Development and Validation of a Nomogram Combined with Albumin and Neutrophil-to-Lymphocyte Ratio Predicting Postoperative Complications after Resection of Colon Cancer

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Abstract

Purpose: The aim of this study was to construct and validate a predictive model combined with albumin and neutrophil-to-lymphocyte ratio (NLR) to predict postoperative complications in patients underwent colon cancer resection.

Methods: We performed a retrospective cohort study of all patients undergoing resection of colon cancer between January 2019 and June 2021 at Sun Yat-sen Memorial Hospital. The general clinical characteristics and systemic inflammatory marker including lymphocytes and neutrophils were gathered retrospectively. The main outcome variables were postoperative complications. Logistic regression analyses were conducted to identify the in potential risk factors that predicting postoperative complications after resection of colon cancer. Nomograms with or without albumin/neutrophil-to-lymphocyte ratio socre (ANS) for postoperative complications were further constructed according to the results of multivariable logistic regression analysis adopting Akaike information criterion.

Results: The preoperative ANS score and intraoperative blood transfusion were determined as independent risk factors predicting postoperative complications. The nomogram including preoperative ANS score had higher C-index (0.821) and also better calibration.

Conclusions: The preoperative ANS score is an effective predictor and one of independent potential risk factors for postoperative complications after resection of colon cancer. The nomogram with preoperative ANS score was constructed with better capability predicting postoperative complications.

Introdution

Colorectal cancer is the third most prevalent kind of cancer and ranks second-leading reason of cancer-related deaths worldwide.(1) Surgical resection is the primary therapeutic modality for colon cancer whether curative or palliative, although recent advances in radiotherapy and chemotherapy.(2) With the development and popularization of laparoscopic technology, laparoscopic-assisted radical resection of colon cancer is more and more favored by gastrointestinal surgeons as it has been shown to be correrated with less postoperative pain, a quicker recovery of bowel movement and accelerating the recovery of patients compared with traditional open approach.(3–5) However, postoperative complications are still the main factor affecting the prognosis of patients undergoing whether laparoscopic-assisted or conventional resection of colon cancer. Early identification and assessment of risk factors for postoperative complications would contribute to informed consent for treatment, consideration of therapeutic modality, and evaluation of high-risk patients for particular and possibly multidisciplinary advertence.

Previously, studies have reported several perioperative risk factors associated with postoperative complications, including American Society of Anesthesiologists (ASA) classification, body mass index (BMI), male sex, visceral fat area, type of resection, longer duration of surgery, and blood loss.(6–10) A growing number of studies have also revealed that systemic inflammatory-based scores, included neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), lymphocyte-monocyte ratio (LMR) and prognostic nutritional index (PNI), were significantly correlated with postoperative complications among patients underwent various types of surgeries.(11–14) However, some researchers demonstrated that the Albumin/ NLR Score (ANS) had higher predictive value as it combined the systemic inflammatory symbol with albumin and concluded that ANS played a significant role in predicting postoperative complication and prognosis for patients with gastric and oral cancer. (15, 16) Nowadays, there is no study evaluating whether the novel and simple model of ANS can well predict postoperative complications in patients underwent radical resection of colon cancer.

As a statistical tool applied to predict an individual's specific result, nomogram has been widely used in clinical research.(16–18) Thus, the purpose of this study was to discover the most predictive systemic inflammatory marker and then combine it with other perioperative valuable variables to develop and validate a nomogram to predict the possibility of postoperative complications in patients underwent resection of colon cancer.

Patients And Methods

Retrospective Study and Patients

We conducted a retrospective study and involved all patients who underwent resection of colon cancer between January 2019 and June 2021 at Sun Yat-sen Memorial Hospital, Sun Yat-sen University. The exclusion criteria of this study were: age < 18 years old; emergency surgery, defined as emergency surgical treatment within 12 hours after admission or after related complications occurred; incomplete data recorded, defined as any variables for demographic characteristics, preoperative laboratory test, intraoperative anesthesia and surgery-related variables and postoperative variables were missing. Study approval was obtained from the Institutional Review Board of Sun Yat-sen Memorial Hospital of Sun Yat-sen University. (No. SYSEC-KY-KS-2021-179) Due to the nature of retrospective analysis, patient informed consent was waived.

