

Establishment of a risk prediction model for conversion to cesarean delivery in multiparous women after a failed trial of labor

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Research Article

Keywords: Multiparous women, Conversion to cesarean delivery, Prediction model

Posted Date: October 22nd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10982458/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Multiparous women are often seen as low-risk, but some still need unplanned cesarean delivery after a failed trial of labor. This is more dangerous than planned cesarean. Known risk factors include older age, high body mass index, induced labor, and large baby, but there is no prediction tool just for multiparous women. A simple model could help find high-risk women and guide decisions.

Methods

We included 85 multiparous women who had cesarean after failed labor (case group) and 170 multiparous women with normal vaginal delivery (control group) at Suining Central Hospital from January 2019 to June 2025. We used t-tests, χ^2 -tests, and multivariate logistic regression to find independent risk factors. We built a prediction model and tested it with the ROC curve and Hosmer-Lemeshow test. We also drew a nomogram using R software.

Results

Seven factors were independently linked to cesarean after failed labor: interdelivery interval (OR = 1.154, 95% CI: 1.070–1.245, $p^* < 0.001$), body mass index at delivery (OR = 1.121, 95% CI: 1.021–1.231, $p^* = 0.017$), fetal head circumference (OR = 1.043, 95% CI: 1.003–1.084, $p^* = 0.035$), Induction of Labor (OR = 4.702, 95% CI: 2.377–9.303, $p^* < 0.001$), labor analgesia (OR = 2.519, 95% CI: 1.267–5.008, $p^* = 0.008$), intrapartum fever (OR = 4.725, 95% CI: 1.112–20.080, $p^* = 0.035$), and degree of amniotic fluid contamination (OR = 3.972, 95% CI: 1.850–8.529, $p^* < 0.001$). The model gave an ROC-AUC of 0.852 (95% CI: 0.802–0.902, $p^* < 0.001$). At the best cutoff of 42.35%, sensitivity was 70.6% and specificity 87.6%.

Conclusion

Our prediction model for cesarean after failed labor in multiparous women has good performance and high accuracy. It may help doctors choose delivery options and improve outcomes for mothers and babies.

Introduction

Although pregnancy and childbirth are physiological processes, cesarean delivery (CD) remains a critical intervention when maternal or fetal indications are present, particularly in cases of dystocia. In recent years, the global CD rate has shown a sustained upward trend ^[1], with an estimated 21.1% of deliveries

now by CD ^[2], and the proportion of intrapartum CD among all cesarean deliveries is increasing annually ^[3].

Compared with vaginal delivery, CD is associated with greater maternal risks, including postpartum hemorrhage, uterine rupture, pelvic adhesions, and a higher likelihood of subsequent preterm birth or stillbirth ^[4, 5]. The context of the delivery further modulates these risks: unplanned CD performed after a failed trial of labor carries a higher risk of severe maternal morbidity than planned pre-labor CD ^[6, 7], and CD performed in the second stage of labor is linked to higher complication rates than that performed in the first stage ^[8]. Consequently, improving the success rate of trial of labor and reducing the incidence of intrapartum conversion to CD represents a pressing clinical priority.

Current predictive models for intrapartum CD have largely been developed for specific populations, such as nulliparous women, those undergoing a trial of labor after cesarean (TOLAC), or patients with induced labor ^[9–11]. In contrast, data on parous women—those with a prior history of vaginal delivery—remain relatively limited. This population has traditionally been perceived as a low-risk group. However, evolving demographic trends, including changes in fertility policy, advancing maternal age, and rising parity, have contributed to a higher prevalence of pregnancy-related complications and comorbidities. These shifts may potentially elevate the risk of intrapartum CD even among parous women.

For a woman with a previous vaginal birth, a failed trial of labor culminating in an unplanned CD can lead to considerable psychological distress and disappointment, both for the patient and the care team. If clinicians could reliably predict which parous women are at increased risk of CD, individualized counseling might be offered—high-risk women could be considered for an elective procedure, while those at low risk could be reassured. Although risk factors for CD have been described, there is currently no established tool that integrates multiple factors to estimate the probability of intrapartum CD in this population.

