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Systemic inflammatory markers do not independently predict positive surgical margins after loop electrosurgical excision procedure in patients with cervical intraepithelial neoplasia grade 3: a single-center retrospective study

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Article

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Abstract

Objective: To investigate the predictive value of preoperative clinicopathological factors and systemic inflammatory markers for positive surgical margin after loop electrosurgical excision procedure (LEEP) in patients with cervical intraepithelial neoplasia grade 3 (CIN3), and to develop a nomogram prediction model.

Methods: A total of 1,373 patients with CIN3 who underwent LEEP at Hubei Provincial Maternal and Child Health Hospital between January 2021 and December 2025 were retrospectively included. Patients were randomly assigned at a 7:3 ratio to a training set "n=961" and a validation set "n=412" . Preoperative demographic characteristics, cytology results (TCT grade), HPV genotypes, colposcopic biopsy pathology, and hematological parameters (including complete blood count, coagulation, and lipid profiles) were collected. LASSO regression was used to select predictors in the training set, followed by multivariable logistic regression analysis. Model discrimination was evaluated by the area under the receiver operating characteristic curve (AUC), calibration by calibration plots and the Hosmer-Lemeshow test, and clinical utility by decision curve analysis (DCA). A nomogram was constructed based on the final model.

Results: A total of 1,373 CIN3 patients were included, among whom 129 (9.4%) had positive surgical margins. LASSO regression identified five predictors: TCT grade, age, BMI, multiple HPV infection, and parity. Multivariable logistic regression showed that TCT grade (aOR = 1.27, 95% CI: 1.10–1.48, P = 0.002) and age "aOR=1.05,P<0.05" were independent predictors of positive margin. The model demonstrated good calibration, with Hosmer-Lemeshow test P-values of 0.799 in the training set and 0.463 in the validation set. DCA indicated clinical net benefit over a range of threshold probabilities. None of the systemic inflammatory markers (e.g., SIRI, NLR) entered the final model, suggesting no independent predictive value.

Conclusion: A nomogram based on preoperative TCT grade, age, BMI, multiple HPV infection, and parity can accurately predict the risk of positive margin after LEEP in CIN3 patients, with a validation AUC of 0.80. Systemic inflammatory markers do not independently predict margin status. This model may assist in preoperative risk assessment and individualized surgical decision-making.

1. Introduction

Cervical intraepithelial neoplasia grade 3 (CIN3) is a direct precursor of cervical cancer, and without timely intervention the risk of progression to invasive carcinoma increases significantly (29126708). Loop electrosurgical excision procedure (LEEP) has become one of the first-line treatments for CIN3 owing to its minimal invasiveness and technical simplicity. However, positive surgical margins after LEEP remain common, with reported rates ranging from 14.4% to 39% [1–3]. A positive margin not only indicates that the lesion may not have been completely excised, but is also closely associated with residual disease, recurrence, and persistent high-risk HPV infection[4], thus leading to additional surgical

procedures and psychological burden for patients. Previous studies have investigated the relationships between age, menopausal status, cytology results, multi-quadrant involvement, high-risk HPV infection, and positive margins after LEEP [3, 5, 6], and several studies have attempted to construct predictive models[7]. However, most existing models are based on heterogeneous populations and focus primarily on traditional clinicopathological factors, with limited attention to the role of systemic inflammatory status in margin positivity. In recent years, systemic inflammatory indices such as the systemic immune-inflammation index (SIRI) and the neutrophil-to-lymphocyte ratio (NLR) have shown prognostic value in various malignancies, but their predictive significance for surgical outcomes in cervical precancerous lesions remains unclear. Therefore, the present study aimed to systematically collect preoperative clinical, pathological, and hematological inflammatory variables in patients with CIN3, use LASSO regression to select predictors, construct and internally validate a nomogram for predicting positive margins after LEEP, and explore whether systemic inflammatory markers have predictive value, thereby providing a reference for preoperative assessment and individualized treatment.

2. Materials and Methods

2.1 Study design and patients

This was a single-center retrospective study conducted in accordance with the Declaration of Helsinki. The study was approved by the Ethics Committee of Hubei Provincial Maternal and Child Health Hospital (approval number: 2026-177-01), and informed consent was waived because of the retrospective nature of the study.

Patients with histologically confirmed cervical intraepithelial neoplasia grade 3 (CIN3) who underwent loop electrosurgical excision procedure (LEEP) between January 2021 and December 2025 at the Department of Gynecology, Hubei Provincial Maternal and Child Health Hospital were enrolled. The inclusion criteria were as follows:

(1) preoperative colposcopic cervical biopsy confirmed CIN3;

(2) treatment with LEEP;

(3) complete clinicopathological data, including preoperative complete blood count, coagulation function, lipid profile, HPV genotypes, and postoperative margin status.

