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The primary aim of *World Journal of Gastrointestinal Surgery* (*WJGS*, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, *etc*.

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ORIGINAL ARTICLE

Retrospective Study

Factors influencing agitation during anesthesia recovery after laparoscopic hernia repair under total inhalation combined with caudal block anesthesia

Yun-Feng Zhu, Fan-Yan Yi, Ming-Hui Qin, Ji Lu, Hao Liang, Sen Yang, Yu-Zheng Wei

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Abstract

BACKGROUND

Laparoscopic hernia repair is a minimally invasive surgery, but patients may experience emergence agitation (EA) during the post-anesthesia recovery period, which can increase pain and lead to complications such as wound reopening and bleeding. There is limited research on the risk factors for this agitation, and few effective tools exist to predict it. Therefore, by integrating clinical data, we have developed nomograms and random forest predictive models to help clinicians predict and potentially prevent EA.

AIM

To establish a risk nomogram prediction model for EA in patients undergoing laparoscopic hernia surgery under total inhalation combined with sacral block anesthesia.

METHODS

Based on the clinical information of 300 patients who underwent laparoscopic hernia surgery in the Nanning Tenth People's Hospital, Guangxi, from January 2020 to June 2023, the patients were divided into two groups according to their sedation-agitation scale score, *i.e.*, the EA group (≥ 5 points) and the non-EA group (≤ 4 points), during anesthesia recovery. Least absolute shrinkage and selection operator regression was used to select the key features that predict EA, and incorporating them into logistic regression analysis to obtain potential predictive factors and establish EA nomogram and random forest risk prediction models through R software.

RESULTS

Out of the 300 patients, 72 had agitation during anesthesia recovery, with an incidence of 24.0%. American Society of Anesthesiologists classification, preoperative anxiety, solid food fasting time, clear liquid fasting time, indwelling catheter, and pain level upon awakening are key predictors of EA in patients undergoing laparoscopic hernia surgery with total intravenous anesthesia and caudal block anesthesia. The nomogram predicts EA with an area under the receiver operating characteristic curve (AUC) of 0.947, a sensitivity of 0.917, and a specificity of 0.877, whereas the random forest model has an AUC of 0.923, a sensitivity of 0.912, and a specificity of 0.877. Delong's test shows no significant difference in AUC between the two models. Clinical decision curve analysis indicates that both models have good net benefits in predicting EA, with the nomogram effective within the threshold of 0.02 to 0.96 and the random forest model within 0.03 to 0.90. In the external model validation of 50 cases of laparoscopic hernia surgery, both models predicted EA. The nomogram model had a sensitivity of 83.33%, specificity of 86.84%, and accuracy of 86.00%, while the random forest model had a sensitivity of 75.00%, specificity of 78.95%, and accuracy of 78.00%, suggesting that the nomogram model performs better in predicting EA.

CONCLUSION

Independent predictors of EA in patients undergoing laparoscopic hernia repair with total intravenous anesthesia combined with caudal block include American Society of Anesthesiologists classification, preoperative anxiety, duration of solid food fasting, duration of clear liquid fasting, presence of an indwelling catheter, and pain level upon waking. The nomogram and random forest models based on these factors can help tailor clinical decisions in the future.

Key Words: Inhalation anesthesia; Sacral block anesthesia; Laparoscopic hernia surgery; Agitation during recovery period; Nomogram; Surgical outcomes; Postoperative complications

Core Tip: This study identified American Society of Anesthesiologists classification, preoperative anxiety, fasting duration, catheterization, and pain level during emergence as major risk factors for emergence agitation. It constructed nomograms and a random forest prediction model with high accuracy and clinical utility, aiding physicians assess and predict emergence agitation and guide personalized medical interventions, improving patient safety and recovery after surgery.

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INTRODUCTION

A groin hernia, commonly referred to as "hernia", is a common disease in the groin area. Usually, it can be pushed back into the abdomen, but if it becomes trapped and cannot be reduced, immediate treatment is required. If a strangulated hernia is not treated promptly, it can cut off blood supply to the intestinal tract, potentially leading to necrosis of the intestines[1]. Laparoscopic hernia repair is favored by both doctors and patients due to its shorter operating time, faster postoperative recovery, and lower recurrence rates[2,3]. However, it requires expert handling of pneumoperitoneum, necessitating proper depth of general anesthesia to tolerate laparoscopy, imposing significant demands on anesthesiologists in terms of intraoperative sedation and pain management, postoperative safety, rapid recovery, and awakening.

Inhalation anesthesia has the advantages of rapid absorption and elimination, good controllability, and rapid awakening[4]. Caudal block anesthesia is simple to administer and is used for pediatric surgery and adult chronic pain management[5]. Combining the two methods effectively provides sedation and pain relief during surgery. Moreover, combining these anesthesia methods reduces the single drug dose and its side effects, and has good controllability, allowing the depth of anesthesia to be adjusted immediately[6]. However, emergence agitation (EA) during recovery from anesthesia remains a challenge in postoperative care. EA involves symptoms such as excessive excitement, confusion of consciousness, loss of sense of direction, illogical speech, and involuntary limb movements. These symptoms usually occur suddenly during recovery from general anesthesia. Studies show that about 19% of adults experience EA after non-cardiac surgery[7]. EA can easily lead to various adverse events such as wound bleeding, dislodged drainage tube, and falling out of bed[8].

Predictive models are commonly used in clinical practice to predict the adverse events and prognosis of survival, *etc.* [9]. They help medical teams identify potential causes and risk factors for EA, improving anesthesia and postoperative care. There is currently no research that clearly identifies risk factors for EA in patients undergoing laparoscopic hernia surgery under general inhalation combined with caudal block anesthesia, and there is a lack of related predictive models.