To address this gap, our objective was to develop a predictive model for intrapartum CD in parous women with a history of vaginal delivery who are attempting a trial of labor. Using logistic regression analysis of retrospectively collected clinical data, we sought to identify key risk factors for a failed trial of labor. The resulting model is intended to assist clinicians in performing individualized risk assessment and optimizing delivery planning, with the ultimate goal of improving maternal and neonatal outcomes.

Materials and Methods

Study Population and Ethics Approval

This study was approved by the Ethics Committee of Suining Central Hospital (Approval Number: KYLLKS20250177). We analyzed the clinical data of singleton, full-term, cephalic presentation parturients who delivered in the obstetrics department of the hospital from January 2019 to June 2025.

A parturient was defined as a pregnant woman who had at least one prior vaginal delivery of a live-born infant.

Inclusion and Exclusion Criteria

Inclusion criteria were: singleton pregnancy, cephalic presentation, gestational age ≥ 37 weeks, and a history of at least one prior vaginal delivery of a live-born infant.

Exclusion criteria were: contraindications to vaginal delivery (such as complete placenta previa, clear cephalopelvic disproportion, severe medical or surgical comorbidities, etc.) or a history of previous cesarean section.

Grouping and Data Collection

According to the research objective, parturients who underwent cesarean delivery after a failed trial of labor were included in the case group (the conversion-to-cesarean group). Multiparous women who had a successful vaginal delivery after trial of labor during the same period were randomly selected at a 1:2 ratio as the control group (the vaginal delivery group).

Clinical data were collected from the hospital medical record system, including: age, gravidity, parity, interdelivery interval, body mass index (BMI) at delivery, gestational age, places of residence, education, bishop score of the cervix on admission, pregnancy with comorbidities and complications, induction of labor, premature rupture of membranes, degree of amniotic fluid contamination, intrapartum fever, postpartum hemorrhage, puerperal infection, fetal head circumference, fetal abdominal circumference, birth weight, infant sex, admission to the NICU.

Statistical Analysis

Statistical analysis was performed using SPSS 26.0 and R (version 4.0.4). Normally distributed continuous data are presented as mean $\pm$ standard deviation, and between-group comparisons were performed using the t-test; categorical data were compared using the χ^2 test. Variables showing statistical significance in univariate analysis were entered into a multivariable binary logistic regression model to identify independent risk factors for conversion to cesarean delivery. The final independent risk factors were then used in R with the rms package to construct a nomogram predicting the risk of conversion to cesarean delivery in multiparous women with a failed trial of labor. The receiver operating characteristic (ROC) curve was plotted and the area under the curve (AUC) was calculated to assess the model's discriminatory ability (AUC > 0.75 was considered to indicate good predictive performance). Model calibration (goodness of fit) was evaluated with the Hosmer-Lemeshow test, with $*p > 0.05$ indicating a good fit. All tests were two-sided, and $*p < 0.05$ was considered statistically significant.

Results

Characteristics of the Study Participants

From January 2019 to June 2025, a total of 255 multiparous women from the Obstetrics Department of Suining Central Hospital who met the inclusion criteria were enrolled. Among them, 85 women who underwent conversion to cesarean delivery due to a failed trial of labor were selected as the case group. Another 170 multiparous women who had a successful vaginal delivery after a trial of labor during the same period were randomly selected at a ratio of 1:2 as the control group.

Results of Univariate Analysis

Univariate analysis revealed statistically significant differences between the two groups in educational level, age, gravidity, parity, interdelivery interval, BMI at delivery, Bishop score, induction of labor, premature rupture of membranes, intrapartum fever, labor analgesia, degree of amniotic fluid contamination, fetal head circumference, fetal abdominal circumference, birth weight, postpartum hemorrhage, and puerperal infection (* $p < 0.05$). See Table 1 for details.