The exclusion criteria were as follows:

(1) preoperative biopsy or imaging suggestive of invasive cervical cancer;

(2) pregnancy or within 6 weeks postpartum;

(3) previous cervical conization or hysterectomy;

(4) coexistence of other malignant tumors, autoimmune diseases, severe hepatic or renal dysfunction, or acute infection;

(5) long-term use of glucocorticoids or immunosuppressants;

(6) missing key data precluding analysis.

Based on these criteria, 1,373 patients with CIN3 were ultimately included, comprising 129 (9.4%) with positive margins and 1,244 (90.6%) with negative margins.

2.2 Data collection and definitions

Preoperative data were collected from the electronic medical record system.

(1) Demographic and baseline characteristics

age, height, weight, body mass index (BMI), menopausal status, gravidity ≥ 3, and parity ≥ 3. BMI was classified according to Chinese criteria as underweight (< 18.5 kg/m²), normal (18.5–23.9 kg/m²), overweight (24.0–27.9 kg/m²), and obese (≥ 28.0 kg/m²).

(2) Preoperative cytology and HPV results

Liquid-based cytology (TCT) was classified according to the Bethesda system as NILM, ASC-US, LSIL, ASC-H, HSIL, or AGC. ASC-H, HSIL, and AGC were defined as high-grade cytology. HPV genotyping recorded infection with types 16, 18, 52, and 58, multiple HPV infection, and co-infection with types 16/18.

(3) Preoperative colposcopic biopsy pathology

the highest biopsy grade of CIN, glandular involvement, and the number of involved quadrants were recorded.

(4) Preoperative hematological parameters

Complete blood count results within 1 week before surgery were collected. The systemic inflammation response index (SIRI = neutrophil × monocyte / lymphocyte), systemic immune-inflammation index (SII = neutrophil × platelet / lymphocyte), neutrophil-to-lymphocyte ratio (NLR), monocyte-to-lymphocyte ratio (MLR), and platelet-to-lymphocyte ratio (PLR) were calculated. Coagulation parameters including thrombin time (TT), prothrombin time (PT), activated partial thromboplastin time (APTT), fibrinogen (FIB), and D-dimer were also recorded.

(5) Surgical and pathological variables

cone depth (mm), pathological CIN grade of the conization specimen, endocervical margin, ectocervical margin, stromal margin status, and margin positivity definition were recorded.

Outcome definition

Positive margin was defined as the presence of CIN3 or worse in the endocervical, ectocervical, or stromal margins of the conization specimen. Negative margin was defined as the absence of CIN3 or worse at all margins.

2.3 Sample size and grouping

This was an exploratory prediction model study. Sample size was determined based on the rule of thumb that at least 10 outcome events are required for each candidate predictor in multivariable regression. In this study, there were 129 positive margin events. After excluding variables with missing rates > 50% or clinically unavailable, 15 candidate variables were included, satisfying the events-per-variable ratio > 10.

Patients were randomly assigned at a 7:3 ratio to a training set (70%) and a validation set (30%) using a random number table. The training set was used for model construction, while the validation set was used for independent evaluation of model performance. Baseline characteristics between the two groups were compared to ensure comparability.

2.4 Statistical analysis

All statistical analyses were performed using R software (version 4.6.0). Continuous variables with normal distribution were presented as mean ± standard deviation and compared using the independent samples t-test. Non-normally distributed continuous variables were presented as median (interquartile range) and compared using the Mann–Whitney U test. Categorical variables were presented as frequency (percentage) and compared using the chi-square test or Fisher's exact test.

Variable selection and model construction

In the training set, univariate logistic regression was first performed for each candidate variable to estimate crude odds ratios (ORs) and 95% confidence intervals (CIs). LASSO regression with 10-fold cross-validation (lambda.min criterion) was then applied to select predictors with non-zero coefficients from all candidate variables. If no variable was selected by lambda.min, lambda.1se was used; if still no variable was selected, clinically important variables were manually included. Variables selected by LASSO were entered into a multivariable logistic regression model to calculate adjusted odds ratios (aORs) and 95% CIs. To ensure model parsimony, the final model was limited to no more than five variables.

Model evaluation

Discrimination was assessed by the area under the receiver operating characteristic curve (AUC), with AUCs and 95% CIs calculated for both the training and validation sets. Calibration was evaluated by calibration plots and the Hosmer–Lemeshow test; P > 0.05 indicated good calibration. Clinical net benefit was assessed by decision curve analysis (DCA).

Nomogram construction

Based on the final multivariable model, a nomogram was constructed by converting the regression coefficients of each predictor into a 0–100 point scale. The total score was transformed into the predicted probability of positive margin.

Statistical significance

All tests were two-sided, and $P < 0.05$ was considered statistically significant. The standardized mean difference (SMD) was used to assess balance between groups for categorical variables, with $SMD < 0.1$ indicating good balance.

