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Construction and Validation of a Risk Prediction Model for Perioperative Stroke in Patients with Hip Fracture

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Abstract: *Objective:* To construct a nomogram prediction model for the risk of stroke in patients with hip fractures during the perioperative period. *Methods:* The clinical data of patients with hip fracture surgery admitted to a Class III Grade A hospital from January 2019 to December 2023 were selected (n = 895). According to the presence or absence of perioperative stroke, the patients were divided into the case group (n = 53) and the control group (n = 842). Univariate and multivariate analyses were used to analyze the risk factors of stroke in patients, and a prediction model was constructed. A nomogram was drawn to visualize the logistic regression prediction model, and the ROC curve and decision curve were used to analyze the prediction efficiency of the logistic regression model. *Results:* Age ≥60 years, BMI ≥24 kg/m^2, history of hypertension, history of diabetes, history of stroke, general anesthesia, abnormal intraoperative blood pressure, and operation time were included in the final prediction model. The AUC of the validation set was 0.955 (95% CI: 0.923–0.986). The calibration curve showed that the predicted probability fitted the actual incidence well (Hosmer-Lemeshow test P = 0.005), and DCA confirmed that the model had a net clinical benefit. *Conclusion:* The risk prediction model constructed in this study can effectively identify patients with a high risk of perioperative stroke after hip fracture surgery, and has good prediction efficiency and clinical practicability, which is convenient for early and accurate prediction of perioperative stroke risk.

Keywords: Hip fracture; Stroke; Risk prediction model

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1. Introduction

Hip fractures are the most lethal type of fracture, and their poor prognosis is closely related to the risk of complications. Studies have shown that perioperative stroke events can increase the risk of death in such patients eightfold [1]. Stroke, as a common and serious complication of hip fracture patients, is caused by acute cerebrovascular disease and cerebral blood supply obstacles; according to the mechanism, it can be divided into ischemic and hemorrhagic types, the former is the result of cerebral vascular stenosis or occlusion, especially the latter non-traumatic parenchymal hemorrhage [2,3]. Perioperative stroke refers to cerebral infarction caused by ischemic or hemorrhagic cerebrovascular events, which occurs from the operation to 30 days after the operation [4]. This complication is highly harmful, and its incidence is positively correlated with the age of the patients [5]. There are significant differences in the risk of type I and type II, among which high-risk surgery can increase the incidence of stroke by about 1.5 times [6]. Once perioperative stroke occurs, it will significantly prolong the postoperative hospital stay, increase medical costs, and further increase the medical burden of the family and society [7]. Therefore, this study constructs a risk prediction model for perioperative stroke in elderly patients with hip fractures, so as to provide a theoretical basis for clinical medical staff to identify high-risk groups early.

2. Materials and methods

2.1. Study subjects

Patients with hip fractures admitted to a Class III Grade A hospital from January 2019 to December 2023 were retrospectively collected as the research subjects. Inclusion criteria: (1) Hip fracture was confirmed by CT, MRI and laboratory examination, in accordance with the relevant criteria of *Surgery (9th Edition)*; (2) age ≥18 years old; (3) patients met the diagnostic criteria[8] of cerebral infarction in the 2023 Chinese guidelines for the diagnosis and treatment of acute ischemic stroke, with neurological localization signs, and confirmed by head CT and/or magnetic resonance imaging (MRI). Exclusion criteria: (1) patients with previous history of drug abuse or addiction; (2) patients with severe infectious diseases or central nervous system injury; (3) patients with previous history of mental disorders, liver and kidney dysfunction, acute cerebrovascular accident, nervous system diseases and multiple injuries; (4) pathological fracture: (5) old fracture; (6) incomplete medical records.

2.2. Data collection

The clinical data of patients were collected through the electronic medical record system, including (1) gender, age, height, and weight; (2) Preoperative indicators: patient's past history (hypertension, diabetes, coronary heart disease, previous history of stroke), anemia, atrial fibrillation, carotid artery stenosis, electrolyte disturbance, preoperative acute cerebral infarction, protein level, heart failure, blood lipid, blood glucose, white blood cell count; (3) Intraoperative indicators: anesthesia type, operation time, intraoperative blood pressure, intraoperative blood loss; (4) Postoperative indicators: postoperative blood pressure, anemia, infection and stroke.

