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A Prediction Model for Pediatric Complicated Appendicitis Based on Clinical, Laboratory, and Imaging Features

Xiaotao Chen
Pengshui Autonomous County People's Hospital
Yi Li
Chongqing Changshou District Maternal and Child Health Hospital
Zhu Yun
vivianyun@foxmail.com

The Second Afliated Hospital of Chongqing Medical University

Research Article

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A Prediction Model for Pediatric Complicated Appendicitis Based on Clinical, Laboratory, and Imaging Features

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Authors:

Xiaotao Chen[1]*, Yi Li[2]*, Zhu Yun[3#].

[1]Department of General Surgery, Pengshui Autonomous County People's Hospital, Chongqing, China;

[2]Department of Surgery, Chongqing Changshou District Maternal and Child Health Hospital, Chongqing, China;

[3]Department of Emergency, The Second Afliated Hospital of Chongqing Medical University, Chongqing, China.

*Xiaotao Chen and Yi Li contributed equally to this work.

Xiaotao Chen

E-mail: 1096194570@qq.com

Yi Li

E-mail: 455571731@qq.com

Correspondence:

Zhu Yun, MD.

Department of Emergency, The Second Afliated Hospital of Chongqing Medical University.

288 Tian’wen Road, Chongqing, 400065, China

Tel: 86-15208289702

E-mail:vivianyun@foxmail.com

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Abstract

Background: Acute appendicitis is a common surgical emergency in children. Early and accurate differentiation between uncomplicated appendicitis (UA) and complicated appendicitis (CA) is crucial for guiding clinical decision-making and reducing postoperative complications. This study aimed to develop and validate a predictive nomogram integrating clinical, laboratory, and imaging features to preoperatively identify CA in pediatric patients.

Methods: We retrospectively reviewed 335 children (≤14 years) who underwent appendectomy for acute appendicitis at our hospital over the past 5 years. After applying exclusion criteria, a total of 226 patients were enrolled and randomly divided into a training set (n=159) and a testing set (n=67) at a 7:3 ratio. Demographic data, clinical characteristics, laboratory findings, and imaging features were collected. Least Absolute Shrinkage and Selection Operator (LASSO) regression was used for feature selection, followed by multivariate logistic regression to construct a predictive nomogram. The model's performance was evaluated using the receiver operating characteristic (ROC) curve, calibration curve (Hosmer-Lemeshow test), and decision curve analysis (DCA).

Results: Following LASSO regression for feature selection, multivariate logistic regression ultimately identified four independent predictors: maximum temperature (Temp_Max), C-reactive protein (CRP), fibrinogen (FIB), and appendix wall thickness. The nomogram demonstrated excellent discriminative ability, with an Area Under the Curve (AUC) of 0.905 in the training set and 0.917 in the testing set. The Hosmer-Lemeshow test yielded a P-value of 0.0868, and the calibration curve showed good agreement between predicted and observed probabilities. Furthermore, DCA indicated that the nomogram provided a significant net clinical benefit across a wide range of threshold probabilities, outperforming individual clinical factors.

Conclusion: We developed and validated a robust nomogram incorporating clinical, laboratory, and imaging indicators. This model exhibits excellent predictive performance and clinical utility, serving as a practical tool for pediatric surgeons to early identify children at high risk of complicated appendicitis and formulate individualized treatment strategies.

Keywords: Complicated appendicitis; Children; Nomogram; LASSO regression; Prediction model; Decision curve analysis

Introduction

Acute appendicitis is one of the most common surgical emergencies in pediatric populations[1]. It encompasses a broad spectrum of severity, ranging from uncomplicated appendicitis (UA) to complicated appendicitis (CA), which includes gangrenous and perforated appendicitis. Accurate preoperative differentiation between UA and CA is of paramount clinical importance. Children with CA often require more aggressive surgical interventions, prolonged antibiotic therapy, and extended hospital stays, and they face a significantly higher risk of postoperative complications[2-5]. Therefore, early and reliable identification of CA is crucial for optimizing treatment strategies and improving pediatric patient outcomes.

Currently, the preoperative diagnosis of CA relies heavily on clinical manifestations, laboratory biomarkers, and imaging examinations. However, clinical presentations in children can be atypical, particularly in younger age groups, making physical examination alone insufficient[6]. While inflammatory markers such as C-reactive protein (CRP) and neutrophil-to-lymphocyte ratio (NLR) are widely used, they lack sufficient specificity to independently predict CA[7]. Similarly, although imaging modalities like ultrasound and computed tomography (CT) can reveal features such as appendix wall thickness or fecalith, their diagnostic accuracy is operator-dependent and may not fully capture the complexity of the disease[8, 9]. Consequently, a single indicator is inadequate for accurately assessing the risk of CA.