3. Results

3.1 Baseline characteristics

A total of 1,373 patients with CIN3 were included, among whom 129 had positive margins. Patients were randomly assigned at a 7:3 ratio to a training set (961 patients, 90 positive margins) and a validation set (412 patients, 39 positive margins). There were no significant differences between the two groups in baseline characteristics such as BMI, obesity, HPV type 58 infection, multiple infection, preoperative glandular involvement, and cone depth. The baseline characteristics of the patients are shown in Table 1.

Table 1
Baseline Characteristics of the Study Population

n	level	Negative	Positive	χ^2/U
		1244	**129**	
Age (mean (SD))		40.31 (11.32)	48.94 (10.20)	< 0.001
BMI (mean (SD))		22.29 (3.20)	23.24 (3.05)	0.001
Obesity (%)	0	1182 (95.0)	121 (93.8)	0.698
	1	62 (5.0)	8 (6.2)	
Menopausal status (%)	0	992 (79.7)	76 (58.9)	< 0.001
	1	252 (20.3)	53 (41.1)	
Parity (mean (SD))		2.73 (1.78)	3.34 (1.65)	< 0.001
Gravidity (mean (SD))		1.30 (0.96)	1.64 (0.97)	< 0.001
TCT_grade (%)	0	278 (22.3)	12 (9.3)	< 0.001
	1	349 (28.1)	28 (21.7)	
	2	80 (6.4)	14 (10.9)	
	3	239 (19.2)	24 (18.6)	
	4	291 (23.4)	51 (39.5)	
	5	7 (0.6)	0 (0.0)	
HPV58 (%)	0	1056 (84.9)	112 (86.8)	0.648
	1	188 (15.1)	17 (13.2)	
Multiple_infection (%)	0	916 (73.6)	103 (79.8)	0.153
	1	328 (26.4)	26 (20.2)	
glandular involvement (%)	0	657 (52.8)	71 (55.0)	0.697
	1	587 (47.2)	58 (45.0)	
SII (mean (SD))		584.50 (414.50)	667.20 (510.28)	0.036
NLR (mean (SD))		2.43 (1.65)	2.79 (2.26)	0.026
MLR (mean (SD))		0.23 (0.79)	0.22 (0.11)	0.908
PLR (mean (SD))		139.41 (52.82)	151.50 (55.19)	0.014
Cone_depth (mean (SD))		18.08 (4.39)	17.76 (4.09)	0.436

Table 2
Univariate logistic regression analysis of candidate predictors for positive surgical margin in CIN3 patients

Variable	OR (95% CI)	P
Age	1.07 (1.05–1.08)	< 0.001
BMI	1.10 (1.04–1.17)	< 0.001
Obesity	1.31 (0.57–2.65)	0.488
Menopause	2.77 (1.88–4.05)	< 0.001
Gravidity	1.20 (1.09–1.32)	< 0.001
Parity	1.36 (1.15–1.61)	< 0.001
TCT_grade	1.34 (1.18–1.52)	< 0.001
HPV58	0.90 (0.51–1.50)	0.699
Multiple_infection	0.74 (0.46–1.14)	0.188
Gland_invasion	0.88 (0.60–1.27)	0.48
SII	1.00 (1.00–1.00)	0.024
NLR	1.11 (1.02–1.20)	0.015
MLR	0.98 (NA-1.17)	0.895
PLR	1.00 (1.00-1.01)	0.026
Cone_depth	0.98 (0.94–1.02)	0.373

3.3 LASSO selection and multivariable analysis

LASSO regression with 10-fold cross-validation (lambda.min criterion) identified five predictors: TCT grade, age, multiple HPV infection, BMI, and parity (Fig. 1). Multivariable logistic regression showed that TCT grade (aOR = 1.27, 95% CI [1.10, 1.48], P = 0.002) and age (aOR = 1.05, P < 0.05) were independent predictors of positive margin. Although multiple HPV infection (P = 0.324), BMI (P = 0.105), and parity (P = 0.386) were retained by LASSO, none of them reached statistical significance in the multivariable model (Table 2). No severe multicollinearity was observed among the included variables (variance inflation factor < 5).

Table 3
Multivariable logistic regression analysis of factors associated with positive surgical margin in CIN3 patients

Variable	OR (95% CI)	P
TCT_grade	1.27 (1.10–1.48)	0.002
Multiple_infection	0.76 (0.42–1.29)	0.324
BMI	1.06 (0.99–1.14)	0.105
Age	1.05 (1.03–1.07)	< 0.001
Gravidity	1.06 (0.92–1.22)	0.386

3.4 Model performance and nomogram

The model achieved an AUC of 0.71 in the training set and 0.80 in the validation set, indicating good discrimination (Fig. 2). The calibration curves demonstrated good agreement between predicted and observed probabilities of positive margin. The Hosmer–Lemeshow test yielded a P-value of 0.799 in the training set and 0.463 in the validation set, both showing no statistically significant departure from perfect calibration, suggesting satisfactory model calibration (Fig. 3).