Data Extraction

The data elements related to the following categories were extracted from database platform including hospital information system (HIS), Docare Anesthesia System (DAS), and laboratory information system (LIS) of our hospital: 1) Patient demographic characteristics: age, gender and weight; 2) Comorbidities: hypertension, diabetes mellitus, coronary heart disease, renal dysfunction and cerebral infarction; 3) Preoperative laboratory indicators defined as the latest tests prior to surgery: hemoglobin, albumin, neutrophils and lymphocytes; 4) Intraoperative anesthesia and surgery-related variables: American Society of Anesthesiologists (ASA) status, surgical type including laparoscopic or open, the total of crystalloid and colloid infusion, urine output, blood loss, blood transfusion and duration of surgery; 5) Postoperative variables: postoperative ICU admission, TNM staging, length of hospital stay, length of postoperative stay and postoperative complications including anastomotic leakage (AL), intestinal obstruction, postoperative bleeding, surgical incision infection (SII), pneumonia, arrhythmia, acute heart failure, thrombosis and sepsis. The NLR and ANS were further calculated. To find out the cut-off value on behalf of the maximum potential effectiveness of albumin and NLR, we adopted Youden index according to our previous study.(19) The cut-off value for albumin and NLR was 33.6 g/L and 3.83 respectively in this study. Both low albumin level and high NLR level have been demonstrated as risk factors for postoperative complications.(11, 12, 20) Therefore, values of albumin below 33.6 g/L were given 1 point, on the contrary, values of NLR over 3.83 were given 1 point. The ANS was a combination of albumin and NLR and each patient's ANS score ranged from 0 to 2 under the current set rule. The main outcome indicator in the present study was postoperative complication.

Univariate and multivariate logistic regression analysis

Patients who occurred whether surgical or medical postoperative complications were divided into complication group and those who didn't were divided into no complication group. Then, we used univariate and multivariate logistic regression analysis to assess the significance of the risk factors for postoperative complications. The features for multivariable comparison were selected by collinearity diagnostics.

Development and validation of the nomograms

In order to establish a predictive model, the Akaike information criterion (AIC) was conducted with and without ANS to select variables through a backward stepwise process from the full multivariable regression model. To supply a quantitative instrument to estimate the individual probability of postoperative complications, we establish nomograms based on these selected variables. The concordance index (C-index) was employed to evaluate the performance of the two nomograms. Calibration curves were plotted to determine the calibration and each calibration curve was corroborated with 1,000 bootstrap resamples conducted for validation, reducing the overfit bias which would overstate the accuracy of the nomogram. The C-indexes and calibration curves of two models were compared evaluate the accuracy difference between two models.

Statistical analyses

Continuous variables were evaluated by *t*-test or Mann-Whitney U-test respectively according to whether the variables conform to the normal distribution or not. Categorical variables were reported as numbers and percentages, which were assessed by chi-square test or Fisher exact test according to the frequencies of variables. Univariable and multivariable logistic analysis was conducted by IBM SPSS software (version 22.0; SPSS Inc, Chicago, IL). Development and validation of nomograms were performed with R software (version 3.4.2; http://www.Rproject.org, "rms" R package). Differences with $P < 0.05$ were considered to be statistically significant.

Results

Patients and general clinical characteristics

A total of 485 patients who underwent resection of colon cancer between January 2019 and June 2021 were extracted from the database platform. 15 patients were excluded due to data missing including preoperative laboratory indicators (hemoglobin and neutrophils: n = 1) and intraoperative anesthesia and surgery-related variables (urine output: n = 8, blood loss: n = 4, duration of surgery: n = 2). 42 patients were excluded due to combined with other types of surgery or preoperative complications. Finally, 428 patients were included in this study, among which, 301 patients were assigned to the primary cohort and 127 patients were assigned to the validation cohort. Postoperative complications occurred in 64 patients (14.95%), including AL (n = 17, 3.97%), SII (n = 6, 1.40%), postoperative bleeding (n = 9, 2.10%), intestinal obstruction (n = 12, 2.80%), pneumonia (n = 5, 0..93%), sepsis (n = 4, 0.93%), thrombosis (n = 4, 0.93%), arrhythmia (n = 2, 0.47%), acute heart failure (n = 4, 0.93%) and others (n = 5, 0.93%).

