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Verification a model of predicting vaginal birth after cesarean delivery in Chinese pregnant women

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Abstract

The objective of our research was to confirm the prediction role of Grobman model for vaginal birth after cesarean (VBAC) in Chinese pregnant women. In this research, 535 pregnant who had once cesarean delivery and the least once subsequent try to a vaginal labor in Jiaxing of China were involved. The Grobman background factors and five new factors were included. Overall, in total of 456 women had successful VBAC, the success percent was 85.2%. The new background variable "maternal height" was considered as an additional predictor for VBAC. The Grobman model's area under the curve (AUC) was 0.811 (95% CI = 0.751–0.870) and the AUC of this modified model combined 2 new factors was 0.834 (95% CI = 0.781–0.886). Nevertheless, there has no markedly difference between these 2 models of the AUC. In conclusion, the Grobman model was suitable for Chinese pregnant. However, further improvements were needed to make a new predictive model of VBAC success rate for Chinese pregnant women through analyzing the clinical data of vaginal trial delivery after cesarean section.

Abbreviations: AUC = area under the curve, BMI = body mass index, CI = confidence interval, OR = odds ratio, ROC = receiver operating characteristic curve, TOLAC = trial of labor after cesarean delivery, VBAC = vaginal birth after cesarean.

Keywords: Grobman, prediction, trial of labor after cesarean delivery, vaginal birth after cesarean

1. Introduction

Over the past few decades, the level of anesthesia, surgery, blood transfusion and drug treatment had been improved, and the percentage of cesarean section was increasing because of the progress of perinatal medicine. For example, in 2008, the cesarean section rate in the United States reached 32.3%.[1] Similarly, studies in Japan reported that the cesarean section rate also reached 19.8% to 34.1%. However, the situation in China is more serious. According to the report of WHO which published in Lancet in 2010, the percent of cesarean section in China was as high as 46.2% to 60%, and social factors account for 25% (about 5 million cases per year). This is far from the ideal rate of cesarean section of 10% to 15% considered by the international health organization.[2,3] Accordingly, the increasing rate of cesarean section leads to more than one third of women of

childbearing age in the world will face various risks of cesarean section, such as bleeding, puerperal infection, pelvic adhesion to varying degrees, endometriosis, intestinal obstruction, intestinal, ureter, bladder and other important organs damage.[4] In addition, repeated cesarean section increases the incidence rate of placenta previa and placenta increta, which increased the dangerous of maternal hemorrhage and hysterectomy.[5] To the perinatal infants, when the percentage of cesarean section falls under 20%, the mortality of perinatal infants reduce with increased the percentage of cesarean section. When the percent of cesarean section rises above 25%, the mortality of perinatal infants even increase.[6] Therefore, the rising cesarean section rate has become an important public health problem.

In order to decrease the percentage of cesarean section and the incidence of its complications, especially to the pregnant women and infants which caused by repeated cesarean section. Thus, a lot of countries had try to establish or update the trial of labor after cesarean delivery (TOLAC) guidelines.[7] It is suggested that pregnant women who meet the indications of first cesarean section can undergo vaginal trial delivery, and the maternal and infant outcomes of vaginal trial delivery after cesarean section should be improved. By contrast, on the basis of evidence-based medicine, a consensus has been reported that vaginal trial delivery after cesarean section was still a reasonable choice for many women who have a cesarean section history. A large number of research data have shown that under the premise of reasonable selection of vaginal trial indications, 60% to 80% of vaginal trial delivery after cesarean section can be successful.[8–10] Compared with repeated cesarean section, the main complications of successful vaginal trial delivery are less, the recovery period is shorter, and the satisfaction of the puerpera is higher, which can benefit the puerpera significantly.[4,11] To balance the strengths and weaknesses of different modes of delivery correctly and guide pregnant women to choose suitable

modes of delivery for successful delivery is a problem that obstetricians must solve. At present, many researchers have constructed prediction models by collecting prospective and retrospective clinical data, and some prediction models have been applied in clinical practice. Grobman is equal to the VBAC prediction model proposed in 2007 for the first maternity examination in early pregnancy.[12] The study lasted for four years and involved 19 institutions. Four types of data were included through the establishment of a prospective cohort study:

(1) basic personal information, including mother's age, the interval between childbirth and so on.
(2) Variables related to previous cesarean section, including vaginal delivery history, etc.
(3) Variables related to the history of pregnancy and childbirth, including the maximum weight of the fetus.
(4) Past disease-related variables.