In recent years, predictive models and nomograms have emerged as valuable tools to integrate multidimensional clinical data for individualized risk assessment[10-12]. The Least Absolute Shrinkage and Selection Operator (LASSO) regression is particularly advantageous in clinical research, as it effectively handles multicollinearity and prevents overfitting by selecting the most relevant predictors from a large set of variables. While several models have been proposed to predict pediatric appendicitis, there remains a need for a simplified, easily applicable, and robust nomogram that combines readily available clinical, laboratory, and imaging indicators specifically for discriminating CA from UA in children.

Therefore, the aim of this retrospective study was to develop and validate a predictive nomogram for complicated appendicitis in children. By utilizing LASSO regression for feature selection followed by multivariate logistic regression, we ultimately identified four independent predictors: maximum temperature (Temp_Max), C-reactive protein (CRP), fibrinogen (FIB), and appendix wall thickness. We

further evaluated the model's discriminative ability, calibration, and clinical utility using Receiver Operating Characteristic (ROC) curves, calibration curves, and Decision Curve Analysis (DCA), aiming to provide pediatric surgeons with a practical tool for early clinical decision-making.

Methods

Study Design and Participants

This was a single-center retrospective cohort study conducted at Pengshui Autonomous County People's Hospital between June 2021 and June 2026. The study was approved by the Institutional Review Board of Pengshui Autonomous County People's Hospital. All procedures were performed in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments.

Pediatric patients (aged ⩽14 years) who underwent appendectomy for acute appendicitis during the study period were consecutively enrolled. The diagnosis of acute appendicitis was confirmed by postoperative histopathological examination in all cases. The primary outcome was complicated appendicitis (CA), defined as the presence of any of the following on postoperative histopathological examination: gangrenous appendicitis, perforated appendicitis, or periappendiceal abscess. Patients without these features were classified as having uncomplicated appendicitis (UA). Exclusion criteria were: (1) age < 1 year (neonates and infants); (2) non-inflammatory or secondary appendiceal diseases (e.g., tumors, chronic appendicitis, Crohn's disease); (3) appendiceal abscess or phlegmon treated conservatively without surgical intervention; (4) severe life-threatening comorbidities or recent major surgery that could confound laboratory or imaging findings; and (5) incomplete clinical, imaging, or laboratory data. A total of 335 children were initially reviewed, and ultimately, 226 patients were enrolled and randomly divided into a training set (n=159) and a testing set (n=67) at a 7:3 ratio. The patient enrollment and exclusion process is illustrated in Figure 1.

Data Collection

Demographic and clinical data were extracted from electronic medical records using a standardized data collection form. The following variables were collected for each patient:

Patient characteristics: age (<6, 6-9, 10-14 years), sex, body mass index (BMI), pre-hospital antibiotic use, time from symptom onset to admission (onset to admission, <24 h vs. ⩾24 h), previous abdominal surgery, peritoneal signs, nausea or vomiting, anorexia, migratory pain, maximum temperature, and heart rate.

Laboratory findings: white blood cell count ($\times 10^9$/L), neutrophil percentage (%), neutrophil count ($\times 10^9$/L), lymphocyte percentage (%), lymphocyte count ($\times 10^9$/L), neutrophil-to-lymphocyte ratio (NLR), platelet count ($\times 10^9$/L), platelet-to-lymphocyte ratio (PLR), C-reactive protein (CRP, mg/L), total bilirubin (μmol/L), albumin (ALB, g/L), D-dimer (mg/L), fibrinogen (mg/dL), urea (mmol/L), creatinine (μmol/L), sodium (Na, mmol/L), and chlorine (mmol/L).

Imaging findings: appendix diameter (mm), presence of fecalith, presence of periappendiceal fluid, and appendix wall thickness (<3 mm vs. ≥3 mm). All patients underwent preoperative contrast-enhanced abdominal–pelvic CT; ultrasonography was not routinely performed. Appendiceal diameter was measured as the maximum outer-to-outer diameter on axial images at the widest point of the appendix. Appendix wall thickness was measured at the site of maximal mural thickness on cross-sectional images perpendicular to the long axis, from the outer serosal margin to the inner mucosal margin, excluding intraluminal fluid or air. All imaging parameters were independently assessed by two experienced radiologists blinded to the final histopathological diagnosis, and discrepancies were resolved by consensus.

Statistical Analysis

Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on their distribution, while categorical data were described as frequencies and percentages. Between-group differences (CA vs. UA) were evaluated using the independent samples t-test or Mann–Whitney U test for continuous variables, and the chi-square or Fisher's exact test for categorical variables, as appropriate.

To reduce dimensionality and avoid multicollinearity among the numerous candidate variables, Least Absolute Shrinkage and Selection Operator (LASSO) regression was initially employed within the training cohort. The variables with non-zero coefficients in the LASSO model were then incorporated into a multivariate binary logistic regression analysis to identify independent risk factors for complicated appendicitis. A threshold of $P < 0.05$ was used to retain variables in the final model. Multicollinearity among the independent predictors was assessed using the variance inflation factor (VIF) and tolerance. A VIF > 5 was considered indicative of potential multicollinearity. Ultimately, four independent predictors (Temp_Max, CRP, FIB, and appendix wall thickness) were identified and used to construct a visual nomogram for estimating the individualized probability of CA.