2.3. Statistical analysis

SPSS 23.0 statistical software was used to analyze the data. The measurement data in accordance with normal distribution were expressed as mean ± standard deviation (SD), and the independent sample t-test was used. Measurement data with skewed distribution were presented as quartiles, and the rank sum test was used. Count data were described as absolute numbers or percentages and analyzed using the chi-square test. $P < 0.05$ was considered statistically significant. Variables with $P < 0.05$ were included in Logistic regression analysis to screen out independent risk factors related to stroke in patients with hip fractures. R4.1.2 software was used to analyze the independent risk factors, and the rms package was used to construct a nomogram model. The receiver operating characteristic curve (ROC), goodness-of-fit test, and calibration curve were used to evaluate the discrimination and calibration of the model, and the accuracy of the model was calculated. The

Decision Curve package was used to draw the decision analysis curve to evaluate the clinical effectiveness of the model.

3. Results

3.1. General information of the subjects

A total of 895 patients were included in this study, including 350 males (39.1%) and 545 females (60.9%). The mean age was 72.46 ± 14.58 years (range 60–99 years). Postoperative stroke occurred in 22 patients with hip fractures, with an incidence of 2.5%. The incidence was 2.6% in men and 1.5% in women.

3.2. Univariate analysis of perioperative stroke in patients with hip fracture

The 895 patients with hip fractures were divided into stroke occurrence group and non-stroke occurrence group, as shown in **Table 1**.

Table 1. Univariate analysis of the risk of perioperative stroke in patients with hip fracture

Variables	Total (*n* = 895)	0 (*n* = 842)	1 (*n* = 53)	Statistic	*P*
Gender, *n* (%)				Squared = 6.41	0.011
1	350 (39.11)	338 (40.14)	12 (22.64)		
2	545 (60.89)	504 (59.86)	41 (77.36)		
Age, *n* (%)				Squared = 5.02	0.025
1	127 (14.19)	125 (14.85)	2 (3.77)		
2	768 (85.81)	717 (85.15)	51 (96.23)		
BMI, *n* (%)				Squared = 149.57	<.001
0	191 (21.34)	188 (22.33)	3 (5.66)		
1	526 (58.77)	521 (61.88)	5 (9.43)		
2	178 (19.89)	133 (15.80)	45 (84.91)		
Method of anesthesia, *n* (%)				Squared = 25.76	<.001
1	511 (57.09)	463 (54.99)	48 (90.57)		
2	384 (42.91)	379 (45.01)	5 (9.43)		
With or without hypertension, *n* (%)				Squared = 28.33	<.001
0	400 (44.69)	395 (46.91)	5 (9.43)		
1	495 (55.31)	447 (53.09)	48 (90.57)		
Diabetes mellitus, *n* (%)				Squared = 47.58	<.001
0	641 (71.62)	625 (74.23)	16 (30.19)		
1	254 (28.38)	217 (25.77)	37 (69.81)		
Coronary heart disease, *n* (%)				Squared = 0.80	0.371
0	718 (80.22)	678 (80.52)	40 (75.47)		
1	177 (19.78)	164 (19.48)	13 (24.53)		
Carotid stenosis, *n* (%)				Squared = 1.09	0.297
0	860 (96.09)	811 (96.32)	49 (92.45)		
1	35 (3.91)	31 (3.68)	4 (7.55)		
Atrial fibrillation, *n* (%)				Squared = 0.05	0.826
0	858 (95.87)	808 (95.96)	50 (94.34)		

