Predicting Vaginal Birth after Cesarean Section: A Cohort Study

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Key Words

Cesarean section · Nomogram · Obstetrics · Labor · Vaginal birth after cesarean · Trial of labor after cesarean delivery

Abstract

Objective: To develop a model to predict vaginal birth after cesarean (VBAC) in our population and to compare the accuracy of this model to the accuracy of a previously published widely used model. **Materials and Methods:** Women attempting trial of labor after cesarean delivery (TOLAC) at our institution from January 1, 2000 through May 30, 2010 were evaluated for inclusion. Demographic and clinical data were collected. Associations of these characteristics with VBAC were evaluated with univariate and multivariate logistic regression. We critically compared the accuracy of the resulting model to a previously published widely utilized model for predicting VBAC. **Results:** A total of 2,635 deliveries with at least 1 prior cesarean delivery were identified. TOLAC was attempted in 599 (22.7%) and resulted in 456 VBACs (76.0%) and 143 repeat cesareans (24.0%). VBAC success was independently associated with age <30 years, a body mass index <30, prior vaginal delivery, prior VBAC, and absence of a recurrent indication for cesarean. This model provided a range of successful probability of VBAC (38–98%) with an area under the receiver operating characteristic curve of

0.723. **Conclusions:** This study provides an accurate and simple model that can be utilized to guide decisions related to TOLAC.

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Introduction

Cesarean delivery rates in the United States currently exceed 32% of all deliveries [1]. Not only is this an all-time high, but it is in epidemic proportion, representing a 53% increase over 10 years starting in 1996 [1]. Although primary cesarean receives much attention, it accounts for only 50% of the increase in cesarean incidence between 2003 and 2009 because the rate of repeat cesarean deliveries is also increasing markedly [2]. Best evidence suggests that trial of labor after cesarean (TOLAC) is a reasonable choice for many women, with vaginal birth after cesarean (VBAC) success rates around 75% overall and complication rates less than 1% [3]. Nevertheless, VBAC rates in the United States currently are 8.5%, down from a high of 28.3% in 1996 [4]. The National Institutes of Health Consensus Development Conference Panel released a statement on VBAC in March 2010 [5, 6]. It emphasized that pregnant women with a prior cesarean should receive appropriate coun-

Table 1. Patient characteristics

Feature	Repeat cesarean (n = 143)	Successful vaginal delivery (n = 456)	p value
Maternal age, years	31 (19–45)	30 (17–43)	0.30
BMI, kg/m ²	26 (18–53)	25 (17–51)	0.029
Parity	1 (1–7)	2 (1–11)	<0.001
Gestational age, weeks	40.0 (37.1–42.3)	39.9 (37.0–42.4)	0.08
Weight gain during pregnancy, kg	12.2 (0–28.1)	11.3 (0–26.8)	0.35
Race and ethnicity (n = 591)			
White and others ^a	110 (78)	333 (74)	0.006
African-American	30 (21)	75 (17)	
Hispanic	2 (1)	41 (9)	
Provider			
Obstetrics and gynecology	112 (78)	327 (72)	0.28
Certified nurse midwife	20 (14)	79 (17)	
Family medicine	11 (8)	50 (11)	
Any prior vaginal delivery (n = 598)	35 (24)	264 (58)	<0.001
Prior vaginal delivery after cesarean (n = 597)	16 (11)	195 (43)	<0.001
Prior cesarean closure (n = 386)			
1 Layer	30 (31)	137 (47)	0.006
2 Layers	66 (69)	153 (53)	
Induced labor	35 (24)	89 (20)	0.08

Values are medians with ranges in parentheses or numbers with percentages in parentheses.

^a Others refers to Asian (n = 27), American Indian/Alaskan native (n = 5), and other (n = 1).

selling concerning VBAC versus elective repeat cesarean in order to make an informed decision. This counseling would presumably include individualized risk-benefit assessment of trial of labor with likelihood of successful VBAC [7–10].

To date, several models are available to predict the probability of successful TOLAC [11–17]. The most utilized and validated model is that first reported by Grobman et al. [11] in 2007. The Grobman predictive VBAC nomogram is based on maternal characteristics that can be obtained at the first prenatal visit. These 6 characteristics are maternal age, body mass index (BMI), race/ethnicity, prior vaginal delivery, prior VBAC, and a recurring indication for cesarean (defined as arrest of dilation or of descent) [11]. The nomogram is based on women with one prior low transverse cesarean who underwent trial of labor with a singleton vertex presentation after 36 6/7 weeks' gestation. To date, there are 2 validation studies evaluating the accuracy of the Grobman nomogram [12, 14]. While the overall accuracy of the model was evident in both populations, questions remain regarding the generalizability of the model across populations with a different racial composition both in the USA and internationally. In addition, more recently, a simpler model

with a scoring system using the Bishop score at the time of admission and excluding race was published [18]. In this study, we developed a new model to predict successful TOLAC in our population, and we compared this model's accuracy to the accuracy of the Grobman nomogram in our population.