Therefore, we conducted a retrospective analysis to identify factors affecting EA in patients undergoing laparoscopic hernia surgery under general inhalation combined with caudal block anesthesia, and constructed a risk prediction model to help take early, targeted measures to reduce EA incidence.

MATERIALS AND METHODS

Research object

This was a retrospective study involving 300 patients who underwent laparoscopic hernia repair surgery at the Nanning Tenth People's Hospital, Guangxi, from January 2020 to June 2023. Inclusion criteria were as follows: (1) Patients who had combined general inhalation anesthesia and sacral epidural block, and were transferred to the post-anesthesia care unit after laparoscopic hernia surgery; (2) Patients with normal intelligence, clear consciousness, and the ability to communicate normally with medical staff; and (3) Patients classified as American Society of Anesthesiologists (ASA)[10] grades I to III. Exclusion criteria were as follows: (1) Pregnant or lactating women; (2) Contraindications to anesthesia; (3) Surgery lasting more than 60 minutes; (4) Other complications, congenital abnormalities, unexplained fever, or infection; and (5) Lacking clinical data such as general information, hematological test results, surgical records, anxiety scale, and visual analog scale assessment results.

Sample size calculation

The main results of this study involve creating a predictive model for EA using logistic regression analysis. According to the events per variable method[11], which requires 10 events per independent variable, we need 60 EA cases for a model with 6 variables. Since EA incidence in adults ranges from 4.7% to 22.2%[12], this translates to needing a sample size of at least 271 to 1277 cases. Considering the actual situation of our hospital, 300 patients were finally included in the study.

Methods

Methods of anesthesia: Once in the operating room, all patients underwent routine electrocardiogram monitoring and intravenous access was established, with their heart rate, blood pressure, pulse oximetry, and electrocardiogram being monitored: (1) General inhalation anesthesia: Inhalation anesthesia was administered at a rate of 3 mL/minute with sevoflurane (Shanghai Hengrui Pharmaceutical Co., Ltd., China, drug approval number H20070172, specification, 250 mL), along with 0.1 mg/kg atracurium besylate and 1.0 μg/kg fentanyl citrate for induction; and (2) Sacral epidural block anesthesia: After general anesthesia, the patient was positioned in the lateral decubitus position with hips and knees flexed at 90° to locate the sacral hiatus. A 6-gauge needle was inserted subcutaneously, followed by a 25-gauge needle angled at 25° to the coronal plane, passing through the sacrococcygeal ligament until a loss of resistance was felt, with no cerebrospinal fluid or blood return upon aspiration. Then, 12 mL of normal saline was injected, followed by 1.0 mL/kg of 0.25% ropivacaine (produced by Ruiyang Pharmaceutical Co., Ltd., China drug approval number H20183152). Once the baseline anesthesia took effect, sevoflurane was continued at a concentration of 2% to 3%, at a rate of 4 L/minute. The anesthesia effect was monitored, and 0.5 μg/kg of fentanyl citrate was given if needed.

Methods of laparoscopic hernia operation: The patient is in a supine position to allow access to the groin area. The doctor makes small incisions, typically about 1 cm below the navel, and injects carbon dioxide gas into the abdomen to create space for the laparoscopic surgery. Through the small incision, the doctor inserts a laparoscope to observe the groin area and guide the operation of surgical tools. The laparoscope allows the doctor to accurately locate the hernia sac. Once located, tension-free mesh is inserted through the incision to cover the hernia, reinforce the abdominal wall, and prevent recurrence. After the surgery, the laparoscope and surgical instruments are removed and the incision is closed with sutures or adhesive tape.

EA criteria

The sedation-agitation scale (SAS)[13], developed by Riker *et al*[13], helps identify and quantify agitation and sedation levels. We used the SAS to assess agitation during the postoperative recovery. The scale ranges from 1 to 7, with a score of ≤ 4 indicating no agitation, and a score of ≥ 5 indicating agitation, where 5 points is mild agitation, 6 points is moderate agitation, and 7 points is severe agitation (Table 1).

Data collection

General information on all patients was gathered, including gender, age, body mass index, history of hypertension, history of diabetes, smoking history, ASA classification, preoperative anxiety, preoperative fasting duration, intraoperative hypothermia (intraoperative body temperature < 36 °C), intraoperative blood loss, operation time, indwelling catheter, and pain degree during recovery. The Self-Rating Anxiety Scale[14] assesses preoperative anxiety with 20 items scored on a 4-point scale. The sum of all items, or the raw score, is then multiplied by 1.25 to get a standard score, with a score of ≥ 50 indicating anxiety. The visual analog scale[15] assesses pain during recovery, with a total of 10 points, where higher scores indicate more severe pain.