As shown in Table 1, compared with non-complication group, patients in the complication group were more male (68.75% *vs*. 55.22%; $P = 0.044$), older age (68.16 ± 13.60 *vs*. 61.68 ± 12.31; $P < 0.001$), and had higher clinical TNM stage (TNM = III-IV: 95.31% *vs*. 84.49%; $P = 0.021$) and higher ANS stage (ANS = 2: 25.00% *vs*. 6.87%; $P < 0.001$). Moreover, patients in the complication group had larger volume of intraoperative blood loss [70.00 (50.00-125.00) *vs*. 50.00 (30.00-100.00); $P = 0.001$], higher intraoperative transfusion rate (57.81% *vs*. 21.45%; $P < 0.001$), lager volume of total crystalloid (1018.73 ± 500.79 *vs*. 854.32 ± 382.09; $P = 0.003$), longer duration of surgery (4.29 ± 1.78 *vs*. 3.41 ± 1.07; $P < 0.001$), higher rate of postoperative ICU admissionm (26.56% *vs*.2.48%; $P < 0.001$), longer length of hospital stay [20.50 (15.00-32.75) *vs*. 13.00 (10.00–15.00); $P < 0.001$] and postoperative stay [13.00 (9.00–24.00) *vs*. 7.00 (6.00–8.00); $P < 0.001$]. In addition, patients in the complication group had higer rate of open surgery (34.92% *vs*. 10.53%; $P < 0.001$).

Table 1
Baseline Characteristics of participants (N = 428)

Characteristic	No complication (N = 364)	Complication (N = 64)	*P*-value
Gender male, n (%)	201 (55.22)	44 (68.75)	0.044
Age, (years; mean ± SD)	61.68 ± 12.31	68.16 ± 13.60	< 0.001
Weight, (kg; mean ± SD)	60.60 ± 10.73	61.54 ± 12.24	0.529
ASA status, n (%)			0.117*
II	205 (56.32)	28 (43.75)	
III	155 (42.58)	35 (54.69)	
IV	4 (1.10)	1 (1.56)	
Clinical TNM stage, n (%)			0.021*
I-II	56 (15.51)	3 (4.69)	
III-IV	305 (84.49)	61 (95.31)	
Co-morbidities, n (%)	164 (45.05)	33 (51.56)	0.335
Preoperative hemoglobin, (g/L; mean ± SD)	119.70 ± 47.83	113.77 ± 27.69	0.336
Preoperative ANS			< 0.001
0	236 (64.84)	30 (46.88)	
1	103 (28.30)	18 (28.12)	
2	25 (6.87)	16 (25.00)	
Surgical type, n (%)			< 0.001
Laparoscopic	323 (89.47)	41 (65.08)	
Open	38 (10.53)	22 (34.92)	
Intraoperative blood loss, (ml; median (IQR))	50.00 (30.00-100.00)	70.00 (50.00-125.00)	0.001*

*: Mann–Whitney *U* test for continuous variables, Fisher Exact for categorical variables with Expects < 10.

Abbreviations: ASA, American Society of Anesthesiologists; TNM, Tumor, Node, Metastasis; ANS, Albumin/NLR Score; ICU, intensive care unit; SD, standard deviation; IQR, interquartile range.

Characteristic	No complication (N = 364)	Complication (N = 64)	P-value
Intraoperative transfusion, n (%)	77 (21.45)	37 (57.81)	< 0.001
Total crystalloid, (ml; mean ± SD)	854.32 ± 382.09	1018.73 ± 500.79	0.003
Total colloid, (ml; median (IQR))	1000.00 (500.00-1000.00)	1000.00 (500.00-1000.00)	0.073*
Urine output (ml; median (IQR))	450.00 (300.00-700.00)	400.00 (300.00-600.00)	0.575
Duration of surgery, (hours; mean ± SD)	3.41 ± 1.07	4.29 ± 1.78	< 0.001
Postoperative ICU admission, n (%)	9 (2.48)	17 (26.56)	< 0.001*
Length of hospital stay (days; median (IQR))	13.00 (10.00–15.00)	20.50 (15.00-32.75)	< 0.001*
Length of postoperative stay (days; median (IQR))	7.00 (6.00–8.00)	13.00 (9.00–24.00)	< 0.001*
*: Mann–Whitney *U* test for continuous variables, Fisher Exact for categorical variables with Expects < 10.			
Abbreviations: ASA, American Society of Anesthesiologists; TNM, Tumor, Node, Metastasis; ANS, Albumin/NLR Score; ICU, intensive care unit; SD, standard deviation; IQR, interquartile range.			