Materials and Methods

This is a historical cohort study that was approved by the Mayo Clinic Institutional Review Board before implementation. All women who attempted TOLAC at the Mayo Clinic, Rochester, Minn., USA, from January 1, 2000 through May 30, 2010 were identified and evaluated for inclusion in the study. As part of the Minnesota Research Authorization, all patients receiving care at the Mayo Clinic are asked to fill in a form indicating whether they approve or disapprove the use of their medical charts for research. This form is updated on a regular basis. Patients who declined the use of their medical records for research were excluded from this analysis. Exclusion criteria were intrauterine fetal demise before delivery, multiple gestation, preterm delivery before 36 6/7 weeks, and elective repeat cesarean.

Data collected included maternal age, BMI, prior vaginal delivery, prior VBAC, indication of prior cesarean, and race/ethnicity. Additional data were gravity, parity, complications of pregnancy, complications of labor and delivery, Apgar scores, birth weight,

Table 2. Univariate analysis for predictors of successful VBAC

Feature	Odds ratio (95% CI)	p value
Maternal age	0.98 (0.95–1.02) ^a	0.28
Race/ethnicity (n = 591)		
White and others ^b	1.00 (reference)	
African-American	0.83 (0.51–1.33)	0.43
Hispanic	6.77 (1.61–28.45)	0.009
BMI	0.96 (0.93–1.00) ^a	0.02
Any prior vaginal delivery (n = 598)	4.27 (2.79–6.52)	<0.001
Prior VBAC (n = 597)	5.98 (3.44–10.38)	<0.001
Indication for prior cesarean (n = 582)		
Failure to progress	0.66 (0.35–1.25)	0.20
Cephalopelvic disproportion	1.05 (0.44–2.51)	0.91
Arrested dilation	0.40 (0.23–0.70)	0.001
Arrested descent	0.79 (0.45–1.38)	0.41
Recurrent	0.52 (0.35–0.77)	0.001
Chorioamnionitis	0.11 (0.01–1.01)	0.05
Nonreassuring fetal heart tones	0.97 (0.64–1.47)	0.87
Preeclampsia	0.30 (0.13–0.71)	0.006
Breech	1.60 (1.04–2.48)	0.04
Multiple gestation	0.96 (0.42–2.18)	0.92
HELLP syndrome	1.23 (0.13–infinity) ^c	0.87
Malpresentation other than breech	6.47 (1.08–infinity) ^c	0.04
Placental issues	5.98 (0.99–infinity) ^c	0.05
Other	0.82 (0.42–1.61)	0.57
Complications of current pregnancy		
Gestational hypertension	0.94 (0.10–9.10)	0.96
Gestational diabetes	0.39 (0.18–0.82)	0.01

HELLP = Hemolysis, elevated liver enzymes, and low platelets.

^a Odds ratio represents a 1-unit increase in the feature listed.

^b Others refers to Asian (n = 27), American Indian/Alaskan native (n = 5), and other (n = 1).

^c Odds ratio, 95% CI, and p value estimated using exact logistic regression.

fetal monitoring assessment, type of anesthesia, and prior uterine layer closure. The outcome of this study was successful VBAC after attempted TOLAC. The probabilities of a successful vaginal delivery according to the Grobman nomogram were obtained using the online calculator found at <http://www.bsc.gwu.edu/mfmu/vagbirth.html>.

Statistical Analysis

Continuous maternal characteristics were summarized with mean, median, and range; categorical maternal characteristics were summarized with number and percentage. Using the Wilcoxon rank sum test, predicted probabilities were compared among patients with successful vaginal delivery and patients with a repeat cesarean. Associations of maternal characteristics with successful vaginal delivery were further evaluated using univariate logistic regression models and summarized with odds ratios (ORs) and 95% confidence intervals (CIs). We also evaluated 2 multi-

Table 3. Multivariate logistic regression using factors reported by the Grobman model [11]

