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ORIGINAL RESEARCH

Development and Validation of a Risk Predictive Model for Adverse Postoperative Health Status of Elderly Patients Undergoing Major Abdominal Surgery Using Lasso-Logistic Regression

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Background: The postoperative health status of elderly patients has a substantial impact on both the individuals themselves and their families, and this impact became more pronounced with advancing age. The aim of this study was to identify risk factors that can predict the health status of patients aged 80 and over after major abdominal surgery and to establish a nomogram model.

Methods: We conducted a retrospective study of elderly patients (aged 80+) who underwent major abdominal surgery at the First Affiliated Hospital of Soochow University from January 2017 to June 2023. Least absolute shrinkage and selection operator (lasso) regression analysis was employed to identify potential perioperative factors associated with the patients' health status one year post-surgery. Subsequently, logistic regression was then used to refine these factors for the model. The nomogram's performance was assessed through discriminative ability, calibration, and clinical utility in both training and validation datasets.

Results: In total, 576 and 145 individuals were allocated to the training and validation sets, respectively. Lasso regression first identified 10 variables as candidate risk factors. After further screening through univariate and multivariate logistic regression, it was confirmed that seven variables, including tumor, operative duration, left ventricular ejection fraction (LVEF), blood transfusion, direct bilirubin, erythrocyte, and self-care, were included in the final nomogram model. The Hosmer–Lemeshow test, with a P-value of 0.835, indicates that the model was well-fitted. The area under the Receiver Operating Characteristic curve (ROC-AUC) for the model on the training set was 0.81 (95% CI 0.764–0.855), and for the validation set, it was 0.83 (95% CI 0.751–0.91). Additionally, the calibration curves and decision curve analyses in both the training and validation sets demonstrated the accuracy and clinical applicability of the predictive model.

Conclusion: The nomogram has a good predictive ability for the health status of older patients aged 80 years and above after abdominal surgery for one year, which can help clinical doctors develop better treatment plans.

Keywords: nomogram, postoperative, health status, aged, 80 and over, major abdominal surgery

Introduction

According to a World Population Prospects Report from the United Nations, the global average life expectancy is projected to reach 77.2 years by 2050.[1] The population of people aged 65 years or older in China reached 165 million as of 2019 aged 80 years or older reaching 26 million, which represents approximately 18% of the global population aged 80 and above.[2] Furthermore, the aging process of China's population continues to accelerate, and the health issues arising

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from this demographic shift are a concern that requires the attention of the entire society. These findings highlight the necessity to prioritize medical research on individuals aged 80 and above.

In ordinary elderly individuals, the decline in postoperative health status due to illness may be temporary and reversible. However, in older patients aged 80 years and above, the high likelihood of significant organ dysfunction and a substantial proportion of frailty[3–5] may have rendered the maintenance of basic cognitive and self-care abilities more important than mere survival. This focus could have contributed to reducing medical and long-term care costs.[6] Reports indicated that approximately 20% of elderly individuals over 80 years old experienced sustained functional decline after surgery.[7] Furthermore, studies showed that over 80% of elderly individuals aged 85 and above faced loss of independence after surgery.[8] Considering that the proportion of elderly people in abdominal surgery could reach 25%,[9] it was crucial to evaluate and predict the overall postoperative health status of this population.

Previous studies have indicated the influence of high-sensitivity troponin T levels, muscle weakness, daily activity capacity, acute kidney injury, and other factors on postoperative mortality or complications in elderly patients.[10–12] The inflammatory changes induced by surgery can exert detrimental effects on the elderly, encompassing cognitive function and other health-related metrics.[13,14] Furthermore, comprehensive preoperative assessment and optimization of the geriatric patient's condition have been reported to yield clinical benefits,[15] and the use of preoperative patient data for risk prediction is an essential component of perioperative medicine. However, it is crucial to acknowledge that the predictive power of any single factor is limited. Therefore, integrating patient data to construct more accurate predictive models is essential to enhance predictive accuracy. Among various tools, nomograms stand out as a visual and user-friendly statistical instrument with high clinical utility. This tool can assist healthcare providers, as well as patients and their families, in anticipating outcomes, identifying risks, and implementing personalized preventive measures.

The existing prediction models lacked relevance to advanced age patients and had not been able to evaluate the overall health status. This study aims to establish and validate a nomogram prediction model for the health status of elderly patients aged 80 and above undergoing major abdominal surgery within one year after surgery, through retrospective analysis of clinical data, providing evidence for accurate identification and effective intervention.

Materials and Methods

Study Participants

This retrospective cohort study enrolled 1000 elderly patients aged 80 years and above who underwent major abdominal surgery between January 2017 and June 2023 in the First Affiliated Hospital of Soochow University. Major abdominal surgery was defined as resection of abdominal parenchymal organs or gastrointestinal anastomosis, with a surgical duration exceeding 2 hours and a hospital stay longer than 3 days.[16,17] Exclusion criteria comprised: (1) Preoperative loss of mobility and self-care ability; (2) Refusal by patients or family members to undergo health status assessment; (3) In-hospital mortality; (4) Significant perioperative data missing. The Ethics Review Committee of the First Affiliated Hospital of Soochow University approved this study (No. 2024–062), which was exempted from informed consent requirements. Registration was completed in the Chinese Clinical Trial Registry (ChiCTR2400085113). This study adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.[18]

Data Collection and Follow-Up

An independent investigator collected baseline and perioperative data using Lex Clinical Data Application 3.2 (Hangzhou Lejiu Healthcare Technology Co., Ltd.) from the Hospital Health Information System (HIS). Simultaneously, we utilized the EQ-5D-5L questionnaires, which are standardly employed for both preoperative and 1-year routine follow-ups of elderly patients in our hospitals, to evaluate patients' health-related quality of life status. This comprehensive tool consists of five dimensions: mobility, self-care, usual activities, pain/discomfort, anxiety/depression, with each dimension rated on a five-level scale.[19] Additionally, a self-assessment score for EQ-VAS was provided by family members who directly care for the patient. It ranges from 0 (the worst imaginable health state) to 100 (the best imaginable health state). Patients were classified into acceptable (≥60) and unacceptable (<60) health status based on EQ-VAS 1 year after surgery (patients who died within 1 year were considered <60) and grouped accordingly. All data were documented in an electronic database and analyzed by an independent statistician.

