Nomogram to predict the risk of preterm birth before 37 weeks and 34 weeks in pregnant women with a short cervix: a retrospective cohort study

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Abstract

Objectives To investigate predictors of preterm birth (PTB) in pregnancies with a short cervix and to create prediction models. Design Retrospective cohort study. Method Logistic regression model was used to identify predictors of PTB. The predictors were used to establish nomogram, which were validated using receiver operating characteristic (ROC) curve and calibration curve. Main outcome measures Preterm birth. Results Overweight or obesity (OR:2.00, 95% CI:1.114-3.51; OR:2.59, 95% CI:1.20-5.60), frequency of pregnancy [?] 3 times (OR:1.97, 95% CI:1.14-3.40), twin pregnancy (OR:4.52, 95% CI:2.40-8.51), in vitro fertilization and embryo transfer (IVF-ET) (OR:2.24, 95% CI:1.19-4.19), gestational age at first diagnosis of short cervix (1st short cervix) (OR:0.953, 95% CI:0.910-0.999), cervical length (CL) at diagnosis of 1st short cervix (OR:0.908, 95% CI:0.86-0.96), history of PTB (OR:7.77, 95% CI:2.47-24.41), and autoimmune disease (OR:10.70, 95% CI:1.87-61.26) were predictors of PTB $<$ 37 weeks, while twin pregnancy, gestational age of 1st short cervix, CL of 1st short cervix, history of PTB, and prepregnancy hypertension were predictors of PTB $<$ 34 weeks. The area under the ROC curve (AUC) of the nomogram predicting PTB $<$ 37 weeks and PTB $<$ 34 weeks were 0.803 and 0.771, respectively. Both models showed good discrimination. Conclusions Gestational age of 1st short cervix, CL of 1st short cervix and other factors are strong predictors of PTB in pregnancies with a short cervix. Nomogram showed good discrimination and calibration, and hence might be effective in predicting risk of PTB for pregnancies with a short cervix. Keywords nomogram; preterm birth; risk factors; short cervix

Introduction

Preterm birth (PTB) is one of the most important causes of perinatal morbidity and mortality[1], occurring in 7-11% of all deliveries[2]. Despite its high prevalence, there are no accurate prediction models to identify women at high-risk for PTB, partly due to the multifactorial etiology of PTB[3].

Cervical length (CL) has been historically linked to PTB. Ultrasound is the most commonly used tool to assess CL for early detection of PTB[4]. Occurrence of a short cervix in the second trimester, frequently detected using transvaginal ultrasonography (TVS), was found to be a strong predictor of preterm birth[5,6]. A universal mid-trimester transvaginal cervical length screening tool may reduce the risk of preterm birth[7]. So far, whether CL values in the first trimester can predict PTB is controversial [8,9]. In addition to CL, several other factors have been found to modify the risk of preterm birth, such as smoking and prepregnancy body mass idex[10,11]. Over the years, nomograms have become indispensable tools in clinical decision making. Therefore, we reasoned that the risk factors of PTB can be used to establish a prediction model to guide obstetricians in identifying patients at risk of PTB.

Thus, we searched for potential predictors of PTB < 37 weeks and 34 weeks in pregnant women with a short cervix and used these factors to establish nomograms.

Methods

Study design and selection of participants

We retrospectively analyzed data of a cohort of pregnant women with a short cervix. All women had their delivery at Peking University First Hospital in Beijing, China, from January 1, 2017 to January 1, 2018. In our center, the pregnancies underwent transvaginal ultrasonography throughout the gestational period and the cervical length is routinely measured. A short cervix was defined as cervical length < 25mm under transvaginal ultrasonography. In women showing signs of miscarriage such as bleeding and contraction, we also recommended transvaginal ultrasonography. Patients with triple gestations, who underwent induced abortions due to personal reasons and patients whose short cervix was first detected after 36 weeks were excluded from this study. Women had received a preventive cervical ligation treatment were also excluded from this study. In the analysis of PTB < 34 weeks, pregnancies whose short cervix was first detected after 33 weeks were excluded.**(Figure 1)** The sonographers who performed the scans were extensively trained and passed a practical examination administered by an expert organization of Beijing.