Table 1
Demographic, obstetric and neonatal characteristics

Characteristic	Vaginal delivery (n = 170)	Cesarean delivery (n = 85)	*p* value
Age (years), mean $\pm$ SD	31.04 $\pm$ 3.90	32.27 $\pm$ 4.11	0.020
Gravidity, median (P25–P75)	3 (2, 4)	3 (3, 4.5)	0.002
Parity, median (P25–P75)	1 (1, 1)	1 (1, 1)	0.030
Interdelivery interval (years), median (P25–P75)	4 (2, 8)	7 (5, 11)	< 0.001
BMI at delivery (kg/m ²), median (P25–P75)	26.61 (24.84, 28.53)	28.23 (25.94, 31.04)	< 0.001
Gestational age (days), median (P25–P75)	276 (271, 281)	278 (273.5, 283)	0.090
Residence, n (%)			0.278
Rural	64 (37.6)	38 (44.7)	
Urban	106 (62.4)	47 (55.3)	
Education, n (%)			0.008
High school degree or less	61 (35.9)	41 (48.2)	
Some college or technical school	26 (15.3)	19 (22.4)	
College grad or higher	83 (48.8)	25 (29.4)	
Bishop score of the cervix on admission (score), median (P25–P75)	3 (2, 4)	3 (2, 4)	< 0.001
Pregnancy comorbidities and complications*, n (%)	89 (52.4)	53 (62.4)	0.130
Induction of labor, n (%)	45 (26.5)	56 (65.9)	< 0.001
PROM**, n (%)	34 (20.0)	28 (32.9)	0.023
Degree of amniotic fluid contamination***, n (%)			< 0.001
Clear	143 (84.1)	52 (61.2)	
Meconium/Blood-stained	27 (15.9)	33 (38.8)	
Labor analgesia, n (%)	77 (45.3)	64 (75.3)	< 0.001
Intrapartum fever, n (%)	4 (2.4)	12 (14.1)	< 0.001
Postpartum hemorrhage, median (P25–P75)	357.5 (300, 395)	530 (465, 647.5)	< 0.001
Puerperal infection, n (%)	1 (0.6)	11 (12.9)	< 0.001

Characteristic	Vaginal delivery (n = 170)	Cesarean delivery (n = 85)	*p* value
Fetal head circumference (cm), mean $\pm$ SD	329.80 $\pm$ 9.008	334.41 $\pm$ 8.883	< 0.001
Fetal abdominal circumference (cm), mean $\pm$ SD	337.94 $\pm$ 14.378	345.32 $\pm$ 13.032	< 0.001
Birth weight (g), mean $\pm$ SD	3296.71 $\pm$ 378.91	3476.00 $\pm$ 366.30	< 0.001
NICU, n (%)			0.085
Male	97 (57.1)	58 (68.2)	
Female	73 (42.9)	27 (31.8)	
Admission to the NICU, n (%)	1 (0.6)	2 (2.4)	0.258

*Pregnancy comorbidities and complications, hypertensive disorders of pregnancy, gestational diabetes mellitus, intrahepatic cholestasis of pregnancy, oligohydramnios, and others.

**PROM, Premature rupture of membranes.

***Degree of amniotic fluid contamination, clear, grade I/II/III, blood-stained amniotic fluid.

Considering that this study aimed to build a predictive model, birth weight, postpartum hemorrhage, and puerperal infection, as indicators of postpartum outcomes, were excluded from the final model. Additionally, some statistically significant variables in the univariate analysis showed collinearity (e.g., premature rupture of membranes and degree of amniotic fluid contamination were highly correlated). After discussion among the research team, 10 variables were finally entered into the multivariate binary logistic regression analysis: age, interdelivery interval, Bishop score, BMI at delivery, induction of labor, labor analgesia, intrapartum fever, fetal head circumference, fetal abdominal circumference, and degree of amniotic fluid contamination.

