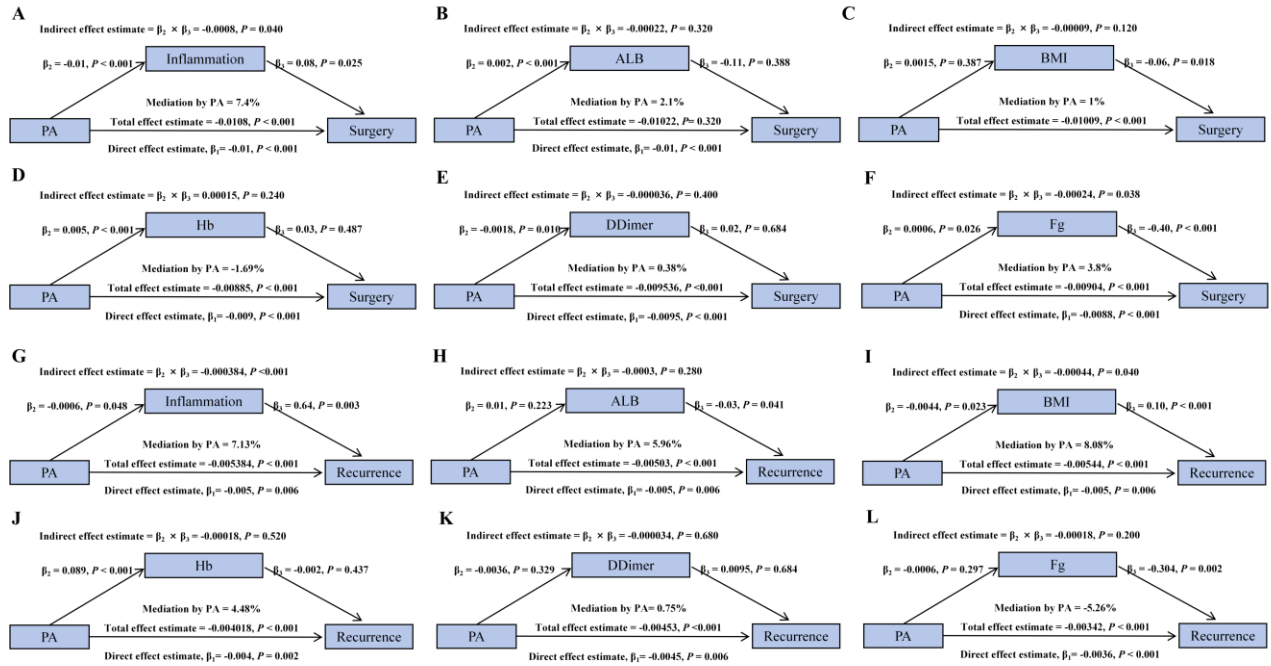
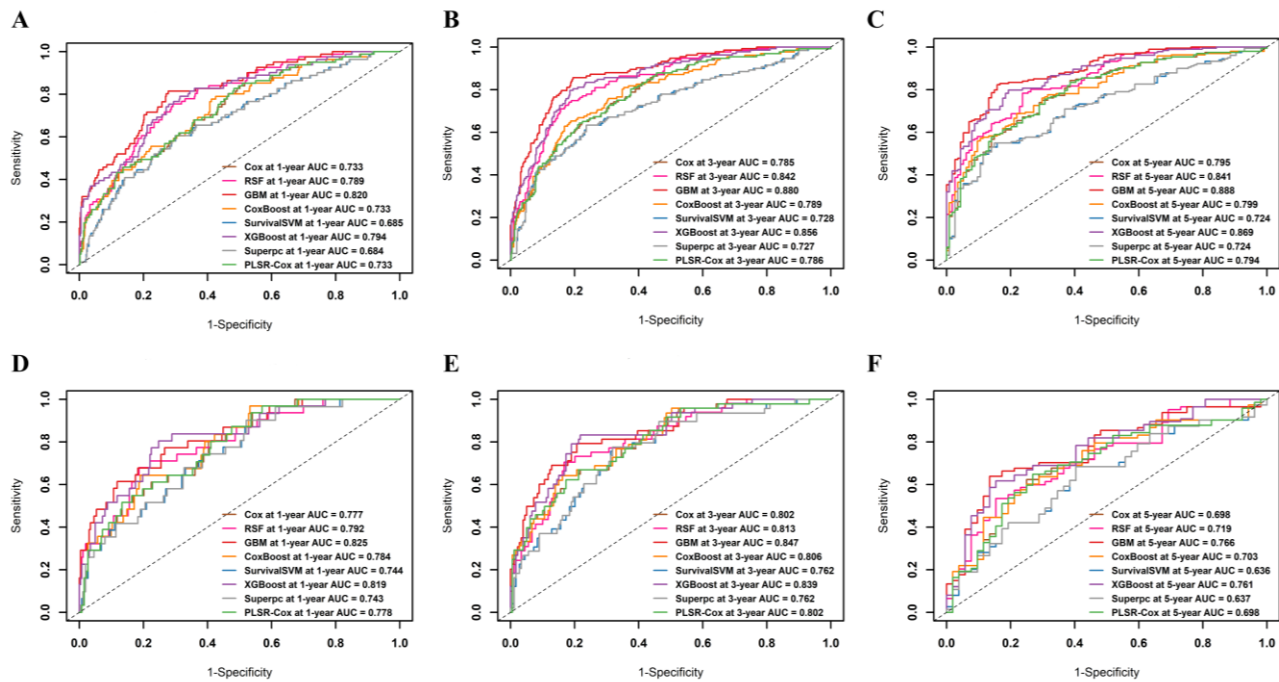