Variables	Total (n = 895)	0 (n = 842)	1 (n = 53)	Statistic	P
1	37 (4.13)	34 (4.04)	3 (5.66)		
Previous history of stroke, n (%)				Squared = 13.20	<.001
0	307 (34.30)	301 (35.75)	6 (11.32)		
1	588 (65.70)	541 (64.25)	47 (88.68)		
With or without anemia, n (%)				Squared = 2.54	0.111
0	567 (63.35)	528 (62.71)	39 (73.58)		
1	328 (36.65)	314 (37.29)	14 (26.42)		
Presence or absence of electrolyte disorder assignment, n (%)				Squared = 1.10	0.295
0	583 (65.14)	552 (65.56)	31 (58.49)		
1	312 (34.86)	290 (34.44)	22 (41.51)		
Preoperative emergency cerebral infarction, n (%)				-	0.617
0	879 (98.21)	826 (98.10)	53 (100.00)		
1	16 (1.79)	16 (1.90)	0 (0.00)		
Protein level, n (%)				Squared = 2.70	0.100
0	564 (63.02)	525 (62.35)	39 (73.58)		
1	331 (36.98)	317 (37.65)	14 (26.42)		
Heart failure, n (%)				Squared = 0.12	0.733
0	862 (96.31)	810 (96.20)	52 (98.11)		
1	33 (3.69)	32 (3.80)	1 (1.89)		
Blood lipids, n (%)				Squared = 6.03	0.014
0	877 (97.99)	828 (98.34)	49 (92.45)		
1	18 (2.01)	14 (1.66)	4 (7.55)		
Blood glucose, n (%)				-	0.255
0	817 (91.28)	771 (91.57)	46 (86.79)		
1	77 (8.60)	70 (8.31)	7 (13.21)		
2	1 (0.11)	1 (0.12)	0 (0.00)		
Leukocyte count, n (%)				Squared = 7.80	0.020
0	11 (1.23)	9 (1.07)	2 (3.77)		
1	624 (69.72)	581 (69.00)	43 (81.13)		
2	260 (29.05)	252 (29.93)	8 (15.09)		
Operation time, n (%)				Squared = 133.78	<.001
1	787 (87.93)	767 (91.09)	20 (37.74)		
2	108 (12.07)	75 (8.91)	33 (62.26)		
Intraoperative blood pressure, n (%)				Squared = 18.26	<.001
0	369 (41.23)	362 (42.99)	7 (13.21)		
1	526 (58.77)	480 (57.01)	46 (86.79)		
Intraoperative blood loss, n (%)				Squared = 1.62	0.445
0	776 (87.00)	727 (86.65)	49 (92.45)		
1	97 (10.87)	94 (11.20)	3 (5.66)		
2	19 (2.13)	18 (2.15)	1 (1.89)		
Anemia, n (%)				Squared = 0.23	0.632
0	382 (42.78)	361 (42.98)	21 (39.62)		
1	511 (57.22)	479 (57.02)	32 (60.38)		

Variables	Total (n = 895)	0 (n = 842)	1 (n = 53)	Statistic	P
Postoperative blood pressure, n (%)				Squared = 2.04	0.153
1	523 (58.44)	497 (59.03)	26 (49.06)		
2	372 (41.56)	345 (40.97)	27 (50.94)		
Co-infection, n (%)				-	0.491
0	884 (98.77)	832 (98.81)	52 (98.11)		
1	11 (1.23)	10 (1.19)	1 (1.89)		

χ^2: Chi-square test, -: Fisher exact

3.3. Multivariate analysis of the risk of perioperative stroke in patients with hip fracture

Multivariate logistic regression analysis was used to analyze the risk factors with statistical significance in univariate analysis, and the forward stepwise method and likelihood ratio test were used to exclude the variables with no statistical significance. Independent variables were assigned in the following manner. Stroke: yes = 1, no = 0; Gender: male = 1, female = 0; Age: < 60 years = 1, ≥60 years = 2; BMI: thin = 1, normal = 2, obese = 3; Anesthesia method: general anesthesia =1, local anesthesia = 2; Hypertension: yes = 1, no = 0; Combined with diabetes 1 = yes, 0 = no; Previous stroke history: yes = 1, no = 0; Blood lipids: yes = 1, no = 0; White blood cell count high = 0, low = 1, normal = 2; Operation time: < 3h = 1, ≥3h = 2, intraoperative blood pressure: normal = 0, abnormal = 1. The results are shown in **Table 2.**

Table 2. Multivariate analysis of the risk of perioperative stroke in patients with hip fracture

