors demonstrates good discriminatory performance in clinical risk stratification. It is suggested that precise intervention strategies should be implemented for high-risk populations in clinical practice to optimize perioperative management.
Keywords: Hip fractures in the elderly; Postoperative delirium; Risk factors; Prediction model

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1. Introduction

Postoperative delirium (POD) is a common clinical acute psychopathological syndrome, primarily manifesting as cognitive dysfunction in patients. The fluctuating process of acute onset is a characteristic feature of this disease [1]. POD has a high degree of concealment, and early stages of the disease may present with changes in emotions, cognition, and behavior, or symptoms such as anxiety, restlessness, irritability, and poor sleep quality [2]. The occurrence of POD often has adverse effects on patients and can rapidly progress, leading to prolonged postoperative recovery time, increased hospital stay, and higher mortality rates.

Research has shown that among all orthopedic patients, those with hip fractures have the highest incidence of POD, ranging from 30–41% [3]. Hip fractures are more common in the elderly population, and with the increasing aging of the population in China, more and more elderly people are troubled by this disease. Therefore, screening high-risk patients and early prevention among elderly orthopedic patients can help reduce the incidence of POD and minimize its harm to patients. However, currently, there is no in-depth research on the identification, prevention, or treatment of POD in domestic orthopedic departments, and there are no relevant clear guidelines or recommendations. Sufficient clinical attention has not been paid to this issue. Therefore, establishing a predictive model for POD occurrence is very important for elderly patients with hip fractures. This study aims to analyze the risk factors associated with POD occurrence and develop a predictive model to achieve early diagnosis, prevention, and treatment, ultimately minimizing the probability of POD in elderly patients with hip fractures.

2. Materials and methods

2.1. General information

A retrospective analysis was conducted on the clinical data of 134 elderly hip orthopedic patients aged over 60 years who underwent elective surgery in our hospital from September 2022 to September 2023. On the 1st to 5th day after surgery, the occurrence of POD was evaluated using the Confusion Assessment Method (CAM) scale. Based on the diagnosis, patients were divided into the POD group (n = 35) and the non-POD group (n = 99).

Inclusion criteria: (1) confirmed diagnosis of hip fracture by imaging examination; (2) meeting the indications for artificial hip replacement surgery and completing the surgery; (3) aged over 60 years, both male and female; (4) clinical data can be collected. Exclusion criteria: (1) patients undergoing emergency surgery; (2) patients with visual and auditory impairments who cannot cooperate to complete delirium assessment; (3) patients whose clinical data cannot be fully collected. This study was approved by the hospital ethics committee.

2.2. Methods

Through literature review, 12 influencing factors closely related to the occurrence of POD were selected and established as observation indicators in this study: gender, age, body mass index, education level, smoking and drinking history, comorbidities, anesthesia method, preoperative blood biochemistry, perioperative electrolyte imbalance, intraoperative anesthesia time, intraoperative blood loss, and perioperative inflammatory factors. The relevant factors of POD occurrence were recorded using tables, independent risk factors for POD occurrence were analyzed, and a risk prediction model was established.

2.3. Statistical methods

SPSS 21.0 was used for statistical analysis. Measurement data were expressed as (mean ± SD) and tested using the t-test. Count data were expressed as (n, %) and tested using the chi-square test. The test level was set at $P < 0.05$.

Independent risk factors for delirium were screened using a multivariate logistic regression model.

3. Results

3.1. General patient information and univariate analysis

There were significant differences between the two groups in terms of age, comorbidity with diabetes, comorbidity with stroke, low preoperative albumin, and high intraoperative blood loss ($P < 0.05$) (**Table 1**).

Table 1. General patient information and univariate analysis

Variable		Occurrence group (n = 35)	Non-occurrence group (n = 99)	t/χ^2 value	P value
Gender (cases)	Male	13	40	0.115	0.734
	Female	22	59		
Age (years)		78.27 ± 3.24	73.54 ± 3.00	7.851	< 0.001
Body Mass Index (kg/m^2)		22.86 ± 1.26	23.01 ± 1.64	0.492	0.624
Education Level	Primary school and below	13	34	0.102	0.950
	Middle/High school	17	51		
	College and above	5	14		
Smoking and Drinking History	Yes	13	40	0.115	0.734
	No	22	59		
Comorbid Hypertension	Yes	15	41	2.153	0.142
	No	20	58		
Comorbid Diabetes	Yes	28	48	10.462	0.001
	No	7	51		
Comorbid Stroke	Yes	22	34	8.642	0.003
	No	13	65		
Anesthesia Method	General anesthesia	1	6	1.573	0.666
	General anesthesia + spinal/nerve block	26	71		
	Spinal anesthesia	2	10		
	General anesthesia + spinal + nerve block	6	12		
Preoperative Blood Biochemistry	Albumin (g/L)	33.09 ± 2.69	36.78 ± 2.94	6.521	< 0.001
	Hemoglobin (g/L)	98.46 ± 15.24	109.67 ± 15.43	0.731	0.466
Perioperative Electrolyte Imbalance	Yes	13	24	2.153	0.142
	No	22	75		
Operation Time (min)		77.23 ± 11.23	76.15 ± 12.27	0.457	0.648
Intraoperative Blood Loss (mL)		205.24 ± 18.99	184.16 ± 16.45	6.254	< 0.001
Perioperative Inflammatory Factors	IL-1 (ng/L)	6.29 ± 1.49	6.18 ± 1.84	0.318	0.751
	IL-10 (ng/L)	30.45 ± 4.51	31.27 ± 3.77	0.230	0.818
	TNF-α (mg/mL)	35.24 ± 4.01	34.16 ± 3.92	1.393	0.166