Outcomes and Groups

Utilizing computer-generated random numbers, we stratified the eligible patients into a training dataset comprising 576 cases and a validation dataset encompassing 145 cases, adhering to an 8:2 ratio. Postoperative health states were categorized into two distinct groups based on the EQ-VAS self-assessment score at the one-year mark following surgery: "acceptable" for scores of 60 or above, and "unacceptable" for scores below 60. The EQ-VAS, reported by family members who provided direct care to the patients, offered a holistic evaluation of health status, transcending the focus on any particular ailment or discomfort. The score ranged from 0, indicative of the worst imaginable health state, to 100, representing the best imaginable health state. Patients who succumbed within the first year post-surgery were assigned an EQ-VAS score of less than 60. By meticulously screening for perioperative confounding factors, we established a nomogram model within the training set to prognosticate the postoperative health status of patients, which was subsequently validated in the validation set.

Statistical Analysis

Continuous variables were subjected to normality assessment using the Shapiro–Wilk test and to the examination of homogeneity of variance with the Levene test. Those variables exhibiting a normal distribution were depicted as means (± standard deviation, SD), whereas non-normally distributed variables were characterized by medians (with interquartile ranges, IQR). Demographic and hospital characteristics, which were continuous in nature, were compared between the two groups using Student's *t*-test for data adhering to a normal distribution and the Mann–Whitney *U*-test for data that deviated from normality. Categorical variables were quantified by absolute and relative frequencies, and group differences were evaluated for statistical significance using the Pearson chi-square test or Fisher's exact test, depending on the context. Missing data, which accounted for less than 20% of the dataset, were managed through multiple imputation techniques.

By employing lasso regression, an appropriate Lambda (λ) value was selected to preliminarily screen and identify significant candidate predictor variables. Subsequently, logistic regression was applied to identify the variables that were ultimately incorporated into the prediction model. The Hosmer–Lemeshow test was utilized to assess the model's stability. A nomogram was constructed based on the selected variables, and the predictive performance was evaluated using the receiver operating characteristic (ROC) curve, the calibration curve was used to assess the model's accuracy, and decision curve analysis (DCA) was conducted to determine the clinical utility. All analyses were conducted using SPSS version 25 (IBM Corp, Armonk, NY) and R version 4.4.1 (R Foundation for Statistical Computing).

Results

Baseline Characteristics

The participant inclusion process is illustrated in Figure 1. A total of 1,000 elderly patients aged 80 and above met the inclusion criteria. However, 11 patients had passed away during their hospitalization, 213 cases could not be contacted or had refused follow-up, 20 patients had lost their ability to care for themselves prior to surgery, and 35 cases had significant missing perioperative data. Ultimately, 721 individuals were included in the analysis, with 576 in the training set and 145 in the validation set.

Initially, the training set was stratified into two cohorts based on EQ-VAS scores at the one-year postoperative mark: an "acceptable" group comprising 460 individuals and an "unacceptable" group consisting of 116 individuals. The "unacceptable" group encompassed 70 patients who succumbed within the first year, yielding a postoperative mortality rate of 12.153% (70 out of 576). Comparative analysis of baseline characteristics between these two groups, including age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and patient medical history, revealed no statistically significant disparities (Table 1). Similarly, the validation set was segmented into an "acceptable" group of 115 individuals and an "unacceptable" group of 30 individuals, with 16 fatalities and a mortality