Variables of interest

We scrutinized the sonographic reports in the electronic database of the hospital to identify patients with a short cervix. The relevant information was then collected from the electronic medical records using their hospital identity of each patient. Throughout the study period, no significant changes was made to the electronic medical database.

We collected the demographic characteristics, obstetric data, risk history, and preexisting comorbidities. The demographic characteristics included were: maternal age at conception and body mass index (BMI) before pregnancy. For robust clinical assessment, BMI was classified into "normal" (18.5[?] BMI [?]23.9kg/m^2), "overweight" (24[?] BMI [?]27.9kg/m^2) and "obesity" (BMI [?]28kg/m^2) groups[12]. None of the women was a smoker or drinker, thus lifestyle factors (e.g., smoking and drinking) were not analyzed in this study. In the obstetrics data, gestational age at diagnosis of short cervix, cervical length and amniotic fluid sludge were collected when the patient's short cervix was first detected. Risk history was defined as having a previous short cervical length or PTB (e.g., induced abortion, intrauterine operation frequency (except abortion) and history of preterm birth). Autoimmune diseases included in the preexisting comorbidities was defined as systemic lupus erythematosus (SLE) or antiphospholipid syndrome (APS) that was found to be related to PTB[13]. To explore the relationship between some pregnancy complications and PTB among participants, we collected data such as polyhydramnios, gestational diabetes mellitus, and blood pressure state.

Statistical analysis

Descriptive data are presented as the mean ± SD or as a frequency. Categorical variables were analyzed using χ^2 or Fisher's exact probability tests as appropriate. Continuous variables were analyzed using the Mann-Whitney U test (because the distribution of the continuous variables included in this study was not normal).

Baseline variables that were considered clinically relevant or candidate variables with a p-value <0.1 in univariate analysis model were included in the multivariate binary logistic regression analysis. The variables included in the multivariate analysis were strictly chosen and assigned the number of events available to optimize the parsimony of the final model. In addition, these variables were subjected to linear regression for collinearity analysis before multivariate regression analysis. Variables with tolerance was < 0.1 or variance inflation factor (VIF) > 10 were excluded from the multivariate binary logistic regression analysis. The goodness-of-fit test for the regression model was performed using the Hosmer-Lemeshow test and the Omnibus test.

The forward LR selection process was used to perform final model selection for the nomogram using a

threshold of p<0.05. At this stage, factors that lacked clinical significance were excluded from the model. The receiver operating characteristic (ROC) curve was used to assess the discriminative power of the nomogram based on the cut-off value and the area under the curve (AUC). It is generally accepted that an AUC of 1.0 indicates perfect accuracy, an AUC of 0.7–0.8 indicates satisfactory discrimination, AUC values > 0.8 represent good discrimination and AUC of 0.5 indicates no relationship[14]. A calibration curve was plotted to evaluate the agreement between the actual results and the predicted values of PTB. A diagonal line of 45 degrees reflects that the model is robust. The nomogram was validated internally using relatively unbiased estimates (1000 repetitions) obtained by the bootstrapping method. The bootstrapping technique is a resampling approach used to randomly draw data and replace them with samples from the original dataset. The nomogram was calibrated by the Hosmer-Lemeshow test of the logistics regression model mentioned above. All statistical analyses were 2-tailed and p values<0.05 were statistically significant. The R Studio V.3.4.1 was used to establish the nomogram and ROC curve. Other analyses were performed using SPSS V.23.0.

Results

Population characteristics

Among pregnant women enrolled in this study, data of 555 women with a short cervix were used to analyze the risk factors of PTB < 37 weeks and 538 were used to identify the predictors of PTB < 34 weeks.**(Figure 1)** Overall, 187/555 (33.7%) women had PTB < 37 weeks and 91/538 (16.9%) patients had PTB < 34 weeks. The gestational age of short cervix at the first time ranged from 11 to 35 weeks among patients who had PTB < 37 weeks and from 11 to 33 weeks among patients who had PTB < 34 weeks.