Variables	Beta	S.E	Z	P	OR	95% CI
Gender	0.49	0.54	0.91	0.360	1.64	[0.57 to 4.70]
Age	0.51	0.92	0.56	0.577	1.67	[0.28 to 10.13]
BMI	2.08	0.71	2.92	0.003	8.04	[1.99–32.53]
Methods of anesthesia	-2.61	0.66	-3.97	<.001	0.07	[0.02–0.27]
Combined hypertension	1.35	0.62	2.16	0.031	3.84	[1.13 to 13.02]
Diabetes mellitus	1.40	0.49	2.84	0.005	4.05	[1.54–10.61]
He had a previous stroke	1.40	0.64	2.21	0.027	4.07	[1.17–14.17]
Blood lipids	2.53	0.88	2.89	0.004	12.60	[2.26–70.29]
White blood cell count	-4.88	1.41	-3.45	<.001	0.01	[0.00 to 0.12]
Duration of surgery	3.65	0.61	6.01	<.001	38.43	[11.69–126.28]
Intraoperative blood pressure	1.33	0.61	2.20	0.27	3.80	[1.16 12.43]

3.4. Construction of risk prediction model for perioperative stroke in patients with hip fracture

Through regression analysis of the included nine independent risk factors and their regression coefficients, the prediction model for stroke in patients with hip fracture was constructed by the formula method, and the nomogram for stroke after hip fracture was presented, as shown in **Figure 1**.

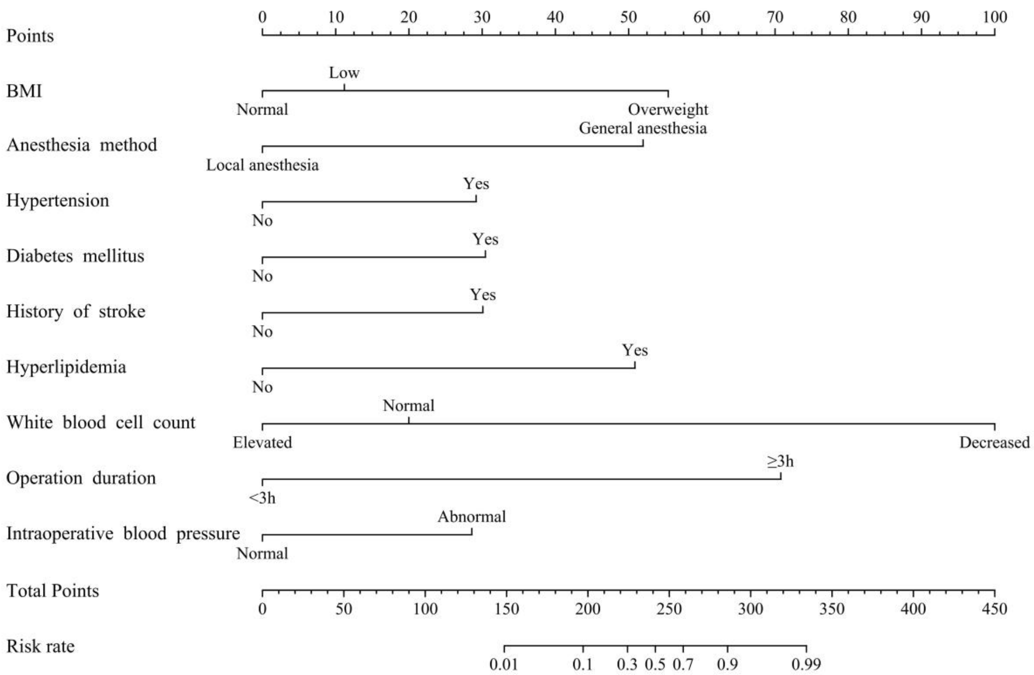

Figure 1. A nomogram model for predicting perioperative stroke in patients with hip fracture

3.5. Validation of the prediction model for perioperative stroke risk in patients with hip fracture

The model was validated by discrimination, calibration, and clinical validity. The results showed that the AUC of postoperative stroke in patients with hip fracture was 0.955 (95% CI: 0.923–0.986). This indicated that the model had good discrimination. See **Figure 1**. Hosmer-Lemeshow test results show $P = 0.009$, which proves that the model predicts well, and the predicted curve is basically consistent with the actual value, as shown in **Figure 2**. The bootstrap method was used to repeat 1,000 times from the original data, and the two-sided test level was 0.05. The results showed that the C-index (95% CI) was better, as shown in **Figure 3**. The DCA decision curve was used to evaluate the clinical effectiveness, and the model curve was closer to the two extreme curves. This model was selected to predict the positive clinical benefit of perioperative stroke in patients with hip fractures, as shown in **Figure 4**. The above results show that the prediction model has preliminary discrimination and calibration ability, but the clinical validity still needs to be further improved.