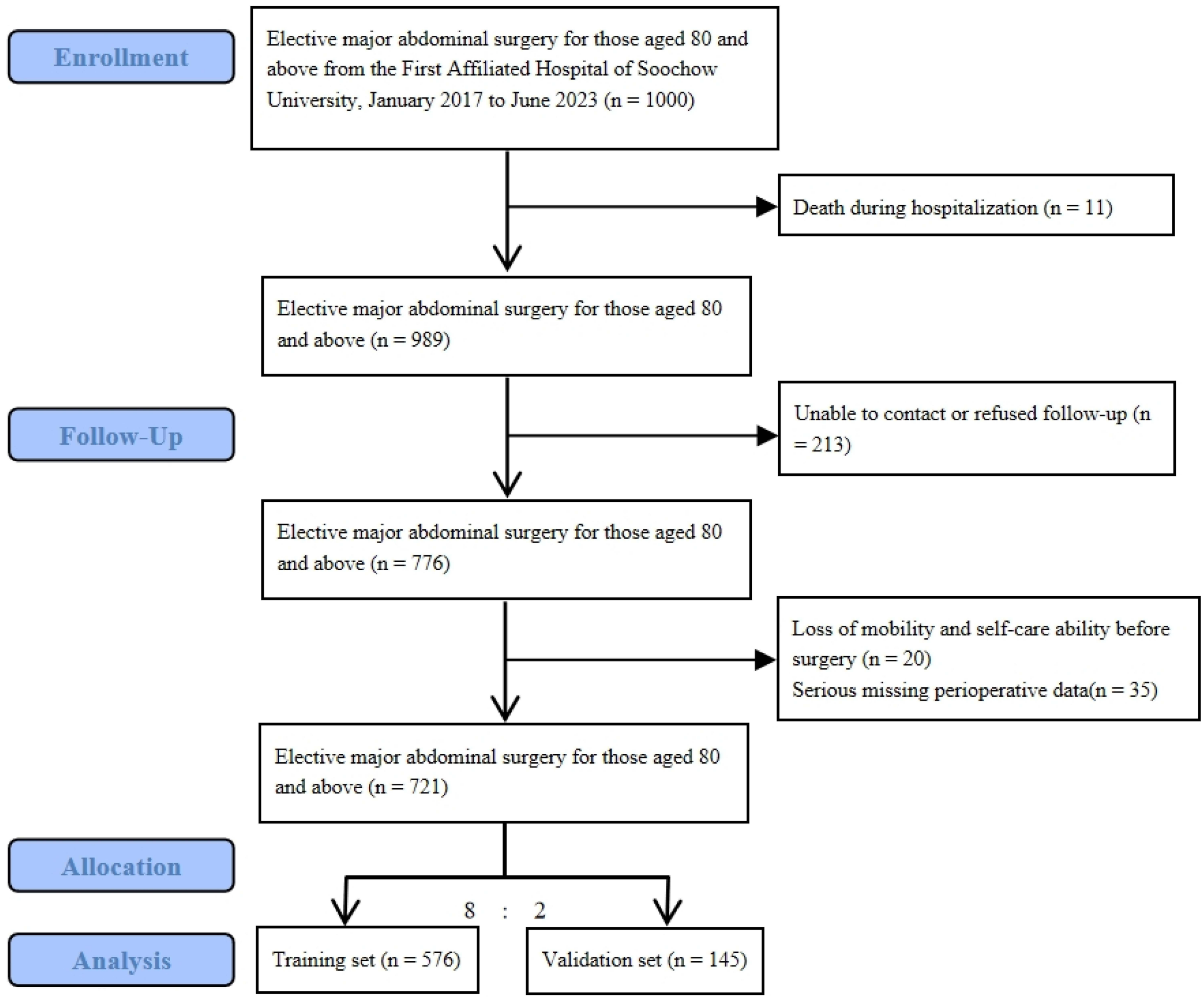

Figure 1 Flow chart for patient screening A total of 1000 patients met the inclusion criteria, and after gradual exclusion based on the exclusion criteria, 721 patients were ultimately used to establish a nomogram prediction model and randomly divided into a training set of 576 patients and a testing set of 145 patients.

rate of 11.034% (16 out of 145). The baseline characteristics of the validation set also exhibited no statistical differences (Table S1).

Comparison of Perioperative Data Between Two Groups

In our analysis of the training dataset, we delineated the surgical-related data and laboratory indicators between two distinct cohorts (Table 2). The unacceptable group was characterized by a higher prevalence of open abdominal procedures, a higher proportion of tumor surgeries, prolonged operative times, extended hospitalizations, and an elevated intraoperative blood transfusion rate when juxtaposed with the acceptable group (all $P<0.05$). Furthermore, the left ventricular ejection fraction (LVEF) values were significantly higher in the acceptable group, indicating better cardiac performance ($P=0.008$). In terms of laboratory indicators, the acceptable group exhibited higher levels of total bilirubin, indirect bilirubin, direct bilirubin, alanine aminotransferase (ALT), albumin, and erythrocyte counts, suggesting better hepatic function and nutritional status (all $P<0.05$). Conversely, the unacceptable group displayed higher levels of high-sensitivity C-reactive protein, a marker of systemic inflammation ($P=0.001$). When evaluating preoperative EQ-5D-5L scale scores, no statistically significant differences were observed in EQ-VAS scores between the two groups. However,

Table 1 Baseline Characteristics

Variables	Training Set (n=576)		
	Acceptable (n=460)	**Unacceptable (n=116)**	***P* value**
Age, Median (IQR), y	82(3)	83(4)	0.538
Gender (male), n(%)	273(59.35)	61(52.59)	0.187
Height, Median (IQR), cm	160(13)	160(12)	0.932
Weight, Median (IQR), kg	58(15)	55(15)	0.125
BMI, Median (IQR),kg/m^2	22.38(3.91)	21.435(4.8)	0.053
ASA classification, n(%)			0.303
I	7(1.52)	3(2.59)	
II	278(60.44)	66(56.90)	
III	171(37.17)	44(37.93)	
IV	4(0.87)	3(2.59)	
Hypertension, n(%)	361(78.48)	99(85.35)	0.544
Diabetes, n(%)	276(60)	68(58.62)	0.787
Coronary disease, n(%)	29(6.30)	10(8.62)	0.375
Heart disease, n(%)	38(8.26)	15(12.93)	0.120
Renal disease, n(%)	216(46.96)	49(42.24)	0.363
Cerebral apoplexy, n(%)	45(9.78)	5(4.3)	0.061
COPD, n(%)	89(19.35)	24(20.69)	0.745
History of surgery, n(%)	199(43.26)	52(44.83)	0.761

Abbreviations: IQR, interquartile range; BMI, Body Mass Index; ASA, American Society of Anesthesiologists; COPD, Chronic Obstructive Pulmonary Disease.

Table 2 Perioperative Data

Variables	Training Set (n=576)		
	Acceptable (n=460)	**Unacceptable (n=116)**	***P* value**
Laparoscope, n(%)	316(68.70)	67(57.76)	0.026*
Surgical site, n(%)			0.062
Upper abdomen	216(46.96)	65(56.03)	
Lower abdomen	217(47.17)	41(35.35)	
Both	27(5.87)	10(8.62)	
Tumor, n(%)	371(80.65)	104(89.66)	0.023*
Operative duration, Median (IQR), min	214.5(98)	238(114)	0.001*
Hospital stay, Median (IQR), d	14(7)	16.5(11)	0.009*
Admission to ICU, n(%)	47(10.22)	16(13.79)	0.270
Blood transfusion, n(%)	74(16.09)	65(56.03)	<0.001*
Crystal liquid volume, Median (IQR), mL	500(500)	500(500)	0.390
Colloidal liquid volume, Median (IQR), mL	500(0)	500(0)	0.477
LVEF, Median (IQR), %	65(8)	62.23(7.98)	0.008*
Total bilirubin, Median (IQR), umol/L	12.4(7.60)	10.55(8.30)	0.006*
Indirect bilirubin, Median (IQR), μmol/L	8.1(5.10)	6.4(5.25)	<0.001*
Direct bilirubin, Median (IQR), μmol/L	4.4(2.90)	3.85(3.60)	0.08*
ALT, Median (IQR), U/L	14.1(12.10)	12.45(10.67)	0.049*
AST, Median (IQR), U/L	19.9(9.20)	18.2(8.62)	0.095

(*Continued*)

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Table 2 (Continued).

