ORIGINAL ARTICLE

Ann Acad Med Singap 2021;50:606-12
https://doi.org/10.47102/annals-acadmedsg.202132

A comparison of antenatal prediction models for vaginal birth after caesarean section

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ABSTRACT

Introduction: An antenatal scoring system for vaginal birth after caesarean section (VBAC) categorises patients into a low or high probability of successful vaginal delivery. It enables counselling and preparation before labour starts. The current study aims to evaluate the role of Grobman nomogram and the Kalok scoring system in predicting VBAC success in Singapore.

Methods: This is a retrospective study on patients of gestational age 37 weeks 0 day to 41 weeks 0 day who underwent a trial of labour after 1 caesarean section between September 2016 and September 2017 was conducted. Two scoring systems were used to predict VBAC success, a nomogram by Grobman et al. in 2007 and an additive model by Kalok et al. in 2017.

Results: A total of 190 patients underwent a trial of labour after caesarean section, of which 103 (54.2%) were successful. The Kalok scoring system (area under curve [AUC] 0.740) was a better predictive model than Grobman nomogram (AUC 0.664). Patient's age (odds ratio [OR] 0.915, 95% CI [confidence interval] 0.844–0.992), body mass index at booking (OR 0.902, 95% CI 0.845–0.962), and history of successful VBAC (OR 4.755, 95% CI 1.248–18.120) were important factors in predicting VBAC.

Conclusion: Neither scoring system was perfect in predicting VBAC among local women. Further customisation of the scoring system to replace ethnicity with the 4 races of Singapore can be made to improve its sensitivity. The factors identified in this study serve as a foundation for developing a population-specific antenatal scoring system for Singapore women who wish to have a trial of VBAC.

Ann Acad Med Singap 2021;50:606-12

Keywords: Antenatal scoring system, caesarean section, obstetrics and gynaecology, trial of labour after caesarean section, vaginal birth after caesarean section

INTRODUCTION

Caesarean section is one of the most common surgeries in the world. In Singapore, caesarean section rates have risen from 17.8% in 1999 to 34.0% in 2009.[1] With a higher number of caesarean sections, counselling and managing birth after caesarean section have become important.

Compared with elective caesarean section, vaginal birth after caesarean section (VBAC) reduces maternal hospital stay and recovery time, and allows future attempts at vaginal birth. It also reduces the risks associated with multiple caesarean sections such as adhesion formation, visceral injury, wound complications and abnormal placentation in any subsequent pregnancy. Placenta accreta spectrum, which may occur after caesarean section, is associated with massive obstetric haemorrhage, leading to a higher risk of hysterectomy and death. A trial of VBAC also carries risks including scar dehiscence and uterine rupture (0.47%),[2] which are associated with significant maternal and neonatal morbidity and mortality.

A lower segment caesarean section (LSCS) is preferred to a classical caesarean section as transverse abdominal incision is associated with less postoperative pain and an improved cosmetic effect.[3] Women with complicated uterine scars including a previous inverted T or J incision, and classical caesarean sections are contraindications to a trial of VBAC,[4] due to insufficient

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CLINICAL IMPACT

What is New

- Kalok additive scoring system was a better predictive model for successful vaginal birth after caesarean (VBAC) compared to Grobman nomogram in the Singapore study population.
- Patient's age, body mass index and history of successful VBAC were important factors for predicting VBAC.

Clinical Implications

- Customisation of a scoring system to improve its sensitivity for use with Singapore women may be explored.
- A population-specific antenatal scoring system allows for individualised counselling at start of pregnancy and facilitates joint decision-making between clinicians and patients.

data on uterine scar integrity and risk of uterine rupture.[2] Women with a history of 2 or more previous caesarean sections are at greater risk of uterine rupture (1.36%), hysterectomy (56/10,000 versus 19/100,000) and blood transfusion (1.99% vs 1.21%).[5] Hence, despite a 6.2% overall risk of perinatal death in the event of uterine rupture,[2] many authorities[3,6] concur that planned VBAC is a clinically safe choice for selected women with a single previous LSCS.