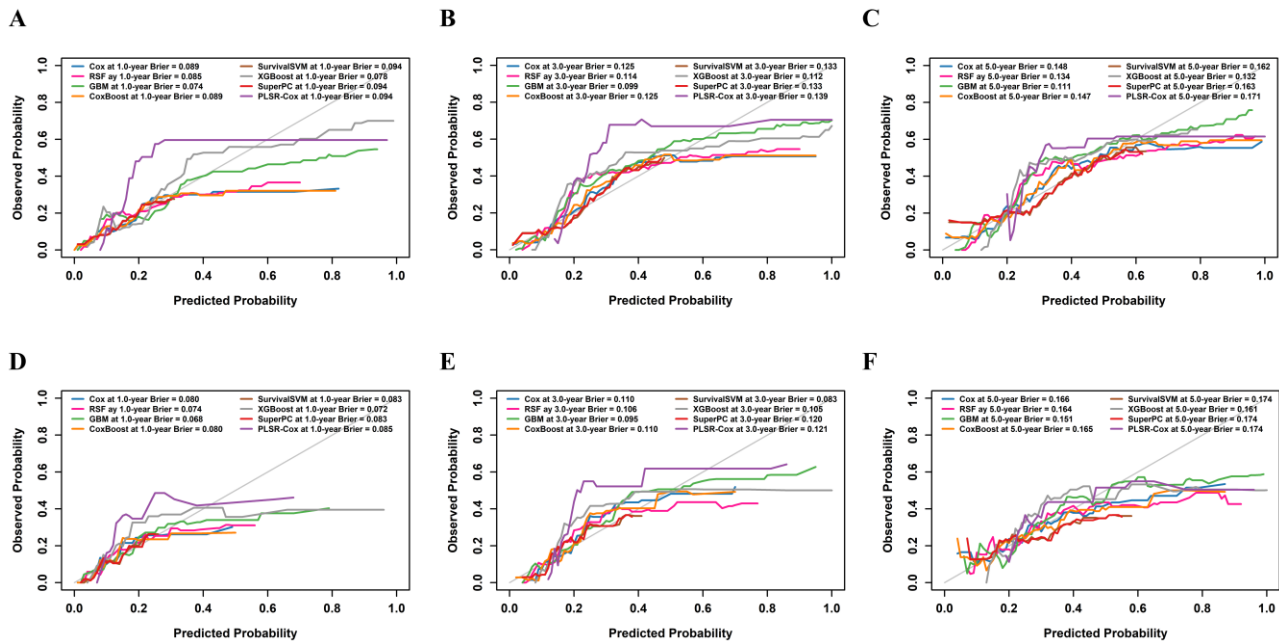


Supplementary Figure 1 Mediation analysis illustrating the role of the inflammatory score (A, G), ALB (B, H), BMI (C, I), Hb (D, J), D-dimer (E, K), and Fg (F, L) in the relationship between PA and abdominal surgery risk (A-F) and endoscopic recurrence risk (G-L). Note: PA, prealbumin; ALB, albumin; BMI, body mass index; Hb, haemoglobin; Fg, fibrinogen.



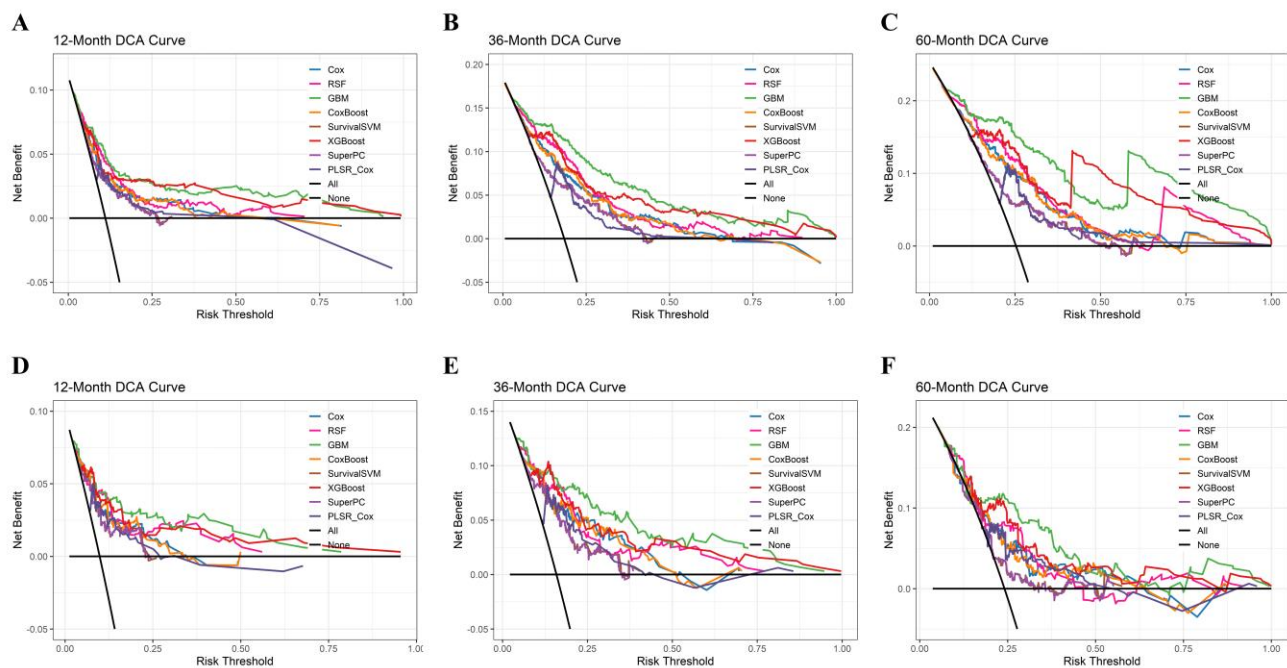
Supplementary Figure 2 Time-dependent ROC curves at 1, 3, and 5 years in the training (A-C) and validation (D-F) cohorts for predicting abdominal surgery.