Variables	Training Set (n=576)		
	Acceptable (n=460)	Unacceptable (n=116)	*P* value
Total protein, Median (IQR), g/L	64.25(9.60)	63.1(9.15)	0.288
Albumin, Mean (SD), g/L	37.617(4.54)	36.553(4.83)	0.026*
Globulin, Median (IQR), g/L	1.4(0.30)	1.4(0.40)	0.385
Albumin/Globulin, Median (IQR)	26.57(5.89)	26.73(6.82)	1
Urea, Median (IQR), mmol/L	5.5(2.60)	5.75(2.80)	0.178
Creatinine, Median (IQR), μmol/L	70.05(22.12)	70(29.90)	0.755
Blood glucose, Median (IQR), mmol/L	5.07(1.30)	5.08(1.29)	0.683
Platelet, Median (IQR), 10^9/L	198(86)	207.5(108)	0.262
Hemoglobin, Median (IQR), g/L	130.1(2.95)	129.6(3.58)	0.065
Leukocyte, Median (IQR), 10^9/L	5.775(2.30)	6.1(3.17)	0.092
Erythrocyte, Mean (SD), 10^9/L	4.023(0.58)	3.702(0.58)	<0.001*
High-sensitivity C-reactive protein, Median (IQR), mg/L	3.695(9.79)	5.88(13.20)	0.001*
Preoperative EQ-VAS, Median (IQR)	80(15)	75(35)	0.089
Mobility 1/2/3/4/5	347/64/32/17/0	65/31/11/6/3	<0.001*
Self-care 1/2/3/4/5	372/53/26/9/0	56/35/12/6/7	<0.001*
Usual activities 1/2/3/4/5	362/55/24/19/0	76/18/12/7/3	0.002
Pain/discomfort 1/2/3/4/5	62/134/199/65/0	5/22/58/29/2	<0.001*
Anxiety/depression 1/2/3/4/5	149/239/58/14/0	31/61/16/6/2	0.075

Note: *P < 0.05.
Abbreviations: IQR, interquartile range; SD, standard deviation; ICU, intensive care unit; LVEF, left ventricular ejection fraction; ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; EQ, EuroQol; VAS, Visual Analogue Scale; 5D, 5 dimensions.

a detailed examination of the five dimensions revealed that the acceptable group outperformed the unacceptable group in the domains of mobility, self-care, usual activities, and pain/discomfort (all P<0.05).

In the validation dataset, the reduced sample size may have mitigated the observed differences between the two cohorts (Table S2). Nonetheless, the unacceptable group still presented with a higher proportion of tumor surgeries, longer operative durations, and a higher rate of intraoperative blood transfusion compared to the acceptable group (all P<0.05). Laboratory assessments revealed that the acceptable group maintained higher levels of total bilirubin, albumin, and globulin, indicative of better hepatic synthesis and protein metabolism (all P<0.05). In contrast, the unacceptable group had increased levels of high-sensitivity C-reactive protein (P=0.042). Additionally, in the validation set, the acceptable group continued to demonstrate superior performance in the dimensions of mobility, self-care, and usual activities when compared to the unacceptable group (all P<0.05).

Selection of Predictive Variables

In the lasso regression analysis of the training set, which encompassed all 46 variables detailed in Table 1 and Table 2, the lambda_min was identified as 0.006969502, and the lambda_1se was determined to be 0.03087923 (Figure 2). To strike a balance between preventing overfitting and retaining significant variables, a preliminary selection of 10 variables was conducted at a lambda value of 0.25. The selected variables included cerebral apoplexy, tumor, operative duration, LVEF, blood transfusion, direct bilirubin, urea, erythrocyte count, self-care, and pain/discomfort.

After confirming the absence of multicollinearity among the previously selected 10 indicators, these variables were subsequently included in a logistic regression model for further analysis. In the initial univariate regression analysis, we found that the P-values for cerebral apoplexy and urea between the two groups were 0.069 and 0.051, respectively. For the remaining eight variables, their P-values in the intergroup comparison were all less than 0.05. Subsequent multivariate regression analysis revealed that, aside from urea and pain/discomfort, the P-values for all other variables were