Model performance was comprehensively evaluated in both the training and testing cohorts.

Discriminative capacity was quantified using the area under the receiver operating characteristic curve (AUC-ROC). Calibration was assessed via calibration curves, comparing predicted probabilities with observed outcomes, and further validated using the Hosmer–Lemeshow goodness-of-fit test. Additionally, decision curve analysis (DCA) was conducted to determine the clinical net benefit of the nomogram across various threshold probabilities. All statistical computations were performed using R software (version 4.4.3), and a two-tailed P-value < 0.05 was considered statistically significant.

Results

Patient Disposition and Baseline Characteristics

The study initially screened 335 pediatric patients (aged ≤14 years) who underwent appendectomy for acute appendicitis. Following the application of strict exclusion criteria, 226 children were ultimately enrolled in the final analysis. Among them, 92 patients (40.7%) were histopathologically confirmed as having complicated appendicitis (CA), while 134 patients (59.3%) were classified as having uncomplicated appendicitis (UA). These participants were randomly allocated into a training cohort (n = 159) and a testing cohort (n = 67) at a 7:3 ratio to facilitate model development and internal validation.

The baseline demographic, clinical, laboratory, and imaging characteristics of the enrolled patients, stratified by CA and UA status, are detailed in Table 1. In brief, the CA group was significantly younger, with a higher proportion of children under 6 years old (21.7% vs. 9.0%, P = 0.006), and had a greater prevalence of pre-hospital antibiotic use (23.9% vs. 16.9%, P = 0.018). Clinically, patients with CA were more likely to have an onset-to-admission time ≥24 h (77.2% vs. 57.5%, P < 0.001) and presented with higher maximum temperatures (37.0℃ vs. 36.7℃, P < 0.001) and faster heart rates (104.18 ± 15.55 vs. 95.13 ± 17.60 beats/min, P < 0.001).

Regarding laboratory findings, the CA group demonstrated significantly elevated inflammatory and coagulation markers, including white blood cell count, neutrophil percentage, neutrophil count, NLR, CRP, fibrinogen, and D-dimer (all P < 0.05). Conversely, lymphocyte percentage, lymphocyte count, albumin, sodium, and chlorine were markedly lower in the CA group (all P < 0.05). For imaging features, the presence of fecalith (72.8% vs. 42.5%, P < 0.001), periappendiceal fluid (77.2% vs. 50.0%, P < 0.001), and an appendix wall thickness ≥3 mm (89.1% vs. 34.3%, P < 0.001) were all significantly more frequent in children with complicated appendicitis.

LASSO Regression and Multivariate Logistic Regression Analyses

To mitigate potential multicollinearity and prevent model overfitting, Least Absolute Shrinkage and

Selection Operator (LASSO) regression with 10-fold cross-validation was initially executed on the training cohort. The optimal penalty parameter was determined at λ min = 0.0451 (Figures 2A – B). This process yielded 10 candidate variables with non-zero coefficients: onset to admission time, maximum temperature, NLR, CRP, albumin, fibrinogen, sodium, fecalith, periappendiceal fluid, and appendix wall thickness.

Subsequently, these candidates were subjected to a multivariate binary logistic regression analysis to identify independent risk factors. The VIF values for the four independent predictors in the final model were 1.176 (Temp_Max), 1.336 (CRP), 1.503 (FIB), and 1.235 (Thickness), all well below the threshold of 5, indicating no significant multicollinearity. Ultimately, four variables remained significantly associated with CA ($P < 0.05$) and were retained in the final model: Temp_Max, CRP, fibrinogen, and appendix wall thickness. These four independent predictors formed the basis for the subsequent nomogram construction.

Nomogram Construction and Valiadation

A predictive nomogram integrating the four independent predictors was constructed to provide a visual tool for estimating the individualized probability of CA in pediatric patients (Figure 2C). The calibration plot demonstrated excellent agreement between the predicted probabilities and the actual observed frequencies of CA in the training cohort (Figure 2D). Furthermore, the Hosmer-Lemeshow goodness-of-fit test yielded a P-value of 0.0868, indicating that the model was well-calibrated.

The discriminative performance of the nomogram was assessed using the receiver operating characteristic (ROC) curve (Figure 3A). The model exhibited outstanding predictive accuracy, with an area under the curve (AUC) of 0.905 in the training cohort and 0.917 in the testing cohort. This consistently high AUC across both cohorts confirmed the robust discriminatory ability of the nomogram in distinguishing CA from UA.