Note: RSF: Random Survival Forest; GBM: Gradient Boosting Machine; CoxBoost: Cox regression with Gradient Boosting; SurvivalSVM: Survival Support Vector Machine; XGBoost: Extreme Gradient Boosting; SuperPC: Super Principal Component Regression; PLSR-Cox: Partial Least Squares Cox Regression.



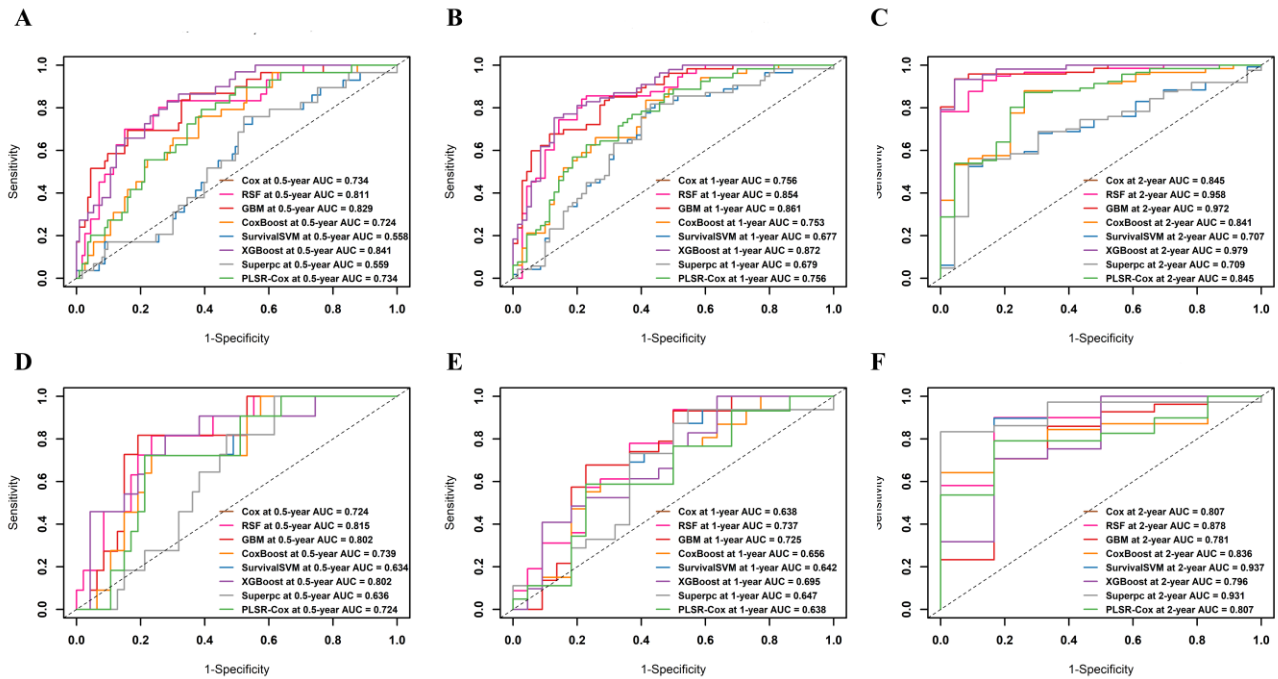
Supplementary Figure 3 Time-dependent calibration curves at 1, 3, and 5 years in the training (A-C) and validation (D-F) cohorts for predicting abdominal surgery.

Note: RSF: Random Survival Forest; GBM: Gradient Boosting Machine; CoxBoost: Cox regression with Gradient Boosting; SurvivalSVM: Survival Support Vector Machine; XGBoost: Extreme Gradient Boosting; SuperPC: Super Principal Component Regression; PLSR-Cox: Partial Least Squares Cox Regression.



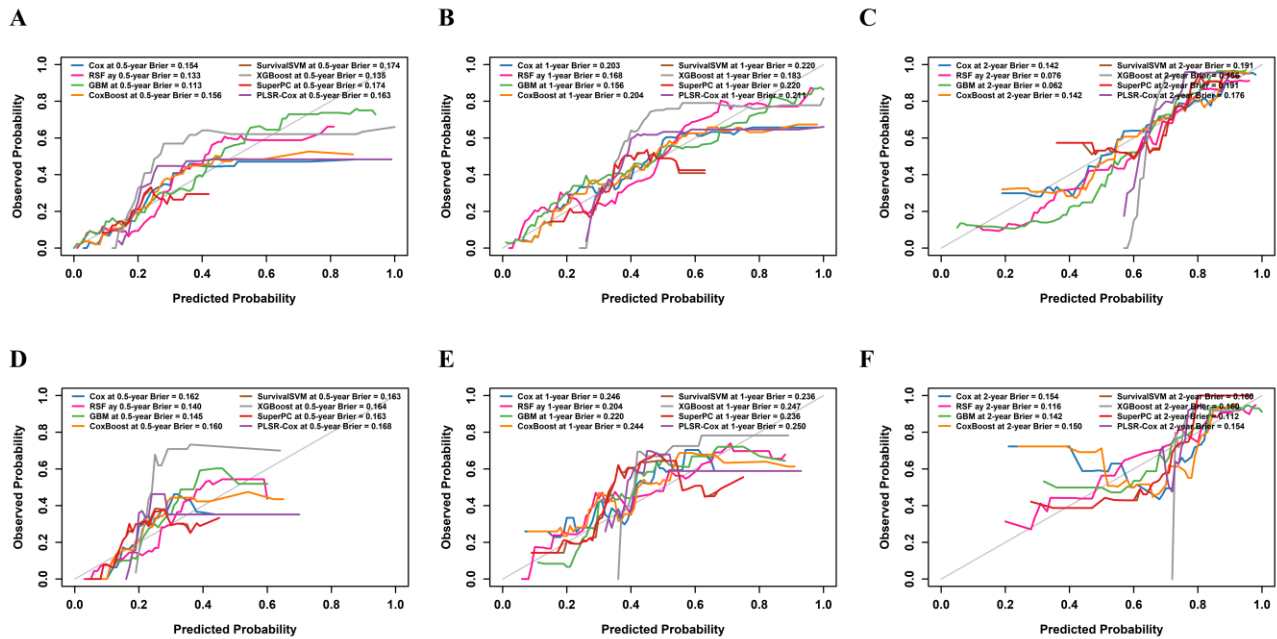
Supplementary Figure 4 Time-dependent Decision curve analysis curves at 1, 3, and 5 years in the training (A-C) and validation (D-F) cohorts for predicting abdominal surgery.