(Table 1)

Risk factors of preterm birth

In the univariate analysis, candidate variables with p-value < 0.1 **(Table 1)** were included in the multivariate binary logistic regression analysis. Overweight or obesity (OR:2.00, 95% CI:1.114-3.51 and OR:2.59, 95% CI:1.20-5.60, respectively), frequency of pregnancy [?]3 times (OR: 1.97, 95% CI:1.14-3.40), twin pregnancy (OR:4.52, 95% CI:2.40-8.51), IVF-ET(OR:2.24, 95% CI:1.19-4.19), gestational age of 1st short cervix (OR:0.953, 95% CI:0.910-0.999), cervical length (CL) of 1st short cervix (OR:0.908, 95% CI:0.86-0.96), history of preterm birth (OR:7.77, 95% CI:2.47-24.41), and autoimmune disease (OR:10.70, 95% CI:1.87-61.26) were found to be significant predictors of PTB < 37 weeks. Twin pregnancy (OR:3.08, 95% CI:1.80-5.29), gestational age of 1st short cervix (OR:0.90, 95% CI:0.86-0.94), CL of 1st short cervix (OR:0.88, 95% CI:0.84-0.93), history of preterm birth (OR:5.94, 95% CI:1.99-17.76), and prepregnancy hypertension (OR:4.66, 95% CI:1.75-12.45)were identified as significant predictors of PTB < 34 weeks. The results of the Hosmer-Lemeshow test were p=0.115 (χ2=12.92, df=8) and p=0.225 (χ2=9.048, df=8), respectively; and those of Omnibus test were p<0.001 (χ2=125.11, df=9) and p<0.001 (χ2=77.18, df=5), respectively, indicating good fit for the logistic regression models of PTB < 37 weeks and PTB < 34 weeks.

(Figure 2)

Nomogram for predicting PTB

The regression coefficients (B) from the multivariate analysis were used to construct models to estimate the risk of PTB. The scoring model of PTB < 37 weeks was as follows: 1.471+0.692*(BMI before pregnancy=1) +0.953*(BMI before pregnancy=2) +2.370*(autoimmune disease=1) +2.050*(History of PTB=1) +0.677*(Twin pregnancy=1) +0.804*(IVF-ET=1)-0.048*Gestational age of 1st short cervix-0.097*CL of 1st short cervix. **(Figure 3A)** The scoring model of PTB < 34 weeks was as follows: 3.072+1.781*(History of PTB=1) +1.125*(Twin pregnancy=1) +1.539*(Prepregancy hypertension=1) -1.103*Gestational age of 1st short cervix-0.125*CL of 1stshort cervix. **(Figure 3B)**

Validation of the nomogram

The discrimination power of the nomogram was determined using the ROC curve. Notably, the AUC value of the model of PTB < 37 weeks was 0.803 (95% CI 0.760–0.847), indicating good discrimination. This model showed a cut-off score of 0.389 with a sensitivity of 65.8% and a specificity of 84.0%. The AUC of the model of PTB < 34 weeks was 0.771 (95% CI 0.717–0.826), implying satisfactory discrimination. The cut-off score of this model was 0.227 with a sensitivity of 62.2% and a specificity of 83.4%.

(Figure 4A)

The calibration of the nomogram was measured by the bootstrap (1000 resample) method. Analysis of the results showed that the predicted probability obtained from the bootstrap correction was not significantly different with the actual probabilities of preterm birth (p = 0.015 and p=0.013, respectively), implying that the nomograms predicting PTB < 37 weeks and PTB < 34 weeks were well-calibrated.