Multivariate Logistic Regression Analysis

Multivariate analysis showed that interdelivery interval, BMI at delivery, induction of labor, fetal head circumference, intrapartum fever, labor analgesia, and degree of amniotic fluid contamination were independent risk factors for conversion to cesarean delivery during a failed trial of labor in multiparous women (*p* < 0.05), as shown in Table 2.

Table 2
Results of binary logistic regression analysis for the risk of CD

Variable	β	OR	95%CI	*p* value
Interdelivery interval (years)	0.144	1.154	1.07–1.245	<0.001
BMI at delivery (kg/m ²)	0.114	1.121	1.021–1.231	0.017
Fetal head circumference (cm)	0.042	1.043	1.003–1.084	0.035
Induction of labor	1.548	4.702	2.377–9.303	<0.001
Labor analgesia	0.924	2.519	1.267–5.008	0.008
Intrapartum fever	1.553	4.725	1.112–20.08	0.035
Degree of amniotic fluid contamination	1.379	3.972	1.85–8.529	<0.001
Model performance				
AUC(95%CI)		0.852	0.802–0.902	<0.001

Establishment and Evaluation of the Nomogram Prediction Model

The seven independent risk factors identified above were incorporated into R software (version 4.0.4). The "rms" package was used to construct a prediction model, and a nomogram was drawn (Fig. 1).

IDI, interdelivery interval, BMI, body mass index, FHC, fetal head circumference, IOL, induction of labor, LA, labor analgesia, IF, intrapartum fever, DOAFC, degree of amniotic fluid contamination.

The total score was obtained by summing the scores of each factor; a higher total score indicates a greater risk of conversion to cesarean delivery. The discriminative ability of the model was evaluated using the receiver operating characteristic (ROC) curve. The area under the curve (AUC) was 0.852 (95% CI: 0.802–0.902, *p* < 0.001), indicating good predictive performance (Fig. 2).

The Hosmer-Lemeshow goodness-of-fit test yielded *p* = 0.120, suggesting that the predicted values of the nomogram model were well-fitted to the actual observed values, with ideal calibration (Fig. 3).

Discussion

Analysis of Factors Affecting Cesarean Delivery

In this study, based on maternal, fetal, and delivery-related factors, we constructed a simplified risk prediction model for intrapartum conversion to CD applicable to multiparous women. The model

ultimately included seven predictors: interdelivery interval, BMI at delivery, induction of labor, fetal head circumference, intrapartum fever, labor analgesia, and degree of amniotic fluid contamination. The model demonstrated good discrimination and calibration, suggesting its potential value in clinical practice for identifying multiparas at elevated risk for CD, thereby aiding efforts to increase the success rate of vaginal trial of labor in this population.

This study found that the interdelivery interval was an independent risk factor for CD in multiparous women (OR = 1.154, 95% CI: 1.070–1.245, $p^* < 0.001$). That is, for each additional year of interdelivery interval, the risk of CD increased approximately 1.154-fold. Studies by Shachar et al. ^[12] and Zhu et al. ^[13] also suggest that a longer interdelivery interval is associated with an increased risk of dystocia and preeclampsia. The underlying mechanism may be that an excessively long interval causes the physiological states of the uterine muscle layer and the cervix to revert toward a nulliparous pattern. The pattern of labor initiation and progression thus becomes more similar to that of primiparas, rendering the woman more susceptible to labor arrest and ultimately leading to a failed trial of labor.

Induction of labor was also identified as an independent risk factor. Women who underwent induction of labor had a significantly higher risk of failed trial of labor compared to those who experienced spontaneous labor. This finding is consistent with reports by Wolfe et al. ^[14] and Ehrenthal et al. ^[15], but is contrary to the conclusion of Middleton et al. ^[16] that induction of labor might reduce the rate of CD for full-term pregnancies. Possible reasons for this discrepancy include: insufficient cervical ripening leading to a poor response to induction agents or mechanical dilation, resulting in slow cervical dilation and abnormal labor progression; the more painful, stronger, and less coordinated contractions induced by oxytocin compared with natural labor, which may increase maternal distress and anxiety, making it more likely for the parturient to abandon the trial of labor; additionally, medical indications for induction in this study population, such as gestational diabetes mellitus or hypertensive disorders, may themselves further increase the risk of CD.