Note: RSF: Random Survival Forest; GBM: Gradient Boosting Machine; CoxBoost: Cox regression with Gradient Boosting; SurvivalSVM: Survival Support Vector Machine; XGBoost: Extreme Gradient Boosting; SuperPC: Super Principal Component Regression; PLSR-Cox: Partial Least Squares Cox Regression.



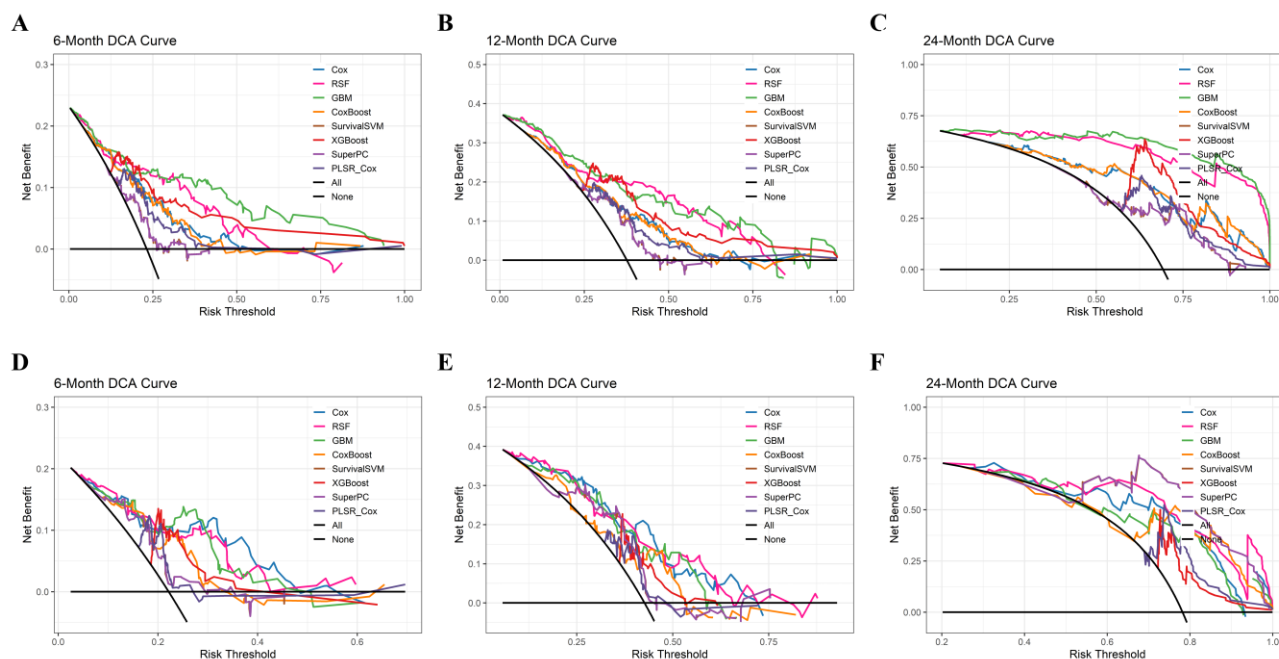
Supplementary Figure 5 Time-dependent ROC curves at 1, 3, and 5 years in the training (A-C) and validation (D-F) cohorts for predicting postoperative endoscopic recurrence.

Note: RSF: Random Survival Forest; GBM: Gradient Boosting Machine; CoxBoost: Cox regression with Gradient Boosting; SurvivalSVM: Survival Support Vector Machine; XGBoost: Extreme Gradient Boosting; SuperPC: Super Principal Component Regression; PLSR-Cox: Partial Least Squares Cox Regression.



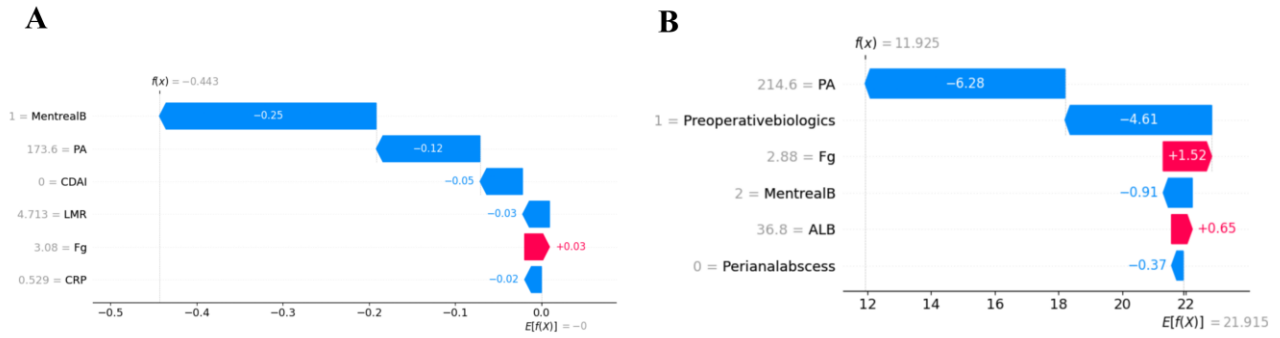
Supplementary Figure 6. Time-dependent calibration curves at 1, 3, and 5 years in the training (A-C) and validation (D-F) cohorts for predicting postoperative endoscopic recurrence.

