Am J Transl Res 2025;17(4):2937-2946
www.ajtr.org /ISSN:1943-8141/AJTR0162330

Original Article

Impact of general anesthesia and spinal anesthesia on postal delirium and risk factors in elderly patients undergoing hip fracture surgery

Li Ma[1], Jie Hao[1], Saijun Wang[1], Kaiyin Yang[2], Wansheng Liang[2], Fengxiang Gu[2]

[1]Department of Anesthesia Surgery, Affiliated Hospital of Gansu University of Chinese Medicine, No. 732 Jiayuguan West Road, Chengguan District, Lanzhou 730020, Gansu, China; [2]Anesthesia and Pain Medical Center, Gansu Provincial Hospital of TCM, No. 418 Guazhou Road, Qilihe District, Lanzhou 730050, Gansu, China

Received November 28, 2024; Accepted March 11, 2025; Epub April 15, 2025; Published April 30, 2025

Abstract: Objective: To compare the effects of general anesthesia (GA) and spinal anesthesia (SA) on postoperative delirium (POD) in elderly patients undergoing hip fracture surgery and to identify associated risk factors. Methods: A retrospective study was conducted on 186 elderly patients who underwent hip fracture surgery at the Affiliated Hospital of Gansu University of Chinese Medicine from January 2021 to January 2023. Patients were categorized into GA and SA groups. The incidence of POD, postoperative pain control, and cognitive function changes were compared. Univariate and multivariate Logistic regression analyses were performed to identify independent risk factors for POD. The predictive value of significant factors was assessed using receiver operating characteristic (ROC) curve analysis. Results: The incidence of POD was significantly higher in the GA group than that in the SA group (27.4% vs. 9.9%, P=0.002). The visual analogue scale scores at 24 hours postoperatively and analgesic drug usage were significantly higher in the GA group (both P<0.001). Cognitive function scores postoperatively were significantly lower in the GA group (P<0.005). Multivariate analysis identified longer operation time (P<0.001, OR: 1.084, 95% CI: 1.047-1.123) and higher intraoperative blood loss (P=0.042, OR: 1.018, 95% CI: 1.001-1.035) as independent risk factors for POD. Conversely, higher preoperative hemoglobin (P=0.002, OR: 0.949, 95% CI: 0.919-0.981) and SA (P=0.021, OR: 0.174, 95% CI: 0.039-0.767) were protective factors. Conclusion: Compared to GA, SA significantly reduces POD incidence and improves postoperative analgesia in elderly hip fracture patients. Optimizing anesthetic strategies and preoperative assessments may enhance postoperative recovery in this population.

Keywords: Hip fracture, spinal anesthesia, postoperative delirium, risk factor analysis

Introduction

Hip fractures result from complete or partial breaks in the hip bone and are more prevalent in individuals over 65 years old [1]. With aging, bone density gradually decreases, weakening bone strength and reducing balance and reaction capabilities, making elderly individuals more prone to hip fractures due to falls [2, 3]. Statistics indicate that osteoporotic fractures affect up to 50% of women and 20% of men over 50 years old [4]. As the population ages, the incidence of hip fractures in the elderly continues to rise.

Following a hip fracture, prolonged bed rest increases the risk of complications such as pulmonary infections, deep vein thrombosis, and pressure ulcers, which can significantly elevate mortality [5]. According to Sing et al. [6], the all-cause mortality rate after a hip fracture ranges from 14.4% to 28.3%.

Surgical treatment is the primary approach for elderly patients with hip fractures. However, due to age-related declines in organ function, anesthesia and surgery pose significantly higher risks in elderly patients than middle-aged individuals. Postoperative complications are more common, with postoperative delirium (POD) being one of the most prevalent complications [7]. POD is an acute neuropsychiatric syndrome occurring within a week after surgery and anesthesia, primarily characterized by cognitive dysfunction and impaired attention [8]. Selecting an optimal anesthetic approach is

https://doi.org/10.62347/NKTA3087

therefore crucial for ensuring surgical success and minimizing adverse outcomes in elderly patients.

For hip fracture surgery in the elderly, the main anesthesia options are regional anesthesia and general anesthesia [9]. General anesthesia (GA) induces unconsciousness through inhaled or intravenous anesthetic agents [10], whereas regional anesthesia involves injecting local anesthetics into the spinal cord or peripheral nerves to alleviate pain [11]. Spinal anesthesia (SA), a form of regional anesthesia, allows patients to remain conscious and maintain spontaneous breathing, potentially reducing central nervous system complications and lowering the risk of POD [12]. However, the specific impact of GA and SA on POD incidence in elderly hip fracture patients remains unclear.

This study aims to compare the effects of GA and SA on POD in elderly patients undergoing hip fracture surgery.