(Figure 4B and Figure 4C)

Comment

Main Findings

In pregnant women with a short cervix in this study, variables identified as predictors of PTB <37 weeks included overweight or obesity, frequency of pregnancy ([?]3 times), twin pregnancy, IVF-ET, gestational age of at first diagnosis of short cervix (1^{st} short cervix), gestational age of at first diagnosis of short cervix (1^{st} short cervix), history of PTB, and autoimmune disease. On the other hand, twin pregnancy, gestational age of 1^{st} short cervix, CL of 1^{st} short cervix, history of PTB, and prepregnancy hypertension were identified as predictors of PTB < 34 weeks. Nomogram of PTB < 37 weeks and PTB < 34 weeks showed good discrimination and agreement, thus can be used in obstetrics to identify patient at risk of PTB, especially those first diagnosed with a short cervix.

Strengths and Limitations

This study was the first to establish nomogram for predicting PTB in patients with a short cervix. We describe predictors of PTB and their associated relationships. The key limitation of this study was that the sample size was not large. This could have affected the power of the effects observed. Although only 12 pregnancies was not clinically-indicated preterm births, the primary outcome of the study is PTB which could be classified into different subtypes according to clinical presentation including spontaneous preterm and clinically-indicated preterm births.

Interpretation

In this study, a total of 555 pregnant women had a short cervix. About 6000 deliveries are recorded yearly in our hospital with a short cervix incidence of about 9.3%. A previous study conducted in our hospital between May 2010 and May 2015 found that the incidence of short cervix was 0.45% for a gestation period of 20 and 24 weeks[15]. It is possible that a variation in the number of subjects studied is responsible for the large difference in the recorded incidence. In the current study, we included patients with a short cervix found at 11-35 weeks of gestation. To minimize severe complications of preterm birth, programs that promote early detection of this condition are often implemented in our hospital. Among such programs, transabdominal ultrasonography is the use to measure the cervical length for pregnant women who agree to undergo antenatal ultrasound examination. Subjects with a cervical length of less than 25mm as well as those that showing signs of miscarriage including bleeding and contraction were subjected to transvaginal ultrasonography for a more accurate assessment. We observed that, among women with a short cervix, BMI before pregnancy was related to PTB. In addition, women who were obese or overweight before pregnancy were at higher risk of PTB compared to those with normal BMI, which is consistent with previous studies[10,16,17]. Of note, we found that autoimmune disease (SLE and APS) increased the risk of PTB < 37 weeks[13]. However, PCOS and hypothyroidism previously associated with PTB were not significantly correlated with occurrence of PTB[18,19]. In the current study, prepregnancy hypertension was associated with PTB < 34 weeks but not PTB < 37 weeks. Analysis of other complications including polyhydramnios, gestational diabetes mellitus

and blood pressure state, showed that they were not significant risk factors of PTB among patients with a short cervix **(Table 1)** . These findings were differed from those reported in a previous two-year retrospective study. This may be due to the fact that the population used in the latter included general pregnant women[16]. This further indicates that patient's baseline information can be used to establish a prediction model for PTB. Among the factors defined in the risk history variable, only PTB was a significant predictor and this is in agreement with a previous report[17]. It is should be noted that induced abortion has also been reported as a risk factor for PTB[20]. We reasoned that the majority of patients (73.0%) in this study were primipara, and this may explain the discrepancy. Moreover, all patients in this study had a short cervix, unlike in other studies. We further observed that LEEP did not increase the risk of PTB in line with what has previously been reported[21]. However, a previous meta-analysis found that LEEP is a risk factor for PTB (<32/34, <28 weeks) [22]. Numerous studies have demonstrated a relationship between HPV infection and PTB[23]. In the current study, however, this could not be clarified owing to the small data collected. Analysis of obstetric data showed that in the 65% of patients that underwent IVF-ET, no collinearity was observed between twin pregnancy and IVF-ET. This suggested that twin pregnancy and IVF-ET are both independent predictors of PTB $<$ 37 weeks among patients with a short cervix. However, IVF-ET was not a predictor of PTB $<$ 34 weeks. In this study, parity was not a risk factor of PTB, and its relationship with PTB is still unclear, and hence requires a more systematic assessment in the future[17,24].