Note: RSF: Random Survival Forest; GBM: Gradient Boosting Machine; CoxBoost: Cox regression with Gradient Boosting; SurvivalSVM: Survival Support Vector Machine; XGBoost: Extreme Gradient Boosting; SuperPC: Super Principal Component Regression; PLSR-Cox: Partial Least Squares Cox Regression.



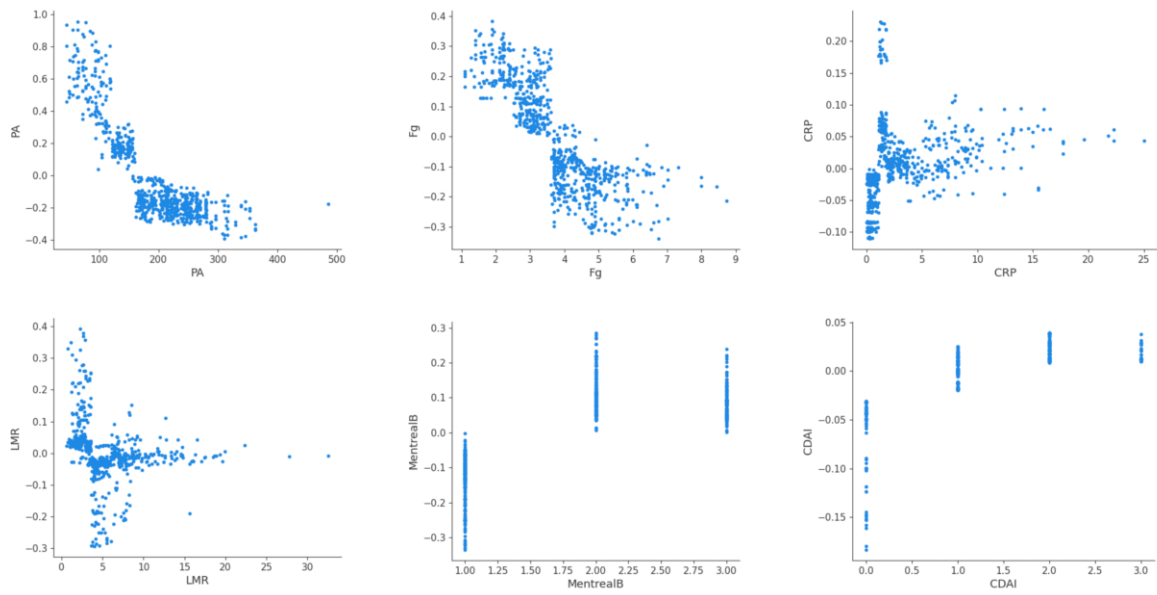
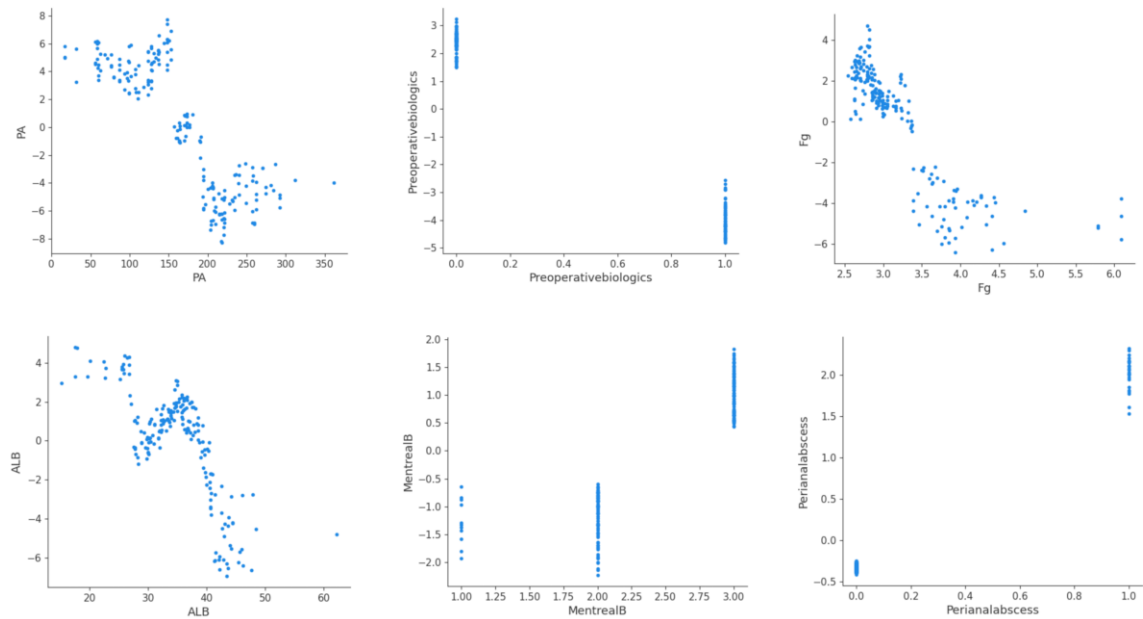
Supplementary Figure 7 Time-dependent Decision curve analysis curves at 1, 3, and 5 years in the training (A-C) and validation (D-F) cohorts for predicting postoperative endoscopic recurrence.