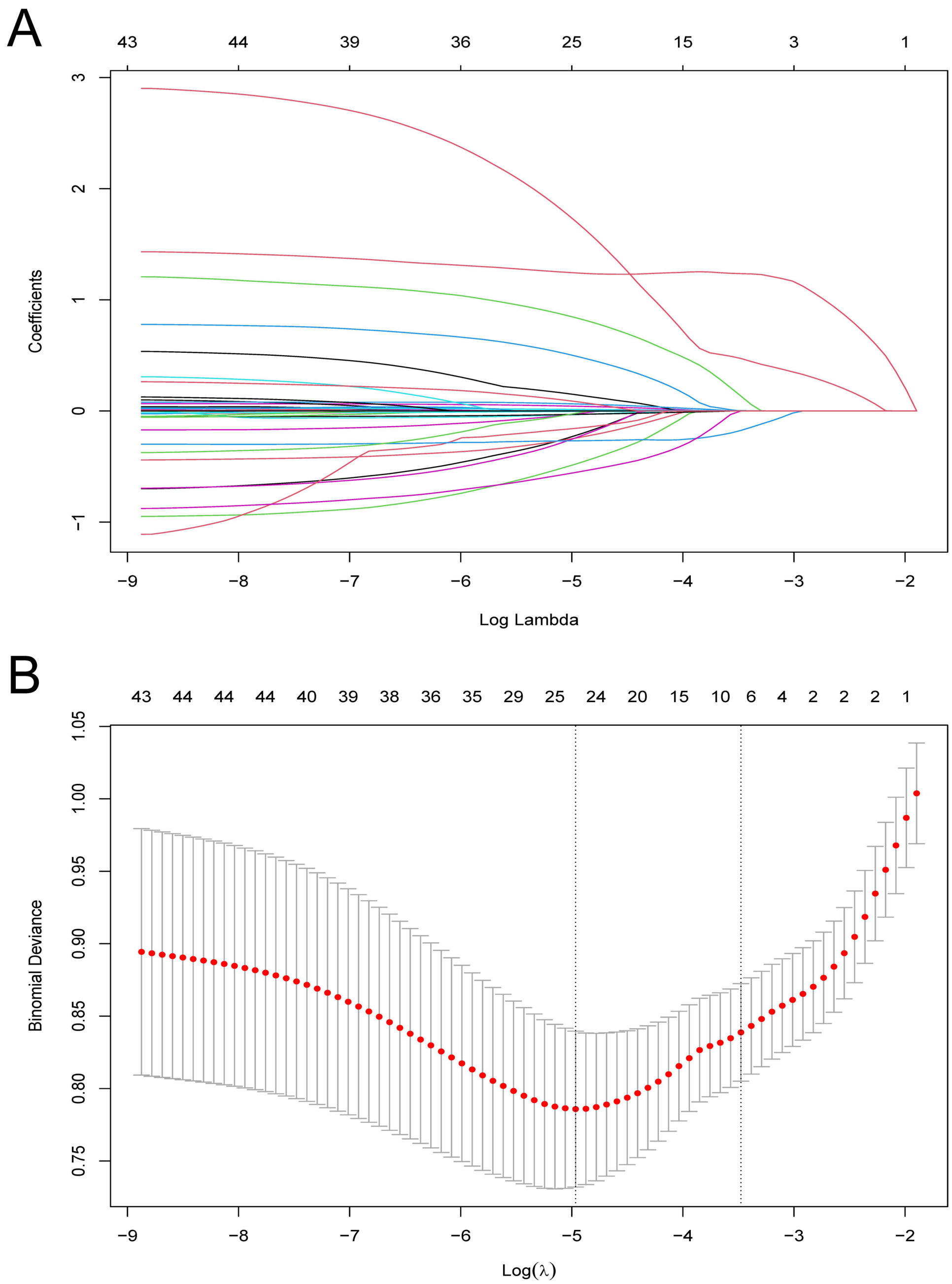

Figure 2 (**A**) Lasso coefficient profiles of the variables. (**B**) The cross-validation results of Lasso regression.

below 0.1 (Table 3). Based on these results and the previously mentioned intergroup comparisons, we decided to exclude cerebral apoplexy, urea, and pain/discomfort from the model.

Tumor (OR 3.326, 95% CI 1.434–7.711), operative duration (OR 1.003, 95% CI 1–1.005), LVEF (OR 0.968, 95% CI 0.932–1.005), blood transfusion (OR 3.832, 95% CI 2.306–6.368), direct bilirubin (OR 1.012, 95% CI 0.999–1.025), erythrocyte (OR 0.621, 95% CI 0.407–0.947), and self-care (OR 2.237, 95% CI 1.67–2.996) were included in the final model (Table 4). The Hosmer–Lemeshow test, with a P-value of 0.835, indicates that the model was well-fitted.

Table 3 Logistic Regression of Candidate Variables

Variables	Unadjusted OR	95% CI	*P* value	Adjusted OR	95% CI	*P* value
Cerebral apoplexy	2.41	0.93–6.21	0.069#	3.17	1.05–9.57	0.041*
Tumor	2.08	1.10–3.95	0.025*	3.67	1.56–8.66	0.003*
Operative duration	1.00	1.00–1.01	<0.001*	1.00	1–1.01	0.093#
LVEF	0.96	0.93–1.00	0.031*	0.97	0.93–1.01	0.099#
Blood transfusion	6.65	4.27–10.35	<0.001*	4.04	2.41–6.76	<0.001*
Direct bilirubin	1.01	1.00–1.02	0.014*	1.01	1.00–1.03	0.075#
Urea	1.08	1–1.16	0.051#	1.08	0.99–1.18	0.100
Erythrocyte	0.39	0.27–0.56	<0.001*	0.67	0.43–1.03	0.065#
Self-care	2.11	1.68–2.65	<0.001*	2.09	1.50–2.92	<0.001*
Pain/discomfort	1.78	1.39–2.29	<0.001*	1.21	0.88–1.67	0.246

Note: **P* < 0.05, #*P* < 0.1.
Abbreviations: OR, odds ratio; CI, confidence interval; LVEF, left ventricular ejection fraction.

Table 4 Logistic Regression with Final Inclusion of Variables

Variables	Adjusted OR	95% CI	*P* value
Tumor	3.33	1.43–7.71	0.005*
Operative duration	1.00	1–1.01	0.051#
LVEF	0.97	0.93–1.01	0.088#
Blood transfusion	3.83	2.31–6.37	<0.001*
Direct bilirubin	1.01	1.00–1.03	0.069#
Erythrocyte	0.62	0.41–0.95	0.027*
Self-care	2.24	1.67–3.00	<0.001*

Note: **P* < 0.05, #*P* < 0.1.
Abbreviations: OR, odds ratio; CI, confidence interval; LVEF, left ventricular ejection fraction.

Establishment and Evaluation of Nomogram Model

A nomogram model was established using the seven variables mentioned above (Figure 3). It can be intuitively seen that older patients aged 80 years and above who undergo non-tumor surgery, have shorter operative durations, higher LVEF values, do not require intraoperative blood transfusion, exhibit lower levels of direct bilirubin, have a higher erythrocyte count, and possess better self-care capabilities are likely to have a favorable health status one year postoperatively.

The ROC curve analysis for our nomogram model yielded an area under the curve (AUC) of 0.81 (95% CI 0.764–0.855) for the training set and 0.83 (95% CI 0.751–0.91) for the validation set, as depicted in Figure 4. These AUC values, surpassing the standard for a strong predictive model, demonstrate the nomogram's reliable predictive power in assessing the postoperative health status of older patients aged 80 and above. We further calculated the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) at various cut-off values along the ROC curve, and the results are shown in Table S3. It is evident that the model demonstrates good generalizability on the validation set. However, the threshold still needs to be adjusted according to specific application scenarios to achieve optimal predictive performance.