Cervical length (CL) detected by ultrasound is one of the most commonly used parameters for early detection of PTB[4]. In the current study, we analyzed the relationship between CL, gestational age, amniotic fluid sludge and overall PTB. We found that the risk of PTB ($<$ 37 weeks or $<$ 34 weeks) increased with decline in CL and with the gestational age at 1st diagnosis of short cervix, however sludge was not a predictor of PTB. Previous works have focused on CL measurements in the second trimester of pregnancy with a short cervix during this period found to be significantly associated with PTB[6]. However, prediction potential of CL in the first or third trimester of pregnancy remains unclear[25]. Because a high rate of short cervix ($<$ 25mm) occurring at 36 weeks of gestation and the low rate of short cervix at 16 weeks of gestation[26], we included pregnancies with a short cervix at first and third trimesters. Considering severe complications of preterm birth, we estimated the risk of PTB at first and third trimesters. Our results showed that CL during this period was a significant predictor of PTB. Particularly, we observed a low and high risk of preterm at third and first trimesters, respectively. This could be due to; (i) the population with a short cervix screened under this study was at high risk of PTB, in which PTB $<$ 37 weeks was 33.7% and PTB $<$ 34 weeks was 16.9%, (ii) a combination of factors including CL and other factors such as gestation age played an important role in the prediction of PTB[16]. This is in line with a previous study that implicated a decrease in CL and the gestational age as a risk factor of PTB $<$ 35 weeks[27].In our study, the predictors of PTB $<$ 37 weeks and PTB $<$ 34 weeks were not consistent. Notably, PTB $<$ 37 weeks was influenced by more factors than PTB $<$ 34 weeks. It was also evident that CL and gestational age of 1st short cervix were both significant predictors of PTB $<$ 37 weeks and PTB $<$ 34 weeks.

In the current study, patients were diagnosed with a short cervix (CL [?] 25mm) using transvaginal ultrasonography (TVCL). An obstetrician was able to assess a patient's risk of PTB $<$ 37 weeks or PTB $<$ 34 weeks using nomograms based on her BMI before pregnancy, autoimmune disease, prepregnancy hypertension, history of PTB, twin pregnancy or singleton pregnancy, mode of fertilization, frequency of pregnancy, gestational age, and CL. TVCL screening at 17-23 weeks allows efficient interventions including potential cost-effectiveness of screening with limited harm[28]. A combination of TVCL screening and our nomogram predictions during the second trimester may be more helpful to an obstetrician's decision regarding intervention. A routine measure of cervical length through transvaginal sonographs is controversial and may not be suitable. However, our hospital's protocol for cervical length measurement (as described in the methods of this report) is recommended during the first and third trimesters. This protocol, together with our nomograms could help obstetricians discover high-risk populations of preterm births during this period thereby allowing drug therapy or monitoring of changes in the cervical length for prevention of preterm births.

In the current study, we did not analyze CL changes over time although has been hypothesized to be related to PTB risk. A previous study found that changes in transvaginal sonographic CL over time was

not a clinically useful test to predict PTB in women[29]. Therefore, a continuous assessment of CL after our nomogram prediction is recommended in order to improve the sensitivity of prediction. Some factors including gestational diabetes mellitus, polyhydramnios, and gestational hypertension have been implicated in PTB risk although the current study did not find them to be significant predictors of overall PTB[16]. Future studies may benefit from a prospective cohort design that allows researchers to collect more detailed information on characteristics of study subjects and to analyze the subtypes of PTB. Moreover, multiple-center studies are further suggested in the future to improve the accuracy of nomogram prediction.

Conclusions

This study demonstrates that gestational age of 1stshort cervix, and CL of 1st short cervix, as well as other factors are predictors of overall PTB $<$ 37 weeks and PTB $<$ 34 weeks among patients with a short cervix. In addition, we have established nomogram that can help obstetricians to identify patients at risk of PTB. A combination of this prediction model and transvaginal ultrasonography may be efficient for clinical screening of short cervix

Disclosure of interests

The authors report no conflict of interest.

Contribution to authorship

YNL and HY contributed to the design of this study. YNL and YYZ conducted the analyses. YNL, YL, ML, YCZ and JC contributed to the interpretation of data. YNL drafted the manuscript. YNL and HY critically revised the manuscript. All the authors approved the version to be published.