Feature	Study population OR (95% CI)	Grobman model OR (95% CI)
Maternal age	0.94 (0.90–0.98) ^a	0.96 (0.95–0.97)
Race/ethnicity		
White and others ^b	1.0 (reference)	1.0 (reference)
African-American	0.60 (0.33–1.09)	0.51 (0.44–0.59)
Hispanic	6.56 (1.45–29.54)	0.51 (0.44–0.59)
BMI	0.94 (0.91–0.98) ^a	0.94 (0.93–0.95)
Any prior vaginal delivery	2.62 (1.39–4.93)	2.43 (2.04–2.89)
Prior vaginal delivery after cesarean	2.88 (1.34–6.19)	2.73 (2.21–3.36)
Recurring indication for prior cesarean	0.56 (0.36–0.86)	0.53 (0.48–0.60)

^a Odds ratio represents a 1-unit increase in the feature listed.

^b Others refers to Asian (n = 27), American Indian/Alaskan native (n = 5), and other (n = 1).

variate logistic regression models. The first model contained the features included in the 2007 nomogram by Grobman et al. [11]. The second model was developed using stepwise regression of the maternal characteristics with the p value set to 0.05 for a feature to enter or leave the model. Model discrimination was summarized using the area under a receiver operating characteristic curve (AUC). The observed and predicted probability of successful VBAC was calculated for our model and presented. Statistical analyses were performed using the SAS software (SAS Institute, Inc., Cary, N.C., USA). All tests were 2 sided; p values less than 0.05 were considered statistically significant.

Results

From January 1, 2000 through May 30, 2010, there were 20,184 deliveries in our institutions. Of those, 2,635 (13.1%) deliveries were in women with at least 1 prior cesarean delivery. After exclusion of women who did not meet our inclusion criteria and those who declined research authorization, the final cohort included 599 women who attempted TOLAC. Of those 599 TOLACs, 456 (76.0%) resulted in VBACs and 143 (24.0%) in repeat cesarean deliveries. The following factors were associated with women who had VBAC compared to those who failed TOLAC: younger age, lower BMI, higher parity, white race, prior vaginal delivery, prior successful VBAC and a prior 2-layer closure of cesarean delivery (table 1). Univariate analyses are presented in table 2.

We evaluated the variables included in the Grobman model and calculated the adjusted ORs derived from our

Fig. 1. Predicted probability of successful vaginal delivery. The scatter plot shows the predicted probability of successful vaginal delivery based on the model outlined in table 3 compared to the calculated probability based on Grobman's model.

Table 4. Multivariate model to predict successful vaginal delivery using features evaluated through stepwise regression

Feature	Odds ratio (95% CI)	p value
Maternal age <30 years	1.53 (1.00–2.36)	0.049
BMI <30	1.82 (1.11–2.97)	0.018
Any prior vaginal delivery	3.17 (1.50–6.80)	0.003
Prior vaginal delivery after cesarean	2.24 (1.25–4.18)	0.006
No recurrent indication	1.81 (1.18–2.76)	0.007

population (table 3). The AUC for the features in this model was 0.757 (95% CI, 0.713–0.801), which is similar to the AUC reported by the original publication being 0.754 (95% CI, 0.742–0.766). Most features listed in table 3 show similar associations with successful VBAC as previously reported by Grobman [11]. However, the associations of race/ethnicity with VBAC success were quite different. Although African-Americans were less likely to have successful VBAC than Whites and others, this difference was not statistically significant in our population. In addition, women of Hispanic descent were significantly more likely to have successful VBAC compared with Whites and others (OR, 6.56; 95% CI, 1.45–29.54). Figure 1 illustrates the predicted probabilities of successful VBAC using the nomogram by Grobman compared with those obtained from the model in table 3.

Table 4 includes the multivariate model developed using stepwise regression of selected features known at the prenatal visit. To address the issue with unexpected increased TOLAC success in Hispanic women, we removed race from the final model. In addition, to simplify the interpretation of the final model, we subcategorized both age and BMI to facilitate the use of the prediction model in patient counseling. In the final model, VBAC success was independently associated with age lower than 30 years, BMI less than 30, prior vaginal delivery, prior VBAC, and absence of a recurrent indication for cesarean delivery. This model provided a successful probability of VBAC ranging from 38 to 98% (table 5). The AUC for this final model was 0.723 (95% CI, 0.680–0.767).