The desire for VBAC differs among patients. Each patient's background, priorities and risk tolerance for rare complications such as uterine rupture is different. Apart from the higher risk of emergency LSCS compared to elective repeat LSCS, there is tremendous psychological distress associated with emergency LSCS.[7] Hence careful counselling prior to labour is important in the management of patients with a previous caesarean section. There are various tools available in the literature to guide decision-making. An antenatal VBAC scoring system functions as a predictive tool for categorising patients into low and high probability groups for achieving VBAC. It can be used as an aid in individualised counselling of patients on the mode of delivery at the start of an antenatal journey, giving patients a realistic expectation of the likelihood of a successful VBAC. This facilitates a joint decision-making model mandated by the Montgomery ruling for informed consent.

The nomogram developed by Grobman et al. 2007[8] has been cross-validated and externally validated in many populations.[9,10] It includes 6 factors that can be obtained during the first antenatal visit: age, body mass index (BMI), race, number of vaginal deliveries since last LSCS, number of vaginal deliveries and recurrent primary indication. As per Grobman et al., recurrent indications for previous caesarean section refer to reasons for a first caesarean section that may happen again in the index pregnancy, such as cephalopelvic disproportion (CPD) and obstructed labour. Non-recurrent indications refer to causes that may not happen again in the index pregnancy such as breech presentation, malposition, malpresentation, or non-reassuring fetal status. The data from each patient is tabulated into a regression model and the predicted success rate is calculated.

The additive scoring system created by Kalok et al. in 2017 includes 5 factors: (1) non-recurrent indication of primary caesarean section; (2) previous vaginal delivery; (3) maternal booking BMI; (4) age; and (5) estimated fetal weight at or above gestational age (GA) of 36 weeks.[11] Factors 1 and 2 are each allocated 2 points and factors 3 to 5 are given 1 point each. The total number of points for each woman is calculated over a total score of 7. Kalok et al. found that a score of 4 or more is predictive of a successful VBAC with a sensitivity of 81% and specificity of 52.3%.

The study aimed to evaluate Grobman nomogram and the Kalok scoring system in predicting a successful vaginal birth after 1 prior caesarean section among the Singapore population.

METHODS

This was a retrospective observational study of antenatal patients of GA 37 weeks 0 day to 41 weeks 0 day, who underwent a trial of labour after 1 previous LSCS in KK Women's and Children's Hospital, Singapore, between 1 September 2016 and 30 September 2017. Patients with intrauterine death, multiple pregnancy or any contraindication to vaginal birth, such as non-cephalic presentation, placenta praevia, previous uterine rupture and previous classical caesarean section were excluded from the study. Patients with unknown previous incision or caesarean section with extension of uterine incision deemed not suitable for vaginal birth were excluded from the study.

Data on maternal demographics, obstetric history, current pregnancy details and outcomes were collected. The variables analysed included indication for previous LSCS, number of vaginal deliveries before the index pregnancy (including successful VBAC), BMI at first antenatal visit, maternal age, gestational diabetes or pre-existing diabetes, fetal outcomes and presence of

uterine rupture or dehiscence. Uterine rupture refers to clinically significant disruption of all uterine layers leading to changes in maternal or fetal status, and is usually diagnosed clinically. Uterine dehiscence refers to clinically occult uterine disruption that may not have any significant clinical signs and symptoms. Both uterine rupture and dehiscence can be confirmed during surgery. The use of induction or augmentation agents was also noted. For comparison with Grobman nomogram, recurrent indications for previous caesarean section included CPD, failure to progress and failed induction. Patients with incomplete documentation were excluded.

The VBAC success rate was estimated using 2 scoring systems: (1) Grobman nomogram via an online publicly accessible calculator designed by Grobman (https://mfmunetwork.bsc.gwu.edu/PublicBSC /MFMU/VGBirthCalc/vagbirth.html); and (2) Kalok additive scoring system. The predicted mode of delivery was then compared with the eventual mode of delivery, and the area under the curve (AUC) of receiver operating characteristic (ROC) curves were analysed. Maternal characteristics were also compared between women who had successful vaginal birth(s) (including previous successful VBAC) and those who did not, using chi-square test for categorical variables and 2-sample t-test for continuous variables. A *P* value of <0.05 was taken as statistically significant. Factors that were found to be statistically significant and/or significant based on literature reviews were then further analysed using binary logistic regression analysis to calculate the odds ratio (OR). The data was analysed using SPSS Statistics software version 26 (IBM Corp, Armonk, US).