Statistical analysis

Statistical analysis was performed using SPSS 23.0 and R Studio software. The normality of continuous variables was tested using the Kolmogorov-Smirnov method. Skewed continuous variables were expressed as median (P_{25}, P_{75}) values,

Table 1 Sedation-agitation scale definitions

Classification	Point	Description
Unable to wake up	1	The patient has little or no response to harmful stimuli, does not communicate, or does not follow instructions
Very calm	2	Patients respond to physical stimuli but cannot communicate or follow commands and may move spontaneously
Calm	3	The patient is awakened by verbal stimulation or slight shaking, but falls asleep again; follow simple instructions
Cool fit	4	The patient is calm, wakes easily, and follows instructions
EA	5	The patient is anxious or mildly agitated and tries to sit up and calm down on verbal instructions
Moderate EA	6	The patient is not calm, despite the doctor's frequent verbal reminders of limitations; the patient needs to be physically restrained and bite the tracheal catheter
Severe EA	7	Patients pulled tracheal tubes, tried to remove them, climbed over bed bars, hit staff, convulsed back to back

EA: Emergence agitation.

and categorical variables were presented as frequencies and percentages. Univariate analysis was conducted using the χ^2 test and Mann-Whitney U test. Least absolute shrinkage and selection operator (LASSO) regression selected the best predictive features among risk factors, which were then analyzed with logistic regression to identify all potential predictors. A predictive model for EA risk was constructed using the R software. A calibration curve was used to assess the model's accuracy. The bootstrap method validated the model internally and measured the discriminatory ability of the model. Furthermore, predictive model's efficiency was evaluated using the receiver operating characteristic curve. A clinical decision curve assessed the clinical utility of the model. A difference was considered statistically significant when $P < 0.05$.

RESULTS

Research process

We conducted this study following the process outlined in Figure 1.

Patient characteristics

Patients were divided into the EA group (≥ 5 points) and the non-EA group (≤ 4 points) based on their SAS scores. Significant differences between the two groups were observed in gender, ASA classification, preoperative anxiety, preoperative fasting duration, intraoperative hypothermia, indwelling catheter, and pain degree during recovery ($P < 0.05$) (Table 2).

LASSO regression to extract important variables

LASSO regression was used to identify the most influential factors among demographic and perioperative indicators. As lambda increased, the coefficients of the initial 16 variables were compressed, leading to unimportant variables being shrunk to 0 (Figure 2A). The lambda value that resulted in the minimum mean squared error within one standard error of the cross-validated error was selected as the optimal value for the model (lambda.1se), which corresponded to 7 selected variables indicated by the right dashed line. These variables, ranked in descending order, include preoperative anxiety, duration of solid food fasting, duration of clear fluid fasting, pain degree during recovery, indwelling catheter, intraoperative hypothermia, and ASA classification (Figure 2B).

Multivariate Logistic regression analysis

The variables selected by LASSO regression were included in the logistic regression model. The results identified ASA classification, preoperative anxiety, duration of solid food fasting, duration of clear fluid fasting, indwelling catheter, and pain degree during recovery as risk factors for EA in patients undergoing laparoscopic hernia repair under combined inhalation and epidural anesthesia (Table 3).

Construct a nomogram prediction model

Based on 6 independent risk factors (ASA classification, preoperative anxiety, duration of solid food fasting, duration of clear fluid fasting, indwelling catheter, and pain degree during recovery), a nomogram predictive model was constructed (Figure 3). For example, if a patient has a recovery pain score of 6, a clear fluid fasting time of 3 hours, a solid food fasting time of 6.9 hours, preoperative anxiety, and ASA classification of grade II, the estimated risk of EA is 32.4% (Figure 4).

Construct random forest prediction model

A random forest prediction model based on multifactor logistic regression analysis was built. The out-of-bag error of the

Table 2 Comparison of patient characteristics between the two groups

	EA (*n* = 72)	Non-EA (*n* = 228)	χ^2/Z	*P* value
Gender				
Male/female	45/27	89/139	12.190	< 0.001
Age (year)	38 (36, 40)	39 (34, 43)	-1.413	0.158
Body mass index (kg/m^2)	23.43 (22.01, 25.03)	23.36 (21.84, 25.19)	-0.372	0.710
Hypertension	11 (15.28)	54 (23.68)	2.278	0.131
Diabetes	13 (18.06)	58 (25.44)	1.651	0.199
Smoking	27 (37.50)	60 (26.32)	3.324	0.068
ASA classification				
I	11 (15.28)	71 (31.14)	-3.068	0.002
II	52 (72.22)	145 (63.60)		
III	9 (12.50)	12 (5.26)		
Preoperative anxiety	59 (81.94)	81 (35.53)	47.371	< 0.001
Preoperative fasting duration (hours)				
Solid food	7.45 (6.95, 7.80)	6.90 (6.60, 7.20)	-7.045	< 0.001
Clear liquid food	3.30 (2.93, 3.50)	2.85 (2.60, 3.20)	-5.709	< 0.001
Intraoperative hypothermia	35 (48.61)	63 (27.63)	10.950	0.001
Intraoperative blood loss (mL)	11 (10, 12)	11 (9, 12)	-0.128	0.898
Operation time (minutes)	41.00 (37.00, 44.00)	40.00 (36.00, 44.75)	-0.525	0.600
Indwelling catheter	44 (61.11)	82 (35.96)	14.204	< 0.001
Pain degree during recovery	6 (6, 7)	5 (4, 6)	-7.901	< 0.001

ASA: American Society of Anesthesiologists; EA: Emergence agitation.

Table 3 Multivariate logistic regression analysis

Variable	*β*	SE	*P* value	OR	95%CI
ASA classification	0.935	0.405	0.021	6.487	1.328-31.671
Preoperative anxiety	2.591	0.508	< 0.001	13.340	4.929-36.101
Duration of solid food fasting	2.259	0.490	< 0.001	4.860	2.482-9.515
Duration of clear fluid fasting	2.119	0.564	< 0.001	4.408	2.035-9.551
Indwelling catheter	0.968	0.444	0.029	2.633	1.103-6.287
Pain degree during recovery	1.172	0.228	< 0.001	10.430	4.268-25.488

ASA: American Society of Anesthesiologists; OR: Odds ratio; CI: Confidence interval.

random forest model is 8.96%, with the importance ranking of 6 most important variables as duration of solid food fasting, pain degree during recovery, duration of clear fluid fasting, preoperative anxiety, ASA classification, and indwelling catheter (Figure 5).