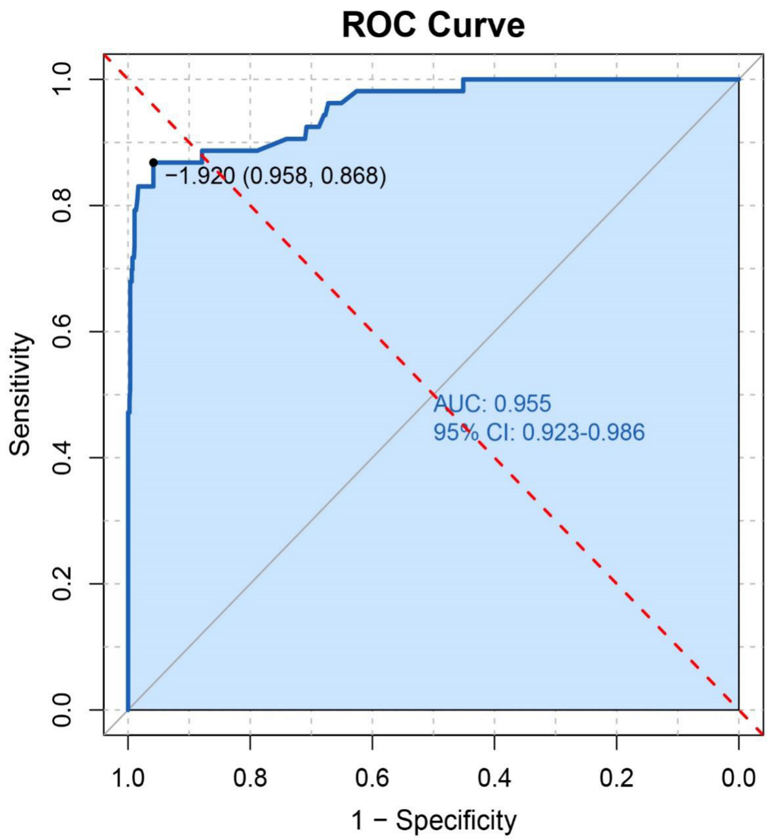

Figure 2. ROC curve for the perioperative stroke risk model in patients with hip fracture

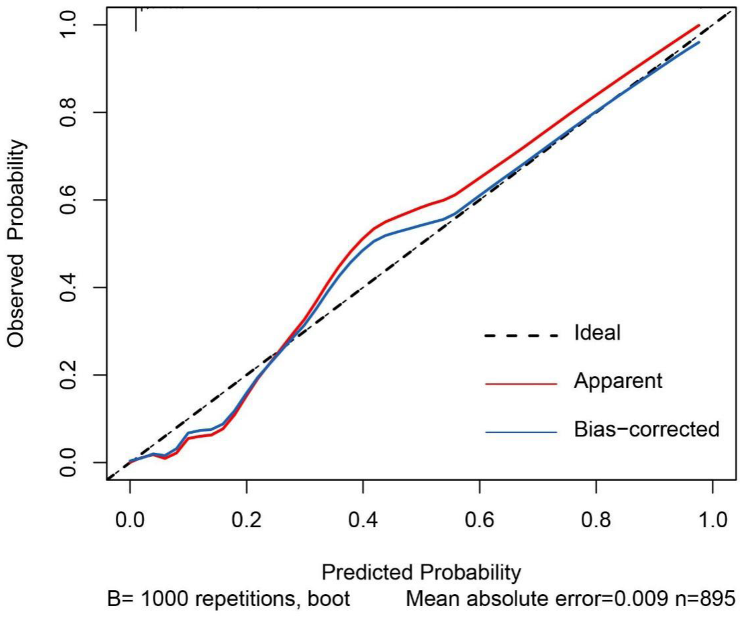

Figure 3. Calibration curve of the perioperative stroke risk model in patients with hip fracture

