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Application of predictive model for vaginal birth after caesarean delivery

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ABSTRACT

Medical practitioners are concerned with the selection of delivery mode after caesarean delivery. Several researchers have developed numerous models for predicting vaginal birth after caesarean delivery. This study selected seven widely used and representative advanced models, such as those of Grobman, Troyer and Parisi, Schoorel, Flamm, Gonen, Weinstein and Smith et al., analysed the constitutions and clinical applications of the models and identified the factors associated with patients to provide midwives a scientific reference for vaginal delivery evaluation of pregnant women after caesarean delivery.

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1. Introduction

The opening of the two-child policy in China has increased the number of women giving birth to a second child after caesarean section since 2016. One important component in this decision-making process is the likelihood that a trial of labour will result in vaginal delivery (VD). The American College of Obstetricians and Gynecologists (ACOG) [1] has shown that from 60% to 80% of VD cases after caesarean delivery (vaginal birth after caesarean delivery, VBAC) of pregnant women can be successful and can reduce maternal morbidity and complication rate. The complication rate in 2010 was less than 1%. Obstetricians and midwives play a vital role in the scientific evaluation and prediction of the success or risk of VD. A perfect prediction model that can evaluate the risk of trial of labour will be beneficial in providing a basis for trial of labour, selecting the delivery mode, enhancing trial production self-efficacy and managing midwifery evaluation [2]. Several researchers have developed numerous models that can provide physicians and midwives the ability to use multiple clinical factors to improve the accuracy of prediction of the likelihood of a VBAC. Although predictive models are not commonly used in obstetrics, these models have been applied in other medical disciplines to guide medical decision making [3]. A screening tools [4] identified some models which were usually used in early pregnancy, late

pregnancy and intrapartum and considered the independent contribution of multiple factors to provide a probability prediction for birth outcome. Seven state-of-the-art and distinctive models were selected, and they are summarised in this paper.

2. Main VBAC prediction models and applications

2.1. Grobman model

The first model of early pregnancy was developed by Grobman et al. [5] of the Northwestern University of Chicago in 2007. The model adopted the logistic model by performing prospective cohort study: $VBAC = \exp(W) / [1 + \exp(W)]$; $W = 3.766 - 0.039(\text{age}) - 0.060(\text{prepregnancy body mass index [BMI]}) - 0.671(\text{African-American race}) - 0.680(\text{Hispanic race}) + 0.888(\text{prior VD}) + 1.003(\text{VBAC}) - 0.632(\text{recurring indication for caesarean})$. The following six predictors were included: age, pre-pregnancy BMI, ethnicity, any prior VD, VBAC and recurring indication for caesarean.

The discriminative performance of the model was assessed using the area under the curve (AUC) of the receiver operating characteristic (ROC). The AUC was between 0.5 and 1.0, where 0.5 represented no discriminative capacity and 1.0 represented excellent discriminative capacity. The advantages of the model were availability of included factors at the first prenatal visit and accurate counselling in early pregnancy. Pregnant women could be personally assessed at an early time. The limitation was that the variables, such as late pregnancy and cervical factors, were ignored. Ethnicity variable applicability was limited in different countries. In

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the past decades, several investigations about this model have been conducted in various regions [6–11]. In the United States, Constantine [6] tested the effectiveness of the original model (2009) and obtained an AUC value of 0.75; a retrospective cohort study was conducted in Nagoya, Japan (2012) and Quebec, Canada (2013), and the results showed that the model was effective with AUC values of 0.81 and 0.72, respectively [7,8]; a large cohort study [9] of 17 hospitals was conducted in Netherlands, with an AUC value of 0.72; Fagerberg [10] proposed three variables, namely, smoking, height, and country of birth on the basis of the original model and obtained an AUC value of 0.74. Several studies confirmed that the ethnicity variable was excluded in the Grobman model [6–12]. The variable however has not been adopted in clinical practice and validated in China.

