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Vaginal birth after caesarean section prediction models: a UK comparative observational study

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ABSTRACT

Objective: Primarily, to assess the performance of three statistical models in predicting successful vaginal birth in patients attempting a trial of labour after one previous lower segment caesarean section (TOLAC). The statistically most reliable models were subsequently subjected to validation testing in a local antenatal population.

Study design: A retrospective observational study was performed with study data collected from the Northern Ireland Maternity Service Database (NIMATs). The study population included all women that underwent a TOLAC (n = 385) from 2010 to 2012 in a regional UK obstetric unit. Data was collected from the Northern Ireland Maternity Service Database (NIMATs). Area under the curve (AUC) and correlation analysis was performed.

Results: Of the three prediction models evaluated, AUC calculations for the Smith et al., Grobman et al. and Troyer and Parisi Models were 0.74, 0.72 and 0.65, respectively. Using the Smith et al. model, 52% of women had a low risk of caesarean section (CS) (predicted VBAC >72%) and 20% had a high risk of CS (predicted VBAC <60%), of whom 20% and 63% had delivery by CS. The fit between observed and predicted outcome in this study cohort using the Smith et al. and Grobman et al. models were greatest (Chi-square test, p = 0.228 and 0.904), validating both within the population.

Conclusion: The Smith et al. and Grobman et al. models could potentially be utilized within the UK to provide women with an informed choice when deciding on mode of delivery after a previous CS.

Introduction

Within the United Kingdom (UK) rates of caesarean section (CS) have seen a steady rise, paralleling that of worldwide trends [1]. In addition to soaring economical costs, increasing numbers of CS are associated with rising rates of adverse perinatal outcome [2]. A potential strategy to reduce rising CS rates is to optimize the rate of trial of labor after cesarean section (TOLAC) within units. Selection of TOLAC over elective repeat caesarean section (ERCS) does not appear to increase maternal psychological morbidity in terms of anxiety, depression or psychological well-being scores and has been shown to be cost effective when the chance of success is greater than 74% [3,4].

Women that have undergone a previous CS must be counseled adequately before deciding on the mode of delivery in subsequent pregnancies. In current obstetric practice increasing numbers of women within the UK are being faced with this decision, requiring accurate local information to inform their choice. Both TOLAC and ERCSMR have potential risks and benefits [5–9] and while the general consensus holds that TOLAC should be encouraged, risk stratification should be performed for women on an individualized basis [9]. The risk of maternal morbidity depends on the outcome of the TOLAC. Women who achieve a vaginal delivery have the lowest rates of complications whereas women who attempt TOLAC

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but end up with an emergency CS have the highest rates of complications [10]. Hence, a key factor in counseling women is the likelihood of success should TOLAC be attempted.

Several prediction models have been developed which aim to determine the chances of a successful TOLAC. These statistical models, when applied to an individual patient's antenatal and pre-delivery parameters, determine a score, which correlates with the probability of achieving a successful vaginal birth. These scoring systems may be utilized in clinical practice to counsel women and inform their decisions [8]. The guideline on *Birth After Previous Caesarean Birth* from the *Royal College of Obstetricians and Gynaecologists* states that; 'the usefulness of such models in assisting women to make the decision on mode of delivery after CS remains to be determined' [7].

Hence, the aim of this study was to evaluate the performance of three different models used as predictors for TOLAC success. The tested statistical models were those of Smith et al. [11], Grobman et al. [12], and Troyer and Parisi [13]. These models had been subject to previous validation testing within individual antenatal populations such as those of North America and Japan but not all have been validated within a UK population [14–16]. All three predictor models were applied to a local population in order to correlate their efficacy in predicting successful TOLAC. Following this, the statistically most robust models would then be subjected to validation testing in the local antenatal population in order to establish its potential utility locally.

Materials and methods

A retrospective observational study was performed following prospective research governance approval. A statistician (RS) was consulted. The study was conducted in a district general obstetric unit, which has approximately 4000 deliveries per annum. All women who had undergone one previous lower segment CS and had attempted TOLAC were included in the study. Data on each subject was obtained from the Northern Ireland Maternity System (NIMATs) database and individual clinical case-notes, with the study spanning the period April 2010 to April 2012. During this time period the unit protocol for management of TOLAC remained unchanged.