Verify the nomogram and random forest prediction model

The prediction model for postoperative EA occurrence and the actual occurrence relationship through the calibration curve were evaluated, and it is found that the calibration curve is close to the reference line, indicating that the model's calibration is good (Figure 6). The receiver operating characteristic curve analysis shows that the nomogram model has an area under the receiver operating characteristic curve (AUC) of 0.947 (95% confidence interval: 0.917-0.978), with a sensitivity of 0.917 and a specificity of 0.877. The random forest model has an AUC of 0.923 (95% confidence interval: 0.862-0.985), with a sensitivity of 0.912 and a specificity of 0.877 (Figure 7). Delong's test shows no significant difference bet-

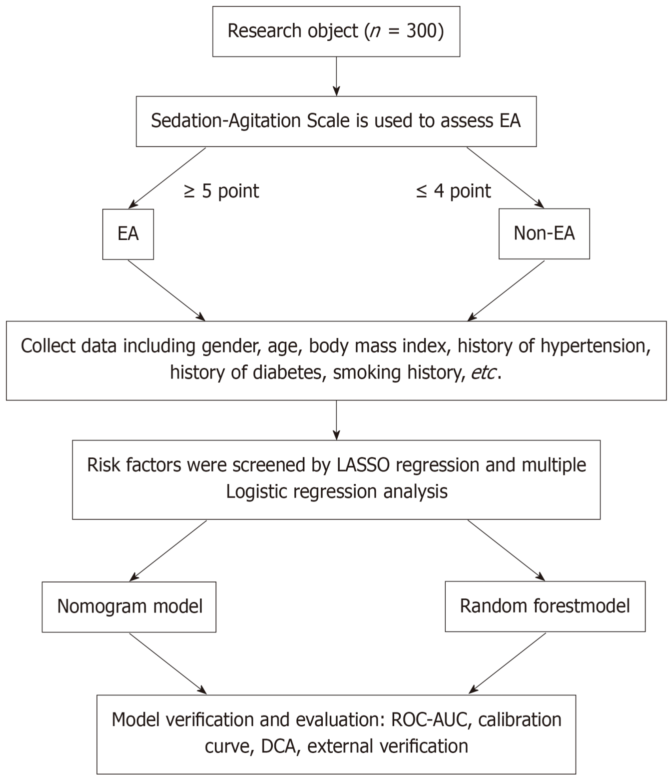

Figure 1 Research process. EA: Emergence agitation; LASSO: Least absolute shrinkage and selection operator; ROC: Receiver operating characteristic; AUC: Area under the receiver operating characteristic curve; DCA: Direct coupling analysis.

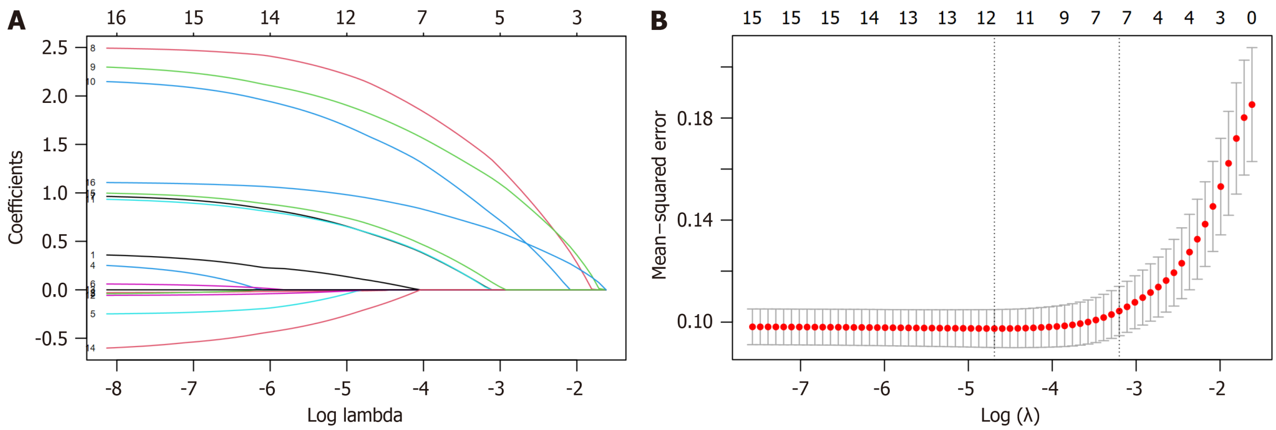

Figure 2 Least absolute shrinkage and selection operator regression and cross-validation curve. A: Least absolute shrinkage and selection operator regression; B: Cross-validation curve.

ween the two models.

Clinical usefulness of predictive models

The decision curve shows that the nomogram model provides good net benefits for predicting EA within a threshold range of 0.02 to 0.96. The random forest model also offers good net benefits within a threshold range of 0.03 to 0.90 (Figure 8).

External validation of the nomogram and random forest model

From November 2023 to April 2024, we tested the models on 50 patients from our hospital. The nomogram model predicted EA with a sensitivity of 83.33% (10/12), a specificity of 86.84% (33/38), and an accuracy of 86.00%. The random forest model also predicted EA with a sensitivity of 75.00% (9/12), a specificity of 78.95% (30/38), and an accuracy of 78.00% (Table 4).