Note: RSF: Random Survival Forest; GBM: Gradient Boosting Machine; CoxBoost: Cox regression with Gradient Boosting; SurvivalSVM: Survival Support Vector Machine; XGBoost: Extreme Gradient Boosting; SuperPC: Super Principal Component Regression; PLSR-Cox: Partial Least Squares Cox Regression.



Supplementary Figure 8. SHAP plots for single-sample explanations of the predicted risk of abdominal surgery (GBM model; A) and postoperative endoscopic recurrence (RSF model; B).

These plots illustrate how individual features contributed to the model output in representative samples.

A**B**

Supplementary Figure 9 SHAP dependence plots for the key features associated with the predicted risk of abdominal surgery (A) and postoperative endoscopic recurrence (B).

Supplementary Table 1 Univariate Cox Regression Analysis of the Newly Diagnosed Crohn's Disease Cohort

	HR (95CI%)	<i>P</i>
Female	0.76(0.55-1.05)	0.099
Smoking	1.33(0.97-1.82)	0.074
BMI (kg/m ²)	0.94(0.90-0.98)	0.008
WBC (10 ⁹ /L)	1.00(0.95-1.05)	0.888
NLR	1.05(1.02-1.07)	<0.001
LMR	0.95(0.91-0.99)	0.033
CRP (mg/dL)	1.06(1.04-1.08)	<0.001
Hb (g/dL)	0.91(0.87-0.97)	0.001
ESR (mm/h)	1.006(1.001-1.011)	0.030
ALB (g/dL)	0.74(0.61-0.90)	0.002
PT (s)	1.14(1.07-1.22)	<0.001
Fg (g/L)	0.90(0.80-1.00)	0.049
DD (mg/L)	1.10(1.04-1.16)	0.001
Montreal A	1.31(1.01-1.71)	0.045
Montreal B	1.32(1.12-1.55)	<0.001
Montreal L1	Ref	
Montreal L2	1.19(0.68-2.06)	0.543
Montreal L3	0.84(0.62-1.14)	0.261
Montreal L4	0.52(0.13-2.14)	0.367
CDAI	1.46(1.23-1.74)	<0.001
Perianal abscess	1.37(1.02-1.84)	0.037
Extraintestinal manifestations	0.92(0.64-1.33)	0.651
Biologics	0.66(0.51-0.87)	0.003

Abbreviation: BMI: Body Mass Index; WBC: White Blood Cell Count; CDAI: clinical disease activity index; CRP: C-Reactive Protein; Hb: Hemoglobin; ESR: Erythrocyte Sedimentation

Rate; ALB: Albumin; PT: Prothrombin Time; TT: Thrombin Time; Fg: Fibrinogen; APTT: Activated Partial Thromboplastin Time; DD: D-Dimer.

Supplementary Table 2 Univariate Cox Analysis of the Primary Surgical Cohort

	HR (95CI%)	<i>P</i>
Age	1.01(1.00-1.03)	0.053
Female	0.91(0.60-1.38)	0.671
Smoking	1.57(1.12-2.18)	0.008
BMI (kg/m ²)	1.044(0.995-1.095)	0.082
WBC (10 ⁹ /L)	1.04(1.00-1.07)	0.031
NLR	1.02(0.99-1.03)	0.072
LMR	0.93(0.85-1.01)	0.092
CRP (mg/dL)	1.01(0.98-1.05)	0.551
Hb (g/dL)	0.995(0.989-1.002)	0.158
ESR (mm/h)	1.005(0.998-1.011)	0.170
ALB (g/dL)	0.97(0.95-0.99)	0.003
PT (s)		
Fg (s)	0.79(0.63-0.99)	0.044
DD (mg/L)	1.00(0.94-1.05)	0.871
Montreal A	1.02(0.75-1.37)	0.917
Montreal B	1.44(1.06-1.96)	0.021
Montreal L1	Ref	
Montreal L2	0.83(0.33-2.10)	0.690
Montreal L3	1.15(0.79-1.67)	0.460
Montreal L4	0.85(0.40-1.82)	0.681
CDAI	2.00(1.30-3.10)	0.002
Perianal abscess	2.26(1.53-3.33)	<0.001
Preoperative-biologics	0.49(0.33-0.72)	<0.001

Abbreviation: BMI: Body Mass Index; WBC: White Blood Cell Count; CDAI: clinical disease activity index; CRP: C-Reactive Protein; Hb: Hemoglobin; ESR: Erythrocyte Sedimentation Rate; ALB: Albumin; PT: Prothrombin Time; TT: Thrombin Time; Fg: Fibrinogen; APTT: Activated Partial Thromboplastin Time; DD: D-Dimer.

Supplementary Table 3 Comparison of Baseline Characteristics Between Training and Validation Cohorts in Newly Diagnosed Crohn's Disease

Baseline characteristics	Training cohort, n = 740	Validation cohort, n = 320	P
Demography			
Gender			0.156
Male	558(75.4)	228(71.2)	
Female	182(24.6)	92(28.7)	
Smoking			0.714
Yes	153(20.7)	63(19.7)	
No	587(79.3)	257(80.3)	
BMI (kg/m ²)	18.6(16.9, 20.8)	18.4(16.6, 20.9)	0.473
Laboratory			
WBC (10 ⁹)	6.3(4.9, 8.1)	6.5(5.3, 8.4)	0.080
NLR	3.69(2.4, 5.8)	3.96(2.45, 6.90)	0.432
LMR	2.71(1.85, 4.56)	2.64(1.46, 4.05)	0.543
CRP (mg/dL)	1.39(0.43, 3.63)	1.65(0.53, 4.71)	0.167
Hb (g/dL)	12.0(10.3, 13.6)	12.1(10.3, 13.6)	0.802
ESR (mm/h)	20.5(9.0, 42.0)	21(9, 45.3)	0.824
PA (mg/L)	153.6(111, 218)	170.1(100, 212.6)	0.524
ALB (g/dL)	3.7(3.2, 4.1)	3.7(3.3, 4.1)	0.871
PT (s)	11.90(11.1, 12.9)	12.05(11.2, 13.1)	0.096
Fg (g/L)	3.7(2.9, 4.6)	3.7(3.0, 4.7)	0.448
DDimer (mg/L)	0.34(0.20, 0.63)	0.31(0.18, 0.65)	0.518
Cronh's disease related			
Montreal classification	A		0.733
A1	92(12.4)	41(12.8)	