The model has large sample size, high reliability and area under the curve (AUC) value of 0.754. The advantage of this model was that it could be used at the early stage of pregnancy to make personalized predictions for different pregnant women, so that pregnant and doctors could work out personalized delivery plans according to the predicted results as soon as possible. However, because it only included pregnant women with a once full-term cesarean section history, the applying of this model was limited. At the same instant, the exact of the prediction results of the model was influenced to some extent because it did not contain the data of late pregnancy (such as pre-eclampsia, etc). At present, this model is more widely used than other models in clinical work, and has been confirmed by cohort studies in many clinical centers. Among them, a large sample retrospective cohort study in Japan confirmed that the prediction model could be applied to Japanese pregnant women.[13–16] Therefore, further demonstrate of the model was needed in the large Chinese pregnant women.

The objective of our research was to demonstrate the prediction role of Grobman model for VBAC in Chinese pregnant and the potential modifications to make the modified model fit for the specific population.

2. Methods

2.1. Study population

Our research was a retrospective cohort research. The research was approved by the ethics committee of Jiaxing Maternity and Child Health Care Hospital. The approved guidelines were as a protocol. We selected the pregnant women in the Jiaxing Maternity and Child Health Care Hospital. These pregnant women gave birth to at least twice from June 2015 to June 2019, including once cesarean section and had at least once TOLAC subsequently. For the pregnant who have a cesarean section history, a 36-week prenatal visit asks that whether she had a willingness to accept TOLAC or cesarean section; whether or not TOLAC is performed depends on a comprehensive assessment before delivery.

2.2. Data collection

At the first antenatal check, all participants received written informed consent. Use electronically standardized medical records. Select the inclusion criteria and study variables to verify the potential optimization factors of the Chinese pregnant

women model by the Grobman model. These variables include: maternal age (years), maternal residence (Jiaxing of Zhejiang province, Other cities of Zhejiang province, Other provinces, corresponding to the "mother race" in the Grobman model), indications for the previous cesarean delivery (recurrent or non-recurrent), history of vaginal delivery, vaginal delivery after the previous cesarean section (yes/no), body mass index (BMI) (kg/m^2), gestational age at delivery (weeks), induction of labor, maternal preeclampsia, cervical effacement at admission (10%), cervical dilatation at admission (cm), station at admission (fifths scale), according to the Grobman study.[17] We also added the maternal height (cm) in the potential model, maternal gestational diabetes, estimated fetal weight (g), labor analgesia and interval time from prior cesarean (months). The exclusion criteria of our research were similar as the Grobman research, including non-head position, prenatal death, preterm birth (<37 weeks), elective repeat cesarean delivery (ERCD), multiple pregnancies, and no indications for previous cesarean section.[12]

2.3. Statistical analysis

The data was analyzed with Stata 14.0. The measurements in accordance with normal distribution were mean ± standard deviation. The comparison between 2 groups were used t test. Median (upper and lower quartile) was used for non-normal distribution. Rank sum test was used for inter-group comparison. Percentage was used for counting data and x^2 test was used for inter-group comparison. $P < .05$ was statistically significant. AUC and the ROC curve were used to test the exact of these models with multivariate logistic regression analysis. The goodness degree of the model was detected by Hosmer–Lemeshow. $P > .05$ showed that the goodness fit of the model.