Table 4 External validation of the risk nomogram for emergence agitation in patients undergoing laparoscopic hernia based solely on aspiration combined with sacral block anesthesia

Models	Reality	Prediction		Total
		EA	Non-EA	
Nomogram	EA	10	2	12
	Non-EA	5	33	38
	Total	15	35	50
Random forest	EA	9	3	12
	Non-EA	6	30	38
	Total	17	33	50

EA: Emergence agitation.

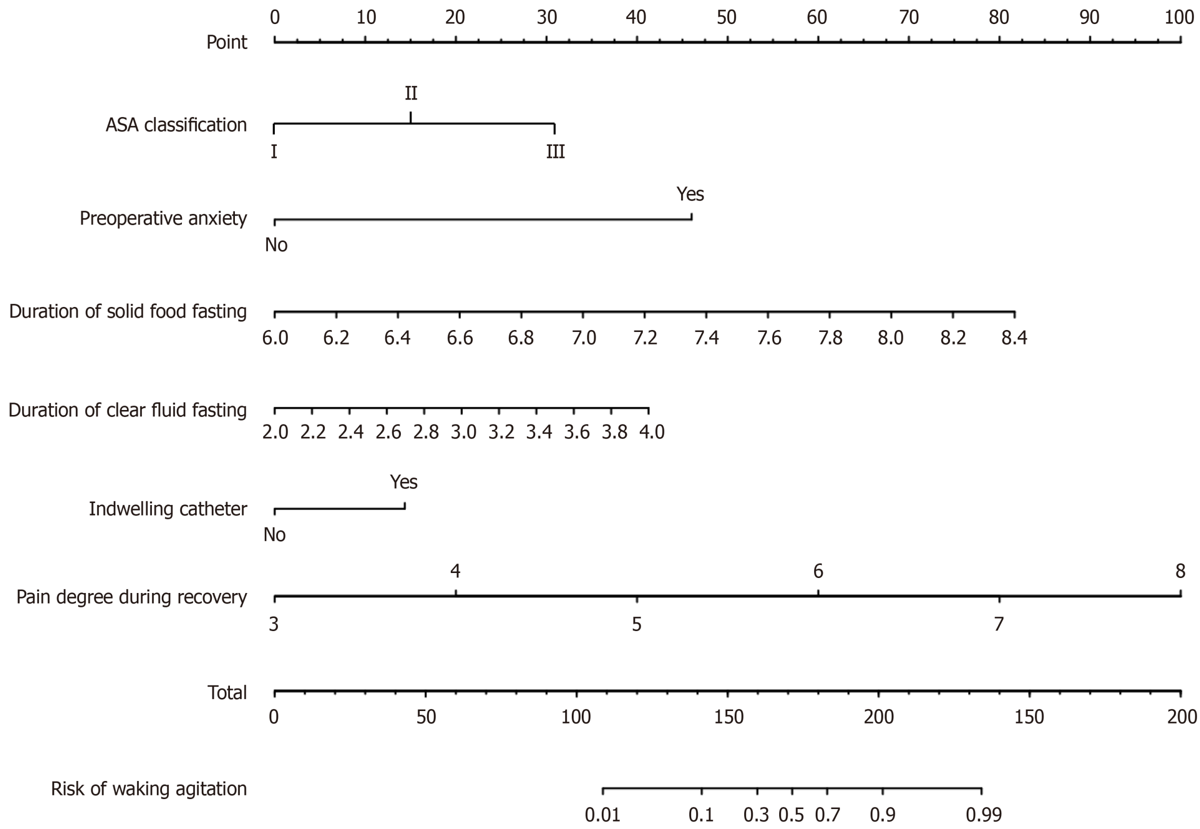

Figure 3 Column chart prediction model. ASA: American Society of Anesthesiologists.

DISCUSSION

EA can lead to self-harm, harm to healthcare providers, catheter removal, airway spasm, displacement, rupture, bleeding, and other adverse outcomes, prolonging hospital stay, increasing healthcare burden, and mortality rates[8,9]. Therefore, it is necessary to identify risk factors for EA early, reduce its incidence, and provide appropriate treatment. Developing a predictive model helps healthcare professionals provide precise medical care and develop personalized and effective treatment plans. The nomogram is a reliable and practical predictive tool that integrates different prognostic and determinant variables to estimate the likelihood of clinical events. They not only display relevant indicators that influence the results of multifactorial regression analysis but also provide a simple graphical representation for prognostic prediction, making it convenient and straightforward[16]. Random forest is a machine learning method widely used in medical research due to its advantages of being less affected by variable collinearity, robust operation, and absence of overfitting[17,18]. It can display the importance of each variable in predictions, serve for data dimensionality reduction, and feature pre-selection. The importance evaluation ranking results it generates can provide reference basis for subsequent clinical decision-making.