Univariable and multivariable analysis between the complication and no complication groups in the primary cohort

The univariate and multivariate logistic regression analysis between the complication and no complication groups in the primary cohort was shown in Table 2. The univariate logistic regression analysis suggested that the following were significantly correlated with postoperative complications: age; weight; preoperative hemoglobin; preoperative ANS; surgical type; intraoperative transfusion; total crystalloid and duration of surgery. Multivariate logistic regression analysis showed significant correlations between the incidence of postoperative complications and age, preoperative ANS, intraoperative transfusion and duration of surgery after adjusting for the effect of the other covariates.

Table 2
Univariable and multivariable logistic regression analysis of factors associated with postoperative complications in the primary cohort.

	No complication (N = 254)	Complication (N = 47)	Univariable logistic regression		Multivariable logistic regression	
			OR (95% CI)	*P*	OR (95% CI)	*P*
Gender male, n (%)	140 (55.12)	30 (63.83)	0.70 (0.37–1.33)	0.270	0.45 (0.18–1.10)	0.080
Age, (years; mean ± SD)	61.59 ± 12.14	67.47 ± 14.00	1.04 (1.01–1.07)	0.004	1.05 (1.01–1.09)	0.007
Weight, (kg; mean ± SD)	60.57 ± 10.95	60.80 ± 12.70	1.002 (1.000-1.004)	0.025	0.98 (0.94–1.02)	0.258
ASA status, n (%)						
II	145 (57.09)	21 (44.68)	Reference		Reference	
III	106 (41.73)	25 (53.19)	1.63 (0.87–3.06)	0.343	0.66 (0.28–1.55)	0.343
IV	3 (1.18)	1 (2.13)	2.30 (0.23–23.16)	0.479	0.91 (0.05–13.41)	0.880
Clinical TNM stage, n (%)						
I-II	41 (16.14)	3 (6.38)	Reference		Reference	
III-IV	213 (83.86)	44 (93.62)	2.82 (0.84–9.53)	0.094	1.85 (0.48–7.16)	0.371
Co-morbidities, n (%)	117 (46.06)	25 (53.19)	1.33 (0.71–2.48)	0.369	0.78 (0.34–1.80)	0.563
Preoperative hemoglobin, (g/L; mean ± SD)						
<80	19 (7.48)	8 (17.02)	Reference		Reference	

Abbreviations:
ASA, American Society of Anesthesiologists; TNM, Tumor, Node, Metastasis; ICU, intensive care unit.

	No complication (N = 254)	Complication (N = 47)	Univariable logistic regression		Multivariable logistic regression	
80 - <90	23 (9.06)	6 (12.77)	0.62 (0.18, 2.10)	0.442	0.85 (0.20–3.66)	0.823
90 - <100	22 (8.66)	3 (6.38)	0.32 (0.08, 1.40)	0.131	0.43 (0.07–2.55)	0.350
100 - <110	17 (6.69)	3 (6.38)	0.42 (0.10, 1.84)	0.249	1.22 (0.18–8.49)	0.840
110 - <120	37 (14.57)	5 (10.64)	0.32(0.09, 1.12)	0.074	1.90 (0.35–10.28)	0.455
>120	136 (53.54)	22 (46.81)	0.38(0.15, 0.98)	0.046	2.36 (0.57–9.76)	0.237
Preoperative ANS						
0	162 (63.78)	21 (46.88)	1.00 (0.99-1.00)	0.478	Reference	
1	68 (26.77)	13 (27.66)	1.18 (1.01–1.38)	0.035	0.71 (0.28–1.77)	0.46
2	24 (9.45)	13 (27.66)	0.95 (0.62–1.47)	0.830	2.69 (1.90–8.06)	0.01
Surgical type, n (%)						
Laparoscopic	225 (88.58)	33 (70.21)	1.01 (1.00-1.02)	0.128	Reference	
Open	29 (11.42)	14 (29.79)	1.003 (1.001–1.006)	0.022	1.90 (0.73–4.92)	0.189
Intraoperative blood loss, (ml; median (IQR))	50.00 (30.00-100.00)	100.00 (50.00-100.00)	1.001 (0.999–1.004)	0.300	1.000 (0.999–1.002)	0.589
Intraoperative transfusion, n (%)	55 (21.65)	28 (59.57)	1.007 (1.002–1.013)	0.015	5.32 (1.87–15.15)	0.002

Abbreviations:

ASA, American Society of Anesthesiologists; TNM, Tumor, Node, Metastasis; ICU, intensive care unit.