The calibration curve, utilizing bootstrapping with 1000 resamples, confirmed the model's precision in both sets, with the curve closely mirroring the ideal 45-degree line, indicating that the model's predictions are reliable (Figure 5). Additionally, decision curve analysis (DCA) highlighted the clinical utility of the nomogram, suggesting that its application could offer substantial benefits in clinical practice (Figure 6).

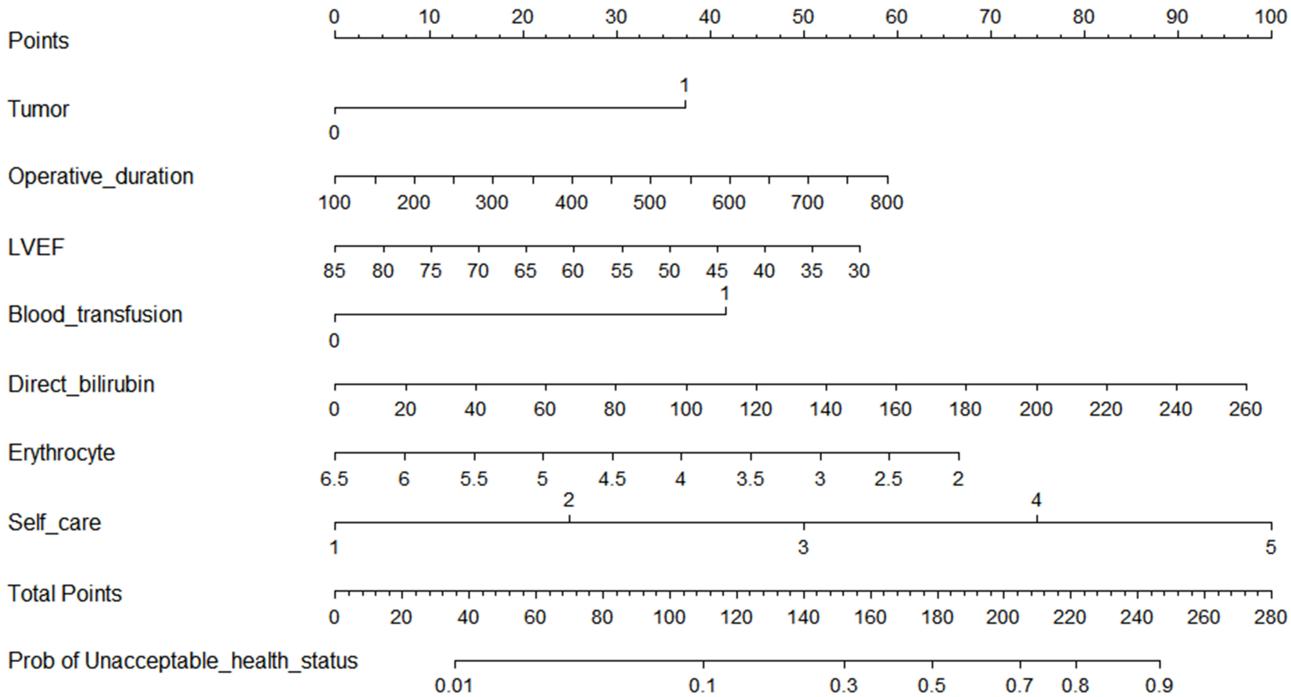

Figure 3 Nomogram for predicting the risk of unacceptable health status after major abdominal surgery.

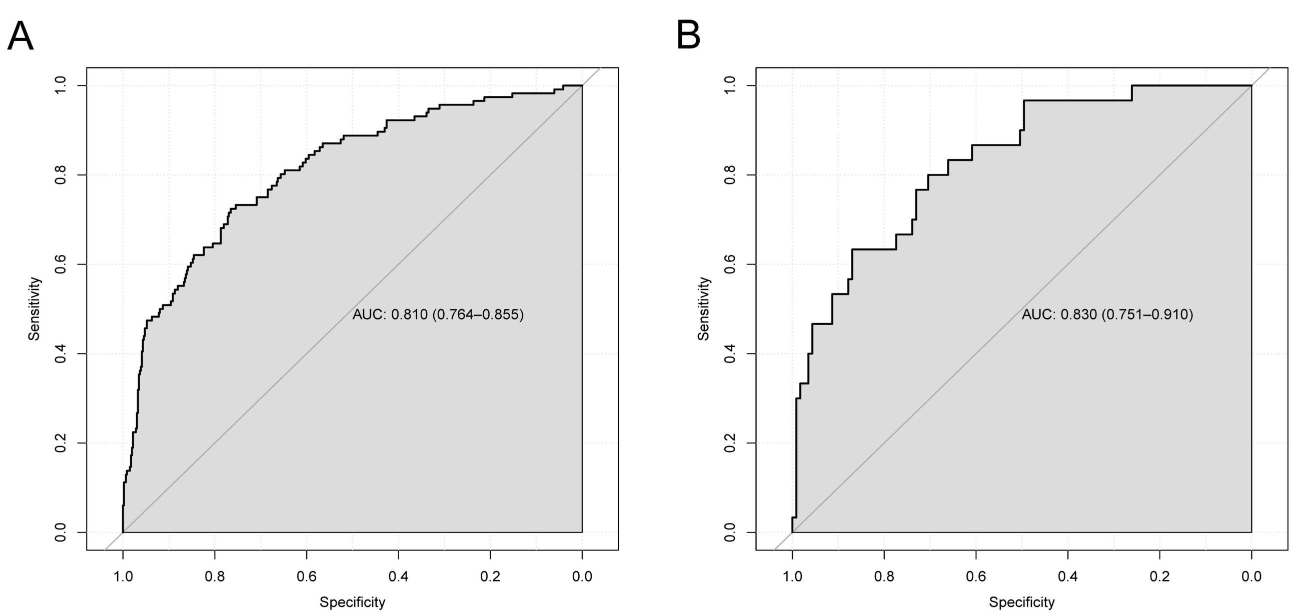

Figure 4 (**A**) ROC curve of the training set. (**B**) ROC curve of the validation set.