Clinical Utility: Decision Curve Analysis

Decision curve analysis (DCA) was conducted to evaluate the clinical utility and net benefit of the nomogram across a range of threshold probabilities (Figure 3B). The DCA curves revealed that the combined model (Combined_clinical_factors) provided a substantially higher net benefit than individual predictors (Temp_Max, CRP, FIB, Thickness) or the "treat all" and "treat none" strategies across a wide spectrum of clinically reasonable thresholds. Additionally, the clinical impact curve (Figure 3C) illustrated the model's practical value, showing a favorable separation between the number of patients

classified as low risk and those who actually experienced the event. These findings confirmed that the nomogram offers superior clinical utility for preoperative risk stratification in children with acute appendicitis.

Discussion

Accurate preoperative discrimination between uncomplicated appendicitis (UA) and complicated appendicitis (CA) in children remains a substantial clinical challenge. In this retrospective study, we developed and validated a predictive nomogram incorporating four readily available indicators—maximum temperature (Temp_Max), C-reactive protein (CRP), fibrinogen (FIB), and appendix wall thickness—identified through LASSO regression followed by multivariate logistic regression. The model demonstrated excellent discriminative ability, with AUCs of 0.905 and 0.917 in the training and testing cohorts, respectively, and exhibited favorable calibration and clinical net benefit across a wide range of threshold probabilities.

The identification of maximum temperature as an independent predictor aligns with the well-established role of fever as a severity-related marker in pediatric appendicitis. A prior study demonstrated that maximum home temperature showed moderate discrimination for complicated appendicitis (AUC 0.657), with a more consistent association between higher temperature and complicated disease among children with confirmed appendicitis[13]. Furthermore, a simple preoperative scoring system for risk stratification of complicated appendicitis in children included body temperature ≥38.0° C as one of its prespecified predictors, underscoring the clinical utility of this readily obtainable parameter[14]. In a separate multivariate analysis, body temperature ≥38° C was associated with an odds ratio of 4.621 for complicated appendicitis, further supporting the strong predictive value of fever in this context[15]. These findings collectively reinforce that elevation in maximum temperature reflects the magnitude of the systemic inflammatory response and serves as a reliable indicator of disease severity in pediatric patients.

CRP emerged as another independent predictor in our model, consistent with its widely recognized role as an acute-phase reactant that reflects the intensity of the inflammatory cascade. A recent retrospective cohort study reported that a CRP cutoff of ≥92.24 mg/L achieved high specificity (0.943) and positive predictive value (0.900) for differentiating complicated from simple appendicitis in children[16]. Another study focusing on the CRP-to-lymphocytes ratio (CLR) demonstrated that CRP levels were significantly higher in complicated appendicitis (88.55 ± 97.75 vs. 27.15 ± 44.74 mg/L),

and the CLR score showed promise as an accessible tool for distinguishing complicated from simple appendicitis, particularly in resource-limited settings[17]. Additionally, a cutoff of 58 mg/L has been proposed, with a sensitivity of 85.7% and specificity of 90.0% for identifying complicated appendicitis when combined with uncomplicated imaging findings[18]. The consistency of these findings across multiple studies and populations supports the inclusion of CRP as a core predictor in our model, and its combination with other biomarkers has been shown to enhance predictive performance.

Fibrinogen (FIB) has emerged as a promising biomarker for complicated appendicitis, reflecting the activation of the coagulation system that accompanies severe inflammation. A study assessing the diagnostic accuracy of fibrinogen in children with suspected appendicitis found that a plasma fibrinogen level >520 mg/dL was associated with an increased likelihood of complicated appendicitis[19]. A subsequent study in preschool children reported a similar threshold of >540 mg/dL[20]. Notably, hyperfibrinogenemia (⩾4.0 g/L) has been identified as an excellent marker for predicting perforated appendicitis in children, with 58.45% of patients with perforated appendicitis exhibiting elevated fibrinogen levels[21]. A multicenter retrospective study further confirmed that fibrinogen, together with neutrophil and CRP, serves as an effective marker for diagnosing complicated appendicitis in children[12]. These findings suggest that fibrinogen serves as a valuable adjunct to conventional inflammatory markers, enhancing the model's ability to identify children at risk for complicated disease.

Appendix wall thickness ⩾3 mm was identified as the strongest imaging predictor in our model. This finding is consistent with established sonographic and CT criteria for acute appendicitis, where appendiceal wall thickness ⩾3.0 mm is recognized as a primary diagnostic indicator[22]. A normal vermiform appendix typically has a wall thickness of less than 2 mm, and mural thickening exceeding this threshold is considered a hallmark of inflammatory involvement[23]. Importantly, abnormal echogenicity and loss of the normal layered structure of the appendiceal wall have been described as specific indicators of gangrenous or perforated appendicitis, providing a direct pathological correlate to our imaging-based predictor[24]. Furthermore, a multivariate analysis of children aged three years and younger identified maximum appendix diameter as an independent risk factor for complicated appendicitis, reinforcing the prognostic significance of imaging-based appendiceal measurements[25]. The strong performance of appendix wall thickness in our nomogram highlights the critical role of preoperative imaging in risk stratification for pediatric complicated appendicitis.