High BMI at delivery was also shown to be an independent risk factor for CD, consistent with most previous studies ^[17, 18]. Although multiparas are generally considered to have a higher success rate of vaginal delivery, the physiological burden of obesity may counteract this advantage in multiparous women. Therefore, weight management during pregnancy, a balanced diet, and moderate exercise remain effective measures for reducing the risk of conversion to CD globally.

Consistent with the findings of Amini et al. ^[19], fetal head circumference was identified as an independent risk factor for failed trial of labor (OR = 1.043, 95% CI: 1.003–1.084, $p^* = 0.035$). For every 1 cm increase in head circumference, the risk increased approximately 1.043-fold. The mechanism is mainly related to cephalopelvic disproportion. Research has shown that fetal head circumference is a reliable ultrasound indicator for diagnosing cephalopelvic disproportion ^[20, 21]. Because in multiparous women, the fetal head typically engages only after the onset of labor, a larger head circumference is more likely to cause obstruction during descent and inadequate flexion, leading to prolonged or arrested labor and ultimately failed trial of labor ^[22]. Furthermore, intrapartum fever, labor analgesia, and the

degree of amniotic fluid contamination were identified as independent risk factors. Labor analgesia may increase the risk of intrapartum fever by interfering with maternal thermoregulation^[23]. Fever, in turn, can lead to weaker uterine contractions, slow labor progress, fetal tachycardia, and a fetal inflammatory response^[24], which further increases fetal oxygen consumption, alters placental perfusion, stimulates the fetal bowel, and results in meconium-stained amniotic fluid^[25]. These events may culminate in labor arrest or fetal distress, thereby precipitating an emergency CD^[25, 26]. Therefore, early recognition and intervention for any of these factors during labor may help reduce the rate of CD.

Comparison with Other Models

Our prediction model specifically targets multiparous women with a prior vaginal delivery, distinguishing it from existing models for nulliparous or TOLAC populations. By using easily obtainable clinical variables and a nomogram format, it offers practical bedside utility. However, it is not intended to replace clinical judgment for primary CD based solely on these tools. Rather, it should serve as a supplement for risk communication and as an auxiliary aid for individualized counseling and shared decision-making.

Conclusion

The predictive model for cesarean delivery after a failed trial of labor in multiparous women, constructed based on the identified independent risk factors, demonstrates good predictive performance and accuracy. It can provide valuable reference for clinicians, thereby helping to optimize delivery decisions and improve maternal and neonatal outcomes.

Strengths and Weaknesses

The strengths of this study include its novel focus on multiparous women without a prior cesarean delivery, a population for which prediction tools are lacking, as well as the use of readily available clinical predictors, good model performance with an AUC of 0.852 and adequate calibration, and the strict exclusion of prior cesarean delivery to avoid confounding by uterine scar. However, several limitations should be noted: the retrospective single-center design carries inherent risks of selection and information bias; the small sample size and lack of external validation may lead to overfitting and limit generalizability; and the absence of decision curve analysis precludes evaluation of the model's net clinical benefit across different risk thresholds.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Suining Central Hospital (Approval Number: KYLLKS20250177, date of approval: 24 September 2025). The study involved retrospective analysis of medical records from patients who delivered between January 2019 and June 2025. All data were fully anonymized and de-identified prior to analysis, and the research posed no more than minimal risk to participants. Therefore,

the Ethics Committee of Suining Central Hospital waived the requirement for informed consent from individual patients. Patient confidentiality was strictly protected throughout the study, and no identifiable personal information was included in the manuscript.

Consent for publication

Not applicable. This manuscript contains no individual person's data in any form (including individual details, images, or videos).