Ethical board approval for this study was obtained from the SingHealth Centralised Institutional Review Board (reference number 2018/2809).

RESULTS

During the study period, there were a total of 482 women who delivered after 1 previous LSCS. Of which, 292 women were excluded from the study (289 opted for elective LSCS, 1 had incomplete records and 2 had stillbirths). A total of 190 women underwent trial of labour after 1 prior LSCS and were included in the analysis. One hundred and three (54.2%) women had a successful VBAC and 87 (45.8%) women required emergency LSCS due to failed VBAC. Those who had a successful VBAC had higher parity, lower mean BMI, a history of prior vaginal delivery or VBAC (Table 1). Women who had a membrane sweep in the antenatal period showed an increasing trend towards a successful VBAC.

The factors that were found to be statistically significant or significant based on literature reviews were further analysed using binary logistic regression analysis (Fig. 1). Previous successful VBAC increased the chance of a subsequent successful VBAC delivery by 4.75 times (Fig. 1). Higher maternal age (OR 0.915, 95% CI [confidence interval] 0.844–0.992) and higher BMI at booking (OR 0.902, 95% CI 0.845–0.960) had lower odds for successful VBAC delivery. Other factors such as parity, recurrent indication for previous LSCS, previous vaginal delivery and membrane sweep were not statistically significant in predicting a successful VBAC.

Of the 103 live term birth from successful VBAC, only 1 (1.0%) neonate was admitted to the Neonatal Intensive Care Unit (NICU), and 3 (2.9%) required special care support. Compared to the 87 live term birth from unsuccessful VBAC, 2 (2.3%) neonates were admitted to NICU and 4 (4.6%) required special care support. The mean () birth weight of neonates delivered via VBAC was 3,092g (standard deviation [SD]=374.28), compared to 3,182g (SD=448.82) (*P*=0.132) for those who delivered via emergency LSCS.

There was 1 case of uterine rupture (0.5%) and 3 (1.6%) cases of uterine scar dehiscence. None of the 19 patients who were induced or augmented in labour had complications of uterine rupture or dehiscence. Emergency LSCS was performed and the rupture or dehiscence was confirmed intraoperatively for all 4 cases. The patient who had the uterine scar rupture was admitted for latent phase of labour, which was prolonged (1,140min). There was non-reassuring fetal status that alerted the team of a possible uterine rupture, and a crash caesarean section was carried out immediately. The patient subsequently underwent a caesarean hysterectomy due to massive postpartum haemorrhage post-closure of the uterus. There was persistent bleeding from the infundibulopelvic ligament into the mesosalpinx despite haemostatic suture (estimated blood loss of 1 litre). The cord gases were: arterial pH 6.7, base excess -17, lactate 4.6, venous pH 6.8, base excess -13.6 and lactate 5.14. The neonate's 1- and 5-minute Apgar scores were 4 and 6, respectively and was subsequently admitted to NICU. The baby was discharged well thereafter.

The mean predicted probability of VBAC among the study population calculated using Grobman nomogram was significantly higher for the group with successful

Table 1. Characteristics of patients who attempted term VBAC during the study period

