Research Square

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Development and validation of a nomogram model for treatment failure in peritoneal dialysis-associated peritonitis patients

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Abstract

Background

To assess the diagnostic utility of a nomogram constructed from combined inflammatory indicators in predicting treatment failure in patients with peritoneal dialysis-associated peritonitis (PDAP).

Methods

This retrospective, single-center observational study included 259 patients with PDAP, who were stratified into a cured group (n = 215) and a treatment failure group (n = 44) based on therapeutic outcomes. Clinical data from both groups were systematically analyzed.

Results

Variables were screened using the least absolute shrinkage and selection operator (LASSO) regression and multivariate logistic regression analyses. The final predictive model incorporated the advanced lung cancer inflammation index (ALI), dialysis duration, pre-admission self-administration of antibiotics, dialysate WBC count on day 5, and serum albumin levels, and was visualized using a nomogram. The concordance index (C-index) for the modeling cohort was 0.93. Receiver operating characteristic analysis demonstrated areas under the curve of 0.93 (95% CI: 0.88–0.98) in the modeling cohort and 0.90 (95% CI: 0.82–0.99) in the validation cohort, indicating excellent discriminative performance and robust calibration of the nomogram in both cohorts.

Conclusions

The nomogram enables effective identification of treatment failure risk in patients with PDAP, thereby offering meaningful guidance for clinical management and decision-making.

Background

Peritoneal dialysis (PD) is an effective form of renal replacement therapy for patients with end-stage renal disease (ESRD). Its advantages include slowing the progression of residual renal function decline, maintaining hemodynamic stability, efficiently clearing middle-molecular-weight toxins, and providing patients with a more autonomous and liberated lifestyle [1, 2]. Despite substantial advances in peritoneal dialysis techniques, peritoneal dialysis-associated peritonitis (PDAP) remains a serious and common complication, contributing significantly to morbidity and mortality among PD patients worldwide [3]. Consequently, improving the prognosis of patients with PDAP remains a major clinical challenge [4]. Malnutrition is another frequent complication in peritoneal dialysis patients and is strongly associated

with adverse clinical outcomes. Its relationship with PDAP prognosis has been extensively documented in the literature [5, 6].

The Advanced Lung Cancer Inflammation Index (ALI) is an integrated marker reflecting systemic inflammatory burden and nutritional status. Ren ZH et al. reported that ALI may serve as a valuable prognostic indicator for PD patients [7]; however, its predictive relevance for peritonitis outcomes in this population remains unclear. Although numerous studies have identified risk factors associated with poor peritonitis prognosis [8–10], the relationships between specific biomarkers in peripheral blood and peritoneal dialysate and peritonitis outcomes warrant further comprehensive investigation and validation. Accordingly, the present study aims to assess the predictive value of a nomogram incorporating composite inflammatory markers for treatment failure in PDAP, thereby providing scientific evidence to support individualized clinical management strategies.

Methods

Study population

This study enrolled patients with PDAP who were hospitalized at the Second Hospital of Anhui Medical University between January 2016 and October 2025. The inclusion criteria were as follows: (1) continuous peritoneal dialysis for at least three months; (2) age ≥ 18 years; and (3) fulfillment of established clinical diagnostic criteria for PDAP. The exclusion criteria comprised: (1) coexisting malignant tumors or hematologic malignancies; (2) concurrent severe systemic infections, such as active tuberculosis or fungal sepsis, that could confound the evaluation of peritonitis outcomes; (3) a history of kidney transplantation or prior conversion to hemodialysis; and (4) incomplete follow-up or missing clinical data precluding assessment of the primary endpoint. The study protocol was approved by the Ethics Committee of the Second Hospital of Anhui Medical University (YX2022-014) and was conducted in strict compliance with the ethical principles of the Declaration of Helsinki.

Data collection

Using the electronic medical records system, data were retrospectively collected for all patients admitted with peritonitis during the study period, and 27 patient characteristics were initially identified as candidate covariates. Demographic variables included sex, age, body mass index (BMI), dialysis duration, underlying comorbidities (such as hypertension and diabetes), and prior antibiotic use. Laboratory parameters comprised peritoneal dialysis fluid-related test results (including dialysate WBC count on days 1, 3, and 5, as well as PD fluid culture outcomes), blood white blood cell (WBC)count, serum albumin, blood urea nitrogen, uric acid, creatinine, serum potassium, serum phosphorus, triglycerides, total cholesterol, hemoglobin, C-reactive protein, low-density lipoprotein, procalcitonin, interleukin-6, and estimated glomerular filtration rate (eGFR). Variables with more than 20% missing data —namely low-density lipoprotein, procalcitonin, interleukin-6, and eGFR—were excluded from the

analysis. Ultimately, 23 variables were included in the final analysis. The formulas for relevant indices were defined as follows: ALI = BMI (kg/m²) × serum albumin (g/L) / NLR; NLR = neutrophil count/lymphocyte count; Body mass index (BMI) (kg/m²) = body weight (kg) / height $(m)^2$.