Conclusions

The main finding of this current study is that, in our population, there are specific risk factors that can be combined in a model to accurately predict successful TOLAC. In the final model, the following factors were independently associated with successful TOLAC: age <30 years, BMI <30, prior successful VBAC, previous vaginal delivery, and absence of a recurrent indication for cesarean delivery. When we compared the accuracy of the Grobman model components in our population, the Grobman model had an overall high accuracy; however, this accu-

Table 5. Predicted and observed success rate based on the final multivariate regression

Predictors of successful VBAC					VBAC success	
age <30	BMI <30	prior vaginal delivery	prior VBAC	no recurring indication	observed, n/N (%)	predicted, %
No	No	No	No	No	4/8 (50)	38
No	No	No	No	Yes	5/10 (50)	53
No	No	Yes	No	No	1/1 (100)	58
No	No	Yes	No	Yes	10/14 (71)	71
No	No	Yes	Yes	No	3/7 (43)	81
No	No	Yes	Yes	Yes	18/19 (95)	89
No	Yes	No	No	No	24/40 (60)	53
No	Yes	No	No	Yes	42/68 (62)	67
No	Yes	Yes	No	No	7/13 (54)	72
No	Yes	Yes	No	Yes	26/29 (90)	82
No	Yes	Yes	Yes	No	24/28 (86)	89
No	Yes	Yes	Yes	Yes	62/64 (97)	94
Yes	No	No	No	No	8/14 (57)	49
Yes	No	No	No	Yes	13/21 (62)	63
Yes	No	Yes	No	No	2/4 (50)	68
Yes	No	Yes	No	Yes	2/4 (50)	79
Yes	No	Yes	Yes	No	4/4 (100)	87
Yes	No	Yes	Yes	Yes	12/12 (100)	92
Yes	Yes	No	No	No	28/44 (64)	63
Yes	Yes	No	No	Yes	58/78 (74)	76
Yes	Yes	Yes	No	No	2/2 (100)	79
Yes	Yes	Yes	No	Yes	16/17 (94)	87
Yes	Yes	Yes	Yes	No	14/15 (93)	92
Yes	Yes	Yes	Yes	Yes	37/40 (93)	96

racy was hampered by the observed unexpectedly increased TOLAC success rate in Hispanic women in our cohort. To avoid these conflicting results and to increase the generalizability of our model, we removed race as a predictive factor in our model. In addition, categorization allowed a simpler way of calculating the predicted success in an easy-to-use table format.

Data are limited that Hispanic women have a different VBAC success rate compared with white women. A 2006 study found the Hispanic VBAC success rate to be 70%, compared with 79% in Whites (adjusted OR, 0.63; 95% CI, 0.51–0.79) [19]. The original Grobman data included more than 2,300 Hispanic women, representing 19% of the included population. In their analysis, the adjusted OR for VBAC success was 0.51 (95% CI, 0.44–0.59) in Hispanic women compared with white women. However, we found that Hispanic women had significantly increased rates of VBAC success. To our knowledge, these are the first data indicating that Hispanic women may have an increased rate of successful VBAC compared with white women.

This increased success is an interesting finding within the context of an overall Hispanic paradox in obstetrics where, despite the socioeconomic risk factors, Hispanic women have overall more favorable perinatal outcomes than non-Hispanic Whites and African-Americans [20–26]. Nonetheless, we also acknowledge that our assessment of the association of Hispanic ethnicity was limited by the fact that there were only 43 Hispanic women in the study, of whom 41 had successful vaginal delivery. Accordingly, we subsequently removed race from our proposed model. Overall, this did not affect the accuracy of the model, and we believe the removal of race from the model will increase this model's generalizability to other populations. In a recent publication that included a new simple score to predict the success of VBAC in labor, race was not found to be a predictor in the final model [18]. This recent study supports our findings that race has a minor role in predicting VBAC success.

In the last 20 years, several models were proposed to help physicians and their patients predict the VBAC success rate [13–16]. The Grobman nomogram is the most

widely used. To date, the Grobman nomogram has been validated in 2 populations outside the original cohort [12, 27]. Our data add support to this model in another distinct US population with different racial components. Our results confirm previous data reporting successful VBAC in 75% or more of women attempting TOLAC [13–16]. Furthermore, our study adds information that may be relevant for the modification of the nomogram – specifically, race/ethnicity to increase the generalizability of the model to other populations. The limitations of our study included the retrospective design that prevented prospective collection of data and introduced a possibility of bias. Another limitation is the small number of

women in the smaller racial groups that are represented in the population in Rochester, Minn., USA, where the study was conducted. Despite those limitations, we believe this study provides an accurate and simple model that can be utilized in our population and can be generalized to a similar population at least in the Upper Midwest of the USA. Further validation in other populations is recommended.

Disclosure Statement

None of the authors has a conflict of interest.

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