Materials and methods

Patient data

A retrospective study was conducted on 186 elderly patients who underwent hip fracture surgery at the Affiliated Hospital of Gansu University of Chinese Medicine between January 2021 and January 2023. This study was approved by the Medical Ethics Committee of the Affiliated Hospital of Gansu University of Chinese Medicine (ethics approval number: 20200416).

Inclusion and exclusion criteria

Inclusion criteria: Patients were diagnosed with hip fractures based on imaging findings [13], underwent hip fracture surgery, had an ASA classification of II or III, were aged 65 years or older, and had complete medical records.

Exclusion criteria: Patients had preoperative consciousness or cognitive disorders, medication allergies, fractures other than hip fractures, coagulation dysfunction, or acute infections.

Anesthesia protocols

Patients in the GA group fasted for 8 hours before surgery. One hour before surgery, they received 5-10 mg of diazepam (Shanxi Xinbaoyuan Pharmaceutical Co., Ltd., batch number: 20210108) orally, along with continuous ECG monitoring and nasal cannula oxygen supplementation. Upon entering the operating room, an intravenous line was established, and a continuous infusion of physiological saline or lactated Ringer's solution was maintained. Anesthesia was induced with cisatracurium besylate (Zhejiang Xianjun Pharmaceutical Co., Ltd., batch number: 20200411) at 0.1 mg/kg, midazolam (Jiangsu Enhua Pharmaceutical Co., Ltd., batch number: MD202046) at 0.1 mg/kg, etomidate (Zhejiang Jiuxu Pharmaceutical Company, batch number: 2020712), and sufentanil (Yichang Renfu Pharmaceutical Company, batch number: 21A03261). After endotracheal intubation, remifentanil (Liaoning Haisike Pharmaceutical Company, batch number: 20A12061) was continuously administered via a micro-pump at 0.1-1.0 μg/(kg·min) with propofol (Sichuan Guorui Pharmaceutical Company, batch number: 2110261) at 0.1 mg/(kg·min). Additional anesthetic agents were administered as needed based on muscle relaxation and anesthesia depth.

The SA group underwent the same preoperative preparations as the GA group. Patients were positioned laterally on their right side, and a lumbar puncture was performed at the L2-3 or L3-4 interspace. A catheter was inserted 4-5 cm deep, and 2 mL of levobupivacaine (Shanghai Hefeng Company, batch number: H31021344) was injected to achieve an anesthetic level of T10.

Observation indicators

Primary outcomes: Postoperative pain management: The visual analogue scale (VAS) score at 24 hours postoperative [14] and the number of analgesic drug administrations were compared between the GA and SA groups.

Cognitive function changes: Cognitive function was assessed preoperatively and postoperatively using the Mini-Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA) scales [15].

Incidence of POD: The incidence of POD was compared between the groups. Independent risk factors for POD were identified through univariate and multivariate logistic regression analyses.

Secondary outcomes: Surgical parameters: Surgery duration, intraoperative blood loss, and length of hospital stay were recorded for both groups.

Postoperative complications: The incidence of postoperative infections and postoperative hypotension was compared between the groups.

Statistical analysis

All statistical analyses were performed using SPSS software. Continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using independent sample t-tests. Categorical variables were expressed as frequencies and analyzed using chi-square tests. POD, as a binary variable, was initially analyzed for potential risk factors through univariate analysis. Variables with significant differences were then included in a multivariate logistic regression model to identify independent predictors of POD. The predictive value of each independent risk factor was assessed using receiver operating characteristic (ROC) curve analysis, with the area under the curve (AUC) calculated. A *P*-value of <0.05 was considered statistically significant.

Results

Comparison of baseline data

A comparison of baseline characteristics between the two groups showed no statistically significant differences in body mass index, age, gender, American Society of Anesthesiologists classification, fracture site, education level, history of hypertension, history of diabetes, cause of fracture, preoperative waiting time, preoperative hemoglobin, or preoperative albumin (all P>0.05), as shown in **Table 1**.

Comparison of surgical conditions

No significant differences were observed between the two groups in terms of surgery duration or hospital stay. However, intraoperative blood loss was significantly higher in the GA group than that in the SA group (P<0.05), as shown in **Figure 1**.

Comparison of postoperative analgesic effects

The GA group had significantly higher VAS scores at 24 hours postoperatively and a greater number of analgesic drug administrations compared to the SA group (both P<0.05), as shown in **Figure 2**.

Comparison of cognitive function changes

There were no significant differences in preoperative MMSE and MoCA scores between the two groups (both P>0.05). However, postoperative MMSE and MoCA scores were significantly lower in the GA group than those in the SA group (both P<0.05) (**Figure 3**).

