ORIGINAL RESEARCH

Predictive Value of the Duke Anesthesia Resistance Scale in Postoperative Delirium among Elderly Patients with Hip Fractures

Zhen Lei, BM; Ling Zhang, BM; Jingjing Yang, BM; Li Ye, MM; Linzhi Xia, BM

ABSTRACT

Objective • This study aimed to investigate the predictive value of the Duke Anesthesia Resistance Scale (DARS) for postoperative delirium in elderly patients following hip fracture surgery.

Methods • A retrospective study was conducted on 90 elderly patients with hip fractures who underwent surgical treatment from January 2018 to January 2021. Patients were categorized into delirium (n=22) and non-delirium (n=68) groups based on postoperative delirium occurrence. Qualitative and quantitative variables were compared between the groups to identify primary risk factors for postoperative delirium. The ability of DARS to predict postoperative delirium was assessed using the receiver operating characteristic (ROC) curve.

Results • Significant differences in age, number of underlying diseases, surgical blood loss, and DARS scores were observed between the delirium and non-delirium groups ($P < .05$). Multivariate logistic regression analysis indicated that DARS scores (OR=2.321), age (OR=2.476), number of underlying diseases (OR=2.209), surgical blood loss (OR=2.267), and postoperative pain (OR=2.287) were significant predictors of postoperative delirium ($P < .05$). Pearson correlation analysis revealed a negative correlation between DARS scores and age, number of underlying diseases, and surgical blood loss ($P < .05$). The ROC curve analysis demonstrated that the area under the curve (AUC) for DARS in predicting postoperative delirium was 0.8255 (95% CI: 0.726~0.924). At a DARS cutoff score of 38, the specificity was 80.28%, and the sensitivity was 81.45%.

Conclusion • The DARS score is a valuable tool for predicting postoperative delirium in elderly patients with hip fractures, with an optimal threshold of 38 points. The use of DARS in predicting postoperative delirium could significantly benefit healthcare providers and improve patient care. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Hip fractures are a common orthopedic ailment primarily affecting the elderly population, with hip arthroplasty being the primary clinical intervention. However, one significant postoperative complication in this demographic is delirium, characterized by acute confusion, disorientation, and changes in behavior or consciousness.[1,2] Delirium can have significant impacts on patients' physical and cognitive function and increase the risk of complications such as falls, pressure ulcers, and infection. It has also been associated with long-term cognitive impairment and an increased risk of mortality.

Recognizing and managing postoperative delirium promptly is crucial to minimize its effects on patient outcomes.[3,4] It can delay recovery in elderly patients with hip fractures and increase the economic burden on healthcare systems.[5,6] Up to 50% of elderly patients who undergo hip fracture surgery experience postoperative delirium, leading to longer hospital stays, increased rates of complications, higher healthcare costs, and long-term cognitive decline.

To improve patient outcomes, early identification of those at risk and implementation of targeted preventive measures are essential. The Duke Anesthesia Resistance Scale (DARS), developed at Duke University Medical Center, is a validated tool used to assess resistance to anesthesia during surgical procedures, including hip fracture surgeries.[7] It measures the level of resistance exhibited by a patient to the effects of anesthesia and provides valuable information for anesthesiologists in optimizing anesthesia delivery.

By tailoring the anesthesia plan to each patient's specific needs using the DARS, adjustments can be made to ensure optimal anesthesia depth and duration. Studies have shown that the DARS improves anesthesia outcomes by reducing complications, shortening recovery times, and improving patient satisfaction. Therefore, it serves as a valuable tool in individualizing anesthesia plans and optimizing patient care during hip fracture surgeries.

This study aims to explore the predictive value of DARS in determining postoperative delirium in elderly patients with hip fractures. By evaluating the resistance factors measured by DARS, we aim to identify potential predictors of postoperative delirium and improve patient outcomes.

PATIENTS AND METHODS

Study Cohort

We selected a cohort of 90 elderly patients who were diagnosed with hip fractures and received surgical treatment in our orthopedic department from January 2015 to February 2019. All participants were informed about the study and provided written consent. The study received approval from the hospital's ethics committee.