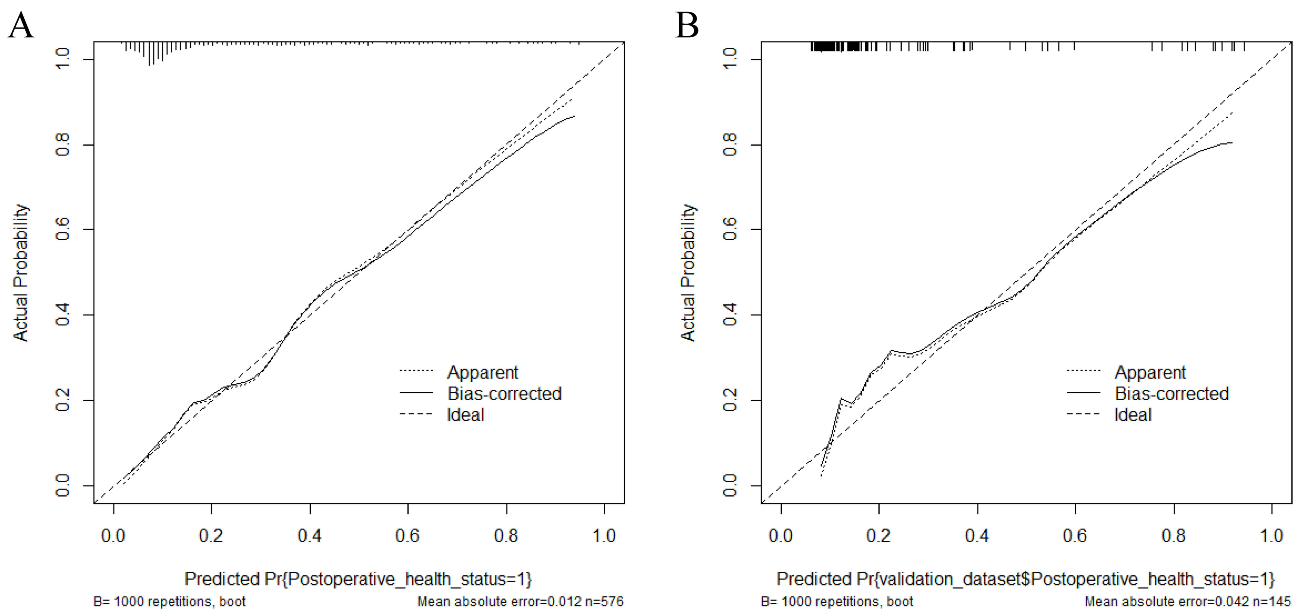

Figure 5 (**A**) Calibration curve of the training set. (**B**) Calibration curve of the validation set.

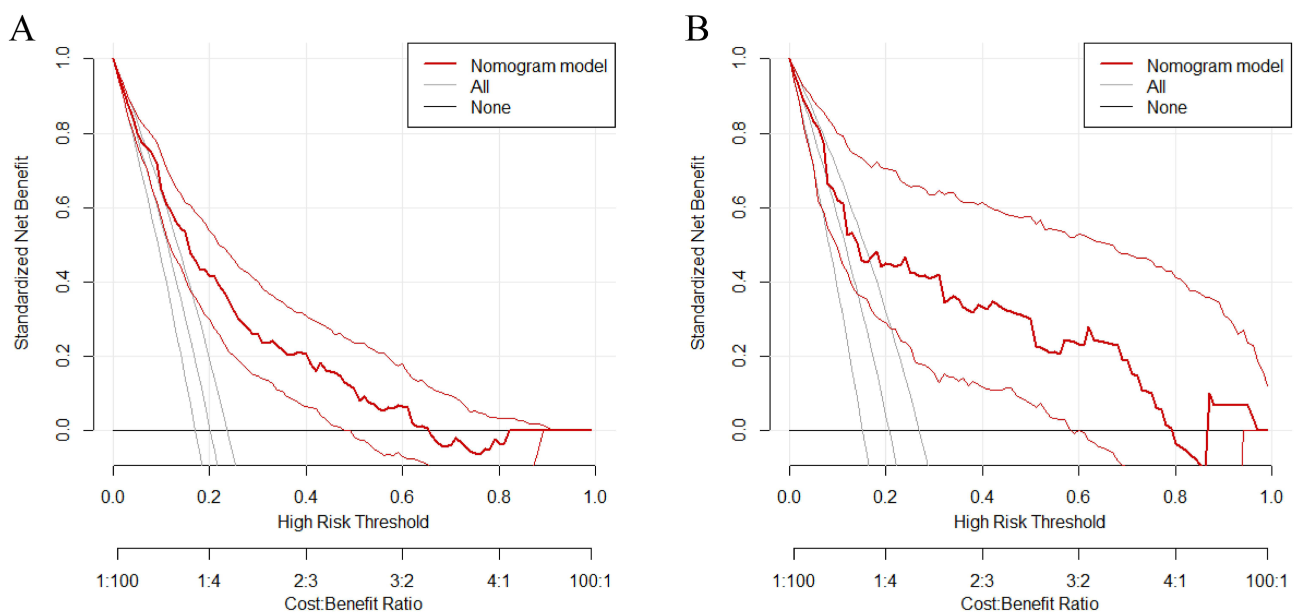

Figure 6 (**A**) DCA of the training set. (**B**) DCA of the validation set.

Discussion

Long-term postoperative health represents a significant patient-centered outcome, which is more likely to be stressful for advanced age individuals and their families, and imposes significant costs on healthcare systems.[7] Previous studies have identified a high prevalence of health issues, including cardiovascular diseases, respiratory diseases, and sarcopenia, among advanced age patients,[20–22] with health status being strongly correlated with quality of life. In this study, we combined Lasso regression and logistic regression to ultimately establish a nomogram of older patients aged 80 years and above undergoing major abdominal surgery, including seven indicators: tumor, operative duration, LVEF, blood transfusion, direct bilirubin, erythrocyte, and self-care. The nomogram was validated in the validation cohort. The AUC of the prediction model on the training set and validation set are 0.81 and 0.83, respectively. Moreover, the calibration curve and DCA confirmed the accuracy and expected clinical application value of the model.