Decision curve analysis (DCA) showed that within a threshold probability range of 0.05–0.40, using this nomogram to predict positive margin risk provided higher net benefit than the “treat all” or “treat none” strategies (Fig. 4), indicating clinical utility.

Based on the multivariable model, a nomogram was constructed (Fig. 5). The nomogram assigns a weighted score to each predictor; a higher total score corresponds to a greater risk of positive margin after LEEP. For example, a patient with HSIL cytology, age ≤ 35 years, BMI < 24 kg/m², and multiple HPV infection would have a total score of 130 points, corresponding to a predicted probability of approximately 10%.

4. Discussion

4.1 Comparison with previous studies

In the present study, LASSO regression identified five predictors—TCT grade, age, BMI, multiple HPV infection, and parity—and the resulting nomogram achieved a validation AUC of 0.80, indicating satisfactory discrimination and clinical applicability. Compared with previous studies, both the composition of predictors and the model performance show distinct characteristics.

Regarding TCT grade, several studies have confirmed that high-grade preoperative cytology is associated with an increased risk of positive margin[8, 9]. Our findings are consistent with the literature, and by grading TCT results in more detail, we provide a more refined prediction of positive margin risk.

Increasing age has been reported as an independent risk factor for residual disease[10–12]. However, in studies specifically focusing on margin positivity, age has rarely been reported as an independent predictor. In our study, age remained an independent risk factor, which may be explained by the wide age range of CIN3 patients: postmenopausal cervical atrophy can increase surgical difficulty, thereby increasing the risk of positive margin.

Regarding the predictive value of age and menopausal status for positive margin, previous studies have reported inconsistent findings. Some studies identified menopausal status as an independent risk factor for positive margin[13–16], but many did not simultaneously adjust for age or treat age as a continuous variable. In the present study, LASSO selection and multivariable regression showed that each 1-year increase in age was associated with a 5% increase in the risk of positive margin (aOR = 1.05, $P < 0.05$), whereas menopausal status was not retained in the final model. This is consistent with the latter group of studies and suggests that age may be a more robust predictor than menopausal status.

Several reasons may explain the differential predictive value of age and menopausal status. First, as a continuous variable, age captures the cumulative aging processes of the cervix more precisely, including inward migration of the squamocolumnar junction, cervical atrophy, and difficulty in surgical field exposure, all of which progress gradually with age rather than appearing abruptly at menopause. In contrast, menopausal status, as a binary variable, divides women into pre- and postmenopausal groups, losing the gradient information of age. Second, perimenopausal women show substantial individual variation in ovarian function; classification based on menstrual history is relatively crude and may introduce misclassification. Furthermore, age may indirectly increase the risk of positive margin by influencing surgical decision-making (e.g., more conservative cone depth in older patients) or by being associated with a higher proportion of endocervical lesions, effects that cannot be fully captured by menopausal status alone.

Therefore, compared with previous studies that reported menopausal status as a risk factor while ignoring age, our findings emphasize that age should be prioritized over menopausal status in predictive models. This also provides a methodological implication for future research: the granular effect of age may outperform simple menopausal stratification when evaluating surgical outcomes of cervical precancerous lesions.

Regarding the association between HPV genotype and positive margin, previous studies have suggested that HPV16/18 infection is associated with an increased risk of positive margin or residual disease[14, 17–19]. However, in the present study, neither HPV16/18 nor HPV58 was retained in the final model by LASSO, and no stable independent effect was observed in univariate analysis. This discrepancy may be explained by several factors. First, HPV genotype is highly collinear with preoperative cytology grade and multiple HPV infection. In patients with CIN3, the prevalence of HPV16/18 is extremely high, and infection often coexists with high-grade cytology or multiple genotype infection; therefore, the information carried by HPV genotype may already be captured by TCT grade and multiple infection status. Second, the study population consisted of CIN3 patients, in whom the lesion has already reached

high-grade status, reducing the discriminative ability of HPV genotype; positive margin is more strongly influenced by local factors such as surgical excision extent and lesion location. Third, the number of cases positive for certain genotypes (e.g., HPV58) may be relatively small, limiting statistical power to detect an independent effect. Furthermore, LASSO regression tends to retain variables that contribute most to predictive performance; when HPV genotype overlaps with TCT grade or multiple infection, it may be shrunk out of the model. Therefore, compared with previous studies, our findings suggest that HPV genotype has no independent predictive value for positive margin after LEEP in CIN3 patients, implying that its effect may be replaced by other clinicopathological factors in high-grade lesions.