The Smith et al. model utilizes logistic regression calculations to determine the probability of TOLAC success. The calculation data include pre-delivery factors such as maternal age, height, ultrasound determined male fetus and an absence of previous vaginal births [11]. The Grobman et al. model also utilizes logistic regression. Relevant data include factors such as maternal age, body mass index (BMI) ethnicity and previous vaginal delivery [12]. A distinct clinical advantage of these models are that they utilize variables that can be readily determined at a prenatal counseling or index antenatal visit. Troyer and Parisi's model utilizes a scoring system based on points [13]. One point is allocated for each of the following: a previous dysfunctional labor, non-reassuring admission fetal cardiotocograph (CTG) in the current pregnancy, absence of previous vaginal delivery, and induction of labor in current pregnancy. This model has the advantages of being mathematically very simple and can be readily applied in the early antenatal period with adjustment for other factors such as induction of labor are accounted for. Table 1 summarizes characteristics of the TOLAC predictor models.

In order to compare the different TOLAC prediction models, data on patient characteristics including maternal age, body mass index (BMI) at the pre-natal visit (kg/m^2), maternal ethnicity, previous vaginal delivery, previous successful TOLAC, recurring indication for CS (notably failure to progress), fetal heart rate (FHR) abnormality, induction of labor, delivery at 41 weeks and delivery at 42 weeks, were recorded and analyzed.

Table 1
Table summarizing the characteristics of three trial of labour after caesarean section prediction models.

Characteristic	Grobman et al.	Smith et al.	Troyer and Parisi
Age	✓	✓	
Fetal sex		✓	
Body mass index	✓		
Height		✓	
Race	✓		
Any previous vaginal delivery	✓	✓	✓
Induction of Labour		✓	✓
Delivery >41 weeks		✓	
Successful Trial of Labor after Caesarean section	✓		
Caesarean Section for failure to progress	✓		✓
Non-reassuring fetal heart rate			✓
Logistic regression calculation	✓	✓	

Statistical analysis was performed using IBM SPSS statistics version 20. Data from the patient cohort was incorporated into all three prediction algorithms to calculate the individual post-test probability of TOLAC success for each patient. The sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) were calculated for each model along with the corresponding 95% confidence intervals, using a score (predicted probability) threshold of $\geq$0.72 to define a "positive" result. To evaluate the potential clinical efficacy of each predictor model, its performance was assessed using receiver operating characteristic curves (ROC), and the area under the curve (AUC) was estimated with the trapezoidal rule [17]. A p value of $<$0.05 was set for statistical significance.

The PPV and NPV results, along with those derived from AUC calculations, determined the most clinically effective predictor model in this population. Statistical validation of this test within the local population was performed using logistic regression of observed TOLAC success rates on the derived predicted VBAC probabilities, reporting the result of the Hosmer–Lemeshow test for goodness of fit of the model, the improvement in classification accuracy, and the Nagelkerke pseudo-R^2 statistic.

Results

The eligible study population included a total of 385 TOLACS; 246 of which were successful (63.9%), and 139 (36.1%) of which required en emergency CS. Patient characteristics are displayed in Table 2.

ROC curves were determined for each prediction model (Fig. 1). The AUC was calculated for each model, and is presented in

Table 2
Characteristics of study population patients attempting VBAC included in the three prediction models.

Characteristic	Mean and standard deviation or Number and percentage
Age (yrs)	31 ± 4.8
BMI at prenatal visit (kg/m^2)	26.3 ± 5.5
Height (cm)	162.7 ± 6.4
Ethnicity (Hispanic/Afro-Caribbean)	0 (0)
Previous vaginal delivery	137 (35.6)
Previous VBAC	136 (35.3)
Recurring indication for caesarean section	111 (28.8)
Non-reassuring fetal heart rate	57 (14.8)
Induction	114 (29.6)
Prostaglandin exposure	71 (18.4)
Gestation 41 and 42 weeks	75 (19.4)
Male fetal sex	194 (50.3)