	No complication (N = 254)	Complication (N = 47)	Univariable logistic regression		Multivariable logistic regression	
Total crystalloid, (ml; mean ± SD)	1000.00 (500.00-1000.00)	1000.00 (500.00-1000.00)	1.002 (1.000-1.003)	0.011	0.9996 (0.9985–1.0008)	0.525
Total colloid, (ml; median (IQR))	1000.00 (500.00-1000.00)	1000.00 (500.00-1000.00)	0.9999 (0.99998-1.0000)	0.107	0.9997 (0.9985–1.0008)	0.570
Urine output (ml; median (IQR))	500.00 (300.00-700.00)	400.00 (300.00-650.00)	0.95 (0.90-1.00)	0.950	0.999 (0.997-1.000)	0.090
Duration of surgery, (hours; mean ± SD)	3.37 ± 1.05	4.31 ± 1.75	1.002 (1.001–1.004)	0.045	1.70 (1.24–2.34)	0.001
Abbreviations:						
ASA, American Society of Anesthesiologists; TNM, Tumor, Node, Metastasis; ICU, intensive care unit.						

Development of the nomograms

Backward stepwise AIC-based multivariable analysis identified age, duration of surgery, intraoperative transfusion and surgical type as independent risk factors for postoperative complications when the ANS was not included in the analysis (Table 3). However, when the ANS was included in the backward stepwise analysis, gender, age, ANS, duration of surgery, urine output, intraoperative transfusion and surgical type were identified as independent risk factors for postoperative complications (Table 3). The above independent predictors were used to develop Model 1 (nomogram without ANS) and Model 2 (nomogram with ANS), respectively (Fig. 1).

Table 3
Risk factors for postoperative complication derived from AIC-based multivariable logistic regression.

	Model 1		Model 2	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Gender male	NA	NA	0.58 (0.27–1.24)	0.160
Age (years)	1.036 (1.006–1.069)	0.019	1.036 (1.004–1.067)	0.026
ANS				
0	NA	NA	Reference	
1	NA	NA	0.64 (0.27–1.52)	0.310
2	NA	NA	2.22 (1.85–5.76)	0.002
Surgery type				
Laparoscopy	Reference		Reference	
Open	2.22 (0.98–5.04)	0.057	2.19 (0.94–5.12)	0.069
Urine output (ml)	NA	NA	0.9991 (0.9978–1.0003)	0.138
Intraoperative blood transfusion	3.29 (1.62–6.69)	0.001	3.07 (1.46–6.47)	0.003
Duration of surgery (hours)	1.59 (1.23–2.05)	< 0.001	1.69 (1.28–2.24)	< 0.001
C-index				
Primary	0.798 (0.729–0.868)		0.821 (0.758–0.883)	
Validation	0.832 (0.767–0.938)		0.853 (0.746–0.961)	

Validation of the nomograms

In the primary cohort, the C-index of the Model 1(nomogram without ANS) was 0.798 (95%*CI*, 0.729–0.868). In the validation cohort, the C-index was 0.832 (95%*CI*, 0.767–0.938). However, when the nomogram combined with ANS (Model 2), higher C-index was observed both in the primary cohort (0.821; 95% CI, 0.758–0.883) and validation cohort (0.853; 95% CI, 0.746–0.961) (Table 3). Then, the calibration curves were conducted in order to evaluate the calibration (Fig. 2). The calibration curves also illustrated that compared with Model 1 (Fig. 2a,c), there was better accordance between the observed occurrence of postoperative complications and the nomogram prediction in Model 2 (Fig. 2b,d)

Discussion

In the present study, we demonstrated that the preoperative ANS was an independent risk factor for postoperative complications in patients following radical resection of colon cancer. Furthermore, a prognostic nomogram combined with the ANS and other perioperative risk factors was further constructed and validated to predict postoperative complications. This visible nomogram could be applied as a convenient means allowing more precise risk stratification of postoperative complications for individual patients which may facilitate early clinical decision-making.