Inclusion Criteria: (1) Patients aged ≥60 years with no surgical contraindications. (2) Patients meeting the World Health Organization's diagnostic criteria for hip fractures[8] and having undergone the corresponding surgery.

Exclusion Criteria: (1) Those with surgical contraindications or known allergies. (2) Patients unwilling to comply or who withdrew from the study. (3) Patients diagnosed with mental disorders or significant infectious diseases. (4) Individuals with impaired heart, lung, liver, or kidney functions.

Methodology

We conducted a retrospective analysis of patients' baseline and clinical data, including age, gender, body mass index, surgery duration, volume of surgical bleeding, postoperative pain, postoperative environment's quietness, underlying diseases, and electrolyte imbalances.

Postoperative Delirium

Within the first 24 hours post-surgery, patients were assessed for postoperative delirium based on the diagnostic criteria from the "Diagnostic and Statistical Manual of Mental Disorders".[9] Manifestations included diminished consciousness, reduced ability to focus and shift attention, attention disorders, memory loss, hallucinations, delusions, communication barriers, and orientation issues. Additionally, patients might exhibit increased agitation or apathy, heightened startle responses, and disturbances in the sleep-wake cycle, including frequent nightmares. It's important to note that these symptoms weren't related to any prior medical conditions.

DARS Assessment

In this study, the DARS score was calculated using the formula: DARS = (12.5 - aaMAC) x BIS. To better understand this calculation, it is important to explain what aaMAC (age-adjusted minimum alveolar concentration) and BIS (Bispectral Index) values represent. The aaMAC is a measure of the concentration of inhalational anesthetic required to maintain an appropriate level of anesthesia in a patient. It takes into account the patient's age and adjusts the minimum alveolar concentration accordingly. A lower aaMAC indicates a higher resistance to anesthesia. The BIS is a monitoring technique that assesses the depth of anesthesia by analyzing the electrical activity in the brain. It provides a numerical value that represents the level of consciousness, with lower values indicating a deeper level of anesthesia. In the DARS calculation, the aaMAC value is subtracted from 12.5, representing the baseline resistance to anesthesia. The result is then multiplied by the BIS value, indicating the depth of anesthesia. This calculation helps assess the overall resistance to anesthesia experienced by the patient during the surgical procedure.[11] The DARS score was calculated using the formula: DARS = (12.5 - aaMAC) × BIS.

Statistical Analysis

Data were analyzed using Statistic Package for Social Science (SPSS) version 21.0 (IBM, Armonk, NY, USA). Normally distributed quantitative data were represented as $\bar{x} \pm s$. Comparisons between two groups were made using paired t tests for quantitative data and χ^2 tests for categorical data. Pearson's correlation was used to analyze the relationship between DARS and patients' clinical metrics. Significant factors from univariate analysis were included in a multivariate analysis using a Logistic regression model. The predictive accuracy of these factors for postoperative delirium was assessed using the receiver operating characteristic (ROC) curve, with a $P < .05$ indicating statistical significance.

RESULTS

Comparison of Basic Information between the Two Patient Groups

Comparison of Basic Information between the Two Patient Groups (Table 1).

Comparison of Clinical Data Between the Two Groups

Statistically significant differences were observed between the two groups in terms of surgical blood loss and DARS scores ($P < .05$). Further details are provided in Table 2.

Table 1. Comparison of Basic Information between the Two Patient Groups.

Items	Number of Cases	Occurrence Group (n = 22)	Non-occurrence Group (n = 68)	χ^2 value	*P* value
Age (years)					
< 75	54	7	47	9.636	.002
≥ 75	36	15	21		
Gender					
Male	52	13	39	0.021	0.886
Female	38	9	29		
Body Mass Index (kg/m^2)					
> 18.5	64	16	48	0.037	0.847
≤ 18.5	26	6	20		
Number of Underlying Diseases					
<3 types	43	6	37	8.557	.003
≥3 types	37	16	21		

Table 2. Comparison of Clinical Data between the Two Patient Groups.