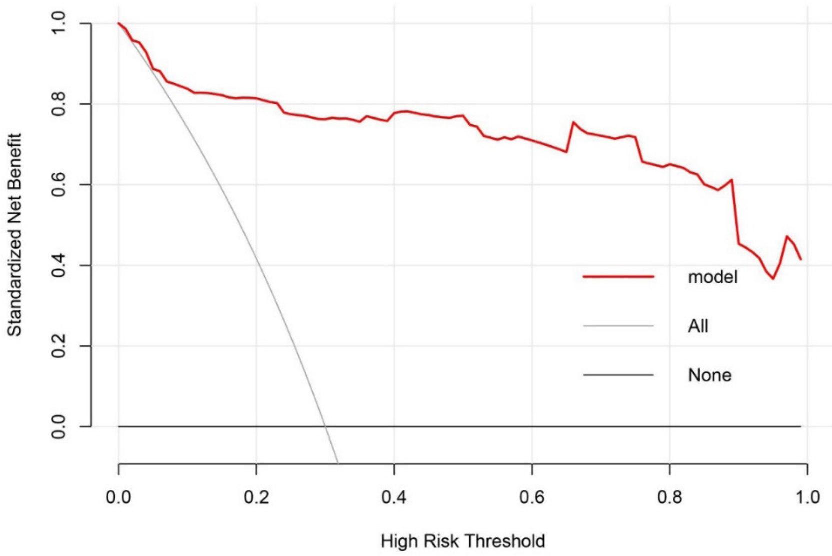

Figure 4. Decision curve analysis of the prediction model perioperative stroke in patients with hip fractures

4. Discussion

4.1. Current status analysis of perioperative stroke in hip fracture patients

Relevant studies have shown that about 5% of stroke patients have hip fractures during the follow-up period after discharge, and the risk of hip fractures is more than 1.5 times higher than that of the same age population [9]. The risk of falls in this population is significantly higher than that in the elderly general population, and the mechanism may be closely related to the decline of postural control caused by visual pathway disorders and proprioceptive system disorders after stroke. As a typical pathological fracture, a hip fracture is often accompanied by multi-system involvement and biomechanical structure damage of the lower extremities. Its protracted course is easy to induce serious complications such as deep vein thrombosis and pressure injury, which eventually lead to a significant increase in mortality [9,10].

Based on the previous research on stroke-related risk factors, 11 independent predictors of stroke were screened out by multivariate logistic regression analysis, and a prediction model for perioperative stroke risk of hip fracture was established. The model had good intuitive performance, and internal verification showed that the model had strong predictive ability. It can help medical staff identify the high-risk population of perioperative stroke in hip fracture as early as possible, and take appropriate intervention measures in time to reduce the occurrence of stroke and its complications.

4.2. Risk factors analysis of stroke in patients after hip fracture surgery

4.2.1. Body mass index >24 kg/m^2

A BMI >24 kg/m^2 indicates that the patient is overweight or obese. Studies have shown that body mass index >24 kg/m^2 is a risk factor [11] for perioperative cerebrovascular accident. Obesity is the core of metabolic syndrome, often accompanied by insulin resistance, dyslipidemia, chronic inflammatory state, and endothelial dysfunction, which are the basis of atherosclerosis and thrombosis. The stress of surgical trauma and anesthesia can further aggravate this hypercoagulable state and inflammatory response, thus inducing acute cerebrovascular events. Therefore, structured health education intervention and stepwise weight control strategies should be implemented to reduce the incidence of neurovascular complications.