3. Results

In the period of our research, 12,175 women who had a cesarean section history in the 58,737 singleton live births, and only 535 women had tried TOLAC. These women's characteristics were showed in Table 1. A total of 456 women received VABC treatment and 79 women did not receive TOLAC treatment with a success rate of 85.2% (Fig. 1). Compared with the group of failed TOLAC, these women of the success group are unlikely to have signs of cesarean section again. These pregnant women who in the failed TOLAC group had a disposition to be a higher BMI and estimated fetal weight. The difference of indications for the previous cesarean delivery, cervical effacement at admission (10%), induction of labor, station at admission (fifths scale) and cervical dilation at admission (cm) compared of two groups were significant ($P < .05$). However, the success and failure of TOLAC in the maternal age (years), maternal residence, vaginal delivery history, gestational age at delivery, interval time from prior cesarean, maternal preeclampsia, maternal gestational diabetes and labor analgesia had no significant differences ($P > .05$).

After the analysis of multiple logistic regression, Table 2 showed the adjusted ORs of the Grobman's model factors. "History of vaginal delivery" and "cervical effacement at admission (10%)" were positively associated with VABC ($P < .05$). "BMI (kg/m^2)", "maternal height", "maternal pre-eclampsia" and "induction of labor" had a negative correlation with VBAC ($P < .05$). With the regression analysis, "BMI (kg/m^2)", "history of vaginal delivery", "induction of labor", "maternal preeclampsia" and "cervical effacement at admission

Table 1

Characteristics of the women undergoing TOLAC.

Characteristic	Successful VBAC (n = 456)	Failed TOLAC (n = 79)	P
Maternal age (years)	30.98 ± 5.20	30.82 ± 5.12	.798
BMI (kg/m^2)	25.98 ± 2.86	26.75 ± 2.90	.028
Maternal height	163.06 ± 6.89	160.65 ± 4.55	.003
Maternal residence			.842
Jiaxing of Zhejiang province	365 (80.0)	64 (81.0)	
Other cities of Zhejiang province	33 (7.3)	7 (8.9)	
Other provinces	58 (12.7)	8 (10.1)	
History of vaginal delivery	30 (6.6)	4 (5.1)	.610
Gestational age at delivery (weeks)	38.16 ± 1.35	38.78 ± 1.64	.513
Induction of labor	23 (5.0)	8 (10.1)	.074
Maternal preeclampsia	6 (1.3)	3 (3.8)	.113
Maternal gestational diabetes	38 (8.3)	9 (11.4)	.375
Estimated fetal weight	3400.89 ± 161.51	3488.42 ± 184.53	.000
Indications for the previous cesarean delivery			.001
Recurrent	53 (11.6)	20 (25.3)	
Non-recurrent	403 (88.4)	59 (74.7)	
Interval time from prior cesarean (months)	38.58 ± 20.57	41.09 ± 26.77	.339
Labor analgesia	136 (29.8)	29 (36.7)	.221
Cervical effacement at admission (10%)	8.78 ± 1.89	6.49 ± 1.46	.000
Cervical dilation at admission (cm)	1.61 ± 1.59	0.89 ± 1.52	.002
Station at admission (fifths scale)	3 (3, 3)	3 (2, 3)	.000

BMI = body mass index, TOLAC = trial of labor after cesarean delivery, VBAC = vaginal birth after cesarean.

(10%)" entered into the VABC prediction model. "Maternal height" was supposed as an additional predictor of VABC.

The Grobman models and modified factors were assessed with the constructed ROC curve to compare in our data (Fig. 2). The AUC of the Grobman model was 0.811 (95% CI=0.751–0.870), and the improved model we added the new variable had an AUC of 0.834 (95% CI=0.781–0.886). However, the AUCs between these 2 models had no significant. As to the modified model, there had no reason to stepwise regression analysis about its fitting or calibration.

4. Discussion

Our research examined the prediction role of Grobman model in Chinese pregnant women and the modified model in order to a

better VBAC prediction. Some differences could be found as expected among the 2 models by using the univariate analysis. However, the modified model had no significant differences limited to the sample size.