Items	Number of Cases	Occurrence Group (n = 22)	Non-occurrence Group (n = 68)	χ^2 value	*P* value
Surgical Duration(min)					
>90	60	16	44	0.481	0.488
≤90	30	6	24		
Surgical Blood Loss(mL)					
>250	40	17	23	12.711	.000
≤250	50	5	45		
Surgical Method					
Hip Joint Replacement	54	15	39	1.732	.421
Proximal Femoral Intramedullary Nail Fixation	25	6	19		
Open Reduction and Internal Fixation	11	1	10		
Preoperative Electrolytes					
Normal	56	15	41	0.440	.507
Imbalance	34	7	27		
Postoperative Electrolytes					
Normal	72	16	56	0.963	.327
Imbalance	18	6	12		
DARS Score (points)		22.28±4.76	31.16±6.28	6.082	.000

Table 3. Multivariate Logistic Regression Analysis on Influential Factors of Postoperative Delirium.

Factors	*B* value	*SE* value	*Ward* value	*OR* value	*95%CI*	*P* value
DARS Score	0.841	0.287	8.607	2.321	1.322~4.073	.000
Age	0.906	0.298	9.256	2.476	1.380~4.440	.000
Number of Underlying Diseases	0.792	0.226	12.297	2.209	1.418~3.440	.000
Surgical Blood Loss	0.818	0.258	10.063	2.267	1.367~3.758	.000
Postoperative Pain	0.827	0.248	11.126	2.287	1.406~3.718	.000

Table 4. Correlation Between DARS Score and Patient's Clinical Parameters.

Indicators	Age	Number of Underlying Diseases	Surgical Blood Loss
r	-0.8330	-0.8013	-0.254
P value	.0015	.0030	.000

Multivariate Logistic Regression Analysis on Factors Influencing Postoperative Delirium

Incorporating variables that showed statistical significance in the univariate analysis as independent variables, postoperative delirium was set as the dependent variable (No=0, Yes=1) for a multivariate logistic regression analysis. The results revealed that factors such as DARS score (OR=2.321), age (OR=2.476), number of underlying diseases (OR=2.209), volume of surgical blood loss (OR=2.267), and postoperative pain perception (OR=2.287) significantly influence the occurrence of postoperative delirium ($P < .05$). Detailed findings can be seen in Table 3.

Correlation Between DARS Score and Patient's Clinical Indicators

Pearson correlation analysis revealed a negative correlation between the DARS score and factors such as age, number of underlying diseases, and surgical blood loss ($P < .05$). For detailed insights, refer to Table 4 and Figures 1 to 3.

Predictive Value of DARS Score for Postoperative Delirium

Using the DARS score as a predictive measure and the actual occurrence of postoperative delirium as the outcome, an ROC curve was plotted. This analysis reveals an Area Under the Curve (AUC) of 0.8255 (95% Confidence Interval: 0.726~0.924) for the DARS score's predictive capacity. At an

Figure 1. Correlation Between DARS Score and Patient's Age

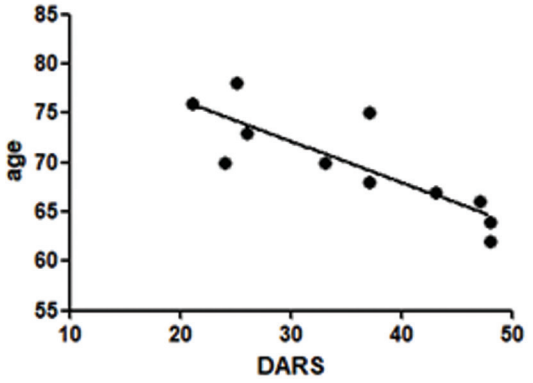


Figure 2. Correlation Between DARS Score and Number of Underlying Diseases in Patients

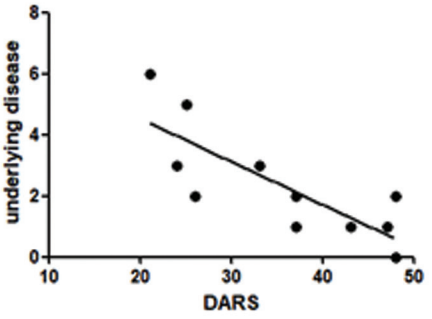


Figure 3. Association Between DARS Score and Volume of Surgical Hemorrhage in Patients