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy protection policies of Suining Central Hospital, but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Authors' contributions

Feng Man: project development, data collection, manuscript writing; Jin-yin Fan: data collection and curation, formal analysis, figure preparation; Yan-qing Liu: conceptualization, methodology, supervision, project administration; Fan Teng and Yong-yi Lei: manuscript writing. All authors read and approved the final manuscript.

Acknowledgements

We thank the medical staff of the Department of Obstetrics, Suining Central Hospital, for their assistance in data collection. We also appreciate the support from the hospital's medical records department for providing access to patient data.

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Figures

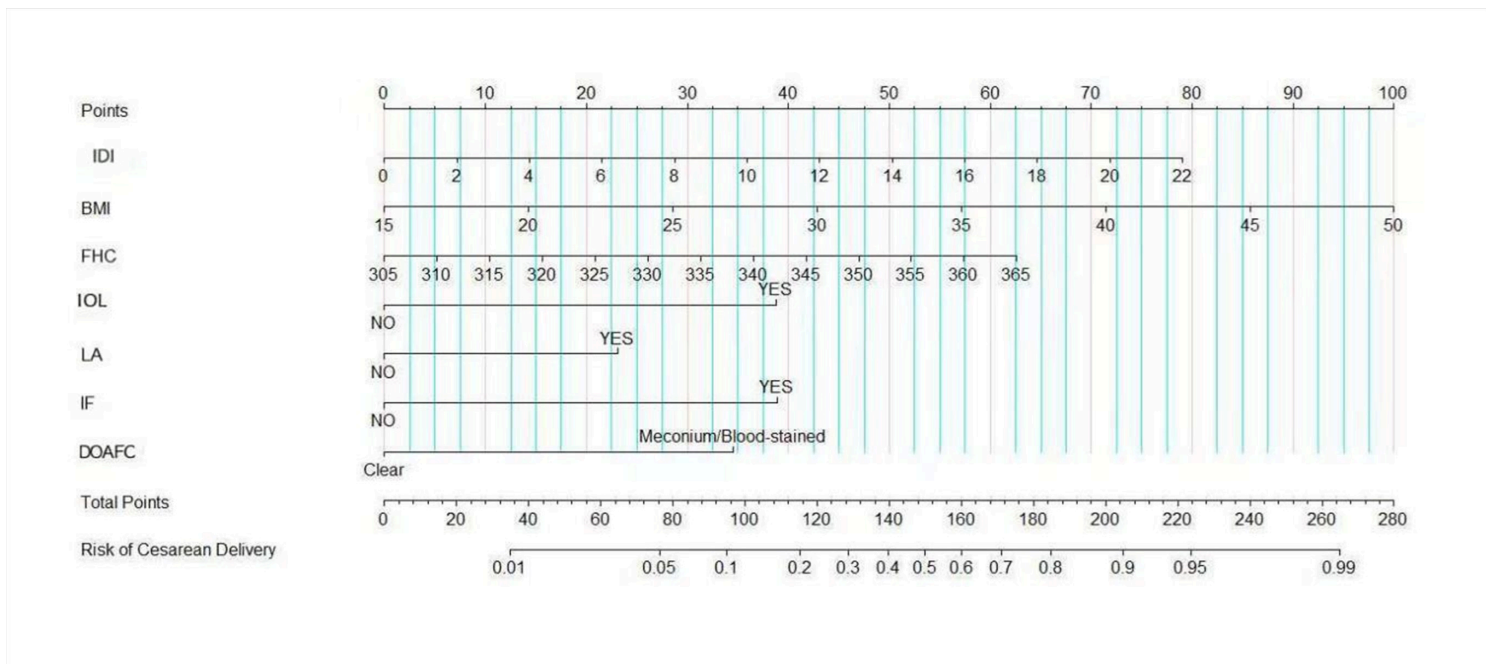


Figure 1

Cesarean delivery risk assessment tool

IDI, interdelivery interval, BMI, body mass index, FHC, fetal head circumference, IOL, induction of labor, LA, labor analgesia, IF, intrapartum fever, DOAFC, degree of amniotic fluid contamination.