A2	547(73.9)	241(75.3)	
A3	101(13.6)	38(11.9)	
Montreal classification	B		0.151
B1	316(42.7)	157(49.1)	
B2	248(33.5)	98(30.6)	
B3	176(23.8)	65(20.3)	
Montreal classification	L		0.347
L1	195(26.4)	73(22.8)	
L2	42(5.7)	25(7.8)	
L3	492(66.5)	219(68.4)	
L4	11(1.5)	3(0.9)	
Cronh's related	disease		
CDAI			0.890
Remission	96(13.0)	37(11.6)	
Mild activity	338(45.7)	144(45.0)	
Moderate activity	270(36.5)	122(38.1)	
Severe activity	36(4.9)	17(5.3)	
Perianal abscess			0.300
Yes	253(34.2)	120(37.5)	
No	487(65.8)	200(62.5)	
Extraintestinal manifestations			0.394
Yes	125(16.9)	61(19.1)	
No	615(83.1)	259(80.9)	
Oral ulcer			0.138
Yes	62(8.4)	36(11.2)	

No	678(91.6)	284(88.8)	
Liver and gallbladder lesions			0.296
Yes	15(2.0)	3(0.9)	
No	725(98.0)	317(99.1)	
Skin lesion			0.920
Yes	24(3.2)	10(3.1)	
No	716(96.8)	310(96.9)	
Eye lesion			1.000
Yes	8(1.1)	4(1.2)	
No	732(98.9)	316(98.8)	
Osteoarthritis			0.582
Yes	25(3.4)	13(4.1)	
No	715(96.6)	307(95.9)	
The use of drugs			
5-aminosalicylic acid	67(9.1%)	28(8.8%)	0.063
Steroid	109(14.7%)	43(13.4%)	0.387
Immunosuppressant	177(23.9%)	84(26.3%)	0.327
Biological agent	453(61.2)	214(66.9)	0.080

Abbreviations: BMI: Body Mass Index; WBC: White Blood Cell Count; CDAI: Clinical Disease Activity Index; CRP: C-Reactive Protein; Hb: Hemoglobin; ESR: Erythrocyte Sedimentation Rate; ALB: Albumin; LMR: Lymphocyte-to-Monocyte Ratio; NLR: Neutrophil-to-Lymphocyte Ratio; PA: Prealbumin; PT: Prothrombin Time; Fg: Fibrinogen; DD: D-Dimer

Supplementary Table 4 Comparison of Baseline Characteristics Between Training and Validation Cohorts in Crohn's Disease Patients Undergoing Primary Surgery

Baseline characteristics	Training cohort, n = 197	Validation cohort, n = 85	P
Demography			
Age	33(26, 45)	31(25, 41)	0.259
Gender			0.189
Female	149(75.6)	71(83.5)	
Male	48(24.4)	14 (16.5)	
Smoking			0.672
Yes	67(34.0)	26(30.6)	
No	130(66.0)	59(69.4)	
BMI (kg/m ²)	17.9(16.0, 20.3)	17.3(15.2, 20.1)	0.191
Laboratory			
WBC (10 ⁹)	6.03(4.38, 7.74)	5.42(4.04, 8.06)	0.429
NLR	3.69(2.31, 5.74)	3.89(2.45, 6.97)	0.404
LMR	2.71(1.81, 4.22)	2.58(1.45, 4.00)	0.326
CRP (mg/dL)	2.01(0.78, 6.26)	2.16(0.77, 7.25)	0.890
Hb (g/dL)	11.5(9.8, 13.3)	11.5(9.6, 12.8)	0.525
ESR (mm/h)	22(12, 41)	21(10, 42)	0.879
ALB (g/dL)	35(30.3, 39.6)	34.9(28.1, 39.3)	0.392
PA (mg/L)	164.7(111.2, 217.9)	170.1(99.2, 214.6)	0.665
PT (s)	11.95(11.3, 12.8)	12.03(11.6, 13.4)	0.486
Fg (g/L)	2.96(2.79, 3.56)	2.95(2.82, 3.46)	0.875
DDimer (mg/L)	0.52(0.29, 1.00)	0.48(0.23, 1.39)	0.8884
Cronh's disease related			
Montreal classification	A		0.358

A1	14(7.1)	6(7.1)	
A2	133(67.5)	64(75.3)	
A3	50(25.4)	15(17.6)	
Montreal classification	B		0.960
B1	11(5.6)	5(5.9)	
B2	80(40.6)	33(38.8)	
B3	106(53.8)	47(55.3)	
Montreal classification	L		0.846
L1	62(31.5)	25(29.4)	
L2	12(6.1)	4(4.7)	
L3	108(54.8)	51(60.0)	
L4	15(7.6)	5(5.9)	
CDAI			0.068
Remission	45 (22.8)	29 (34.1)	
Activity	152 (77.2)	56 (65.9)	
Perianal abscess			0.759
Yes	28(14.2)	14(16.5)	
No	169(85.8)	71(83.5)	
The use of drugs			
5-aminosalicylic acid	53(26.9)	30(35.3)	0.089
Steroid	52(26.4)	26(30.6)	0.342
Immunosuppressa nt	72(36.5)	33(38.8)	0.688
Biological agent	74 (37.6)	29(34.1)	0.677