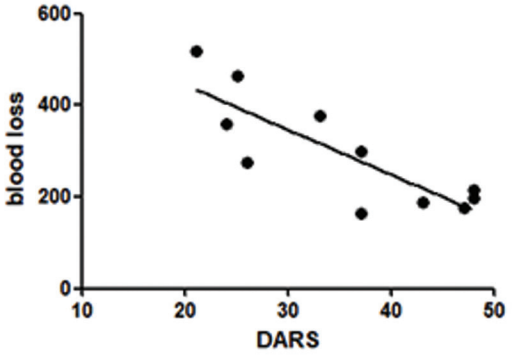
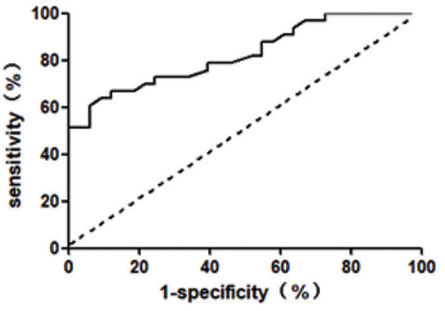


Figure 4. ROC Curve Illustrating the Predictive Value of DARS Score for Postoperative Delirium



optimal cutoff value of 38 for the DARS score, the specificity is 80.28%, and the sensitivity is 81.45%. Further details can be observed in Figure 4.

DISCUSSION

Delirium manifests clinically as difficulties in maintaining attention, disruptions in the sleep-wake cycle diminished tactile perception, and significant fluctuations in consciousness levels. While the precise pathophysiological mechanisms underlying delirium remain elusive, several potential predisposing factors have been suggested. These include infections, inflammation, metabolic abnormalities (notably electrolyte imbalances, anemia, and hypoalbuminemia), surgical interventions, pain, and the use of certain drugs, such as benzodiazepines.[12-14] The onset of delirium can considerably hamper postoperative recuperation, leading to poorer patient outcomes, extended hospitalizations, and augmented financial burdens.[15,16]

The outcomes of the multivariate logistic regression analysis in this research indicate that factors such as age (OR=2.476), the number of underlying diseases (OR=2.209), surgical blood loss (OR=2.267), and postoperative pain sensation (OR=2.287) are significant contributors to postoperative delirium ($P < .05$). Based on these findings, the conclusions can be delineated as follows: (1) Age: Delirium in elderly patients can be precipitated by cerebral degenerative changes, diminished cerebral blood flow, decreased glucose metabolic function, reduction in acetylcholine levels, heightened norepinephrine, and increased gamma-aminobutyric acid. Notably, the incidence of delirium rises with age, especially in those aged over 75.[17,18] (2) Number of Underlying Diseases: Existing underlying diseases may amplify the postoperative stress and associated risks, thereby triggering delirium. Hence, comprehensive pre- and postoperative assessment and management of elderly hip fracture patients with multiple comorbidities are essential to mitigate the risk of postoperative delirium. Such an approach entails preventative strategies like pain management, adequate hydration, maintenance of circulatory stability, and the provision of tailored care and support.[19,20] (3) Surgical Blood Loss: The physiological disturbance caused by blood and fluid loss during surgery can induce an abnormal stress response in elderly patients, who often have reduced self-regulatory capabilities. If the internal homeostasis is not promptly re-established, this may lead to the onset of delirium.[21] (4) Postoperative Pain Sensation: Postoperative pain, a frequent and especially prevalent adverse reaction among the elderly, can exacerbate physical and mental stress, thus elevating the risk of delirium.[22] Research highlights a close connection between postoperative pain and delirium, with pain-induced stress potentially disrupting sleep, augmenting anxiety, and fostering confusion, thereby precipitating delirium.[23] Moreover, postoperative pain can influence a patient's appetite and emotional state, further compounding the delirium risk. Hence, robust postoperative pain management, encompassing pharmacological interventions, physical therapies, psychological support, and non-pharmacological strategies, must be personalized to minimize patient discomfort and curtail the likelihood of postoperative delirium. By adhering closely to the original text, this revised translation corrects minor discrepancies, enhances readability, and aligns with an academic style.