Some rencent reports have demonstrated that several systemic inflammatory markers may be predictors of postoperative complications following different major surgeries. (11–14) Specifically, previous studies revealed that various immunenutritional scores or inflammation-based scores, including CAR (C-reactive protein to albumin ratio), NLR, PLR and PNI were associated with short-term outcomes after surgery for colorectal cancer. (21–24) In the present study, the association between ANS and postoperative complications after radical resection of colon cancer was determined. The NLR is a classic systemic inflammation biomarker and can be calculated easily by circulating neutrophils and lymphocytes easily obtained from routine preoperative blood testswithout extra expenses; while hypoalbuminemia, resulting from malnutrition particularly in cancer patients, is correlated with an increased risk of postoperative infectious complications, and the mechanism for this seems to be a composite of impaired healing and impaired immune response. (25, 26) Due to the ANS was combined with albumin and NLR which represented the inflammatory reaction of liver and myeloid/lymphoid tissue, respectively, thence, we chosed the ANS to improve the predictive power of the nomogram predicting postoperative complications after radical resection of colon cancer.

In the present study, the preoperative ANS was determined to be an independent risk factor associated with postoperative complications after radical resection of colon cancer. Furthermore, the C-index of AIC-based multivariable analysis was 0.821 by including the ANS which was higher than removing ANS whose C-index was 0.798. The calibration curve also demonstrated that using ANS could significantly enhance the predictive value of the nomogram for radical resection of colon cancer. As is known to all, albumin is a negative acute-phase protein combined with decreased expression and growed losses within inflammation procedures. In general, hypoalbuminemia means malnutrition in acute and chronically ill patients. Previous studies have also demonstrated that hypoalbuminemia is a significant risk factor in postoperative mortality, morbidities and length of hospital stay in different patients.(27, 28) Although the possible mechanisms between inflammation and short-term poor prognosis remain unknown, our study indicate that preoperative ANS can be utilized as an independent risk factor for postoperative complications after radical resection of colon cancer.

Except for ANS, intraoperative blood transfusion was identified as another independent risk factor for postoperative complications after radical resection of colon cancer in the backward stepwise AIC-based multivariable analysis. Previous study demonstrated that blood transfusion was correlated with an increasing occurrence of postoperative infections around anastomoses, most probably secondary to transfusion-associated immunological suppression.(29–31) In addition, Jannasch et al. indicated that there was a 1.5-fold risk of anastomotic leak with blood transfusion within radical resection of colon cancer, despite without distinguishing of the amount of blood units administrated.(32) On the other hand, hemoglobin is association with perfusion and oxygenation of the anastomotic margins, an indispensable factor for anastomotic healing. Some studies have also demonstrated that a hemoglobin level less than 11 g/dL may increase the risk of anastomotic leak, as explained by a declined ability to supply oxygen to the tissues and subsequent hazard of ischemia.(33, 34) Although blood transfusion may be one of the risk factors for postoperative complications, blood transfusion acted as one of the important components of perioperative fluid management for surgical patients. However, we should strictly grasp the blood transfusion guidelines and avoid unnecessary blood transfusion, thereby reducing the risk of postoperative complications.

Besides, gender, age, duration of surgery, urine output and surgical type were also included in the present nomogram model. The combination of those variables in our nomogram enhanced the predictive value, which further indicated the critical roles of those variables in forecasting the probability of postoperative complications after radical resection of colon cancer.

However, the present study still has several limitations. The first of which is that the statistical models are developed based on a retrospective study in a single center. In this aspect, a future prospective research to verify the outcomes would be meaningful. Lack of validation based on external dataset is another limitation. Thirdly, as surgical manipulation may have significant impact on patients' short-term outcome, therefore, different surgical groups should be taken into account in the future study.

Conclusions

This study developed and validated a nomogram based on albumin and neutrophil-to-lymphocyte ratio and other perioperative risk factors to predict postoperative complications in patients with resection of colon cancer. This visable nomogram indicates the significant role of systemic inflammation in predicting postoperative complications. Moreover, surgeons could now utilize this simple model to assess the possibility of a patient occuring complications and to produce personalized clinical decisions about administration options.