Diagnosis

A diagnosis of PDAP required fulfillment of at least two of the following criteria [11]: (1) abdominal pain and/or cloudy dialysate; (2) dialysate white blood cell count > 1 × 10⁸/L with polymorphonuclear leukocytes comprising > 50%; and (3) a positive dialysate microbial culture.

Outcomes

Patients were stratified into two groups based on PDAP treatment efficacy. Cured group: Clinical symptoms resolved after 2–3 weeks of appropriate antibiotic therapy, peritoneal effluent became clear, the dialysate white blood cell count decreased to > 1 × 10⁸/L, and dialysate microbial cultures were negative. Treatment failure group: refractory peritonitis, defined by persistent clinical symptoms after more than five days of standard antibiotic therapy; or fungal peritonitis with a positive peritoneal fluid culture necessitating catheter removal; requirement for temporary or permanent hemodialysis due to severe peritonitis-related complications; or death occurring during hospitalization or within 30 days of peritonitis onset. The primary endpoints included discharge after clinical improvement following antibiotic treatment; development of refractory or fungal peritonitis; need for temporary or permanent hemodialysis due to severe peritonitis-related complications; and death during hospitalization or within 30 days after discharge.

Statistical Analysis

Categorical variables are presented as n(%), and intergroup comparisons were performed using the χ^2 test or Fisher's exact test, as appropriate. Continuous variables are expressed as mean ± standard deviation or as median with interquartile range (25th, 75th percentiles). Between-group comparisons were conducted using the independent samples T-test for normally distributed data and Wilcoxon's rank-sum test for non-normally distributed data. Variables were evaluated through Lasso analysis and multivariate logistic analysis to construct the predictive model. The model was visualized as a nomogram and internally validated using bootstrap resampling. Predictive performance was assessed by receiver operating characteristic (ROC) curve analysis, calibration curves, and decision curve analysis (DCA). *P* value < 0.05 was considered statistically significant. All statistical analyses were performed using R software (version 4.5.1; R Foundation for Statistical Computing).

Results

Clinical baseline characteristics

A total of 259 patients with PDAP who met the inclusion and exclusion criteria and were admitted to the Second Hospital of Anhui Medical University between January 2015 and October 2025 were enrolled. Based on treatment outcomes, patients were categorized into a cured group (n = 215, 83.0%) and a treatment failure group (n = 44, 17.0%). Compared with the cured group, patients in the treatment failure group exhibited significantly higher blood white blood cell counts, longer dialysis duration, elevated c-reactive protein (CRP) levels, increased dialysate WBC counts on days 3 and 5, and a higher prevalence of pre-admission self-administration of antibiotics. The distribution of causative pathogens also differed markedly between the two groups, with fungal infections being more prevalent in the treatment failure group. In contrast, serum albumin levels and ALI values were significantly lower in the treatment failure group. All of these differences were statistically significant ($P < 0.05$). No significant differences were observed between the two groups with respect to age, sex, body mass index, diabetes, hypertension, serum potassium, serum phosphorus, uric acid, total cholesterol, or triglyceride levels ($P > 0.05$), as shown in Table 1.

Lasso analysis

The dataset was randomly partitioned into a training cohort of 182 cases and a validation cohort of 77 cases in a 7:3 ratio. Variable selection in the training cohort was performed using LASSO regression, as shown in Fig. 1. To achieve the best possible model fit, predictors were selected according to the 1-standard-error (1-SE) criterion (left vertical dashed line in Fig. 1B). Ultimately, LASSO analysis identified six candidate predictors with potential prognostic value for PDAP treatment failure: the advanced lung cancer inflammation index (ALI), dialysis duration, pre-admission self-administration of antibiotics, dialysate WBC count on day 5, CRP, and serum albumin.

Table 1
Clinical characteristics comparison between the cured group and the treatment failure group

Variable	**Total(*n* = 259)**	**Cured group (*n* = 215)**	**treatment failure group (*n* = 44)**	***P* value**
Age (years)	56(49.5,66)	56(50,66)	55.5(49,66.5)	0.700
Sex,n(%)				0.090
Male	120(46)	94(44)	26(59)	
Female	139(54)	121(56)	18(41)	
BMI (kg/m^2)	23.05(20.88,25.67)	23.32(20.88,25.95)	22.45(21.07,23.85)	0.064
Diabetes,n(%)	46(18)	40(19)	6(14)	0.569
Hypertension,n(%)	207(80)	172(80)	35(80)	1.000
Pre-admission self-administration of antibiotics,n(%)	50(19)	32(15)	18(41)	<0.001
Dialysis duration (years)	3(1.58,5.08)	2.92(1.46,4.5)	4.71(2.65,7.58)	<0.001
Pathogen type,n(%)				<0.001
Culture negative	54(21)	48(22)	6(14)	
GPB	130(50)	114(53)	16(36)	
GNB	59(23)	48(22)	11(25)	
Fungi	12(5)	1(0)	11(25)	
Mixed bacteria	4(2)	4(2)	0(0)	
Dialysate WBC count on day 1 ($\cdot 10^9/L$)	1607(469,4290.5)	1802(433.5,4290.5)	1006(664.75,3340)	0.575
Dialysate WBC count on day 3 ($\cdot 10^9/L$)	244(91.5,1353)	189(75,892.5)	1004(472.25,2998)	<0.001
Dialysate WBC count on day 5 ($\cdot 10^9/L$)	59(19,350)	41(15.5,156)	1425(362,2094.75)	<0.001
CRP (mg/L)	65.5(32.92,122.3)	57.8(29.45,118.65)	93.25(63.5,206.85)	<0.001
Blood WBC ($\cdot 10^9/L$)	7.53(5.62,10.7)	7.2(5.48,10.35)	8.16(6.51,13.09)	0.030