Cooter Wright M et al.[7] investigated the DARS score derived from processed EEG readings (namely, the bispectral index or BIS) and concentrations of end-tidal volatile anesthetics adjusted for age. They discerned that, among elderly surgical patients, a diminished DARS score was correlated with an augmented risk of postoperative delirium. This observation gave rise to the hypothesis that a decreased DARS score might also be indicative of perioperative neurocognitive deficits. In line with this, our research, utilizing multivariate logistic regression, identified the DARS score (OR=2.321) as a significant determinant of postoperative delirium ($P < .05$), a finding congruent with prior studies. Pearson correlation analysis revealed a negative association between the DARS score and factors like age, the tally of underlying ailments, and volume of surgical blood loss ($P < .05$). This inverse relationship suggests that with the escalation in age, number of coexisting conditions, and surgical blood loss, the DARS score tends to decline. Such a pattern might hint at the fact that an advanced age, a greater count of underlying health issues, and lesser surgical blood loss correlate with a subdued DARS score. The ROC curve indicates the DARS score's ability to predict postoperative delirium with an AUC of 0.8255 (95%CI: 0.726~0.924). With the DARS score at its most predictive threshold of 38, it offers a specificity of 80.28% and a sensitivity of 81.45%, underscoring its robust predictive prowess.

The identification of risk factors, including the DARS score, has important implications for clinical practice in the assessment and management of elderly hip fracture patients to reduce the risk of postoperative delirium. Firstly, healthcare providers can utilize the DARS score as a screening tool during preoperative assessments. By incorporating the DARS score into routine evaluations, anesthesiologists and other healthcare professionals can identify patients who may be at a higher risk of developing postoperative delirium. This allows for proactive planning and tailored interventions to mitigate the risk factors associated with delirium. Based on the identified risk factors, healthcare providers can implement preventive measures. For instance, advanced age is a known risk factor for postoperative delirium. In light of this, healthcare providers can employ geriatric-specific care protocols, including comprehensive geriatric assessments and management strategies. These may involve optimizing medication regimens, managing preexisting medical conditions, and addressing sensory impairments or cognitive deficits that may contribute to delirium. Additionally, healthcare providers can focus on optimizing pain management and minimizing surgical blood loss. Adequate pain control and effective hemostasis techniques are crucial in reducing the risk of delirium. This may involve using

multimodal analgesia approaches, considering regional anesthesia techniques, and employing blood conservation strategies during surgery. Furthermore, healthcare providers can play a key role in postoperative care. Regular monitoring and early detection of delirium symptoms are vital. Implementing protocols such as the Confusion Assessment Method (CAM) or the Delirium Observation Screening (DOS) scale can aid in the timely identification and management of delirium. Prompt intervention, including non-pharmacological measures such as orientation techniques, early mobilization, and addressing modifiable risk factors like sleep deprivation or dehydration, can help mitigate the impact of delirium. By utilizing the identified risk factors and integrating the DARS score into clinical practice, healthcare providers can adopt a proactive and individualized approach to assess and manage elderly hip fracture patients. This comprehensive approach aims to reduce the risk of postoperative delirium by addressing modifiable factors and implementing targeted interventions throughout the perioperative period.

To encapsulate, the DARS score offers a noteworthy predictive insight into postoperative delirium among elderly hip fracture patients, with 38 as the most effective cutoff value. Nonetheless, this study is not without its shortcomings. Variabilities in aspects such as surgical techniques, the specific location of fractures, and the criteria for outcome assessment precluded a quantitative synthesis. As such, there's an urgent need for comprehensive, multicenter prospective investigations.

ETHICAL COMPLIANCE

The ethics committee of Affiliated Hospital of Wuhan Sports University approved this study. Signed written informed consents were obtained from the patients and/or guardians.

CONFLICT OF INTEREST

The authors have no potential conflicts of interest to report relevant to this article.

AUTHOR CONTRIBUTIONS

ZL and LZ designed the study and performed the experiments, JY and LY collected the data, JY, LY and LL analyzed the data, ZL and LZ prepared the manuscript. All authors read and approved the final manuscript. ZL and LZ contributed equally to this work.

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