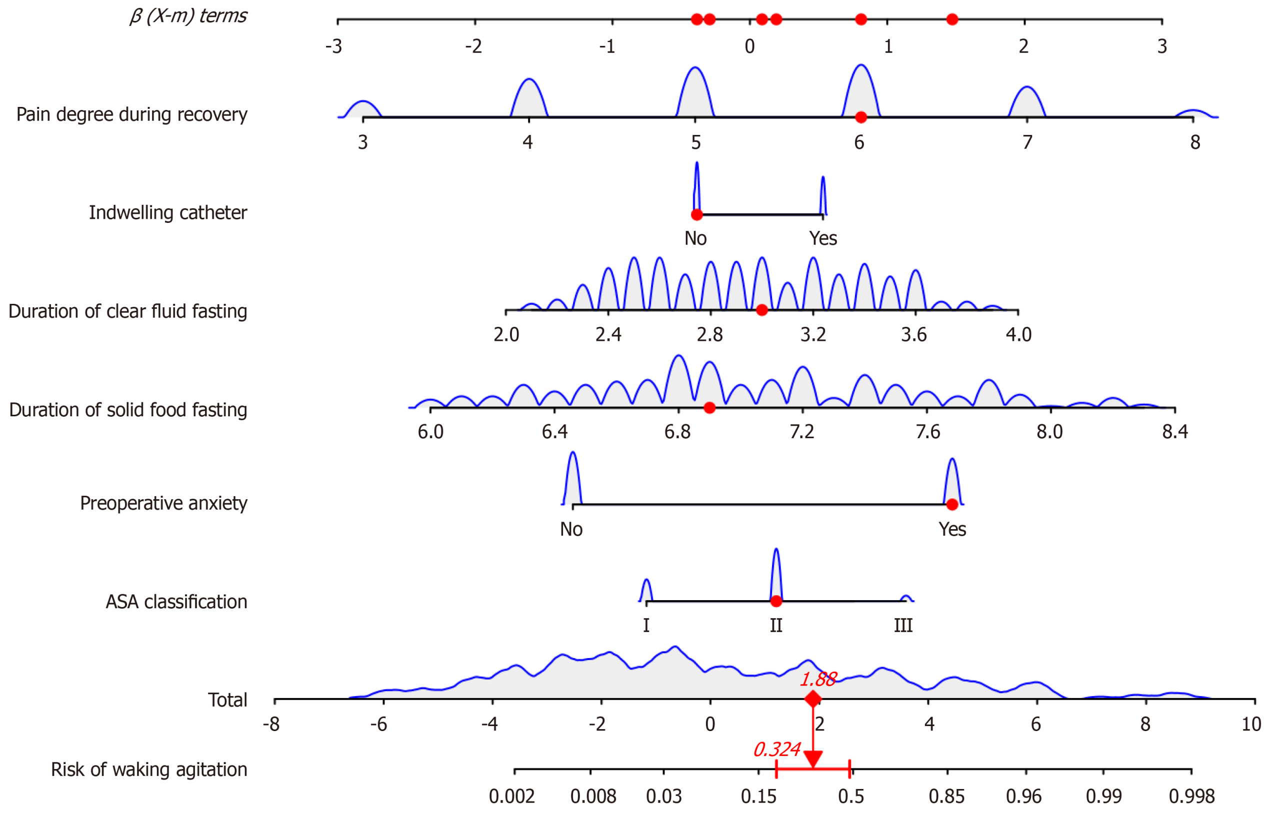

Figure 4 The example's nomogram. ASA: American Society of Anesthesiologists.

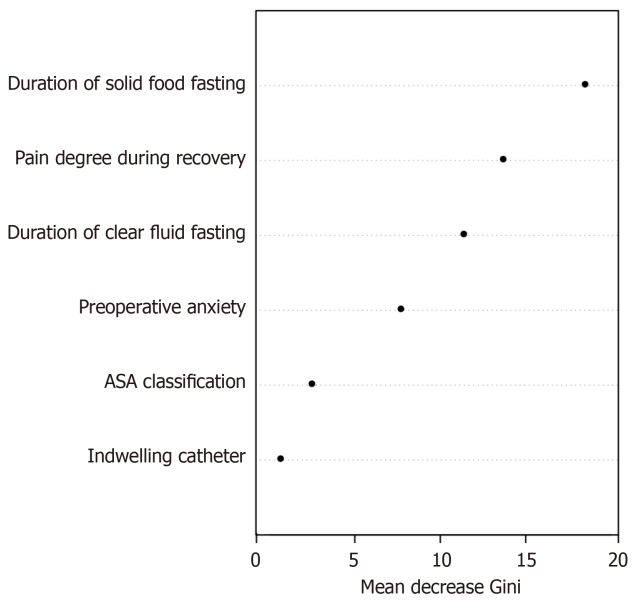

Figure 5 Importance of predictive variables affecting. ASA: American Society of Anesthesiologists.

How to screen important features from multidimensional and complex medical data, deeply explore influencing factors, and make subsequent intervention measures more targeted is a question worth pondering. In this study, the incidence of EA was 24%. LASSO regression and multivariate logistic regression determined ASA classification, pre-operative anxiety, duration of solid food fasting, duration of clear fluid fasting, indwelling catheter, and pain degree during recovery as risk factors for EA. The random forest model further revealed the importance ranking of these factors affecting EA in patients undergoing laparoscopic hernia surgery with total intravenous anesthesia combined with caudal block anesthesia as follows: ASA classification, preoperative anxiety, fasting time for solid food, fasting time for clear liquids, indwelling catheter, and pain level during the awakening period. Both models are effective at predicting EA, with the nomogram model having an AUC of 0.947 and the random forest model an AUC of 0.923. The nomogram model has a good net benefit in predicting EA within a threshold range of 0.02 to 0.96, while the random forest model has a good net