Variable	Total(*n* = 259)	Cured group (*n* = 215)	treatment failure group (*n* = 44)	*P* value
Haemoglobin (g/L)	95.88 ± 23.18	95.36 ± 20.2	98.42 ± 34.46	0.571
Potassium (mmol/L)	3.57(3.12,4.06)	3.57(3.12,4.06)	3.49(3.13,4.02)	0.536
Phosphorus (mmol/L)	1.29(1.05,1.64)	1.31(1.06,1.63)	1.24(1,1.68)	0.528
Serum uric acid (μmol/L)	341(284.5,391.5)	343(296,397)	320(268,368.75)	0.063
Blood urea nitrogen (mmol/L)	16.14(12.63,20.79)	16.26(12.84,20.88)	14.12(10.53,20.57)	0.036
Creatinine (μmol/L)	786(622,997.5)	803(637.5,1037.5)	727(554.5,900)	0.025
Total cholesterol (mmol/L)	3.96(3.34,4.69)	3.98(3.39,4.71)	3.59(3.13,4.47)	0.110
Triglycerides (mmol/L)	1.2(0.82,1.73)	1.2(0.82,1.67)	1.25(0.86,1.96)	0.627
Serum albumin (g/L)	28.5 ± 6.06	29.23 ± 5.92	24.95 ± 5.50	<0.001
ALI	7.56(4.02,13.31)	8.87(4.66,14.7)	4.17(2.45,7.18)	<0.001

WBC white blood cell,BMI body mass index,GPB gram-positive bacteria,GNB gram-negative bacteria,CRP: c-reactive protein,ALI advanced lung cancer inflammation index.

Table 2
Multivariate logistic regression analysis results for PDAP treatment failure

Variable	β	SE	Waldχ^2	OR(95%CI)	*P* value
Pre-admission self-administration of antibiotics	1.2800	0.6412	2.00	3.597(1.024□12.637)	0.046
Dialysis duration	0.2118	0.0847	2.50	2.145(1.180□3.902)	0.012
Dialysate WBC count on day 5	0.0015	0.0003	4.54	1.849(1.418□2.412)	<0.001
CRP	0.0016	0.0034	0.48	1.168(0.619□2.205)	0.632
Serum albumin	-0.1194	0.0544	-2.19	0.331(0.123□0.888)	0.028
ALI	-0.1580	0.0650	-2.43	0.231(0.071□0.753)	0.015

PDAP peritoneal dialysis-associated peritonitis,WBC white blood cell, CRP c-reactive protein,ALI advanced lung cancer inflammation index.

Multivariate logistic regression analysis

The dependent variable was treatment failure in PDAP patients, and the independent variables were predictors selected through LASSO analysis. Multivariate logistic regression analysis was subsequently performed. The results demonstrated that ALI (OR 0.231, 95%CI 0.071–0.753; $P < 0.05$), dialysis duration(OR 2.145, 95%CI 1.180–3.902; $P < 0.05$), pre-admission self-administration of antibiotics (OR 3.597, 95%CI 1.024–12.637; $P < 0.05$), dialysate WBC count on day 5 (OR 1.849, 95%CI 1.418–2.412; $P < 0.05$), and serum albumin (OR 0.331, 95%CI 0.123–0.888; $P < 0.05$) were identified as independent predictors of treatment failure in patients with PDAP (Table 2)

PDAP peritoneal dialysis-associated peritonitis,WBC white blood cell,ALI advanced lung cancer inflammation index.

Figure 2 Nomogram for predicting treatment failure in PDAP patients.

Nomogram for predicting treatment failure in PDAP patients

A risk prediction model for PDAP treatment failure was constructed by integrating the five independently identified predictive variables using R statistical software, and was subsequently visualized as a nomogram (Fig. 2). The total points represent the sum of the scores assigned to each of the five variables, with each variable option corresponding to a specific score in Fig. 2. The predicted probabilities of treatment failure associated with different total scores are displayed at the bottom of the nomogram. Higher cumulative scores indicate a greater risk of treatment failure in patients with PDAP. Notably, the predicted probability of treatment failure exceeds 50% when the total score reaches 100 points and surpasses 95% when the score reaches 120 points.

3A: ROC curve for the modelling cohort;3B: ROC curve for the validation cohort.

Internal validation and assessment of the Nomogram prediction model

Model discriminatory power In the modeling cohort, the ROC curve demonstrated strong discriminatory performance of the model, with an AUC of 0.93 (95% CI: 0.88–0.98), a sensitivity of 0.81, and a specificity of 0.90. In the validation cohort, the AUC was 0.90 (95% CI: 0.82–0.99), with a sensitivity of 0.85 and a specificity of 0.89, indicating excellent discriminative ability of the nomogram, refer to Fig. 3. Internal validation of the modelling cohort using bootstrap resampling (1,000 iterations) yielded a concordance index (C-index) of 0.93.