The combined model incorporating these four predictors demonstrated excellent discriminative

ability, with AUCs of 0.905 and 0.917 in the training and testing cohorts, respectively. These values are comparable to or exceed those reported in other recent pediatric appendicitis prediction models. Our model's superior performance may be attributed to the integration of clinical, laboratory, and imaging parameters, which captures complementary dimensions of the disease process—systemic inflammatory response (temperature and CRP), coagulation activation (fibrinogen), and local anatomical severity (appendix wall thickness). The clinical utility of our nomogram was further supported by decision curve analysis, which demonstrated that the model provided a higher net benefit than individual predictors across a wide range of threshold probabilities. This finding is particularly relevant for pediatric surgeons, as it suggests that the nomogram can assist in identifying children who may benefit from more aggressive preoperative management, such as early administration of broad-spectrum antibiotics, timely surgical intervention, or referral to a tertiary care center. By providing an individualized probability estimate, the nomogram may facilitate shared decision-making between clinicians and families, and help optimize resource allocation in both high-resource and resource-limited settings.

Several limitations of this study should be acknowledged. First, this was a single-center retrospective study, and the findings may not be generalizable to other populations or healthcare settings. External validation in a multicenter cohort is warranted to confirm the model's performance. Second, although all patients underwent preoperative contrast-enhanced abdominal–pelvic CT, the absence of routine ultrasonography limits the comparability of our imaging predictors with those derived from ultrasound-based studies. Third, the model was developed using data from a single institution over a specific time period, and temporal changes in clinical practice or diagnostic protocols could affect its applicability. Finally, while the nomogram demonstrated favorable calibration, the Hosmer-Lemeshow test P-value of 0.0868, although not statistically significant, suggests that calibration could be further refined with a larger sample size.

Conclusions

In conclusion, we developed and validated a practical nomogram incorporating four readily available indicators for predicting complicated appendicitis in children. The model demonstrated excellent discriminative ability, favorable calibration, and clinical utility, offering pediatric surgeons a valuable tool for preoperative risk stratification and individualized clinical decision-making. Future studies should focus on external validation in diverse pediatric populations and prospective evaluation of the model's impact on clinical outcomes.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Pengshui Autonomous County People's Hospital. It is a retrospective study using data from pediatric patients with appendicitis and did not involve any prospective intervention, drug, or device. Therefore, a clinical trial registration number is not applicable. Written informed consent was obtained from the parents or legal guardians of all pediatric patients.

Data availability

The datasets generated and analysed during the current study are not publicly available due to patient privacy and institutional ethical restrictions but are available from the corresponding author on reasonable request.

Consent for publication

Yes.

Competing interests

The authors have no conflicts of interest to disclose.

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Author' Contributions

X.T.C and Y.L. performed the statistical analyses, analyzed the data, and wrote the main manuscript text. Z.Y. conceived and designed the study, and supervised the entire project. All authors reviewed and approved the final manuscript.

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Not applicable.

Table and Figure Legends

Variable	Subgroup	Uncomplicated appendicitis (n = 134)	Complicated appendicitis (n = 92)	P value
Patient characteristics				
Age,years	<6	12 (9.0)	20 (21.7)	0.006
	6-9	41 (30.6)	33 (35.9)	
	10-14	81 (60.4)	39 (42.4)	