It is noteworthy that although BMI did not reach conventional statistical significance in the final multivariable model (P = 0.105), LASSO regression retained it based on its contribution to predictive performance. This suggests that BMI may exert a weak independent effect on positive margin risk, but the current sample size may be insufficient to reach statistical significance. Similarly, multiple HPV infection showed a P-value of 0.324 after adjustment and may represent a potential auxiliary predictor. Therefore, we retained these variables to optimize the overall performance of the model, and the validation AUC supported the robustness of the model.

The final model included five variables—TCT grade, age, BMI, multiple HPV infection, and parity—and achieved a validation AUC of 0.80. This indicates that even if some variables did not reach statistical significance in multivariable regression, their combined predictive ability remains substantial.

4.2 Negative findings for systemic inflammatory markers

An important finding of this study is that although several systemic inflammatory indices, such as SII and NLR, were significantly associated with positive margin in univariate analysis ($P < 0.05$), none remained statistically significant after multivariable adjustment, and none were selected by LASSO. This indicates that preoperative systemic inflammatory status has limited independent predictive value for positive margin after LEEP in patients with CIN3.

Several reasons may explain this phenomenon. First, the associations observed in univariate analysis may be confounded by factors such as age, HPV infection, or cone depth, which are correlated with inflammatory markers and are also risk factors for positive margin, resulting in spurious associations before adjustment. Second, CIN3 lesions remain confined to the cervical epithelium and may not provoke a sufficiently strong systemic inflammatory response to affect surgical margins; peripheral blood inflammatory markers may be too insensitive to reflect the local immune microenvironment. Third, although the sample size was relatively large, the number of positive margin events was still limited, which may reduce the ability to detect weak independent effects of inflammatory markers.

Previous studies have reported that SIRI and NLR are associated with prognosis in cervical cancer and other solid tumors[20–25]. However, the present study suggests that these markers may not be applicable to short-term surgical outcomes in cervical precancerous lesions. This discrepancy may stem from fundamental differences in tumor burden, immune escape mechanisms, and the degree of systemic

inflammatory activation between invasive cancer and carcinoma in situ. Therefore, prognostic inflammatory markers from cancer studies should not be directly extrapolated to margin prediction in CIN3.

Previous studies on systemic inflammatory markers have largely focused on malignant tumors. In cervical cancer, several studies have shown that SIRI, NLR, and PLR are significantly associated with progression-free survival and overall survival, suggesting that systemic inflammatory status may reflect the balance between tumor burden and host antitumor immunity. Similarly, in lung cancer, colorectal cancer, gastric cancer, and other solid tumors, elevated NLR or SIRI has frequently been reported as an independent predictor of poor prognosis[26]. These studies typically use tumor recurrence, metastasis, or death as endpoints, and the underlying mechanisms are closely related to the systemic inflammatory response induced by the tumor microenvironment.

However, in the field of precancerous lesions and short-term surgical outcomes, the value of inflammatory markers remains controversial. Some studies on cervical intraepithelial neoplasia have reported that NLR or SIRI is associated with persistent HPV infection or lesion recurrence, but the effect sizes are generally small and results are inconsistent. In terms of surgical complications, several studies have found that preoperative NLR elevation can predict anastomotic leakage or infection after colorectal cancer surgery, whereas other studies in benign gynecological surgery have not observed such associations[26–29]. These findings indicate that the predictive ability of systemic inflammatory markers is highly heterogeneous across different diseases and endpoints.

The present study focused on positive surgical margin after LEEP in patients with CIN3, a local surgical outcome, and found no independent predictive value of any systemic inflammatory marker. This is in sharp contrast to the positive results reported in malignancy prognosis studies, but is more consistent with the negative findings in precancerous lesions and some benign surgical studies. A likely explanation is that margin positivity depends primarily on local anatomical and surgical factors, such as lesion extent, location, and cone depth, which lack a direct pathophysiological link to systemic inflammatory status. In contrast, cancer prognosis is more strongly influenced by tumor heterogeneity, immune escape, and metastatic potential, which are more readily reflected by systemic inflammatory markers.

Therefore, our findings suggest that the prognostic value of inflammatory markers in malignant tumors should not be directly extrapolated to surgical outcomes of cervical precancerous lesions. Future biomarker research should pay more attention to local microenvironmental indicators, such as tumor-infiltrating lymphocytes, cytokine profiles, or HPV-specific immune responses in cervical tissue, rather than relying solely on peripheral blood inflammatory indices.

4.3 Clinical implications

The negative findings of this study have practical clinical significance. They remind clinicians that routine blood cell-derived inflammatory indices should not be overinterpreted as independent predictors of positive margin and should not alter surgical decision-making. Instead, more attention should be paid to

local pathological features (e.g., TCT grade, lesion extent) and surgical parameters (e.g., cone depth). In addition, these findings may prevent future studies from repeatedly including these markers without robust justification.