4.2.2. Methods of anesthesia

This study shows that patients receiving general anesthesia are more likely to have a stroke than those receiving regional anesthesia, which is consistent with the study by Zhou *et al.* [3], and may be related to the use of 3 to 4 drugs such as intravenous anesthetics, inhaled anesthetics, and analgesics during general anesthesia. The pharmacological properties of reducing peripheral vascular resistance and cardiac output, and the acidosis caused by hypocapnia and hypoxia caused by hyperventilation will also cause a decrease [12] in blood pressure, eventually leading to cerebral hypoperfusion, and leading to the occurrence of central nervous system complications. At the same time, studies [13] on anesthesia physiology have pointed out that there are two risk factors in patients with general anesthesia: peripheral vasodilatation and decreased cardiac output. The synergistic effect of the two factors reduces cerebral blood flow to a critical threshold, and the risk factor of cerebrovascular accident increases. Therefore, it is recommended to choose anesthetic drugs with less effect on cerebral blood vessels to maintain the stability of cerebral circulation during the operation.

4.2.3. History of diabetes

This study shows that preoperative diabetic hip fractures are associated with a higher risk of postoperative stroke. Some studies have confirmed that diabetes is an independent predictor of stroke events after hip fracture, and its risk factors are derived from chronic inflammation and abnormal vascular remodeling caused by insulin resistance [13,14]. At the same time, the degree of blood glucose variability also plays an important role in accelerating the occurrence of adverse cardiovascular and cerebrovascular events [15]. Other studies have shown that hip fracture patients with diabetes mellitus are at high risk of stroke, which may be related to high blood viscosity and hypercoagulable state in diabetic patients[16]. Therefore, perioperative blood glucose management programs should be implemented for patients with diabetes and hip fracture: (1) Preoperative nutritional intervention should be combined with continuous glucose monitoring to optimize the level of glycosylated hemoglobin, (2) to standardize insulin administration to correct insulin resistance, and (3) to control stress hyperglycemia by adjusting the proportion of dietary fiber and carbohydrate measurement, so as to systematically reduce the risk of postoperative acute cerebrovascular events.

4.2.4. History of hypertension

The results of this study suggest that patients with a history of hypertension are more likely to have a stroke after a hip fracture. This may be related to the increase in the body's blood pressure level, which increases the damage degree of intracranial small arteries, induces cerebral atherosclerosis, causes small artery wall thickening, stenosis, and other lesions, and increases the risk [17] of cerebrovascular accident. According to the American Stroke Association [18], hypertension can increase the risk of stroke, especially when blood pressure is not well controlled during surgery, which is more likely to cause cerebrovascular problems. The study also found that people with a stroke caused by high blood pressure have more difficulty recovering and are more likely to die [19], become disabled, and have a recurrence than those with a stroke caused by other causes. Therefore, patients with hypertension after hip fracture surgery should be focused on monitoring blood pressure changes. According to the patient's age and blood pressure classification, blood pressure should be controlled within a reasonable range to minimize the risk of stroke in hip fracture patients with a history of hypertension.

4.2.5. History of stroke

The results of this study suggest that patients with a history of stroke are more likely to have a stroke after hip fracture surgery. The study found a 13-fold increased risk of recurrent stroke in patients with a history of stroke. Yu *et al.* [20] found that clinical observations showed that patients with previous stroke had a significantly increased risk of a second stroke after undergoing hip fracture surgery. Its pathological mechanism is mainly related to the impairment of cerebrovascular regulation function and old infarction focus after stroke. When there is circulatory fluctuation or metabolic imbalance, the oxygen supply regulation ability of the damaged brain area is limited, which is easy to induce ischemic damage of nerve cells, and then lead to the recurrence of cerebrovascular events. Therefore, for such patients, it is necessary to focus on the implementation of precise hemodynamic management during the perioperative period, and maintain the balance of cerebral oxygen supply and demand to the maximum extent by continuous monitoring of cerebral perfusion pressure and intracranial blood flow, so as to effectively prevent the recurrence of stroke.

4.2.6. Intraoperative blood pressure abnormalities

This study shows that abnormal intraoperative blood pressure is one of the risk factors for postoperative stroke in patients with hip fractures. Intraoperative hypotension is a risk factor [21] for perioperative stroke, which may be related to blood volume reduction, electrolyte imbalance, and severe anemia caused by prolonged fasting and water deprivation before surgery. In addition, there may be bone cement implantation reactions, improper management of intraoperative controlled hypotension or large blood loss, and the influence of the depth of anesthesia. If the blood pressure is not maintained effectively and timely, it can lead to long-term hypoperfusion of brain tissue, and then cause ischemia and hypoxia injury. Studies have shown [22] that the increase of blood pressure variability during surgery not only disrupts the hemodynamic homeostasis at the capillary level, but also induces capillary hypoperfusion through abnormal shear stress of vascular endothelium, which in turn leads to tissue oxygenation disorder. Therefore, medical staff should strengthen the management of intraoperative blood pressure, control blood pressure before surgery, and do a good job of preoperative psychological care for patients to avoid increasing the risk of stroke.