Comparison of POD and adverse reaction rates

POD occurred in 26 cases in the GA group and 9 cases in the SA group. The incidence of POD was significantly higher in the GA group than that in the SA group (P<0.05).

Regarding postoperative complications, the GA group had 5 cases of postoperative infection and 9 cases of postoperative hypotension, while the SA group had 7 cases of postoperative infection and 4 cases of postoperative hypotension. No significant differences were observed in the incidence of postoperative infection, hypotension, or nausea and vomiting between the two groups (all P>0.05), as shown in **Table 2**.

Univariate analysis of POD showed that age, preoperative hemoglobin, operation time, intraoperative blood loss, 24-hour postoperative VAS score, preoperative MMSE score, preoperative MoCA score, and anesthesia type were significantly associated with the occurrence of POD (P<0.05, **Table 3**).

Multivariate analysis of POD

Multivariate logistic regression analysis of the significant factors from the univariate analysis revealed the following:

Age (P=0.161, OR: 2.245, 95% CI: 0.725-6.952), 24-hour postoperative VAS score (P=0.717, OR: 1.121, 95% CI: 0.605-2.074) and preoperative MoCA score (P=0.136, OR: 0.877, 95% CI: 0.757-1.039) were not independent risk factors for POD.

Longer operation time (P<0.001, OR: 1.084, 95% CI: 1.047-1.123) and greater blood loss (P=0.042, OR: 1.018, 95% CI: 1.001-1.035) were identified as independent risk factors for postoperative delirium.

Table 1. Comparison of baseline data

	General anesthesia group (n=95)	Spinal anesthesia group (n=91)	χ^2/t	P
BMI (kg/m^2)	21.87±2.77	22.28±2.72	1.015	0.311
Age			0.566	0.452
<75 years	63	65		
≥75 years	32	26		
Gender			0.264	0.607
Male	28	30		
Female	67	61		
ASA Classification			0.689	0.407
Level II	65	57		
Level III	30	34		
Fracture Site			0.123	0.726
Femoral Neck	68	63		
Intertrochanteric	27	28		
Educational Level			0.265	0.606
Junior High School and below	39	34		
High School and above	56	57		
History of Hypertension			0.262	0.609
Yes	25	21		
No	70	70		
History of Diabetes			0.273	0.601
Yes	15	17		
No	80	74		
Cause of Fracture			1.226	0.268
Fall	78	80		
Traffic Accident	17	11		
Preoperative Waiting Time (d)	3.69±1.31	3.38±1.40	1.563	0.120
Preoperative Hemoglobin (g/L)	119.47±17.53	118.02±15.82	0.594	0.553
Preoperative Albumin (g/L)	39.25±4.21	38.78±4.24	0.748	0.456

Note: BMI, body mass index; ASA, American Society of Anesthesiologists.

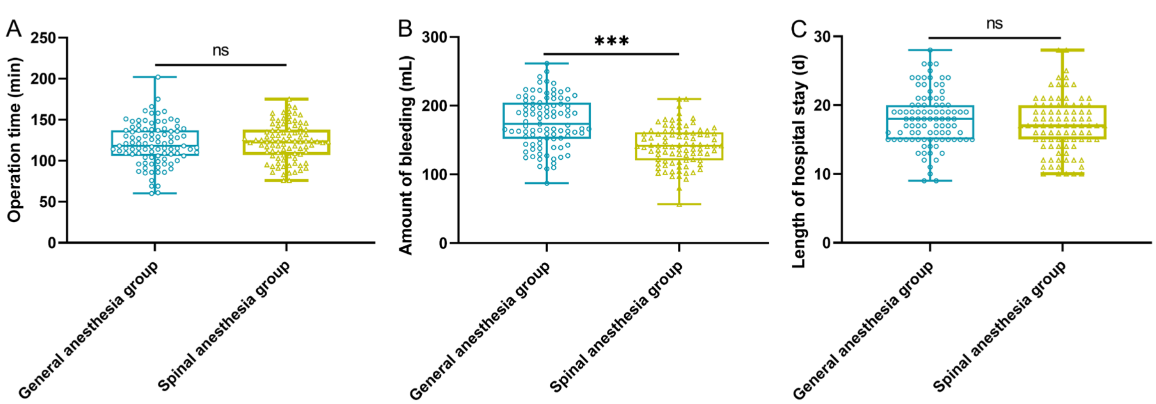

Figure 1. Comparison of surgical conditions. Note: ns means P>0.05 for comparison between the two groups, *** means P<0.05 for comparison between the two groups.

Higher preoperative hemoglobin (P=0.002, OR: 0.949, 95% CI: 0.919-0.981) and SA (P=0.021, OR: 0.174, 95% CI: 0.039-0.767) were identified as independent protective factors.