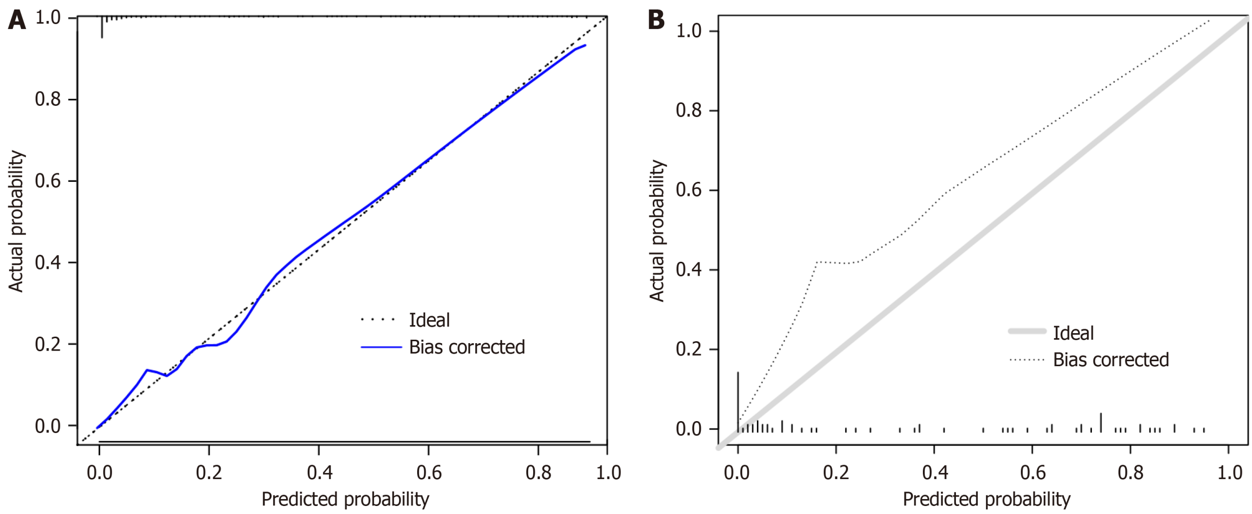

Figure 6 Calibration curve. A: Calibration curve of the column diagram; B: Calibration curve of the random forest.

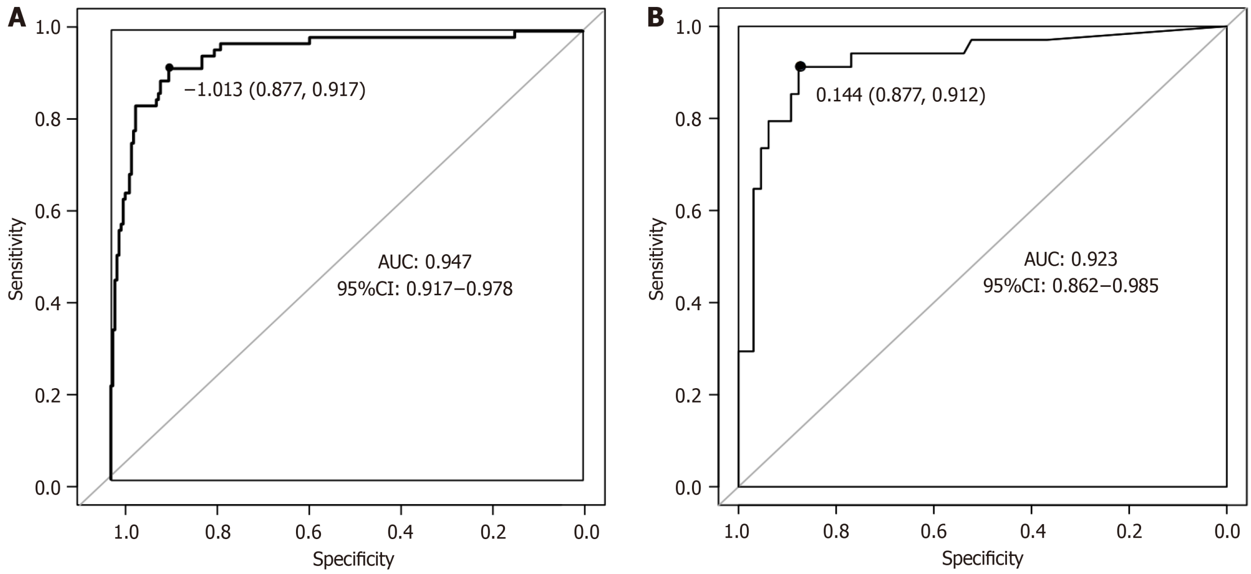

Figure 7 Receiver operating characteristic curve. A: Receiver operating characteristic curve of the nomogram; B: Receiver operating characteristic curve of the random forest. AUC: Area under the receiver operating characteristic curve; CI: Confidence interval.

benefit within the threshold range of 0.03 to 0.90, showing high clinical application value. Therefore, clinicians can use these models, along with the importance ranking of factors, to better target interventions and reduce EA in patients undergoing laparoscopic hernia surgery with total intravenous anesthesia combined with caudal block anesthesia.

A meta-analysis of 21 studies on postoperative agitation in non-cardiac surgery patients found that a high ASA classification is the main risk factor for EA[19]. The ASA classification system assesses the patient's condition and surgery risk before an operation. The higher the ASA classification, the worse the patient's condition and tolerance to anesthetic drugs, and the more likely there will be fluctuations in respiration, circulation, and internal environment during anesthesia and surgery[20], which results in difficulty in maintaining adequate anesthesia depth, thereby increasing the risk of EA. The study used general inhalation combined with caudal block, and the individual differences in extraneural fat tissue may also affect how anesthesia spreads and its intensity. Ropivacaine may be absorbed more slowly in the epidural space[21]. In addition, a narrower epidural space caused by increased lumbar vertebrae may limit the caudal block and affect the duration of epidural anesthesia[22]. Moreover, the ASA classification is subjective and does not take into account whether all the pathological or physiological processes that occur have a significant impact on the results, so more research is needed. Based on our findings, we recommend using deeper anesthesia techniques or adjusting anesthetic drugs to reduce the risk of EA. Relevant literature indicates that ketamine and lidocaine are highly effective in preventing EA and managing pain[23].