Statistics had shown that the percentage of cesarean section in China is rising year by year. Currently, the rate of pregnant again after cesarean section is increasing, and they are all facing the problem of choosing the mode of delivery. Although the pregnant women with successful vaginal delivery have an advantage over elective re-cesarean section in terms of economics and incidence of complications, the complications of failed vaginal delivery are significantly higher than those of elective re-cesarean section.[18] VBAC is undoubtedly the best mode of delivery for scarred uterus with second pregnancy. However, China has not yet developed a mature TOLAC risk
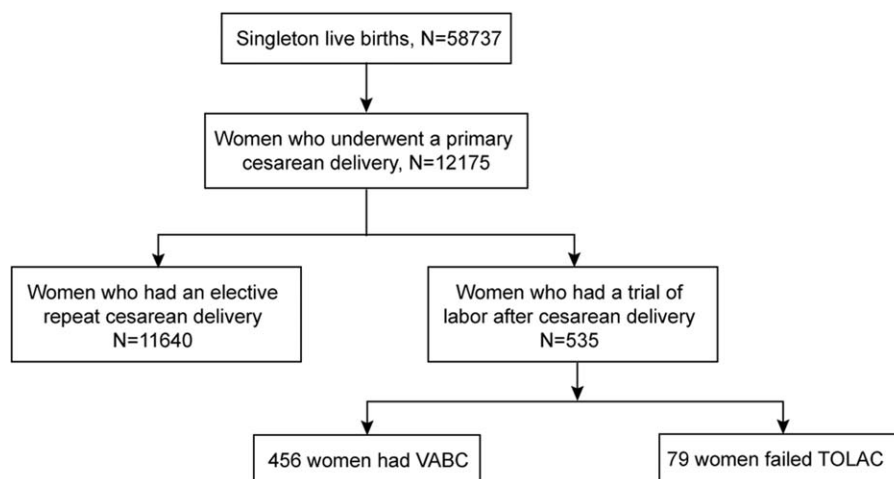

Figure 1. Flow-chart of the research groups selection process.

Results of the model for vaginal birth after cesarean delivery after stepwise regression analysis.

Variables	OR (95% CI)	P
Maternal age (years)	0.961 (0.588–1.567)	.217
BMI (kg/m^2)	0.925 (0.732–1.167)	.002
Maternal height	1.082 (0.859–1.363)	.006
Maternal residence		
Jiaxing of Zhejiang province	1.000 (Ref)	
Other cities of Zhejiang province	1.256 (0.533–2.959)	.343
Other provinces	1.968 (0.898–4.315)	.401
History of vaginal delivery	3.235 (1.380–7.582)	.042
Gestational age at delivery (weeks)	0.975 (0.732–1.228)	.716
Induction of labor	0.438 (0.009–0.887)	.024
Maternal preeclampsia	0.063 (0.024–0.479)	.025
Cervical effacement at admission (10%)	1.832 (0.729–4.234)	.000
Cervical dilation at admission (cm)	1.225 (0.589–2.545)	.319
Station at admission (fifths scale)	1.739 (0.770–3.927)	.397

Results of full model for VBAC delivery after stepwise regression analysis, according to Grobman[17] background variables supplemented with information on maternal height. The multiple logistic regression models included all variables listed in the respective columns.

prediction model. However, the widely use risk prediction model abroad has poor predictive efficiency in Chinese TOLAC pregnant women, which is not completely applicable to China.

This study concluded that the success rate of vaginal trial delivery was 85.2% in local population. Logistic multivariate analysis indicated that history of vaginal delivery, cervical effacement at admission (10%), BMI (kg/m^2), maternal height, maternal preeclampsia and induction of labor were important factors in the success of TOLAC. This conclusion was consistent with many research results, such as Flamm,[19] Smith,[20] Grobman,[12] and so on, which showed that these factors were important for the success of TOLAC after cesarean section. Successful secondary vaginal delivery is an advantageous factor.