Variable	Subgroup	Uncomplicated appendicitis (n = 134)	Complicated appendicitis (n = 92)	P value
Patient characteristics				
Gender	Male	98 (73.1)	60 (65.2)	0.202
	Female	36 (26.9)	32 (34.8)	
BMI, kg/m²		17.66 ± 3.40	17.29 ± 3.21	0.422
Pre-hospital antibiotic use	No	118 (88.1)	70 (76.1)	0.018
	Yes	16 (11.9)	22 (23.9)	
Onset to admission	＜24h	77 (57.5)	21 (22.8)	<0.001
	≥ 24h	57 (42.5)	71 (77.2)	
Previous abdominal surgery	No	133 (99.3)	92 (100.0)	0.406
	Yes	1 (0.7)	0 (0.0)	
Peritoneal signs	No	10 (7.5)	6 (6.5)	0.786
	Yes	124(92.5)	86 (93.5)	
Nausea or vomiting	No	69 (51.5)	36 (39.1)	0.067
	Yes	65(48.5)	56 (60.9)	
Anorexia	No	83 (61.9)	41 (44.6)	0.010
	Yes	51(39.1)	51 (55.4)	
Migratory pain	No	43 (32.1)	27 (29.3)	0.661
	Yes	91(67.9)	65 (70.7)	
Maximum temperature		36.7 (36.5,36.9)	37.0 (36.7,37.7)	<0.001
Heart rate		95.13 ± 17.60	104.18 ± 15.55	<0.001
Laboratory findings				
White blood cell count, ×10⁹/L		11.63 ± 6.31	14.45 ± 6.08	<0.001
Neutrophil percentage, %		76.95 (58.95,85.80)	83.55 (75.00,88.55)	<0.001
Neutrophil count, ×10⁹/L		9.21 ± 6.17	12.03 ± 5.88	<0.001
Lymphocyte percentage, %		15.61 (8.60,31.85)	9.75 (6.23,16.38)	<0.001
Lymphocyte count, ×10⁹/L		1.62 (1.12,2.08)	1.44 (0.86,2.05)	0.037
Neutrophil-to-lymphocyte ratio (NLR)		4.53 (1.77,9.53)	6.43 (4.67,14.48)	<0.001
Platelet count, ×10⁹/L		299.87 ± 68.51	300.59 ± 76.21	0.941
Platelet-to-lymphocyte ratio (PLR)		178.59 (135.64,247.19)	221.74 (141.53,328.33)	0.019
C-reactive protein (CRP), mg/L		10.69 (2.94,41.89)	67.26(32.47,103.65)	<0.001
Total bilirubin, μmol/L		11.25 (7.90,15.20)	11.45 (8.13,17.10)	0.599
Albumin, g/L		47.50 (45.00,49.63)	45.65 (42.43,47.70)	<0.001
D-dimer, mg/L		0.45 (0.21,0.91)	0.80 (0.34,1.78)	<0.001
Fibrinogen, mg/dL		340.60 ± 109.32	489.87 ± 126.54	<0.001
Urea, mmol/L		3.90 (3.40,4.70)	3.84 (3.10,4.75)	0.431
Creatinine, μmol/L		45.00 (37.00,52.25)	43.00 (35.00,54.75)	0.381
Sodium, mmol/L		138.35 (136.60,139.88)	135.65 (133.90,137.18)	<0.001
Chlorine, mmol/L		100.00 (98.45,102.70)	97.90 (94.93,99.60)	<0.001
Imaging findings				
Appendix diameter, mm		10.00 (8.00,11.00)	11.00 (10.00,13.75)	<0.001
Fecalith	No	77 (57.5)	25(27.2)	<0.001

Variable	Subgroup	Uncomplicated appendicitis (n = 134)	Complicated appendicitis (n = 92)	P value
Patient characteristics				
Periappendiceal fluid	Yes	57(42.5)	67 (72.8)	<0.001
	No	67 (50.0)	21 (22.8)	
	Yes	67 (50.0)	71 (77.2)	
Appendix wall thickness	＜3mm	88 (65.7)	10 (10.9)	<0.001
	≥ 3mm	46(34.3)	82 (89.1)	

Table 1. Baseline characteristics of pediatric patients with uncomplicated and complicated appendicitis.

Comparison of demographic, clinical, laboratory, and imaging features between children with uncomplicated appendicitis (UA, n = 134) and complicated appendicitis (CA, n = 92). Continuous variables are expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on distribution, while categorical variables are presented as frequencies (percentages). Between-group differences were assessed using the independent samples t-test or Mann–Whitney U test for continuous data, and the chi-square or Fisher's exact test for categorical data, as appropriate. BMI, body mass index; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; CRP, C-reactive protein; ALB, albumin; FIB, fibrinogen; Na, sodium.

Variables	Multivariable	
	Odds ratio (95% CI)	*P*
Maximum temperature	2.814(1.456, 5.442)	0.002
C-reactive protein (CRP), mg/L	1.011(1.002, 1.021)	0.017
Fibrinogen, mg/dL	1.007(1.003, 1.010)	<0.001
Appendix wall thickness ≥3mm	10.967(4.573, 26.304)	<0.001

Table 2. Multivariate logistic regression analysis for identifying independent predictors of complicated appendicitis in the training cohort.

Multivariate binary logistic regression was performed in the training cohort (n = 159) to identify independent risk factors for complicated appendicitis in children. Data are presented as odds ratios (OR) with 95% confidence intervals (CI). Temp_Max, maximum temperature; CRP, C-reactive protein; FIB, fibrinogen.