Previous studies have linked preoperative anxiety to EA[24]. The results of this study also confirm that preoperative anxiety is a risk factor. On the one hand, laparoscopic surgery is a traumatic event that may trigger stress; on the other hand, preoperative anxiety and tension can affect sleep and dietary habits and emotional reactions before surgery, and

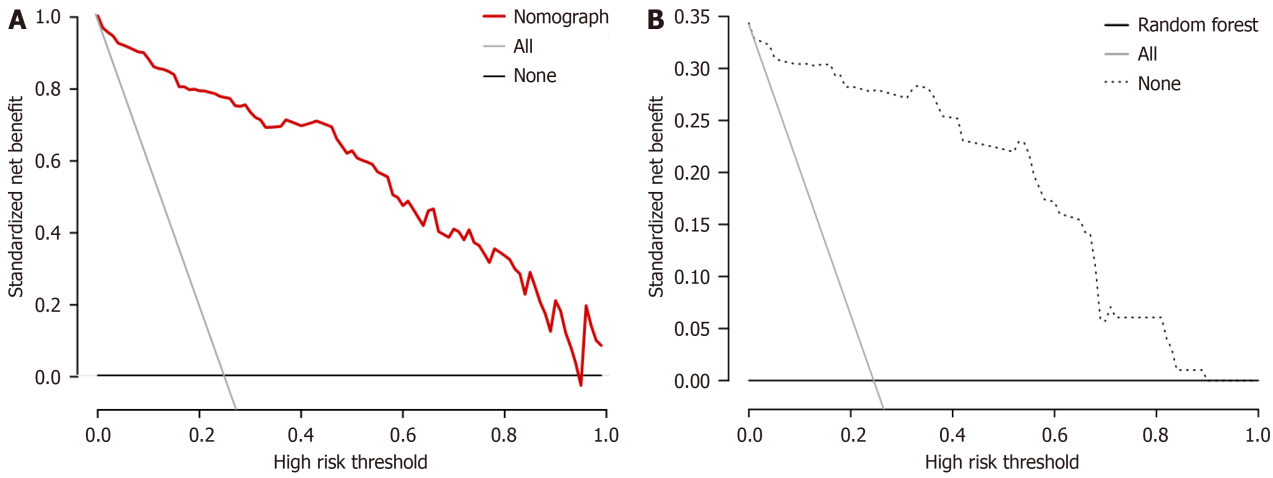

Figure 8 Clinical decision curve. A: Decision curve of a column graph; B: Decision curve of a random forest.

procedural stimuli during surgery can activate the patient's sympathetic nervous system, prolonging arousal and increasing EA incidence. Additionally, increased blood pressure and heart rate enhance stress responses. Excessive stress can lead to enhanced adrenal cortical function in the body and elevated levels of cortisol, aldosterone, and other hormones in the blood, which raises blood sugar, trigger metabolic abnormalities, and cause postoperative cognitive dysfunction, thereby inducing EA[25].

Preoperative fasting is required for laparoscopic hernia surgery, but there is limited research on its impact on EA. The ASA and other organizations recommend fasting from solid foods for 6 hours and clear fluids for 2 hours before surgery [26]. In this study, the agitation group had significantly longer fasting times than the non-agitation group, exceeding recommended limits. Prolonged preoperative fasting (solid or liquid foods) increases the risk of EA. Prolonged preoperative fasting may lead to metabolic, physical, and psychological discomfort in patients, ultimately resulting in abnormal neurological behaviors and increasing EA incidence[27]. Furthermore, studies indicate that extended preoperative fasting leads to patient anxiety, and the level of anxiety is related to the duration of fasting[28]. The interaction between preoperative anxiety and fasting time may also contribute to EA. More research is needed to understand this interaction. Therefore, it is recommended that effective preoperative education be conducted in clinical practice to facilitate the translation of recommended preoperative fasting guidelines into clinical practice and reduce EA incidence.

Indwelling catheters are commonly used in the perioperative period to collect urine for measuring urine output and assessing blood volume. However, indwelling catheters may cause bladder discomfort, irritation and burning sensations, pain, urgency, and frequency during the postoperative awakening period[29], which increases the risk of EA. Although laparoscopic surgery is minimally invasive and efficient, the manipulation of muscle traction can still cause postoperative pain. This pain may lead to reflex resistance during the awakening period, triggering complications such as tachycardia and hypoxemia[30], and may also lead to complex neurobehavioral responses[31], resulting in EA. A systematic study reported that inadequate postoperative analgesia is a risk factor for EA[32]. Based on the aforementioned study, it is recommended to use multimodal postoperative analgesia, particularly preventive analgesia, such as local nerve blocks before the surgery ends. This can control pain early in the recovery phase and reduce pain level. Effective pain management can decrease patient anxiety and discomfort, which may help reduce EA occurrence.

CONCLUSION

In summary, ASA classification, preoperative anxiety, duration of solid food fasting, duration of clear fluid fasting, indwelling catheter, and pain degree during recovery are key risk factors for postoperative agitation in patients undergoing laparoscopic hernia surgery under combined inhalational and epidural anesthesia. This study created nomogram and random forest prediction models that are accurate and clinically useful. These models help clinicians assess the risk of postoperative agitation and guide early intervention and monitoring.

FOOTNOTES

Author contributions: Zhu YF and Qin MH wrote the manuscript; Zhu YF, Yi FY, and Qin MH collected the data; Lu J, Liang H, Yang S, and Wei YZ guided the study; and all authors reviewed, edited, and approved the final manuscript and revised it critically for important intellectual content, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

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