2.2. Troyer and Parisi scoring model

In 1992, Troyer and Parisi [13] developed a model using a scoring system. They analysed 264 women with prior caesarean delivery and identified the main influencing factors of the delivery mode. The model contained four variables, namely, a previous dysfunctional labour, non-reassuring admission foetal heart tracing on admission, no previous VD and labour induction, and each variable was given 1 point. The points ranged from 0 to 4. The parturients with the lowest score (0) had the highest VBAC rate (91.5%), and those with a score of 3 or 4 had the lowest VBAC rate (46.1%). Vinueza et al. [14] applied Troyer scoring model in a retrospective cohort study of 263 samples in 2000. They confirmed the inverse relationship between the scoring model and the VBAC outcome. The model was therefore convenient for calculation. The model was also effective for application in medical decision making of early pregnancy. However, the sample size was small, and the data were obtained retrospectively without using logistics regression. This model has not been extensively used in clinical applications, and its accuracy and applicability were limited.

2.3. Schoorel prediction model

Schoorel et al. [9] developed an appropriate Western European population-based prediction model in 2013, which could be used to counsel in the third trimester of pregnancy in the Netherlands. $P(\text{success}) = 100\% \times 1 / \{1 + \exp [-(1.647 + 0.371 \times \text{white} - 0.032 \times \text{pre-pregnancy BMI} - 0.537 \times \text{previous non-progressive labor} + 1.045 \times \text{previous VD} - 0.515 \times \text{induction of labor} - 0.487 \times \text{estimation fetal weight (EFW)} \geq P90)]\}$.

The following six variables were included: pre-pregnancy BMI, white ethnicity, previous non-progressive labour, previous VD, induction of labour and estimation of foetal weight (EFW) $\geq P90$. The AUC value obtained was 0.71, which indicated good discriminative capability. The model was the first to incorporate the foetal weight as a variable. The limitations of the model were that pre-pregnancy BMI and EFW variables were difficult to collect in clinical applications, and the model also involved ethnicity. Thus, the model should be further validated by future studies.

2.4. Flamm model

Flamm et al. [15] conducted a prospective study of 5022 pregnant women and developed a scoring system to predict the likelihood of vaginal birth in California in 1997. In Flamm's research, only the variables collected at the time of hospital admission were used. The following five variables were significantly affected and added as scores: age < 40 (2 points), vaginal birth history (according to the caesarean delivery before and after time divided into 0 to 4 points), reason other than failure to progress for the first caesarean delivery

(1 point), cervical effacement at admission > 75% (2 points) and cervical dilatation 4 cm or more at admission (1 point). The total score ranged from 0 to 10 points; 0 to 2 points corresponded to a success rate of 49.1%; 3 to 7 points corresponded to success rates of 59.9%, 66.7%, 77%, 88.6% and 92.6%, respectively. The corresponding success rate of 8–10 points was 94.9%. The prediction model was used at the time of admission for labour. As a result, current clinical trials need to be further explored.

2.5. Gonen model

Gonen et al. [16] developed a scoring system in Israel in 2004. Variables were categorised in accordance with information about the first prenatal visit, the onset of labour and during labour. Each of the four significant variables was assigned a score ranging from 0 to 3 as follows: previous VBAC (0–3 points), indication for first caesarean delivery (0–3 points), cervical dilation (0–2 points) and gestational age (0–2 points). Scores ≤ 0 to 2, between 3 and 6 and between 7 and 10 were associated with success rates of 42%, 81% and 98%, respectively. The model was accurately incorporated into the indication for the first caesarean delivery, and this variable was difficult to obtain in clinical applications.