Model calibration Calibration curves were constructed for both the modelling and validation cohorts, demonstrating close agreement between the bias-corrected prediction curves and the ideal reference line. Model fit was further assessed using the Hosmer-Lemeshow goodness-of-fit test, yielding the following results: modelling cohort, $\chi^2 = 10.409$, $P = 0.238$; validation cohort, $\chi^2 = 10.123$, $P = 0.257$. In both cohorts, P-values exceeded 0.05, indicating no statistically significant difference between the

predicted probabilities and the observed outcomes. These findings collectively suggest that the model exhibits good calibration and an adequate overall fit. Refer to Fig. 4.

4A: Calibration plot for the modelling cohort; 4B: Calibration plot for the validation cohort.

Clinical utility Decision curve analysis (DCA) demonstrated that, across a wide range of threshold probabilities, the net clinical benefit of applying this model exceeded that of the "all interventions" and "no interventions" strategies. Specifically, the model provided superior net benefit when the risk threshold ranged from 1% to 93% in the modelling cohort and from 1% to 85% in the validation cohort. These findings indicate that the model has substantial clinical utility for guiding decision-making. Refer to Fig. 5.

5A: DCA curve for the modelling cohort; 5B: DCA curve for the validation cohort.

Discussion

This study is the first to integrate the advanced lung cancer inflammation index (ALI), serum albumin, dialysate WBC count on day 5, dialysis duration, and pre-admission self-administration of antibiotics to construct a predictive model for treatment failure in patients with PDAP. The model's strong predictive capability was confirmed through internal validation, with ROC analyses demonstrating AUC exceeding 0.90 in both the modelling and validation cohorts. This nomogram enables clinicians to make more informed therapeutic decisions by providing an intuitive assessment of disease risk in patients with PDAP.

We identified ALI as an independent predictor of treatment failure in PDAP. Although no prior studies have directly explored the association between ALI and PDAP, the prognosis of PDAP has been extensively examined in relation to its individual components, including body mass index (BMI), serum albumin, and the neutrophil-to-lymphocyte ratio (NLR). Malnutrition and metabolic deterioration are also well-established determinants of renal disease prognosis. Previous investigations have reported associations between BMI, albumin levels, and PDAP outcomes [12–15], highlighting their roles as common nutritional and metabolic indicators influencing PDAP prognosis. The NLR, a simple and cost-effective parameter calculated as the ratio of absolute neutrophil to lymphocyte counts in peripheral blood, has emerged as a novel inflammatory marker of adverse outcomes in peritonitis. Evidence indicates that an elevated NLR is independently associated with an increased risk of treatment failure and catheter removal during PDAP episodes [16].ALI serves as an integrated index reflecting both nutritional status and systemic inflammatory burden and has been increasingly linked to outcomes in chronic inflammatory conditions, including hypertension, heart failure, and malignancies [17–20]. Its potential value in monitoring inflammation and nutritional status in patients with chronic kidney disease (CKD) was highlighted by Li XT et al. [21], who demonstrated a significant correlation between ALI levels and CKD. Moreover, ALI has been shown to be a stronger predictor of all-cause mortality in CKD patients than other nutritional or inflammatory markers [22]. The present study demonstrates that lower ALI levels are significantly associated with a higher risk of treatment failure in patients with PDAP, and this

inverse relationship persists after adjustment for potential confounders. In clinical practice, monitoring ALI may therefore facilitate prognostic assessment and risk stratification in PDAP patients.

Our analysis identified serum albumin as an independent protective factor in PDAP prognosis, demonstrating a strong inverse association with the risk of treatment failure. Consistent with our findings, numerous studies have reported a close relationship between hypoalbuminemia and both the incidence and prognosis of PDAP [23, 24]. In the present study, serum albumin levels were markedly lower in patients who experienced treatment failure. Hypoalbuminemia is widely recognized as a marker of malnutrition [25], a condition that diminishes resistance to infection and impairs immune function, thereby predisposing patients to immune dysregulation. Prior investigations have further shown that hypoproteinemia independently predicts discontinuation of peritoneal dialysis in patients with peritonitis, including outcomes such as catheter removal or death [26]. Collectively, these findings reinforce the prognostic significance of hypoalbuminemia in PDAP treatment failure and underscore the importance of routine albumin monitoring and targeted nutritional interventions in peritoneal dialysis patients to reduce the risk of adverse outcomes.

This study further confirms prolonged dialysis duration as an independent risk factor for PDAP treatment failure, indicating a strong association between extended dialysis exposure and an increased likelihood of adverse outcomes. This finding is supported by multiple prior investigations. For instance, a single-center study reported that patients receiving long-term peritoneal dialysis faced a significantly higher risk of peritonitis treatment failure and catheter removal, often necessitating conversion to hemodialysis, compared with those with shorter dialysis durations [27]. This association may be attributable to the development of drug-resistant bacterial strains, deterioration of local host defense mechanisms, and cumulative peritoneal membrane injury over time. Consequently, dialysis duration should be regarded as a key prognostic indicator, warranting the adoption of more rigorous preventive and therapeutic strategies in the management of patients undergoing long-term peritoneal dialysis.