The results of multivariate analysis showed that the height of pregnant women was a protective factor for the success of vaginal delivery (OR=1.082). This conclusion is consistent with the results of many studies. Jeong et al explored the influencing factors of the mode of re-delivery after cesarean section in 652 women through prospective study. After correction analysis, height can be used as an independent influencing factor for the success of TOLAC in low-risk pregnancy (OR=0.88).[21] Sheiner et al demonstrated that the percentage of cesarean section (21.3% vs 11.9%, OR=2) was markedly higher in the short stature group (height less than 155 cm) than those without short stature group after surveyed 159,210 pregnant.[22] Smith et al collected the data of 159,210 pregnant which showed that the percentage of cesarean section in the short stature group (height less than 155 cm) was more higher than the non-short stature group (21.3% vs 11.9%, OR=2).[20] Thus, we should give special
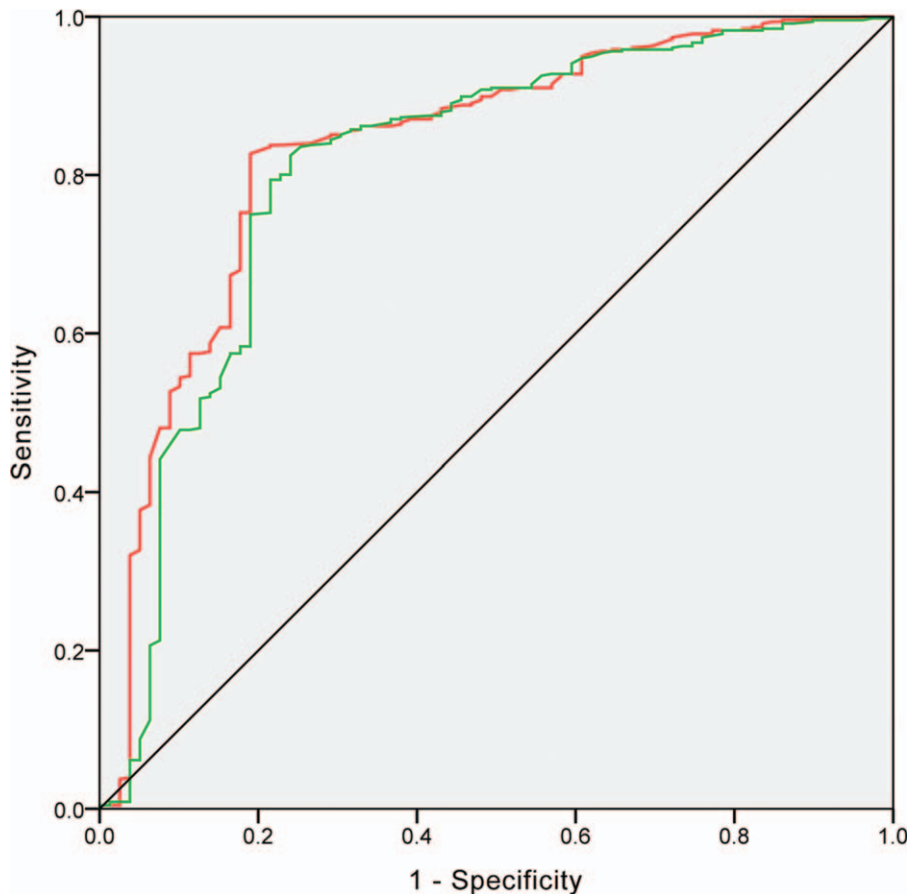

Figure 2. The receiver operating characteristic curve of the model after logistic regression used to forecast the VBAC success rate in the labor test. Blue line: a group based on the Grobman background variable; red line: according to the results of the full model of VBAC. VBAC=vaginal birth after cesarean.

attention to the vaginal trial delivery of short stature pregnant in our subsequent clinical work.

However, this study is an exploratory study. The main shortcomings and limitations of this study are that the sample size is insufficient. It is only a single-center study, and the research scope is narrow. Thus, the extrapolation of this prediction model may not reflect the actual situation of the Chinese pregnant women. Further larger sample of prospective multi-center and many other relevant factors were involved may improve the precision of this prediction model.

5. Conclusions

In conclusion, the Grobman model was suitable for Chinese pregnant women. On this basis, further improvements were made to establish a new predictive model of VBAC success rate for Chinese pregnant women by analyzing the clinical data of vaginal trial delivery after cesarean section. All TOLAC pregnant and lying-in women should closely monitor the progress of labor and changes of fetal heart rate, strengthen the identification of fetal heart rate monitoring, so as to ensure the safety of mother and child and reduce the occurrence of adverse outcomes of mother and child.

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