Declarations

Conflicts of Interest :

Authors declare no Conflict of Interests for this article.

Ethical Approval:

Study approval was obtained from the Institutional Review Board of Sun Yat-sen Memorial Hospital of Sun Yat-sen University. (No. SYSEC-KY-KS-2021-179) Due to the nature of retrospective analysis, patient informed consent was waived.

Funding Declaration:

None.

Author's contribution:

J. W., J. Z. and K. W. wrote the main manuscript text, S.Y. collected the data, H.H. prepared the figures 1-2, C.W. designed the manuscript. All authors reviewed the manuscript.

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Figures

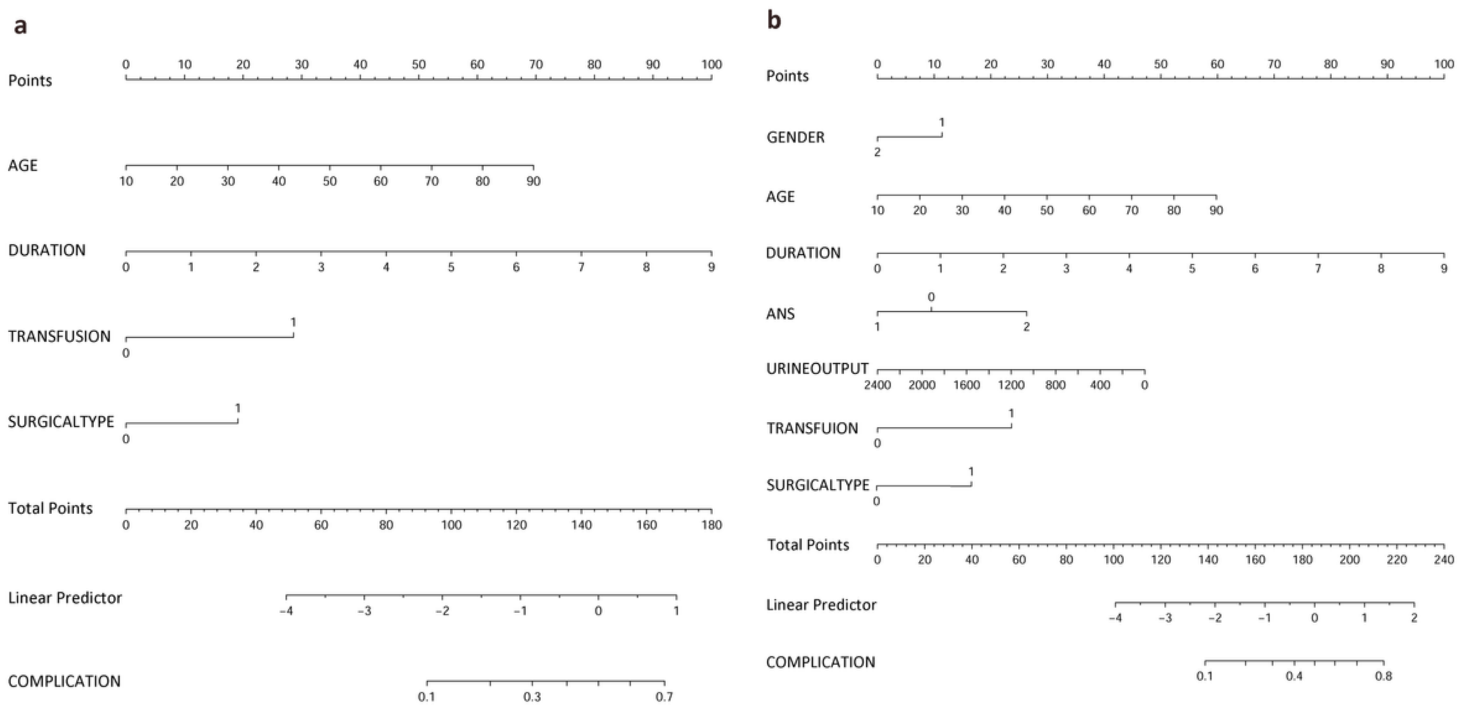

Figure 1

Nomograms derived from the AIC-based multivariate analyses. (a) The nomogram without ANS; (b) The nomogram incorporating ANS. AIC, Akaike information criterion; ANS, albumin/NLR score.