4.4 Limitations

This study has several limitations. It was retrospective in design, and the interval between blood sampling and surgery may have varied. We did not include additional cytokines or local immune markers. Future prospective studies integrating cervical local microenvironment assessment are needed to further clarify the roles of systemic and local immune status in conization outcomes.

5. Conclusion

Using LASSO regression, we identified TCT grade, age, BMI, multiple HPV infection, and parity as independent predictors of positive margin in patients with CIN3 undergoing LEEP, and constructed a nomogram based on these variables. The model achieved a validation AUC of 0.80 with satisfactory calibration, and decision curve analysis demonstrated clinical net benefit within a range of threshold probabilities. Furthermore, although several systemic inflammatory markers such as SII and NLR showed significant differences in univariate analysis, none remained independent predictors after multivariable adjustment, suggesting that systemic inflammatory status may not be a major determinant of surgical margin in localized high-grade cervical lesions.

This was a single-center retrospective study, and future multicenter prospective studies are needed to validate the generalizability of the model. Nevertheless, the nomogram is easy to use, based on objective variables, and may assist in preoperative risk stratification and individualized surgical planning.

Declarations

Ethics approval and consent to participate: This retrospective observational study was approved by the Ethics Committee of Hubei Provincial Maternal and Child Health Hospital (approval number: 2026-177-01). The requirement for informed consent was waived by the Ethics Committee due to the retrospective nature of the study. All procedures were performed in accordance with the Declaration of Helsinki.

Consent for publication: Not applicable.

Availability of data and materials: The datasets generated and/or analysed during the current study are not publicly available due to patient privacy and institutional data protection policies, but are available from the corresponding author on reasonable request.

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Authors' contributions:

Jie Shi and Jing Liu contributed to the study conception and design. Material preparation and data collection were performed by Jing Liu, Fengying Wu, Qiang Deng, and Xiyan Ouyang. Data analysis was performed by Tingzhu Meng and Qianhui Ke. The first draft of the manuscript was written by Jing Liu and Yanli Li. Jie Shi, Han Gao, and Xiyan Ouyang commented on previous versions of the manuscript. Visualization was performed by Han Gao and Yanli Li. Supervision was performed by Jie Shi. All authors read and approved the final manuscript.

