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## CLINICAL ARTICLE

## Prediction of vaginal birth after cesarean delivery

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## ABSTRACT

**Objective:** To examine factors associated with successful vaginal birth after cesarean (VBAC) and to validate a previously established prediction model. **Methods:** In a retrospective study, data were obtained for women with one prior low-transverse cesarean procedure who underwent a trial of labor with a cephalic singleton pregnancy at term at one UK hospital between January 2000 and August 2013. Univariate analysis and logistic regression analysis were used to identify maternal demographic characteristics significantly associated with successful VBAC and factors independently associated with this outcome, respectively. A prediction model was built, and predicted probabilities were compared with observed frequencies. For validation, probabilities were also calculated by a previous prediction model. **Results:** Overall, 1463 women formed the cohort. Successful vaginal delivery was achieved in 1050 (71.8%) women. The only factors significantly associated with unsuccessful VBAC were Asian (odds ratio [OR] 1.59, 95% confidence interval [CI] 1.14–2.23) or African (OR 1.80, 95% CI 1.23–2.64) ethnic origin, and previous cesarean for failure to progress (OR 6.39, 95% CI 4.81–8.49). The predicted and observed probability of successful VBAC were well correlated (Spearman  $\rho$ , 0.905;  $P = 0.002$ ). The established prediction model was less accurate. **Conclusion:** Previous cesarean performed for failure to progress and Asian/African ethnic origin were associated with unsuccessful VBAC. The performance of a previous prediction model was inferior.

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## 1. Introduction

The rising rate of primary cesarean delivery has led to an increase in the proportion of women who have had a previous cesarean procedure. Pregnant women with previous cesarean delivery might be offered either planned vaginal birth after cesarean (VBAC) or an elective repeat cesarean. The proportion of women who decline VBAC might further increase the incidence of cesarean delivery. For women with one previous uncomplicated lower-segment transverse cesarean procedure, the option of a planned VBAC or repeat cesarean delivery for an uncomplicated term pregnancy with no contraindication for vaginal delivery should be discussed during the prenatal period of a subsequent pregnancy. Indeed, the Royal College of Obstetricians and Gynecologists in the UK suggests that every woman fulfilling these criteria should discuss these two options before 36 weeks of pregnancy and should be informed that the likelihood of achieving a planned VBAC is between 72% and 76% [1]. The likelihood of successful vaginal delivery is one of the most important factors in the decision-making process during the prenatal counseling of these women.

Many factors have been associated with an improved chance of successful VBAC, including the indication for cesarean delivery, ethnic origin, body mass index (BMI), and prior vaginal delivery [2–11]. Assessing an individual woman's chance of successful VBAC is possible using these factors, and several prediction models have been described. For example, Grobman et al. [7] produced a model based on factors available at the first prenatal visit. This model enables a clinician to give an individual probability of outcome to a pregnant woman, and is perhaps the most widely used. The predicted outcome is a reasonably accurate assessment of a woman's chance of achieving VBAC if she were to opt for a trial of labor.

The aim of the present study was to examine factors associated with a successful attempt at VBAC in a retrospective study population, and to assess the accuracy of the Grobman prediction model when applied to this study population.

## 2. Materials and methods

In a retrospective study, the maternity database of St George's Hospital, London, UK, was searched to identify all women with a previous low-transverse cesarean delivery who attempted a vaginal birth with cephalic presentation between January 1, 2000, and August 31, 2013. Women with multiple pregnancies, more than one previous cesarean procedure, or preterm delivery were excluded from the study, as were those who underwent a planned repeat cesarean and

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those with an unknown indication for the previous cesarean delivery. Written confirmation was obtained from the local ethics committee that formal approval was not necessary for the study owing to its retrospective nature and absence of identifiable details.

Data were collected on maternal characteristics, including age, booking BMI (calculated as weight in kilograms divided by the square of height in meters), ethnic origin, smoking status, medical disease complicating pregnancy, and recurrent indication of previous cesarean delivery (e.g. cesarean for failure to progress). Data were also obtained for factors related to obstetric history (e.g. any previous vaginal delivery). All the variables assessed could be ascertained at the first prenatal visit.

SPSS version 20 (IBM, Armonk, NY, USA) was used to analyze the data. Univariate analysis was conducted to identify variables that were significantly different between women with successful VBAC and those with failed VBAC. Significant factors were then entered into a logistic regression model.

A receiver operating characteristic (ROC) curve was constructed for the likelihood of successful VBAC using the equation derived from the logistic regression analysis. A forced entry model was used. The probability of successful VBAC was categorized into deciles (<0.1, 0.1–0.2, 0.2–0.3, 0.3–0.4, 0.4–0.5, 0.5–0.6, 0.6–0.7, 0.7–0.8, 0.8–0.9, >0.9). The predicted and observed number of successful VBAC in each group was calculated and used to produce scatter plots. The probabilities predicted by a previously established prediction model [7] were also calculated to validate the present prediction model.  $P \leq 0.05$  was considered to be statistically significant.

### 3. Results

During the study period, 7253 women with a previous cesarean procedure had a subsequent delivery. Of these, 4221 (58.2%) attempted labor. The indication for the previous cesarean was known for 1463 women, who formed the cohort for the present study.