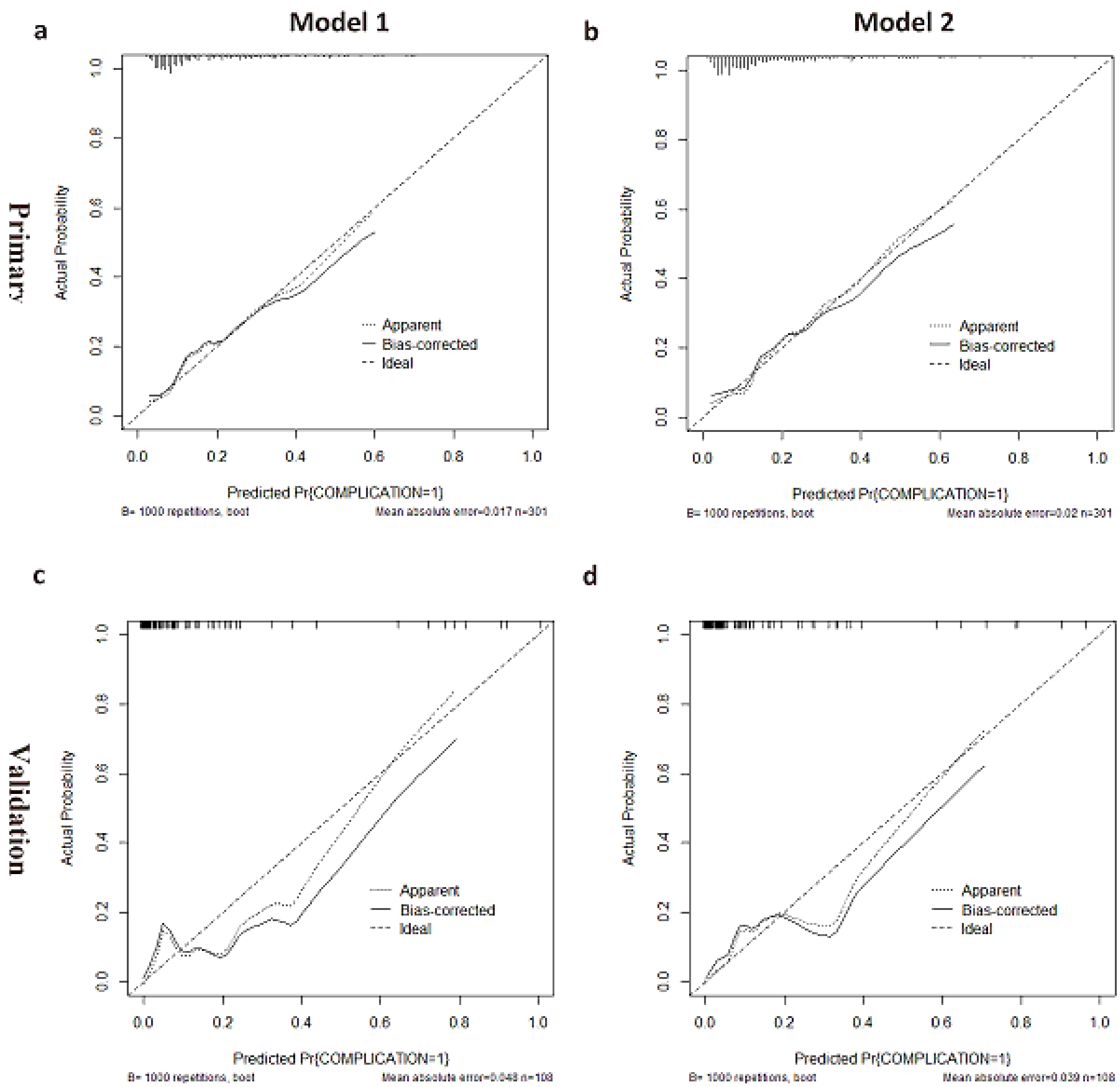

Figure 2

Calibration curves of nomograms. Calibration curves of the Model 1 and Model 2 in the primary (a and b) and validation cohort (c and d).