The white blood cell (WBC) count in peritoneal dialysate is a pivotal parameter for the diagnosis of PDAP and for assessing therapeutic response. According to the ISPD guidelines, a persistently elevated dialysate WBC count on day 5 beyond a defined threshold indicates a poor treatment response or refractory peritonitis, reflecting insufficient antimicrobial efficacy or the presence of a complicated infection [11]. In the present study, dialysate WBC count on day 5 was strongly associated with PDAP treatment failure, a finding further supported by multiple predictive modeling studies. For example, a retrospective analysis examining the relationship between peritoneal dialysate WBC counts following initial antibiotic therapy and PDAP prognosis demonstrated that dialysate WBC count on day 5 $\geq 2000 \times 10^6$/L was significantly associated with increased risks of 60-day and six-month mortality, while a count $\geq 100 \times 10^6$/L was significantly linked to a higher likelihood of PDAP treatment failure [28]. Moreover, a multicenter predictive model developed using data from Thailand showed that dialysate WBC count on day 5 more accurately reflects treatment efficacy [29]. Collectively, these findings suggest that incomplete clearance of inflammatory cells from peritoneal effluent serves as a critical early warning marker of treatment failure.

The findings of this study indicate that pre-admission self-administration of antibiotics is associated with an increased risk of treatment failure in patients with PDAP. This observation is consistent with a multicenter study that identified antibiotic use prior to hospitalization as a significant predictor of treatment failure [24]. Self-administered antibiotics may elevate the risk of adverse outcomes by resulting in inadequate antimicrobial coverage, delaying the initiation of standardized therapy, or promoting the development of bacterial resistance. Accordingly, clinical practice should place greater emphasis on patient education in peritoneal dialysis populations, underscoring the importance of seeking timely medical evaluation for symptoms such as abdominal pain or turbid dialysate, and discouraging unsupervised antibiotic use to optimize treatment outcomes in PDAP.

This study has several limitations. First, the unavailability of certain cases and clinical indicators—such as procalcitonin and interleukin-6—due to incomplete data resulted in a limited sample size and the omission of potentially relevant variables. Second, the comprehensiveness of the predictive model may have been constrained by the lack of consideration of dynamic changes in key variables during treatment and their influence on treatment failure outcomes. Finally, as this was a single-center study with only internal validation, the generalizability of the findings may be limited. Future studies incorporating multicenter data are therefore required to further validate and refine the predictive performance of the model.

Conclusions

In summary, this study developed a predictive model with strong discriminatory ability, robust calibration, and meaningful clinical utility, incorporating the advanced lung cancer inflammation index (ALI), serum albumin, dialysate WBC count on day 5, dialysis duration, and pre-admission self-administration of antibiotics. Presented in the form of a nomogram, the model facilitates individualized and precise estimation of treatment failure risk in patients with PDAP, thereby providing an effective instrument for risk stratification and clinical decision-making in this population.

Abbreviations

PDAP	Peritoneal dialysis-associated peritonitis
LASSO	Least absolute shrinkage and selection operator
ALI	Advanced lung cancer inflammation index
PD	Peritoneal dialysis
ESRD	End-stage renal disease
BMI	Body mass index
WBC	White blood cell
eGFR	Estimated glomerular filtration rate
NLR	Neutrophil-to-lymphocyte ratio
ROC	Receiver operating characteristic
AUC	Area under the curve
DCA	Decision curve analysis
CRP	C-reactive protein
GPB	Ggram-positive bacteria
GNB	Gram-negative bacteria

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of the Second Hospital of Anhui Medical University (YX2022-014) and was conducted in strict compliance with the ethical principles of the Declaration of Helsinki. All patients signed written informed consent before study enrollment.

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Authors' contributions

N.Z. and M.L.designed the study, conducted the analyses, and drafted the manuscript. G.L. conceived and designed the study and provided overall supervision. L.S.and T.Z. were involved in data collection. All authors reviewed, edited, and approved the final manuscript. Q.Y., D.L., H.L., and J.C. were responsible for patient enrolment and follow-up.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