3.2. Multivariate logistic regression analysis of POD occurrence in elderly hip fracture patients

Based on the univariate analysis in Table 1, five potential influencing factors related to POD occurrence in elderly hip fracture patients were initially screened. Using POD occurrence status (not occurred = 0, occurred = 1) as the dependent variable, the above five variables were quantitatively assigned and incorporated into a multivariate logistic regression model. After fitting analysis, it was shown that increased age, comorbid diabetes, history of stroke, and preoperative hypoalbuminemia were independent risk factors for POD occurrence. Specific results are shown in **Table 2** and **Table**

3.

Table 2. Independent variable assignment

Independent variable	Value assignment
Age	Assigned with actual age
Comorbid Diabetes	No comorbidity = 0; Comorbidity = 1
Comorbid Stroke	No comorbidity = 0; Comorbidity = 1
Preoperative Albumin Level	Assigned with actual albumin level
Intraoperative Blood Loss	Assigned with actual blood loss volume

Table 3. Multivariate logistic regression analysis of elderly hip fracture patients

Factors	Regression coefficient	Standard error	Wald χ^2	*P* value	OR value	95%CI
Age	1.406	0.524	5.964	0.016	5.012	1.401–8.225
Comorbid Diabetes	2.621	1.770	5.026	0.033	10.119	1.776–101.34
Age	6.827	1.544	17.064	< 0.001	4.196	1.994–14.201
Preoperative Albumin Level	-0.641	0.054	24.110	0.001	0.617	0.801–1.164
Intraoperative Blood Loss	-0.012	0.041	0.025	0.817	0.941	0.921–1.779

3.3. Nomogram prediction model construction for POD occurrence in elderly hip fracture patients

In this study, the rms package in the R language was used to visualize the model, resulting in a risk nomogram for POD in elderly hip fracture patients, as shown in Figure 1. The nomogram model was validated using Bootstrap, and the results showed a C-index value of 0.849, indicating good agreement of the model, as illustrated in Figure 2. The ROC curve was plotted, and the results demonstrated that the AUC of the nomogram model for predicting POD occurrence in elderly hip fracture patients was 0.896 (95% CI: 0.841–0.951, $P < 0.001$), with specificity, sensitivity, and Youden's index of 0.989, 0.907, and 0.893, respectively (**Figure 3**).

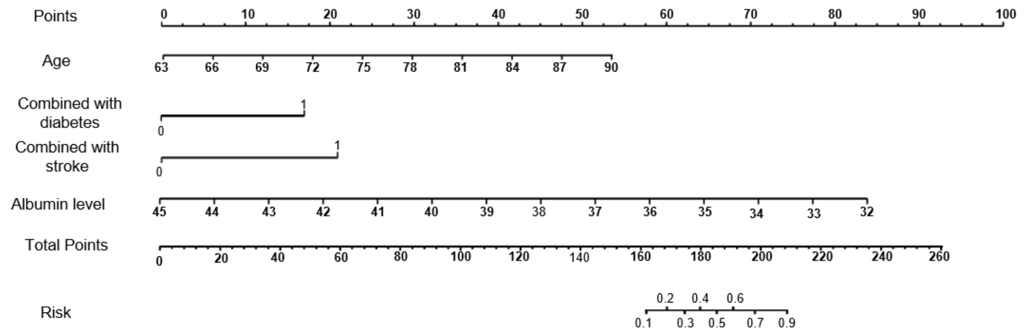

Figure 1. Nomogram model for predicting POD occurrence in elderly hip fracture patients.

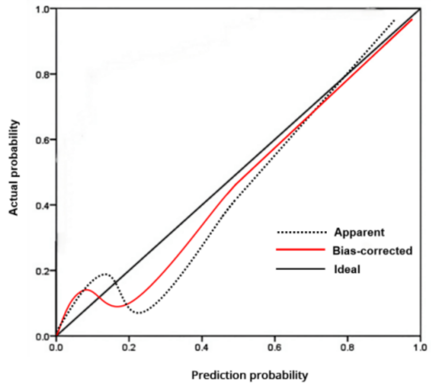

Figure 2. Internal validation chart of POD occurrence in elderly hip fracture patients.