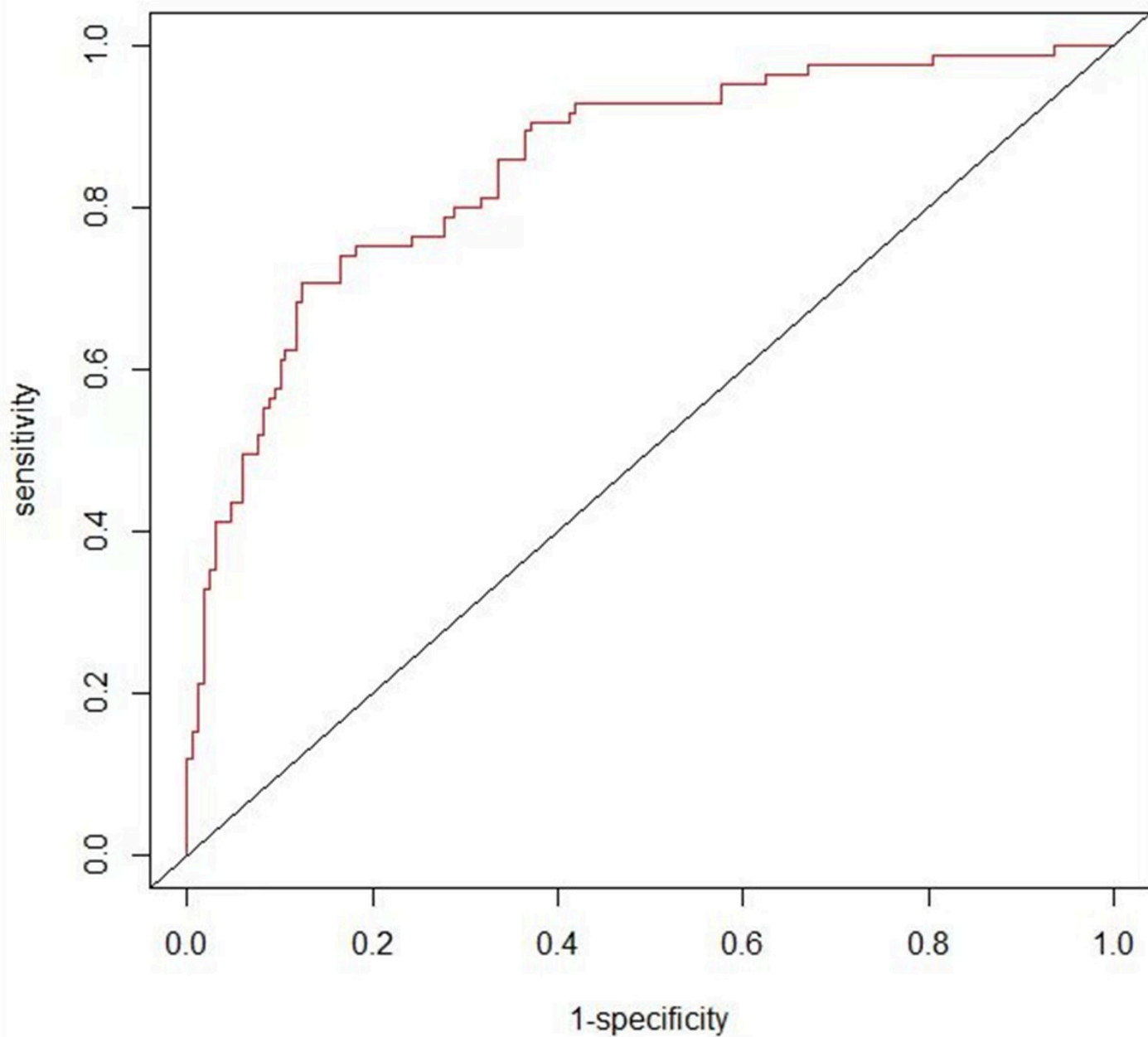


Figure 2

ROC curve of the model of nomogram graph prediction