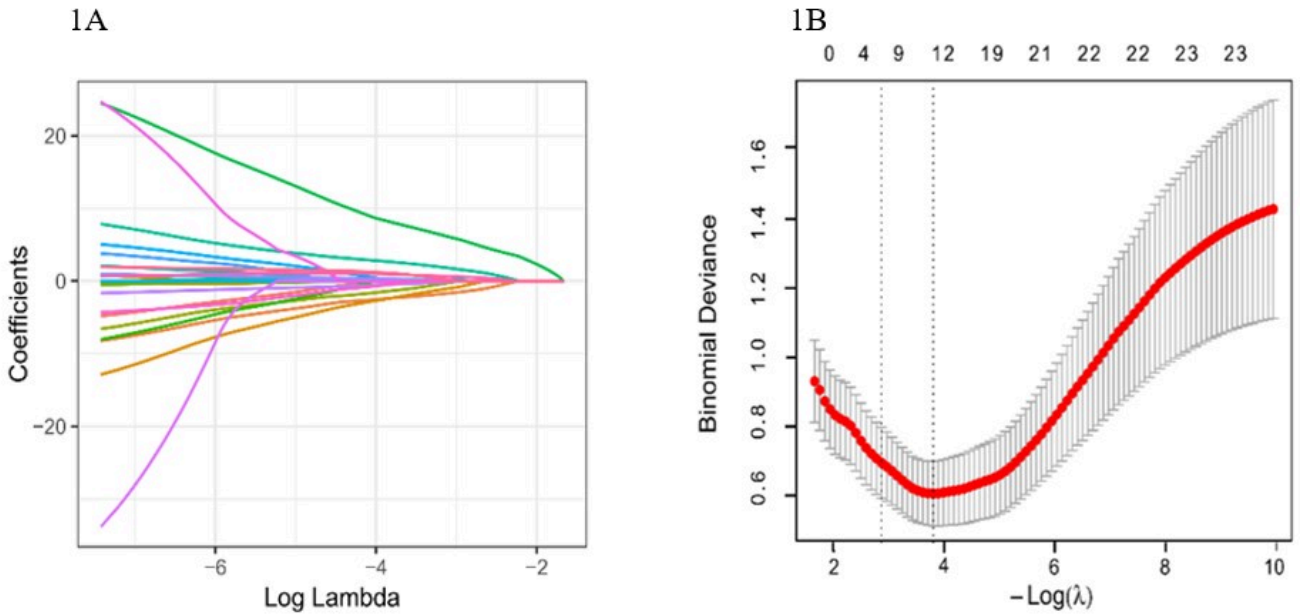


Figure 1

Variable selection via LASSO regression analysis

1A: LASSO regression coefficient path diagram; 1B: LASSO regression cross-validation curve

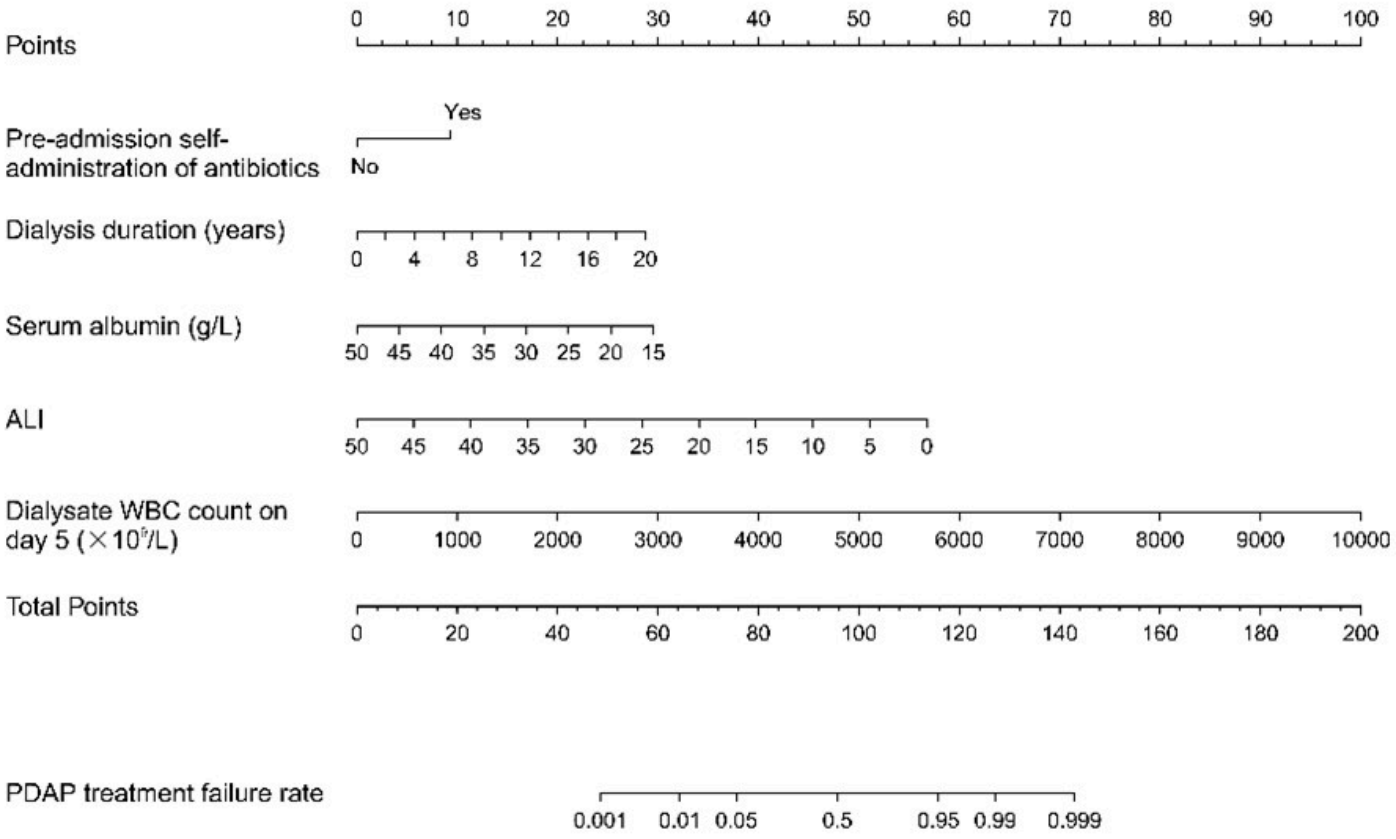


Figure 2

Nomogram for predicting treatment failure in PDAP patients.