Some predictive models have been established for the prognosis of elderly patients. Choi JY et al established a prognostic classification model for postoperative adverse outcomes in elderly surgical patients,[23] focusing primarily on the 90-day postoperative time point and mortality as the outcome. Luo YG et al established a nomogram model for postoperative delirium in elderly patients undergoing major abdominal surgery,[24] and Zhang K et al established a predictive model for major adverse cardiovascular events in elderly patients undergoing non-cardiac surgery.[25] However, these studies did not focus on patients aged 80 years or older. In contrast, Huang L et al developed a predictive model for assessing frailty, applicable for frailty assessment in individuals aged over 80 years,[26] although this study was unrelated to surgery or anesthesia. Compared with these studies, our research has the following advantages: Firstly, we target elderly patients aged 80 and above, and currently there is a lack of prognostic prediction models specifically for this population. Secondly, we innovatively evaluated the preoperative status of elderly patients aged 80 and above in five dimensions using the EQ-5D-5L scale and included them in the analysis, which helps to establish a more reasonable prediction model. In addition, this study predicts the overall health status of patients one year after surgery, rather than a single malady, which is more in line with the actual needs of prognosis for elderly patients aged 80 and above.

Furthermore, existing literature had established a link between preoperative frailty and postoperative recovery, as well as health-related quality of life in patients.[25,27] Our study aligned with this body of work, as we assessed the preoperative health status and incorporated self-care into our nomogram model. Self-care was indicative of frailty to a certain degree, given the established correlation between frailty and sarcopenia,[28,29] which in turn led to a diminished capacity for self-care.[30] Additionally, while the other three dimensions of the EQ-5D-5L scale exhibited significant differences upon non-parametric testing, they were not included in the final model. This may have been due to patients being more sensitive to changes in their self-care abilities, as well as the ability of Lasso regression to directly eliminate collinear variables. The feature selection property of Lasso regression aided in identifying and excluding variables that were less influential or collinear, thereby enhancing the model's predictive accuracy and interpretability.

The one-year overall mortality rate for patients in this study was 12.153% in the training set and 11.034% in the validation set, which was lower than the previously reported one-year mortality rate of 24.3% for elderly patients aged 80 and above following major abdominal surgery.[31] This discrepancy may have been attributed to the inclusion of non-tumor patients in the analysis, which likely mitigated the influence of tumor-related factors on mortality. Tumors are directly linked to the prognosis of elderly patients, with those aged 80 and above demonstrating poorer outcomes compared to individuals in the 65–79 age group.[32,33] Furthermore, elevated direct bilirubin levels have been associated with postoperative cognitive impairment in elderly patients.[32] Notably, this study revealed for the first time a positive correlation between elevated direct bilirubin and postoperative health status in elderly patients aged 80 and above.

Operative duration was influenced by the complexity of lesion resection and had been linked to unfavorable prognoses. Zeitlinger et al identified an independent association between operative duration and an increased risk of surgical site infection.[34] Teplitsky et al reported correlations between operative duration and short-term complication and mortality rates.[35] Additionally, intraoperative blood transfusion had been implicated in the incidence of postoperative complications.[35,36] It is important to clarify that this predictive model did not advocate for the forced reduction of operative duration or the denial of blood transfusions to patients during surgery. The critical aspect was the proactive identification of risk factors and the pursuit of rational interventions aimed at enhancing the patient's preoperative health status.

LVEF historically served as a cornerstone parameter in the diagnosis of heart failure, effectively reflecting a patient's cardiac function. Parikh RV et al developed a risk prediction model that leveraged LVEF to assess 1-year heart failure deterioration and mortality.[37] In line with this, our study demonstrated that higher preoperative LVEF values were advantageous for patients' health status one year postoperatively. The fundamental function of cardiac ejection, represented by LVEF, was to circulate and transport red blood cells to local tissues, in which process, red blood cells managed one of the most critical biological processes: oxygen loading, transport, and delivery.[38] Red blood cells were also implicated in the body's immune function.[39,40] Given their decreased tolerance, changes in red blood cell counts in

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elderly patients aged 80 and above could significantly impact the balance of oxygen supply and demand, as well as the maintenance of immune function.

There may be several limitations worth discussing in this study. Firstly, the grouping criteria for this study were based on postoperative EQ-VAS provided by caregivers, which may be subjective. Nonetheless, it should be noted that the social attributes of extremely elderly patients define the priority of their direct caregivers in assessing the patient's condition, and this overall assessment of the patient's condition is more valuable in the real world. Secondly, we will divide the dataset into a training set and a validation set, but this validation is still internal validation, and external validation needs to be included in the subsequent plan. Thirdly, we elected not to utilize machine learning. This decision was informed by the consideration that our study cohort, comprising elderly patients aged 80 and above, had an insufficient sample size for machine learning, which could lead to intractable overfitting. Moreover, nomograms offer superior interpretability and clinical applicability.

Conclusion

In this study, we identified tumor, operative duration, left ventricular ejection fraction (LVEF), blood transfusion, direct bilirubin, erythrocyte count, and self-care as independent risk factors for the postoperative health status of older patients aged 80 years and above one year following major abdominal surgery. With these variables, we constructed a nomogram and validated its predictive accuracy. This tool could assist clinical physicians and patients' families in early risk identification, enabling the development of tailored treatment and nursing strategies, and ultimately enhancing the postoperative quality of life for advanced age patients.

Ethical Statement

This study was approved by the Ethics Committee of the First Affiliated Hospital of Soochow University (No. 2024-062). Given that the data used in this study were derived from patients' historical records and follow-up results from routine medical processes in our center, a waiver of informed consent was granted. All authors confirm that this study complies with the ethical standards set forth in the Declaration of Helsinki and its subsequent revisions regarding medical research involving human subjects, and strictly adheres to the principles of patient data confidentiality.

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Disclosure

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