In total, 1050 (71.9%) of the 1463 women who attempted VBAC had a successful vaginal delivery. A significantly higher proportion of women carrying a male fetus were unsuccessful in VBAC ( $P = 0.013$ ) (Table 1). Prior vaginal delivery did not affect the outcome of VBAC. Birth weight was significantly higher for women with failed VBAC than for those who had a successful vaginal delivery ( $P < 0.001$ ) (Table 1).

In the univariate analysis, ethnic origin, maternal BMI, induction of labor, and prior cesarean for failure to progress were associated with the likelihood of successful VBAC. The logistic regression analysis

included only factors that would be known at the time that a delivery plan is made. As a result, birth weight, gestational age at delivery, induction of labor, and fetal sex were not included. Among the remaining factors, the only independent significant predictors were ethnic origin and prior cesarean for failure to progress in labor (Table 2). Bootstrapping did not change the odds ratios (data not shown).

Table 3 compares the observed and predicted probabilities. Table 4 shows the predicted probabilities and characteristics of five study women who had increasing probability of successful VBAC ranging from minimum to maximum.

The area under the ROC curve for the likelihood of successful VBAC was 0.72 (95% confidence interval [CI] 0.69–0.76) (data not shown). The scatter plot of the correlation between the present prediction model and that of Grobman et al. [7] showed some variation (Fig. 1), although the correlation was significant ( $r = 0.53$ ,  $P < 0.001$ ). In the scatter plot of median predicted probability versus observed probability for each decile of the data (Fig. 2), the correlation was highly significant (Spearman  $\rho = 0.905$ ,  $P = 0.002$ ).

### 4. Discussion

Among the present study population, the overall success of a VBAC attempt was 71.9%. The logistic regression analysis showed that prediction of a successful VBAC attempt is possible with moderate success (area under the ROC curve 0.72). The study also confirmed previous findings that ethnic origin and history of a previous cesarean for failure to progress in labor are two important factors in determining successful VBAC. However, it was not possible to confirm the effect of maternal booking BMI, prior vaginal delivery, or maternal smoking status on the likelihood of a successful attempt at VBAC. This might be due to a smaller sample size than in other studies. Cahill et al. [12] reported that previous vaginal delivery improves the chance of successful VBAC, and that composite maternal morbidity is less common among women undergoing a repeat elective cesarean as compared with those who attempt vaginal delivery.

Several models have been established to predict the success of VBAC. The prediction model of Grobman et al. [7] assessed in the present study was based on a large number of women attempting VBAC. In that study, 73% of women had a successful VBAC, and the area under the ROC curve was 0.75 (95% CI 0.74–0.77). Although the present results compare favorably with Grobman et al.'s study [7], the area under the ROC curve for the Grobman prediction model applied to the present data was 0.61 (95% CI 0.58–0.65). Thus, the predictive nomogram developed in the USA, which includes six variables identifiable at the first prenatal visit, predicts success of a trial of labor less accurately in the present study population.

**Table 1**  
Characteristics of the study population.<sup>a</sup>

Characteristic	Failed VBAC (n = 413)	Successful VBAC (n = 1050)	P value
Maternal age, y	32.6 ± 4.8	32.2 ± 5.2	0.20
Body mass index at booking <sup>b</sup>	26.8 ± 5.5	26.0 ± 5.2	0.021
Ethnic origin			<0.001
White European	159/691 (23.0)	532/691 (77.0)	
Asian	122/371 (32.9)	249/371 (67.1)	
African	94/278 (33.8)	184/278 (66.2)	
Mixed/other	38/123 (30.9)	85/123 (69.1)	
Smoker	10/71 (14.1)	61/71 (85.9)	0.008
Previous vaginal birth	60 (14.5)	143 (13.6)	0.65
Previous cesarean for failure to progress	230 (55.7)	169 (16.1)	<0.001
Length of pregnancy at birth, wk.	39.7 ± 2.0	40.1 ± 1.2	<0.001
Induction of labor	84 (20.3)	117 (11.1)	<0.001
Birth weight, g	3486 ± 605	3400 ± 485	0.005
Male/female neonate	234/179	519/531	0.013
Pre-pregnancy diabetes	16/35 (45.7)	19/35 (54.3)	0.018
Medical condition complicating pregnancy	43/119 (36.1)	76/119 (63.9)	0.046

Abbreviation: VBAC, vaginal birth after cesarean.

<sup>a</sup> Values are given as mean ± SD, number/total number (percentage), or number (percentage), unless stated otherwise.

<sup>b</sup> Calculated as weight in kilograms divided by the square of height in meters.

**Table 2**  
Logistic regression analysis for the prediction of failed attempt at vaginal birth after cesarean.<sup>a</sup>

Factor	B	Odds ratio (95% confidence interval)	P value
Booking body mass index	0.010	1.01 (0.98–1.04)	0.49
Smoking status	−0.81	0.45 (0.19–1.05)	0.064
Ethnic origin			
White	Ref.	1.0	
Asian	0.466	1.59 (1.14–2.23)	0.007
African	0.587	1.80 (1.23–2.64)	0.003
Other/mixed	0.333	1.40 (0.79–2.45)	0.246
Previous cesarean for failure to progress	1.854	6.39 (4.81–8.49)	<0.001
Any medical condition complicating pregnancy	0.126	1.13 (0.70–1.84)	0.61

<sup>a</sup> The constant for the regression was −1.171.

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