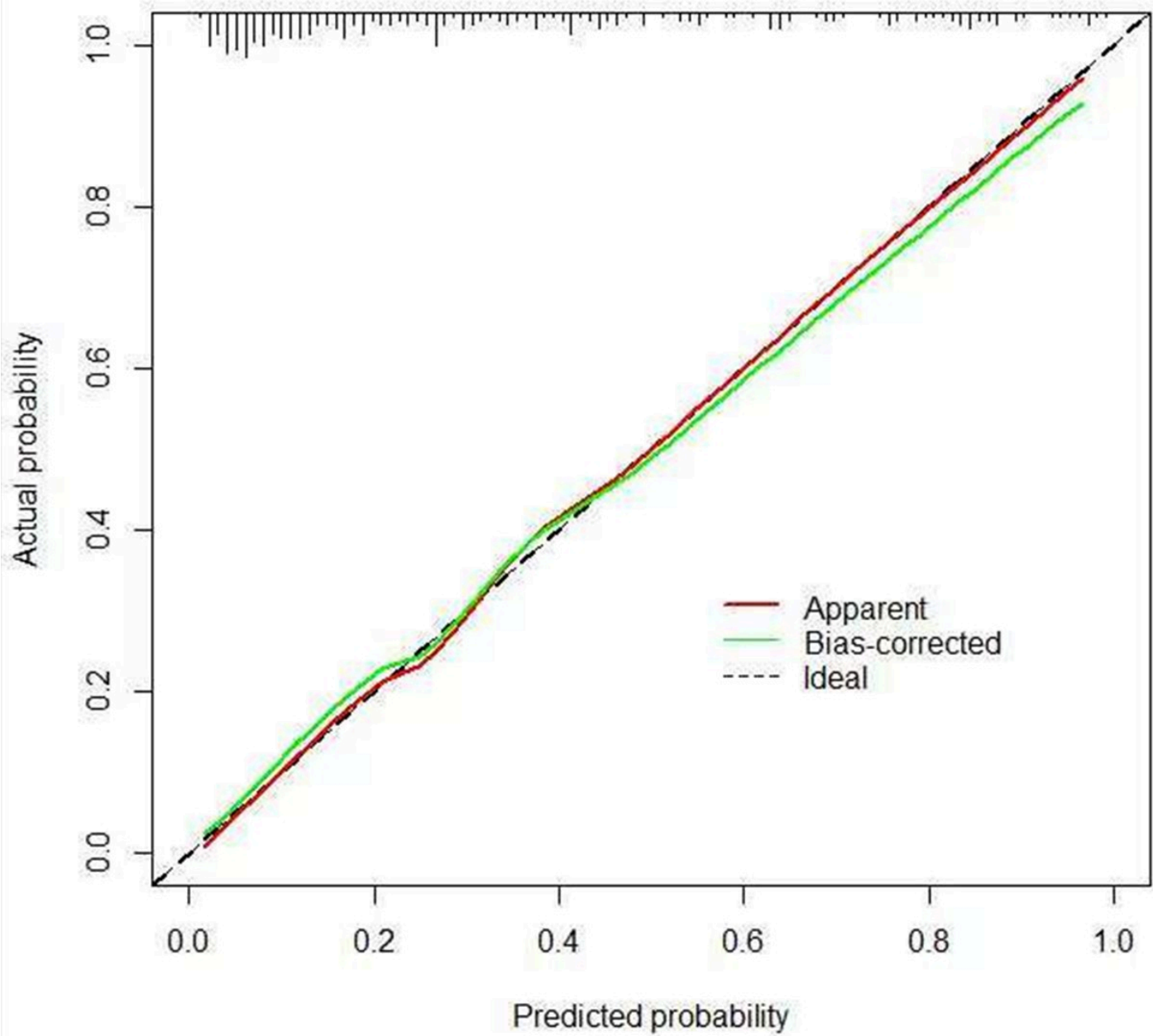


Figure 3

Calibration curve of nomogram prediction model