2.6. Weinstain model

This retrospective study [17] covered a 10-year period (1981–1990), included 471 women and developed a predictive score for VBAC in Israel in 1996. The following variables of the Weinstain model with significant values were included: vaginal birth before caesarean delivery (2 points); bishop score ≥ 4 (0–4 points); and the two following indications for primary caesarean delivery, namely, malpresentation and pregnancy-induced hypertension (0–6 points). The maximal score was 12. If scores ≥ 4 , ≥ 6 , ≥ 8 , ≥ 10 and 12 points, then the likelihood rates of VBAC were 58%, 67%, 78%, 85% and 88%, respectively. The study indicated that the chance for a successful VBAC was 90% higher for a woman who had a caesarean delivery for a previous breech than for any other reason. Mu Tian et al. [18] claimed that the Weinstain model was superior to the six other models. The conclusion however was limited because of the small sample size of 53 cases. The Weinstain et al. model was based on retrospective evaluation of data and should be tested in a further study.

2.7. Smith model

Smith et al. [19] included 23286 women who attempted VBAC at or after a 40-week gestation. The model adopted the logistic regression model by using retrospective analysis to calculate the risk rate of caesarean delivery in Scotland in 2004. The factors associated with emergency caesarean delivery were maternal age, maternal height, male foetus, no previous vaginal birth, prostaglandin-induced labour and birth at the 41st or 42nd week. In the validation group, the low value of predicted risk of caesarean delivery was 20% and the high predicted risk was 40%. The AUC value was 0.677. Mone et al. [20] analysed the applicability of three models, namely, Smith, Grobman and Troyer, for 385 eligible pregnant women in Northern Ireland in the period of 2010–2012 and concluded that the Smith model was the most suitable for the population in this study. Another potential weakness of the model was that it was derived from women delivering at or after 40-week gestation, and the study lacked data on other factors, such as BMI and the indication for previous caesarean delivery.

3. Significant variables in the prediction models

The models discussed above can be divided into three types, namely, early pregnancy models such as the Grobman model, the third trimester of pregnancy models such as the Schoorel and Smith models and admission labour model such as the Flamm, Gonen, Weinstein and Troyer models. Amongst all the variables of the seven models above, prior VD had the highest frequency of occurrence, was consistently found by all models and associated with an increased likelihood of VBAC [5–7,16–19]. Women that had a prior VD had a 28-fold increase in the likelihood of VBAC compared with those without a prior VD [21,22]. The variable with the second highest frequency of occurrence was the timing of VD; women who had VD before caesarean delivery were 1.5–1.8 times more likely to have a VBAC compared with those without [15–17]. The delivery rate was 3.5 times higher in patients with VBAC than those with VD before caesarean delivery; women with VBAC had 3.4 times success rate compared with women with no history of VBAC [15]. The variable with the third highest frequency was the number and indication of prior caesarean deliveries. Two studies [15,17] claimed that women with a non-recurrent indication for caesarean delivery had a significantly higher likelihood of VBAC compared with those with a recurrent prior caesarean indication. A cervical factor also existed; research showed that labour cervical dilatation ≥ 4 cm had a higher success rate of expansion than < 4 cm. A positive correlation existed between the effacement $\geq 25\%$ and the success rate of VBAC [15,17].

4. Summary and prospect

The seven models discussed above present relatively satisfactory efficiency, especially the Grobman model, and are characterised by extensive application potential, large sample size and strong perspective. These predictive model variables however were not established in accordance with the characteristics of pregnant women in China. As a result, whether these models are suitable for the prediction of VBAC in pregnant women after caesarean delivery in China has not been clinically verified.

In August 2016, the Obstetrics and Gynecology branch of the Chinese Medical Association issued an expert consensus on the management of VBAC and presented the indications and contra-indications of VBAC [23]. Constructing a predictive model fitting in with the prediction of pregnancy after caesarean delivery to the obstetric medical personnel will therefore be helpful to evaluate the feasibility of VD and will also be of high significance for the selection of the appropriate delivery mode and the enhancement in the confidence of pregnant women in selecting VD [24].

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.ijnss.2017.12.006>.

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