Details of ethics approval

The research protocol used in this study was reviewed and approved by the Institutional Ethics Committee of Peking University First Hospital: Approval number: 2019[578], Date: 01/06/2019. As this is a retrospective observational study, the Medical Ethical Committee waived the informed consent requirement for this study. Approval to obtain clinical data from the hospital database was obtained from the office of the medical director of the hospital. All patient information was kept confidential.

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Figure legend

Figure 1. Flowchart of study cohort.

Figure 2. Logistic regression models for predictors of PTB $<$ 37 weeks and PTB $<$ 34 weeks. PTB: preterm birth; BMI: body mass index; IVF-ET: *in vitro* fertilization and embryo transfer.

Figure 3. Profile of a nomogram to estimate risk of preterm birth $<$ 37 weeks (A) and preterm birth $<$ 34 weeks (B) in patients with a short cervix. Draw a line perpendicular from the corresponding axis of each risk factor until it reaches the top line labeled "Points". Sum up the number of points for all risk factors then draw a line descending from the axis labeled "Total Points" until it intercepts the lower line to determine preterm birth probabilities. For binary variables, 0 = no and 1 = yes. For BMI before pregnancy categories, 0 = normal, 1 = overweight, 2 = obesity. Abbreviations: BMI = body mass index.

Figure 4. Validation of the nomogram. (A) The AUC of the models of PTB $<$ 37 weeks and PTB $<$ 34 weeks from observed data (nomogram) was 0.803 and 0.771, respectively. AUC=area under ROC. (B)

Calibration curve for evaluating the agreement between the results and the predicted possibilities of PTB $<$ 37 weeks. (C) Calibration curve for evaluating the agreement between the results and the predicted possibilities of PTB $<$ 34 weeks.

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Table 1. Characteristics of pregnancies with a short cervix.

Variables	**PTB < 37 weeks n=187 (%)**	***p*-value**	**PTB < 34 weeks n=91(%)**	p-value
Demographic characteristics				
Age	32.8±4.2	0.014	32.4±42	0.657
BMI before pregnancy				
Normal(18.5-23.9 kg/m^2)	87(27.6)		41(13.3)	

Variables	**PTB < 37 weeks n=187 (%)**	*p*-value	**PTB < 34 weeks n=91(%)**	p-value
overweight(24.0-27.9 kg/m^2)	43(47.3)	0.000	19(22.4)	0.040
obesity([?]28.0 kg/m^2)	20(50.0)	0.001	11(28.9)	0.018
Obstetric data				
Pregnancy frequency				
0 to 2 times	126(29.8)		63(15.3)	
[?]3 times	61(47.3)	0.000	28(22.6)	0.060
Pregnancy interval (year)	4.2±3.4	0.685	4.4±36	0.540
Multiparous				
no	132(32.6)		62(15.7)	
yes	55(36.7)	0.367	29(20.1)	0.228
Twin pregnancy				
no	110(24.9)		57(13.3)	
yes	77(67.5)	0.000	34(30.9)	0.000
Mode of fertilization				
nature	116(26.4)		57(13.3)	
IVF-ET	70(60.9)	0.000	34(31.2)	0.000
Gestational age of 1st short cervix (week)	26.2±5.5	0.000	24.9±5.9	0.000
CL of 1st short cervix (mm)	18.8±5.1	0.000	17.9±6.1	0.000
Amniotic fluid sludge				
no	117(32.8)		83(15.9)	
yes	10(66.7)	0.006	8(53.3)	0.001*
Gestational age of delivery (week)	32.3±4.3		29.3±4.5	
Risky history				
Induced abortion				
0	132(32.8)		70(17.9)	
[?]1 time	55(36.2)	0.446	21(14.3)	0.319
Later-period spontaneous abortion				
0	180(33.5)		86(16.5)	
[?]1 time	7(38.9)	0.635	5(29.4)	0.184*
Intrauterine operation frequency(except abortion)				
0	153(32.5)		76(16.6)	
[?]1 time	34(40.5)	0.153	15(18.5)	0.676