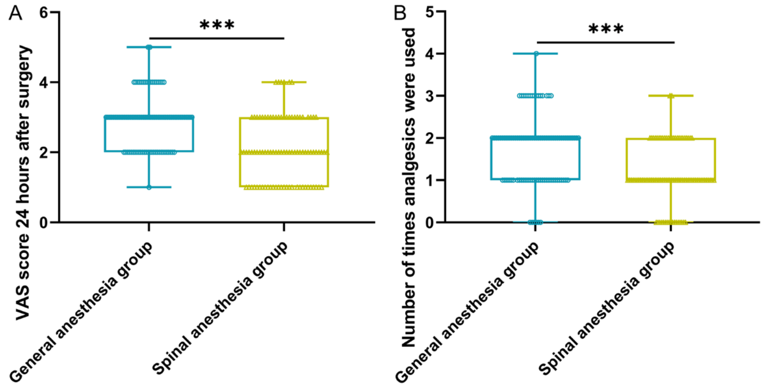

Figure 2. Postoperative analgesic effects. Note: *** indicates P<0.001 compared between the two groups. VAS, visual analogue scale.

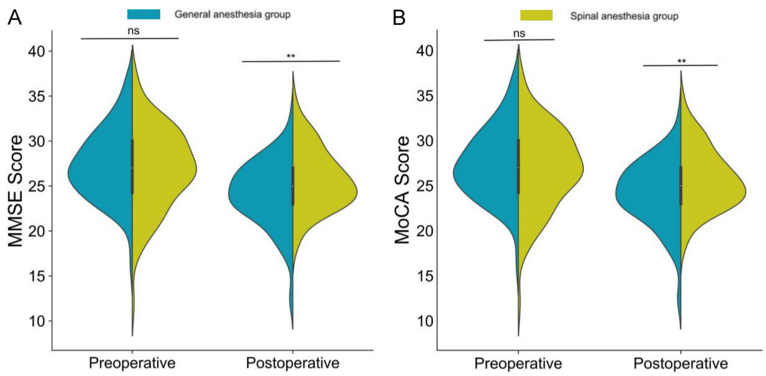

Figure 3. Comparison of cognitive function changes. Note: ns means P>0.05 for comparison between the two groups, *** means P<0.05 for comparison between the two groups. MMSE, mini-mental state examination; MoCA, Montreal cognitive assessment.

These findings are summarized in **Table 4**.

Predictive value of independent risk factors for POD

ROC curve analysis was performed to assess the predictive value of preoperative hemoglobin, operation time, blood loss, and anesthesia type for POD. The AUC values for these factors were 0.699, 0.865, 0.774, and 0.643, respectively, indicating that these independent risk factors have good predictive value for POD (**Figure 4**).

Discussion

Hip fractures are a common and severe condition in elderly patients, with surgery being the primary treatment. However, due to age-related declines in physiological function, elderly patients face higher anesthesia and surgical risks, with POD being one of the most prevalent complications [16]. This study aimed to compare the effects of GA and SA on POD incidence in elderly hip fracture patients and to analyze associated risk factors.

This study found no significant difference in surgery duration or hospital stay between the GA and SA groups. However, intraoperative blood loss was significantly higher in the GA group than that in the SA group. A possible explanation is that GA induces vasodilation, leading to increased intraoperative bleeding [17]. In contrast, SA blocks sympathetic nerve activity, reducing blood flow in the surgical area and thereby decreasing intraoperative blood loss [18]. These findings are consistent with a study by Zorrilla-Vaca et al. [19], which reported that regional anesthesia in lumbar spine surgery is associated with lower rates of nausea and vomiting, shorter hospital stays, and reduced intraoperative blood loss compared to GA.

Postoperative VAS scores at 24 hours and analgesic drug usage were significantly higher in the GA group than those in the SA group. This suggests that GA may heighten postoperative pain sensitivity, leading to an increased need for analgesics. In contrast, SA provides more effective regional pain control, reducing postoperative pain and improving patient comfort. The improved pain control associated with SA may also help lower the risk of POD by minimizing physiological stress responses.

The incidence of POD was 26% in the GA group and 9% in the SA group, demonstrating a statistically significant difference. These results suggest that SA may significantly reduce the risk of POD in elderly patients undergoing hip fracture surgery. A possible explanation is that SA maintains patient consciousness and reduces central nervous system depression, thereby lowering the risk of cognitive impairment. Additionally, SA has been associated

Table 2. Postoperative delirium and adverse reaction rates

Comparison	Postoperative delirium	Postoperative infection	Postoperative hypotension	Postoperative nausea and vomiting
General anesthesia group (n=95)	26	5	9	16
Spinal anesthesia group (n=91)	9	7	4	9
χ^2	9.295	0.454	1.844	1.931
P	0.002	0.500	0.175	0.165