PDAP peritoneal dialysis-associated peritonitis,WBC white blood cell,ALI advanced lung cancer inflammation index.

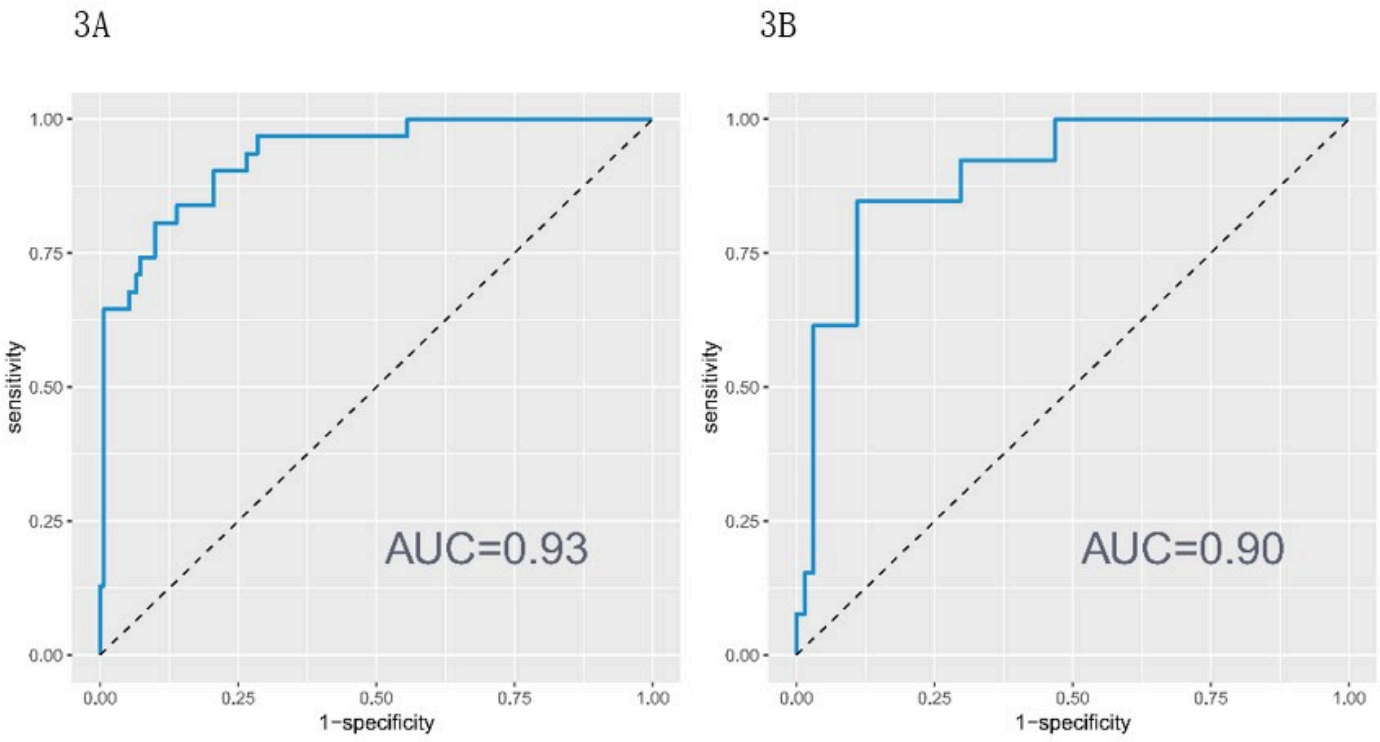


Figure 3

Receiver operating characteristic curve of the nomogram

3A: ROC curve for the modelling cohort;3B: ROC curve for the validation cohort.