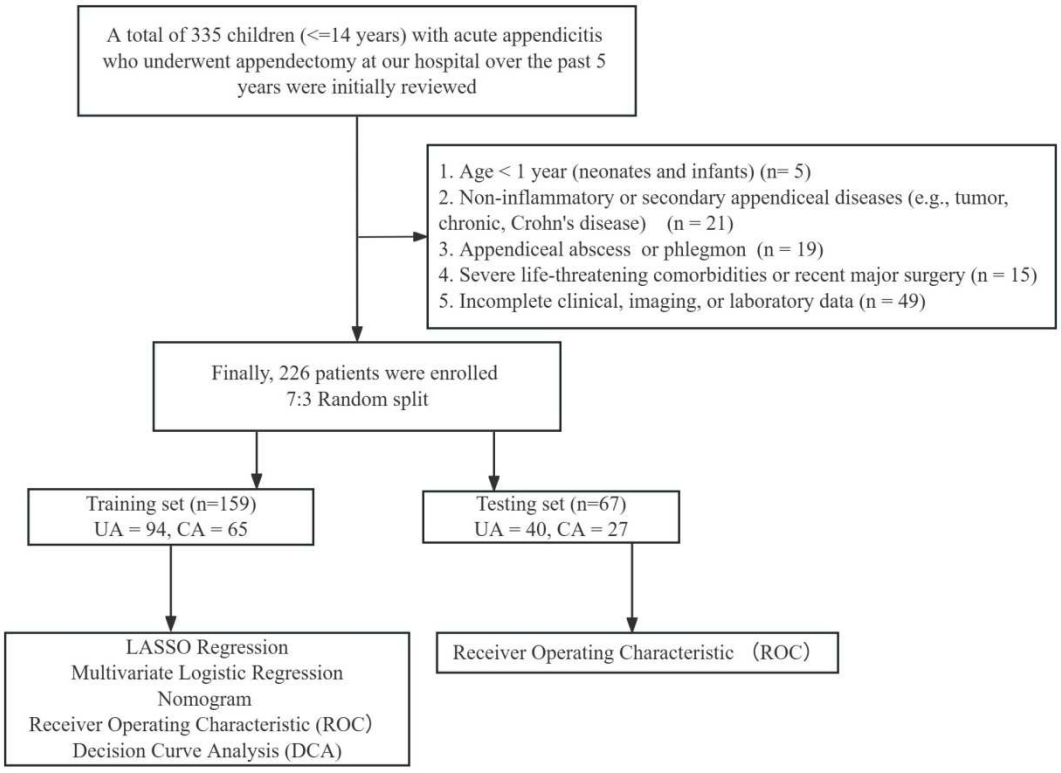


Figure 1. Flow diagram of patient enrollment and study allocation.

A total of 335 pediatric patients (≤14 years) with acute appendicitis were initially assessed for eligibility. After sequentially applying the exclusion criteria, 226 patients were ultimately enrolled and randomly allocated to a training set (n = 159) and a testing set (n = 67) at a 7:3 ratio for model development and internal validation. CA, complicated appendicitis; UA, uncomplicated appendicitis.

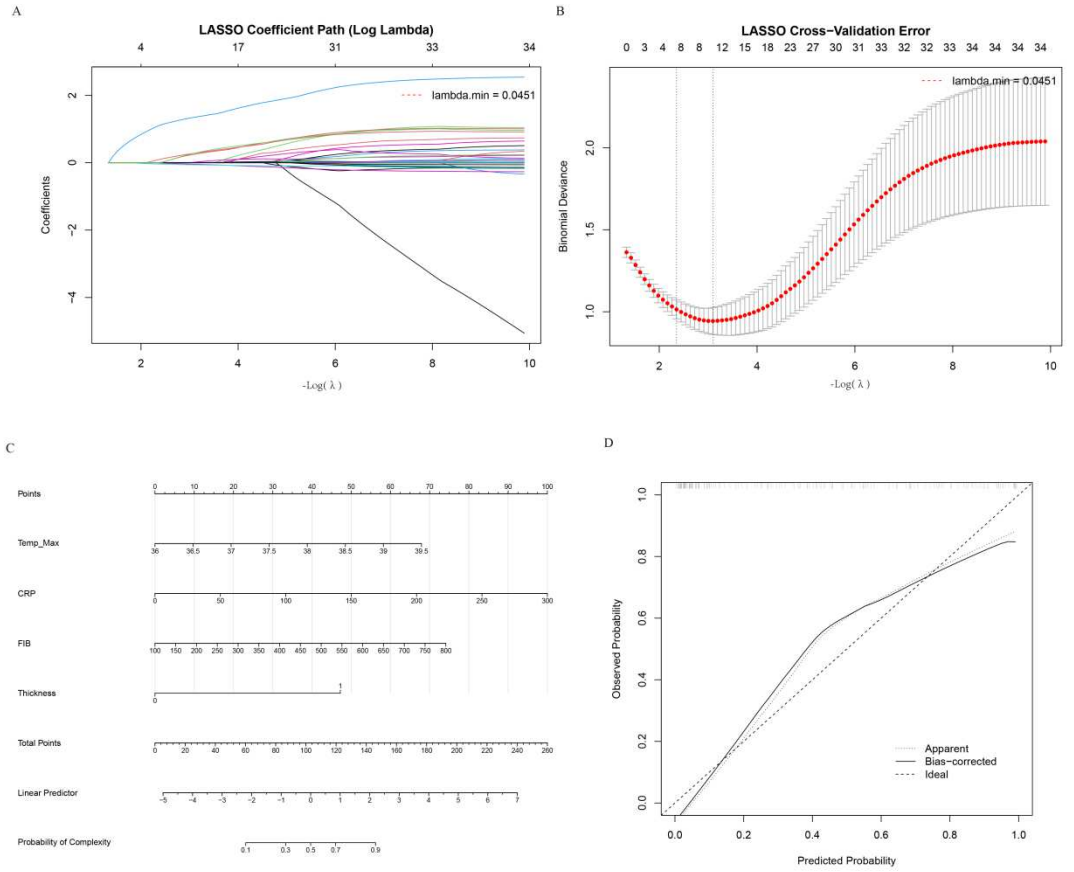


Figure 2. LASSO regression, nomogram construction, and calibration performance for predicting complicated appendicitis in children.