Table 3. Single factor results

	Postoperative delirium (n=35)	Non-Postoperative delirium (n=151)	OR (95% CI)	P
BMI (kg/m^2)	21.71+3.09	22.15+2.66	0.943 (0.824-1.079)	0.392
Age				0.042
<75 years	19	109	2.185 (1.020-4.654)	
75 years	16	42	0.458 (0.215-0.973)	
Gender				0.972
Male	11	47	0.986 (0.455-2.247)	
Female	24	104	1.014 (0.459-2.240)	
ASA Classification				0.706
Level II	22	100	1.159 (0.529-2.463)	
Level III	13	51	0.863 (0.402-1.853)	
Fracture Site				0.498
Femoral Neck	23	108	1.310 (0.585-2.828)	
Intertrochanteric	12	43	0.763 (0.349-1.669)	
Educational Level				0.777
Junior High School and below	13	60	1.116 (0.528-2.436)	
High School and above	22	91	0.896 (0.419-1.915)	
History of Hypertension				0.149
Yes	12	34	0.557 (0.254-1.263)	
No	23	117	1.795 (0.810-3.978)	
History of Diabetes				0.991
Yes	6	26	1.005 (0.399-2.896)	
No	29	125	0.995 (0.375-2.638)	
Cause of Fracture				0.367
Fall	28	130	1.548 (0.565-3.855)	
Traffic Accident	7	21	0.646 (0.250-1.667)	
Preoperative Waiting Time (d)	3.54+1.34	3.54+1.36	1.000 (0.759-1.311)	0.999
Preoperative Hemoglobin (g/L)	108.69+16.10	121.10+15.99	0.954 (0.930-0.977)	<0.001
Preoperative Albumin (g/L)	38.81+4.24	39.07+4.22	0.986 (0.903-1.076)	0.749
Surgery Duration (min)	145.20+16.77	115.98+21.83	1.076 (1.048-1.105)	<0.001
Blood Loss (mL)	188.60+33.05	152.39+34.64	1.030 (1.018-1.143)	<0.001
Hospital Stay (d)	17.91+4.44	17.44+3.86	1.031 (0.940-1.131)	0.521
VAS Score at 24 hours Postoperatively	2.91+0.85	2.40+0.95	1.821 (1.197-2.770)	0.005
Number of Analgesic Drug Usages	1.46+0.85	1.42+0.84	1.113 (0.353-4.258)	0.863
Preoperative MMSE Score	27.14+4.88	27.21+4.04	0.996 (0.912-1.087)	0.93
Preoperative MoCA Score	23.31+3.40	24.87+3.67	0.892 (0.807-0.986)	0.026
Anesthesia Method				0.003
General Anesthesia	26	69	3.433 (1.557-8.209)	
Spinal Anesthesia	9	82	0.291 (0.128-0.663)	

Note: BMI, body mass index; ASA, American Society of Anesthesiologists; MMSE, mini-mental state examination; MoCA, Montreal cognitive assessment; VAS, visual analogue scale.

Table 4. Multivariate results

	Postoperative delirium (n=35)	Non-Postoperative delirium (n=151)	OR (95% CI)	P
Age				0.161
<75 years	19	109	2.245 (0.725-6.952)	
75 years	16	42	0.445 (0.144-1.380)	
Preoperative Hemoglobin (g/L)	108.69+16.10	121.10+15.99	0.949 (0.919-0.981)	0.002
Surgery Duration (min)	145.20+16.77	115.98+21.83	1.084 (1.047-1.123)	<0.001
Blood Loss (mL)	188.60+33.05	152.39+34.64	1.018 (1.001-1.035)	0.042
VAS Score at 24 hours Postoperatively	2.91+0.85	2.40+0.95	1.121 (0.605-2.074)	0.717
Preoperative MoCA Score	23.31+3.40	24.87+3.67	0.877 (0.757-1.039)	0.136
Anesthesia Method				0.021
General anesthesia	26	69	5.762 (1.303-25.474)	
Spinal anesthesia	9	82	0.174 (0.039-0.767)	

Note: VAS, visual analogue scale; MoCA, Montreal cognitive assessment.