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Figures

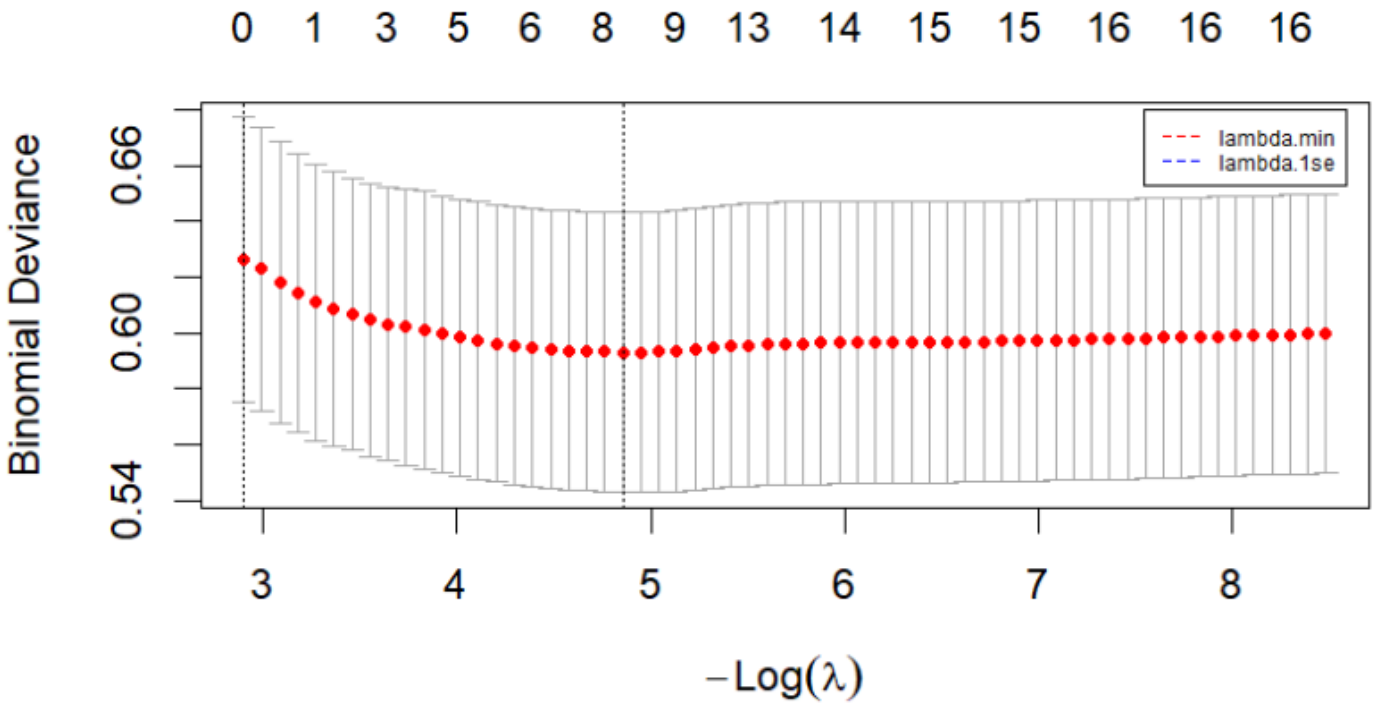


Figure 1

Multivariable logistic regression analysis of factors associated with positive surgical margin in CIN3 patients

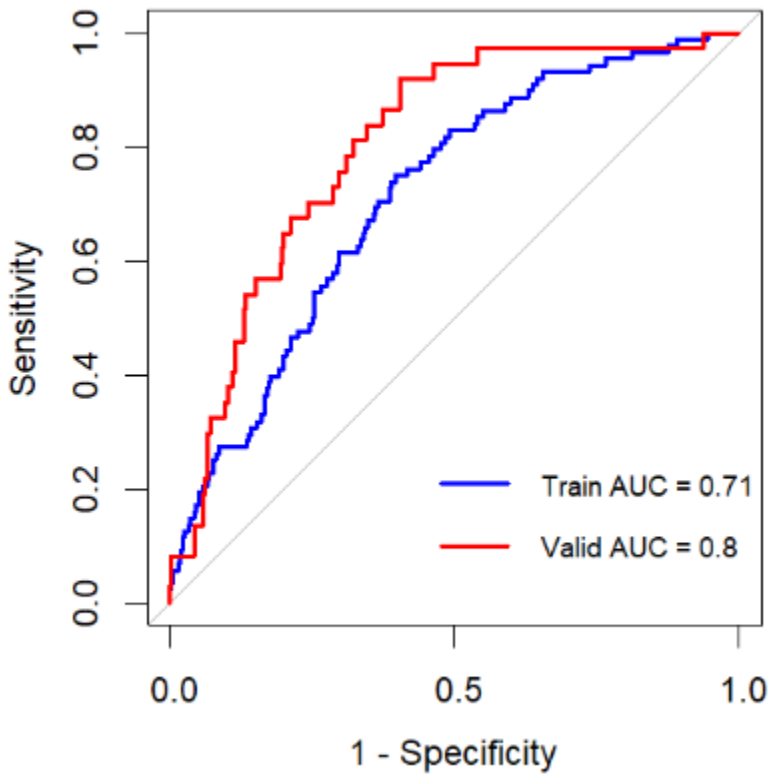


Figure 2

Receiver operating characteristic (ROC) curves for the prediction model in the training and validation sets.

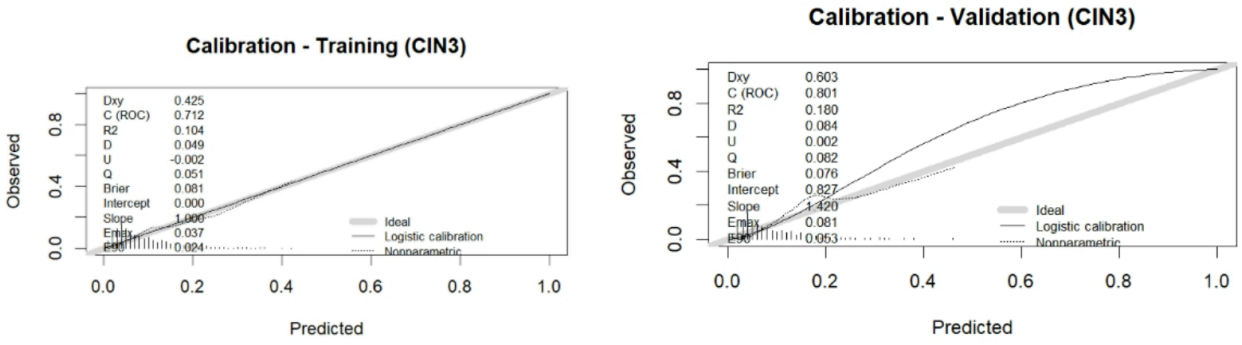


Figure 3

Calibration curves for the prediction model in the training and validation sets.