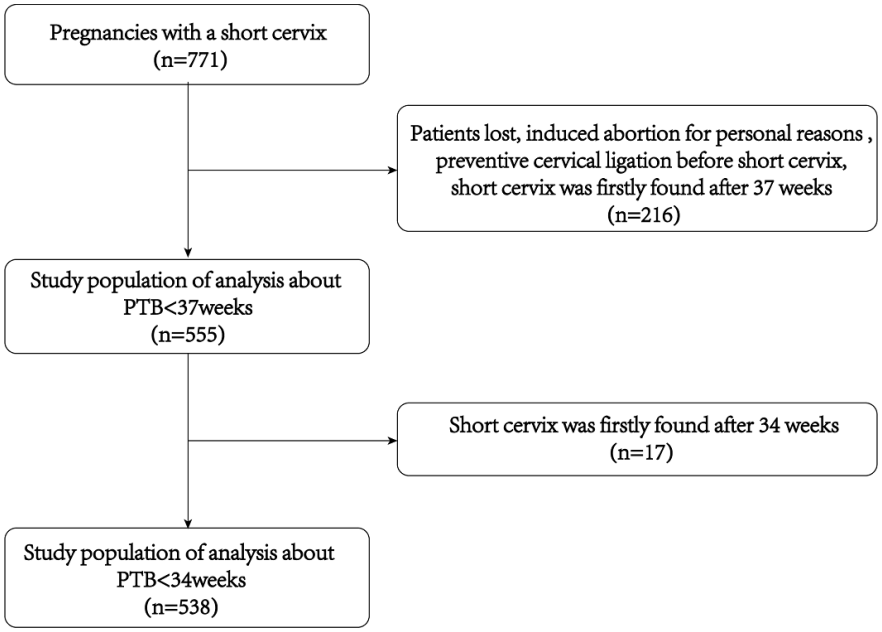
Variables	**PTB < 37 weeks n=187 (%)**	***p*-value**	**PTB < 34 weeks n=91(%)**	p-value
History of forceps midwifery				
no	187(33.9)		91(17.0)	
yes	0(0)	0.554*	0	1.000*
History of cesarean delivery				
no	36(33.1)		79(16.3)	
yes	21(38.9)	0.395	12(23.1)	0.212
History of PTB				
no	175(32.5)		84(16.1)	
yes	12(70.6)	0.001	7(41.2)	0.014*
History of short cervix				
no	181(33.3)		85(16.1)	
yes	6(54.5)	0.195*	6(54.5)	0.005*
History of PPROM				
no	183(33.5)		89(16.8)	
yes	4(50.0)	0.452*	2(25.0)	0.539
History of LEEP				
no	176(33.5)		86(16.9)	
yes	11(37.9)	0.620	5(17.9)	0.800*
Preexisting comorbidities				
Autoimmune disease				
no	177(32.7)		86(16.4)	
yes	10(71.4)	0.007*	5(35.7)	0.070*
PCOS				
no	179(33.0)		86(16.3)	
yes	8(61.5)	0.040*	5(41.7)	0.037*
hypothyroidism				
no	172(34.1)		83(17.0)	
yes	15(30.0)	0.562	8(16.3)	0.908
Pregestational diabetes mellitus				
no	180(33.2)		88(16.8)	
yes	7(53.8)	0.141*	3(23.1)	0.469*
Pregestational hypertension				
no	178(33.5)		83(16.1)	
yes	9(39.1)	0.573	8(36.4)	0.020*
Polyhydramnios#				
no	178(33.3)		86(16.6)	
yes	9(42.9)	0.365	5(23.8)	0.376*
Gestational diabetes mellitus#				
no	123(34.9)		62(18.1)	