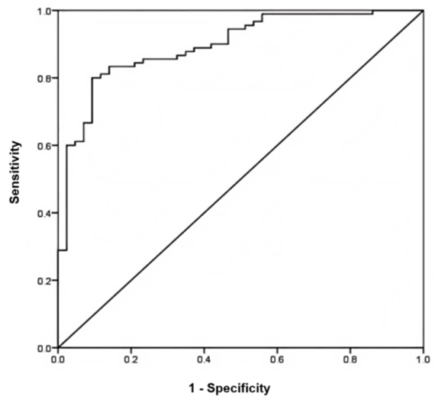

Figure 3. ROC curve for internal validation of the nomogram model predicting POD occurrence in elderly hip fracture patients.

4. Discussion

POD is relatively common among elderly hip fracture patients undergoing surgical treatment. As one of the common adverse events in hospitalized elderly patients, it is closely related to a significant increase in morbidity and mortality [4]. Therefore, identifying delirium risk factors to achieve effective prediction of POD occurrence is crucial for improving the quality of life of elderly patients and enhancing clinical prognosis.

In this study, univariate analysis showed significant differences in age, comorbidities such as diabetes and stroke, preoperative albumin levels, and intraoperative blood loss between the POD and non-POD groups ($P < 0.05$). Further multivariate logistic regression analysis identified age, diabetes, stroke, and low preoperative albumin levels as independent risk factors for POD.

Increasing age is significantly associated with POD risk. This is because, as age increases, the transmission efficiency of cholinergic neurotransmitters in the human body gradually decreases, and the biosynthetic volume of acetylcholine also decreases accordingly. However, dopamine levels may increase relatively out of balance, breaking the dynamic balance of neurotransmitters in the central nervous system and leading to metabolic homeostasis disorders of neurotransmitters, which is one of the important pathological mechanisms that induce POD [5]. Additionally, the results showed that elderly patients with comorbidities such as diabetes and stroke are more prone to POD. When elderly individuals have multiple comorbidities, their multi-system organ functions show progressive degeneration, making them more susceptible to varying degrees of organ function insufficiency, leading to a weakening of the stress compensatory mechanism [6]. Previous clinical evidence has shown that patients with a history of diabetes have a significantly increased risk of POD compared to those without diabetes, and this risk increases stepwise with poor blood glucose management, suggesting a potential pathophysiological association between metabolic disorders and abnormal neural function regulation [7]. Simultaneously, studies have shown that patients with a history of stroke have a significantly higher risk of postoperative delirium than those without a history of stroke, which may be closely related to white matter lesions, subcortical structural damage, and abnormal neural transmission pathways caused by stroke [8].

This study further confirms that low preoperative serum albumin levels are an independent risk factor for POD in elderly hip fracture patients. These patients often experience metabolic imbalances and decreased energy metabolism efficiency due to traumatic stress, or limited oral nutritional intake due to cerebrovascular disease, leading to a negative nitrogen balance state of insufficient protein synthesis and accelerated catabolism [9]. As a key biochemical indicator reflecting the body's nutritional reserve, serum albumin concentration reduction is not only a core biological marker of malnutrition but is also closely related to endothelial dysfunction, blood-brain barrier integrity disruption, and neuronal energy metabolism disorders. Previous studies have shown that preoperative high-protein nutritional supplementation can optimize the clinical outcomes of surgical patients. Therefore, dynamically monitoring and promptly correcting the serum albumin levels of hip fracture surgery patients is crucial for improving their postoperative prognosis [10]. It's worth noting that intraoperative blood loss was significant in univariate analysis but lost statistical significance in the multivariate model, suggesting that its effect may be masked by collinearity with other variables or limited by sample size, requiring further validation with a larger sample size.

The nomogram model established in this study integrates four independent risk factors. By evaluating patients' age, history of diabetes and stroke, and serum albumin levels before surgery, individualized risk scores can be quantified, which helps identify high-risk patients early and implement layered interventions. The ROC curve shows an AUC of 0.896 (95% CI: 0.841–0.951, $P < 0.001$), indicating high predictive value. Its specificity, sensitivity, and Youden index reach 0.989, 0.907, and 0.893, respectively, suggesting that this model can effectively screen high-risk delirium patients in clinical practice, facilitating early intervention and reducing delirium incidence and harm.

5. Conclusion

In summary, increasing age, comorbidities such as diabetes and stroke, and preoperative hypoalbuminemia are key independent risk factors for postoperative POD in elderly hip fracture patients. The nomogram prediction model based on the above risk factors demonstrates good discriminatory performance in clinical risk stratification. It is recommended to implement precision intervention strategies for high-risk populations in clinical practice to optimize perioperative management effectiveness. However, this study has certain limitations, such as a small sample size, potential selection bias, and the exclusion of possible influencing factors like preoperative cognitive function assessment, sleep disorders, and medication use. Future research will focus on large-scale, multi-factor studies to further optimize the model and improve the accuracy of prediction models.

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Disclosure statement

The author declares no conflict of interest.

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