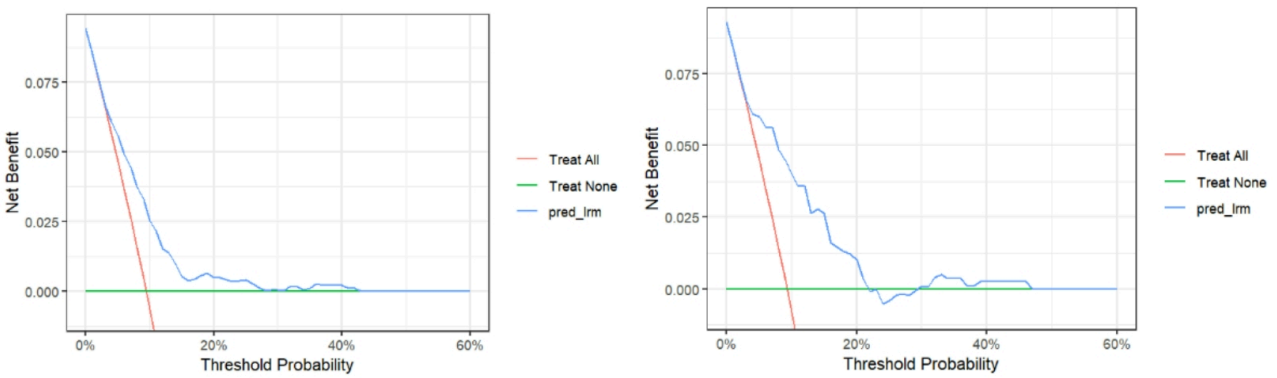


Figure 4

Decision curve analysis (DCA) for the prediction model in the training and validation sets.

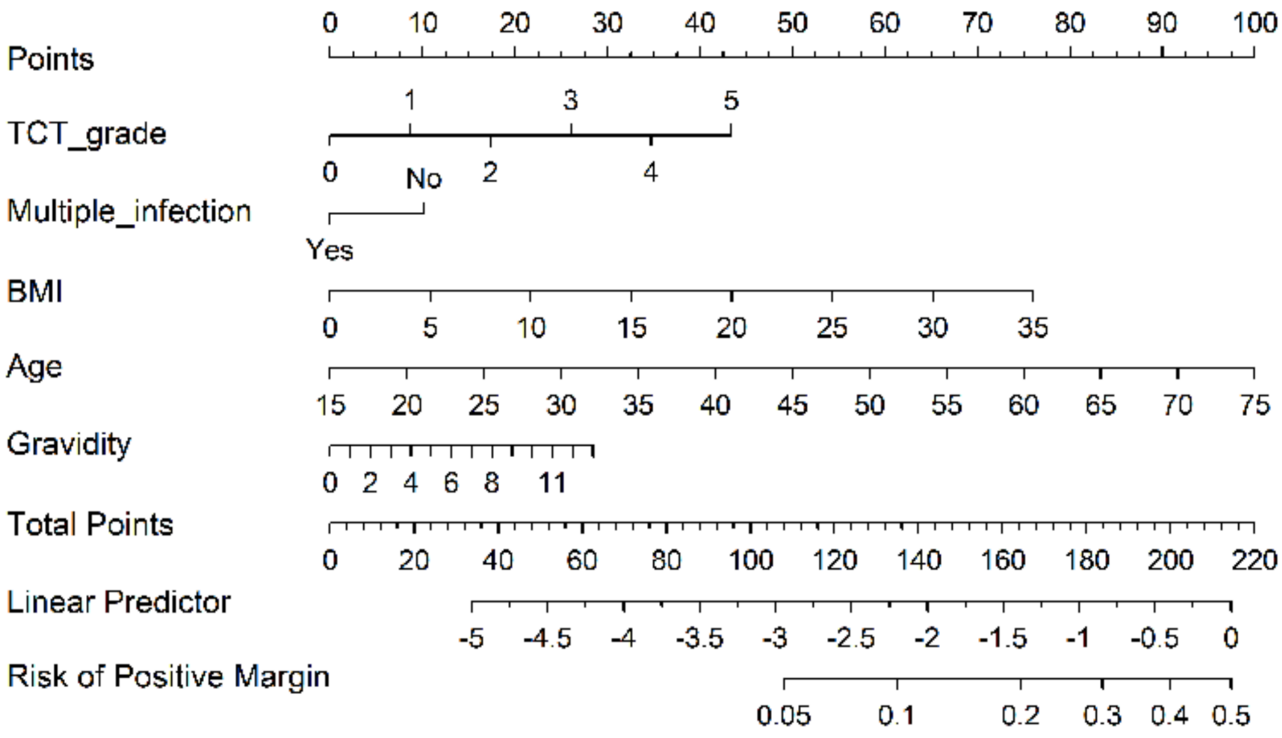


Figure 5

Nomogram for predicting the risk of positive surgical margin after LEEP in patients with CIN3.