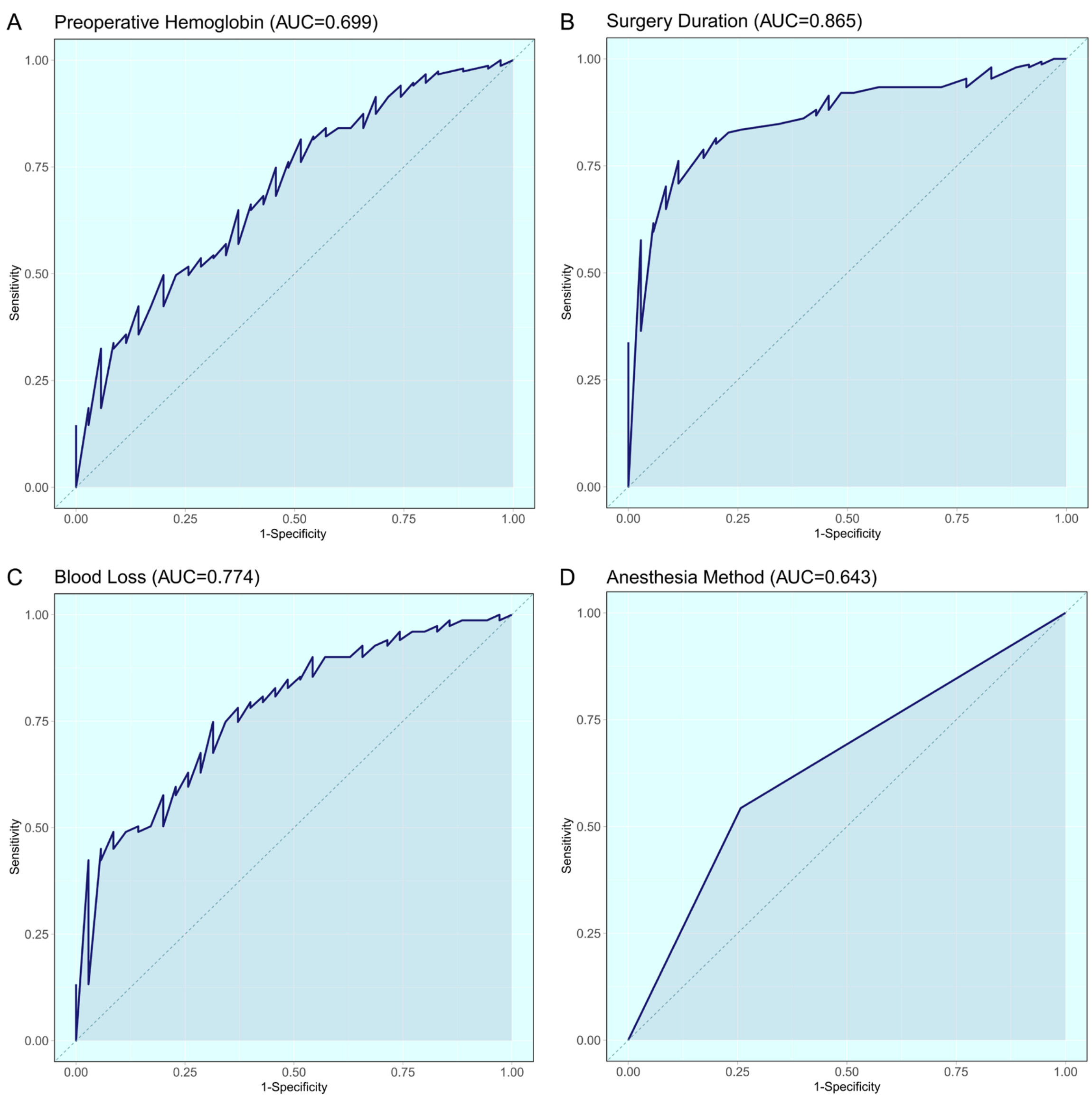

Figure 4. ROC curve of independent influencing factors for predicting postoperative delirium. ROC, receiver operating characteristic.

with reduced intraoperative blood loss and a lower stress response, both of which may contribute to a decreased risk of delirium.

Previous studies have also suggested that certain local anesthetics may better control surgical stress responses, further supporting the potential protective effects of SA against POD [20].

The results of the multivariate logistic regression analysis identified preoperative hemoglobin levels, surgery duration, blood loss, and anesthesia method as independent risk factors for POD. ROC curve analysis showed that the AUC values for predicting POD were 0.699 (preoperative hemoglobin), 0.865 (operation time), 0.774 (blood loss), and 0.643 (anesthesia method), indicating that these factors have good predictive value.

A lower preoperative hemoglobin level may indicate poor nutritional status or chronic disease, which increases the risk of postoperative complications [21]. Additionally, longer surgery duration and greater blood loss may lead to prolonged postoperative recovery, elevating the risk of POD. A study by Sui et al. [22] found that prolonged surgery in elderly patients increases the likelihood of POD, severely impacting cognitive function, extending hospital stays, and increasing medical costs. Therefore, optimizing preoperative assessment and perioperative management may help reduce the incidence of POD.