(A) LASSO coefficient profiles of the candidate variables. Each curve represents the trajectory of a coefficient as the regularization parameter log(λ) increases. (B) Ten-fold cross-validation error curve. The optimal penalty parameter (lambda.min = 0.0451) was selected based on the minimum cross-validated error. (C) The constructed nomogram incorporating the four independent predictors (Temp_Max, CRP, FIB, and appendix wall thickness) identified by multivariate logistic regression. (D) Calibration curve of the nomogram in the training cohort. The x-axis indicates the predicted probability of complicated appendicitis, and the y-axis shows the observed probability. The dashed diagonal line represents perfect calibration, while the solid line depicts the model's performance. LASSO, least absolute shrinkage and selection operator; Temp_Max, maximum temperature; CRP, C-reactive protein; FIB, fibrinogen.

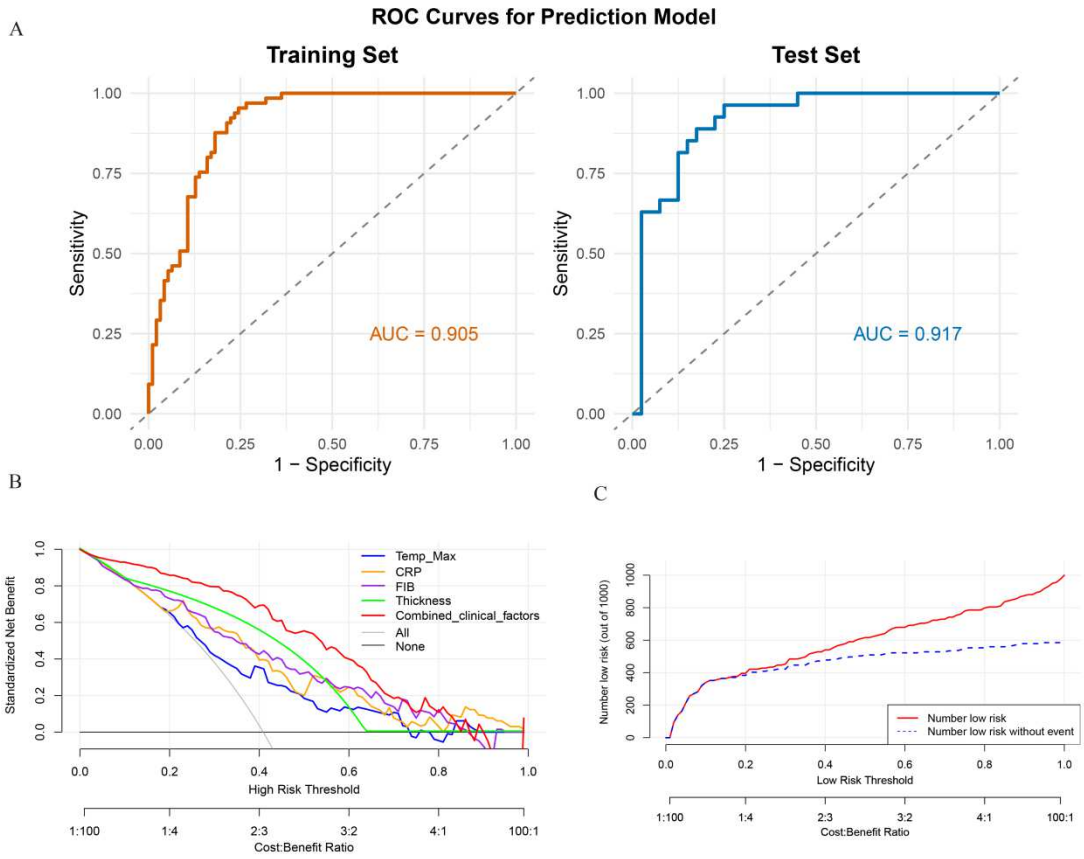


Figure 3. Receiver operating characteristic (ROC) curves and decision curve analysis (DCA) of the nomogram.

(A) ROC curves for the training and testing cohorts, demonstrating excellent discriminative ability with AUC values of 0.905 and 0.917, respectively. (B) Decision curve analysis evaluating the clinical net benefit of the nomogram across various threshold probabilities. The y-axis represents the standardized net benefit, and the x-axis represents the high-risk threshold. The red curve represents the combined clinical factors model, which demonstrates a superior net benefit over individual predictors (Temp_Max, CRP, FIB, Thickness) and the "All" or "None" strategies across a wide range of clinically reasonable thresholds. (C) Clinical impact curve showing the number of patients classified as low risk (red solid line) versus the number of low-risk patients without the event (blue dashed line) across different risk thresholds. AUC, area under the curve.

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