Variables	**PTB < 37 weeks n=187 (%)**	*p*-value	**PTB < 34 weeks n=91(%)**	p-value
yes	64(31.5)	0.412	29(14.9)	0.341
Blood pressure state#				
normal	156(32.0)		79(16.7)	
Gestational hypertension	4(18.2)	0.765*	1(4.8)	0.230*
Preeclampsia without serious manifestation	4(33.3)	1.000*	0	0.230*
Preeclampsia with serious manifestation	15(68.2)	0.000	7(33.3)	0.082*
Chronic hypertension complicating pregnancy	8(66.7)	0.047	4(33.3)	0.132*

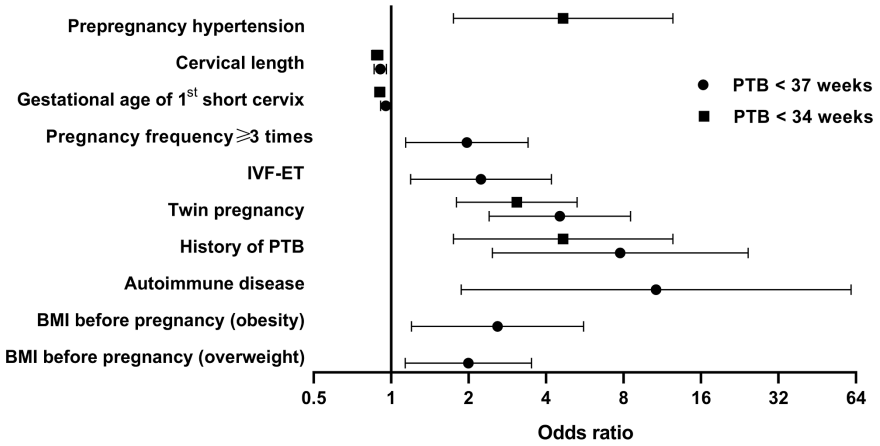
PTB: preterm birth; BMI: body mass index; IVF-ET: *in vitro*fertilization and embryo transfer; CL: cervical length; PPROM: preterm premature rupture of membrane; LEEP: loop electrosurgical excision procedure; PCOS: polycystic ovary syndrome

*Fisher's Exact Test

#Pregnancy complications.

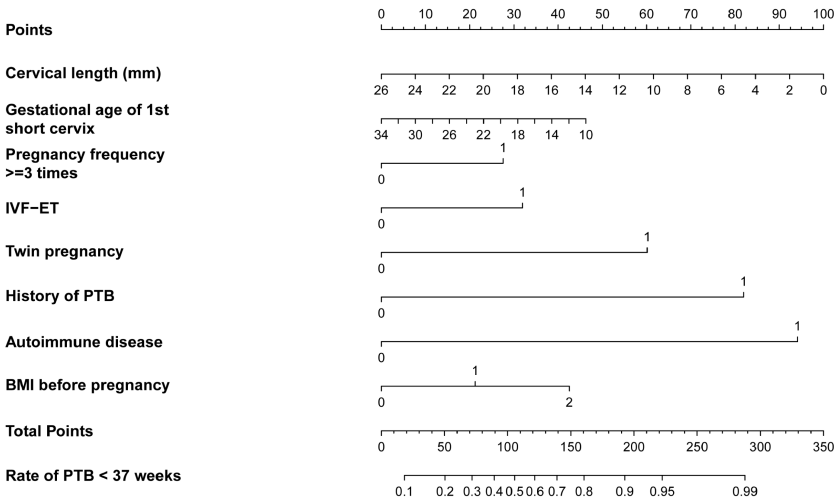


Logistic regression model for predictors of preterm birth.



	PTB < 37 weeks		PTB < 34 weeks	
variate	B	p value	B	p value
BMI before pregnancy				
normal		0.008		
overweight	0.692	0.016		
obesity	0.953	0.015		
Autoimmune disease	2.371	0.008		
History of PTB	2.050	0.000	1.781	0.001
Twin pregnancy	1.509	0.000	1.125	0.000
IVF-ET	0.804	0.012		
Pregnancy frequency≥3 times	0.677	0.015		
Gestational age of 1st short cervix	-0.048	0.047	-0.103	0.000
Cervical length	-0.097	0.001	-0.125	0.000
Prepregnancy hypertension			1.539	0.002

A.



B.