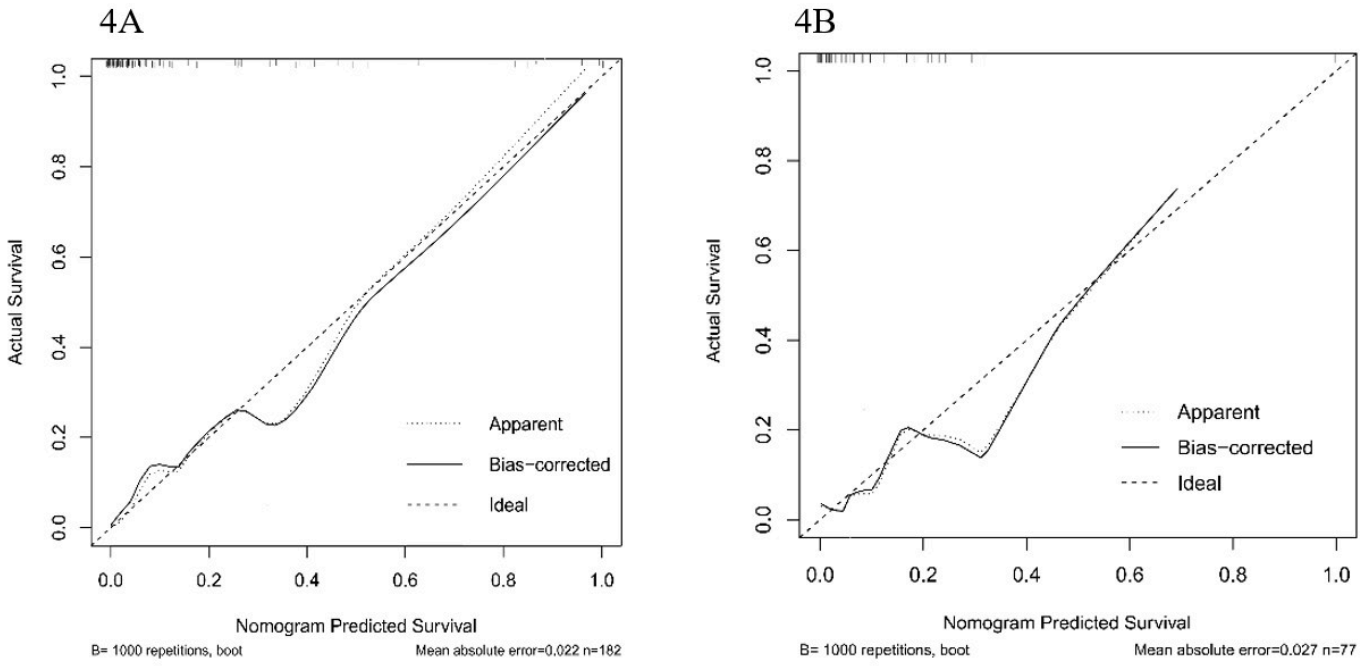


Figure 4

Calibration plots of internal validation.

4A: Calibration plot for the modelling cohort; 4B: Calibration plot for the validation cohort.

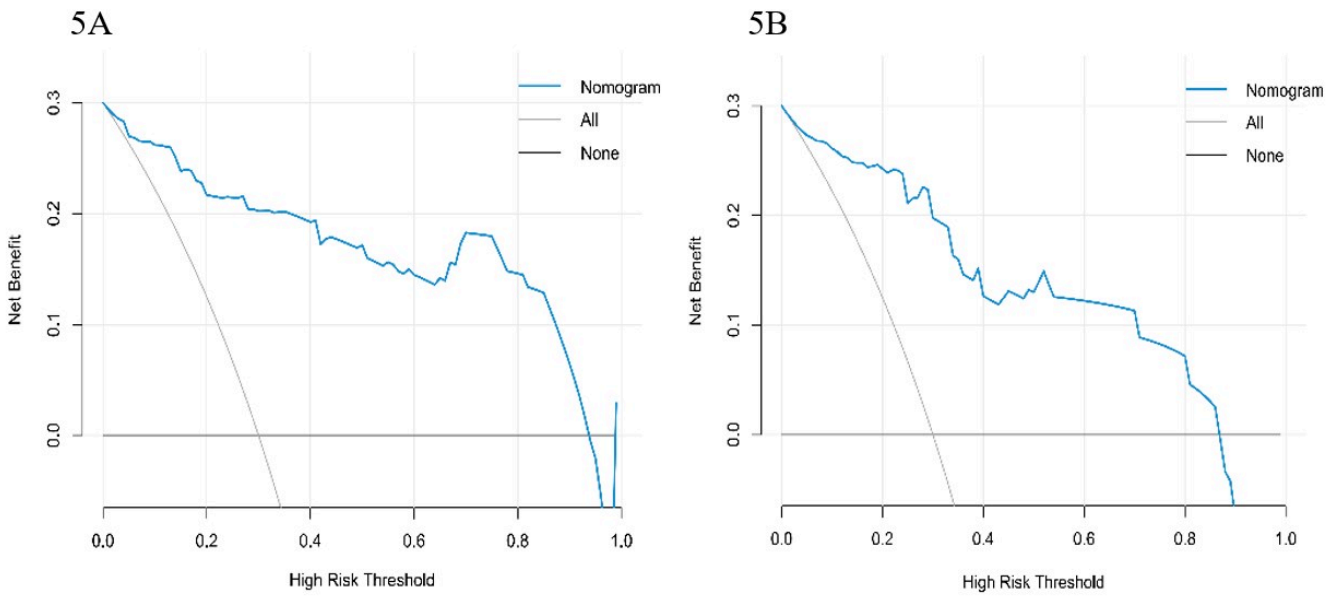


Figure 5

Decision curve analysis curve of the nomogram.

5A: DCA curve for the modelling cohort; 5B: DCA curve for the validation cohort.