The anesthesia method was also identified as an independent risk factor for POD, reflecting the significant impact of anesthesia techniques on neurocognitive function in elderly patients. GA may increase the risk of cognitive dysfunction by depressing central nervous system activity, whereas SA preserves consciousness and minimizes neurological impairment. Belrose et al. [23] reported that GA is associated with delayed neurocognitive recovery in certain patients. These findings suggest that in clinical practice, choosing the appropriate anesthesia method can improve postoperative pain management and reduce the risk of POD.

However, some studies have reported no significant difference in cognitive dysfunction incidence between GA and regional anesthesia in elderly hip fracture patients [24]. This highlights the need to individualize anesthesia selection based on patient-specific factors and the nature of the surgery to optimize recovery outcomes.

Additionally, a study by Zhang et al. [25], which retrospectively analyzed 566 cases of spinal surgery in elderly patients, also identified blood loss as an independent risk factor for POD. Other factors such as preoperative anxiety, elevated C-reactive protein, and hyponatremia were also associated with increased POD risk, emphasizing the need for comprehensive perioperative monitoring.

This study provides a detailed comparative analysis of GA and SA in elderly patients undergoing hip fracture surgery, offering new insights into postoperative delirium and associated risk factors.

Unlike previous studies, this research conducted detailed comparisons across multiple dimensions, including POD incidence, postoperative pain control, cognitive function changes, surgical conditions, and adverse event rates.

This study employed both univariate and multivariate logistic regression analyses to accurately identify independent risk factors and protective factors for POD.

It confirmed that longer operation time and higher blood loss were independent risk factors, while higher preoperative hemoglobin and SA were independent protective factors.

By calculating AUC values from ROC curves, this study quantified the predictive value of key risk factors, aiding in early clinical intervention and perioperative management optimization.

This provides more precise and actionable insights than previous studies.

This study has several limitations. First, as a retrospective study, there is a potential for selection bias, which may affect the accuracy of the findings. Second, the study only compared GA and SA, without considering other anesthesia techniques that may also influence

POD risk. In addition, this study did not assess long-term cognitive outcomes, making it unclear how different anesthesia methods affect long-term prognosis.

Future studies should adopt prospective designs and include long-term follow-up assessments to provide more robust conclusions.

In conclusion, SA demonstrates favorable anesthetic effects in elderly patients undergoing hip fracture surgery, offering comparable pain control to GA while reducing POD incidence.

A comprehensive preoperative assessment, including cognitive function, age, and perioperative risk factors, is essential for optimizing anesthesia strategies. Tailoring anesthesia choices to individual patients can effectively lower POD risk and enhance postoperative recovery.

Disclosure of conflict of interest

None.

Address correspondence to: Fengxiang Gu, Anesthesia and Pain Medical Center, Gansu Provincial Hospital of TCM, No. 418 Guazhou Road, Qilihe District, Lanzhou 730050, Gansu, China. E-mail: gufx888@163.com

References

[1] McDonough CM, Harris-Hayes M, Kristensen MT, Overgaard JA, Herring TB, Kenny AM and Mangione KK. Physical therapy management of older adults with hip fracture. J Orthop Sports Phys Ther 2021; 51: CPG1-CPG81.

[2] Alexiou KI, Roushias A, Varitimidis SE and Malizos KN. Quality of life and psychological consequences in elderly patients after a hip fracture: a review. Clin Interv Aging 2018; 13: 143-150.

[3] Loggers SAI, Van Lieshout EMM, Joosse P, Verhofstad MHJ and Willems HC. Prognosis of nonoperative treatment in elderly patients with a hip fracture: a systematic review and meta-analysis. Injury 2020; 51: 2407-2413.

[4] Coughlan T and Dockery F. Osteoporosis and fracture risk in older people. Clin Med (Lond) 2014; 14: 187-191.

[5] Bigoni M, Turati M, Leone G, Caminita AD, D'Angelo F, Munegato D and Zatti G. Internal fixation of intracapsular femoral neck fractures in elderly patients: mortality and reoperation rate. Aging Clin Exp Res 2020; 32: 1173-1178.

[6] Sing CW, Lin TC, Bartholomew S, Bell JS, Bennett C, Beyene K, Bosco-Levy P, Bradbury BD, Chan AHY, Chandran M, Cooper C, de Ridder M, Doyon CY, Droz-Perroteau C, Ganesan G, Hartikainen S, Ilomaki J, Jeong HE, Kiel DP, Kubota K, Lai EC, Lange JL, Lewiecki EM, Lin J, Liu J, Maskell J, de Abreu MM, O'Kelly J, Ooba N, Pedersen AB, Prats-Uribe A, Prieto-Alhambra D, Qin SX, Shin JY, Sørensen HT, Tan KB, Thomas T, Tolppanen AM, Verhamme KMC, Wang GH, Watcharathanakij S, Wood SJ, Cheung CL and Wong ICK. Global epidemiology of hip fractures: secular trends in incidence rate, post-fracture treatment, and all-cause mortality. J Bone Miner Res 2023; 38: 1064-1075.