4.2.7. White blood cell count

This study found that postoperative white blood cell count abnormality was an independent predictor of postoperative stroke in patients with hip fractures. This result is consistent with the study by Yao *et al.* [23], who confirmed that increased white blood cell count was a significant risk factor for perioperative stroke through a retrospective analysis of 361 elderly patients with hip fractures. Most of the patients with hip fractures are very elderly, often accompanied by a variety of underlying diseases. An elevated white blood cell count may be a response to an occult or undetected infection (e.g., urinary tract infection, respiratory tract infection, pressure sores, etc.), which itself is an important risk factor for stroke. On the other hand, leukopenia may indicate the presence of malnutrition, extreme immunosuppression, or more serious underlying disease states, which may reduce the patient’s ability to cope with surgical trauma and stress, and the risk of organ dysfunction (including cerebrovascular events) is correspondingly increased. Therefore, nursing staff should improve the awareness of the risk of stroke, identify high-risk patients with abnormal white blood cells early, and establish targeted nursing programs.

4.2.8. High blood lipids

The results of this study found that preoperative dyslipidemia is an important risk factor for perioperative stroke, which is basically consistent with the prospective study of Ni *et al.* [24]. In 169 hip fracture patients, the incidence of dyslipidemia and perioperative cerebrovascular events was 2.3 times higher than that in the normal group. Related studies have shown that hyperlipidemia promotes atherosclerosis and arterial stenosis, which increases the risk [25] of stroke. This may be related to high LDL-C level, which leads to microcirculation disorders in the cerebral perfusion area by promoting the formation of atherosclerotic plaque and increasing platelet aggregation. While low HDL-C weakens the vascular endothelial repair ability and anti-inflammatory function, it synergistically aggravates the risk of perioperative cerebral ischemia. Therefore, nurses should comprehensively evaluate the blood lipid status and medication history of patients before surgery. It is necessary to focus on the importance of continuous use of statins to maintain the stability of blood lipids and prevent the risk of stroke, and urge patients to take medication regularly until the day of surgery.

4.2.9. Operation time

This study confirmed that prolonged operation time is an independent risk factor for perioperative stroke in patients with hip fractures. The prolonged operation time directly reflects the increased surgical traumatic stress. This may be related to the complex operation, the difficulties encountered during the operation, and more bleeding and fluid transfer, which will aggravate the physiological stress response of the patient. This strong stress state will lead to the massive release of stress hormones such as catecholamines and cortisol, which will cause blood pressure fluctuation and heart rate increase, and increase the cardiac load, which may induce arrhythmias such as atrial fibrillation, or lead to the unstable rupture of the original atherosclerotic plaque, and ultimately greatly increase the risk[26] of perioperative ischemic stroke. In addition, prolonged anesthesia itself will challenge the stability of the circulatory system, increase the probability of hypotension events, and cause cerebral hypoperfusion. Therefore, clinical medical staff should implement the whole process of patients from preoperative to postoperative, more targeted monitoring and intervention, and ultimately play a key role in improving the prognosis of patients.

5. Conclusion

This study focused on the high risk of perioperative stroke in patients with hip fractures, and successfully constructed and validated a nomogram model for predicting the risk of this complication. The results show that the nomogram model can more accurately identify patients with a high risk of stroke during the perioperative period of hip fracture, and provides an important quantitative reference tool for clinical medical staff in preoperative evaluation, early warning, formulation of personalized nursing intervention plans, and optimal allocation of medical resources. Although the prediction model constructed in this study shows good performance in the sample of a single center, there may be a certain bias in the results due to the limited sample. Future studies can further conduct multi-center and prospective validation, and explore the clinical application effect of the model and its practical value in improving the prognosis of patients.

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Disclosure statement

The authors declare no conflict of interest.

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