Abbreviations: BMI: Body Mass Index; WBC: White Blood Cell Count; CDAI: Clinical Disease Activity Index; CRP: C-Reactive Protein; Hb: Hemoglobin; ESR: Erythrocyte Sedimentation

Rate; ALB: Albumin; LMR: Lymphocyte-to-Monocyte Ratio; NLR: Neutrophil-to-Lymphocyte Ratio; PA: Prealbumin; PT: Prothrombin Time; Fg: Fibrinogen; DD: D-Dimer

Supplementary Table 5 Univariate and multivariate Cox regression in the training cohort of the newly diagnosed Crohn's disease cohort

	Univariate		Multivariate	
	HR (95CI%)	<i>P</i>	HR (95CI%)	<i>P</i>
Female	0.78(0.53-1.16)	0.218		
Smoking	1.31(0.91-1.90)	0.150		
BMI (kg/m ²)	0.95(0.91-1.00)	0.051		
WBC	1.02(0.96-1.08)	0.587		
NLR	1.05(1.02-1.08)	0.001		
LMR	0.96(0.91-1.01)	0.084	0.94(0.89-0.99)	0.038
CRP (mg/dL)	1.09(1.05-1.12)	<0.001	0.62(0.46-0.82)	0.010
PA	0.991(0.989-0.994)	<0.001	0.991(0.988-0.994)	<0.001
Hb (g/dL)	0.90(0.84-0.96)	0.002		
ESR (mm/h)	1.01(1.00-1.01)	0.023		
ALB (g/dL)	0.73(0.58-0.91)	0.006		
PT (s)	1.18(1.08-1.28)	<0.001		
Fg (g/L)	0.90(0.79-1.02)	0.094	0.70(0.61-0.81)	<0.001
DD (mg/L)	1.09(1.03-1.15)	0.004		
Montreal classification	A	1.22(0.89-1.65)	0.215	
Montreal classification	B	1.31(1.08-1.58)	0.007	1.26(1.03-1.54) 0.022
Montreal classification	L1	Ref		
Montreal classification	L2	1.44(0.76-2.73)	0.262	
Montreal classification	L3	0.81(0.57-1.16)	0.244	

Montreal classification	L4	0.66(0.16-2.73)	0.565		
CDAI		1.48(1.20-1.82)	<0.001	1.26(1.03-1.54)	0.022
Perianal abscess		0.75(0.53-1.06)	0.105		
Extraintestinal manifestations		0.57(0.18-1.79)	0.336		

Abbreviation: BMI: Body Mass Index; WBC: White Blood Cell Count; CDAI: clinical disease activity index; CRP: C-Reactive Protein; Hb: Hemoglobin; ESR: Erythrocyte Sedimentation Rate; ALB: Albumin; PT: Prothrombin Time; TT: Thrombin Time; Fg: Fibrinogen; APTT: Activated Partial Thromboplastin Time; DD: D-Dimer.

Supplementary Table 6 Univariate and multivariate Cox regression analyses of the training cohort for primary surgical Crohn's disease patients.

	Univariate		Multivariate	
	HR (95CI%)	<i>P</i>	HR (95CI%)	<i>P</i>
Age (years)	1.02(1.01-1.04)	0.010		
Female	0.98(0.62-1.54)	0.914		
Smoking	1.46(0.99-2.17)	0.057		
BMI (kg/ m ²)	1.03(0.97-1.09)	0.290		
BMI (>18.5 kg/ m ²)	1.17(0.79-1.73)	0.425		
WBC	1.04(0.99-1.08)	0.128		
NLR	1.02(0.99-1.05)	0.061		
LMR	0.94(0.85-1.04)	0.257		
LMR (>1.76)	0.54(0.35-0.84)	0.006		
CRP (mg/ dL)	1.01(0.97-1.06)	0.507		
CRP (>20 mg/L)	1.47(0.99-2.18)	0.053		
PA			0.996(0.992-0.999)	0.016
Hb (g/ dL)	0.93(0.86-1.01)	0.094		
ESR (mm/h)	1.00(0.99-1.01)	0.111		
ESR (>20 mm/h)	1.06(0.72-1.58)	0.761		
ALB (g/ dL)	0.96(0.93-0.98)	0.001	0.966(0.934-0.999)	0.041
PT (s)	0.96(0.80-1.15)	0.634		
Fg (s)	0.73(0.56-0.95)	0.021	0.62(0.46-0.82)	<0.001
DD (mg/L)	0.98(0.91-1.06)	0.611		
Montreal A	1.22(0.86-1.72)	0.266		

Montreal B	1.39(0.98-1.98)	0.067	1.35(0.96-1.91)	0.088
Montreal L1	Ref			
Montreal L2	1.14(0.44-2.94)	0.787		
Montreal L3	0.99(0.64-1.52)	0.956		
Montreal L4	0.86(0.38-1.95)	0.716		
CDAI (active)	1.76(1.05-2.94)	0.033		
Perianal abscess	2.10(1.33-3.32)	0.001	1.72(1.08-2.76)	0.023
Preoperative- biologics	0.47(0.30-0.73)	<0.001	0.44(0.27-0.70)	<0.001

Abbreviation: BMI: Body Mass Index; WBC: White Blood Cell Count; CDAI: clinical disease activity index; CRP: C-Reactive Protein; Hb: Hemoglobin; ESR: Erythrocyte Sedimentation Rate; ALB: Albumin; PT: Prothrombin Time; TT: Thrombin Time; Fg: Fibrinogen; APTT: Activated Partial Thromboplastin Time; DD: D-Dimer.