[7] Che YJ, Qian Z, Chen Q, Chang R, Xie X and Hao YF. Effects of rehabilitation therapy based on exercise prescription on motor function and complications after hip fracture surgery in elderly patients. BMC Musculoskelet Disord 2023; 24: 817.

[8] Li T, Li J, Yuan L, Wu J, Jiang C, Daniels J, Mehta RL, Wang M, Yeung J, Jackson T, Melody T, Jin S, Yao Y, Wu J, Chen J, Smith FG and Lian Q; RAGA Study Investigators. Effect of regional vs general anesthesia on incidence of postoperative delirium in older patients undergoing hip fracture surgery: the RAGA randomized trial. JAMA 2022; 327: 50-58.

[9] Viderman D, Nabidollayeva F, Aubakirova M, Yessimova D, Badenes R and Abdildin Y. Postoperative delirium and cognitive dysfunction after general and regional anesthesia: a systematic review and meta-analysis. J Clin Med 2023; 12: 3549.

[10] Jung J and Kim T. General anesthesia and sleep: like and unlike. Anesth Pain Med (Seoul) 2022; 17: 343-351.

[11] Shams D, Sachse K, Statzer N and Gupta RK. Regional anesthesia complications and contraindications. Anesthesiol Clin 2024; 42: 329-344.

[12] Stewart J, Gasanova I and Joshi GP. Spinal anesthesia for ambulatory surgery: current controversies and concerns. Curr Opin Anaesthesiol 2020; 33: 746-752.

[13] Babcock S and Kellam JF. Hip fracture nonunions: diagnosis, treatment, and special considerations in elderly patients. Adv Orthop 2018; 2018: 1912762.

[14] Liang S, Li S, Zhong Z, Luo Q, Nie C, Hu D and Li Y. The effect of lidocaine-prilocaine cream combined with or without remimazolam on VAS and APAIS anxiety score in patient undergoing spinal anesthesia. Drug Des Devel Ther 2024; 18: 3429-3441.

[15] Ciesielska N, Sokolowski R, Mazur E, Podhorecka M, Polak-Szabela A and Kedziora-Korna-

towska K. Is the Montreal Cognitive Assessment (MoCA) test better suited than the Mini-Mental State Examination (MMSE) in mild cognitive impairment (MCI) detection among people aged over 60? Meta-analysis. Psychiatr Pol 2016; 50: 1039-1052.

[16] Wu J, Yin Y, Jin M and Li B. The risk factors for postoperative delirium in adult patients after hip fracture surgery: a systematic review and meta-analysis. Int J Geriatr Psychiatry 2021; 36: 3-14.

[17] Bonanno FG. Management of hemorrhagic shock: physiology approach, timing and strategies. J Clin Med 2022; 12: 260.

[18] Frithiof R and Rundgren M. Activation of central opioid receptors determines the timing of hypotension during acute hemorrhage-induced hypovolemia in conscious sheep. Am J Physiol Regul Integr Comp Physiol 2006; 291: R987-996.

[19] Zorrilla-Vaca A, Healy RJ and Mirski MA. A comparison of regional versus general anesthesia for lumbar spine surgery: a meta-analysis of randomized studies. J Neurosurg Anesthesiol 2017; 29: 415-425.

[20] Poon KS, Chang WK, Chen YC, Chan KH and Lee TY. Evaluation of stress response to surgery under general anesthesia combined with spinal analgesia. Acta Anaesthesiol Sin 1995; 33: 85-90.

[21] Suh YS, Nho JH, Seo J, Jang BW and Park JS. Hip fracture surgery without transfusion in patients with hemoglobin less than 10 g/dL. Clin Orthop Surg 2021; 13: 30-36.

[22] Sui X, Duan Q, Liu K and Li C. Postoperative delirium after long-term general anesthesia in elderly patients, how to reduce it?: protocol of a double-blinded, randomized, placebo-controlled trial. Medicine (Baltimore) 2021; 100: e25885.

[23] Belrose JC and Noppens RR. Anesthesiology and cognitive impairment: a narrative review of current clinical literature. BMC Anesthesiol 2019; 19: 241.

[24] Bhushan S, Huang X, Duan Y and Xiao Z. The impact of regional versus general anesthesia on postoperative neurocognitive outcomes in elderly patients undergoing hip fracture surgery: a systematic review and meta-analysis. Int J Surg 2022; 105: 106854.

[25] Zhang WP, Chang WX, Liu WY, Li ZJ and Mao JW. Analysis of risk factors for postoperative delirium in elderly patients undergoing spinal surgery. Zhongguo Gu Shang 2024; 37: 700-705.