Characteristics	Total	Unsuccessful VBAC	Successful VBAC	*P* value
Patients, no. (%)	190	87 (45.8)	103 (54.2)	–
Age, mean (SD), years	32.0 (4.47)	32.1 (4.06)	31.6 (4.79)	0.454
Parity, mean (SD)	1.59 (1.03)	1.38 (0.77)	1.78 (1.19)	0.008
Race				0.685
Chinese	53 (27.9)	22 (41.5)	31 (58.5)	
Malay	83 (43.7)	37 (44.6)	46 (55.4)	
Indian	33 (17.4)	18 (54.5)	15 (45.5)	
Others[a]	21 (11.1)	10 (47.5)	11 (52.4)	
BMI at booking visit, mean (SD), kg/m^2	25.2 (5.41)	26.7 (5.68)	23.9 (4.88)	0.001
Recurrent indication[b] for previous LSCS, no. (%)	60 (31.6)	33 (55.0)	27 (45.0)	0.083
Previous vaginal delivery, no. (%)	63 (33.2)	21 (33.3)	42 (66.7)	0.015
Previous VBAC, no. (%)	40 (21.1)	10 (25.0)	30 (75.0)	0.003
GDM/pre-existing DM, no. (%)	25 (13.2)	11 (44.0)	14 (56.0)	0.769
Membrane sweep, no. (%)	11 (5.8)	5 (23.8)	16 (76.2)	0.003
Last EFW measured, mean (SD), g	2675 (676.38)	2678 (734.06)	2673 (626.70)	0.962
Duration from last LSCS, mean (SD), year	4.9 (3.12)	4.9 (3.23)	4.9 (3.05)	0.941
Induction/augmentation agent used, no. (%)	19 (10.0)	8 (42.1)	11 (57.9)	0.734

BMI: body mass index; DM: diabetes mellitus; EFW: estimated fetal weight; GDM: gestational diabetes mellitus; LSCS: lower segment caesarean section; SD: standard deviation; VBAC: vaginal birth after caesarean section
[a] Other nationalities such as Filipino, Vietnamese, Thai, etc.
[b] Recurrent indication for previous LSCS includes cephalopelvic disproportion, failure to progress, failed induction

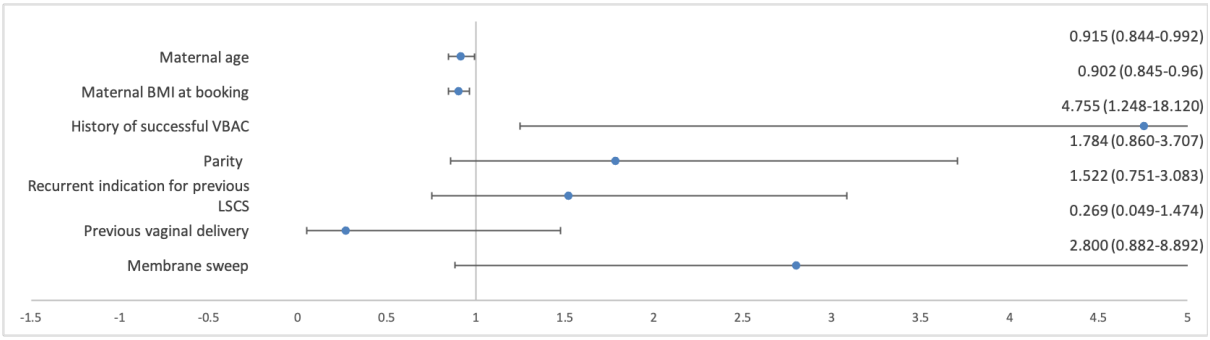

Fig. 1. Logistic regression analysis of the factors associated with successful vaginal birth after caesarean section in the study population.
BMI: body mass index; LSCS: lower segment caesarean section; VBAC: vaginal birth after caesarean section

VBAC (78.9%, SD 13.274) compared to that of the group with unsuccessful VBAC (71.0%, SD 12.934) (P<0.001, 95% CI -11.770 to -4.021). The model's prediction of VBAC success rate is represented by the ROC curve in Fig. 2. The AUC of this curve is 0.664 (95% CI 0.585–0.742).

Table 2 illustrates the sensitivity and specificity of the Kalok scoring system, with either a score of 4 or more (used by Kalok et al.) or a score of 3 or more indicating successful VBAC. When applied to our study population, the scoring system is as sensitive (76.7% vs 81%) but less specific (28.7% vs 52.3%)

Table 2. Effectiveness of the additive scoring system developed by Kalok et al.

	Score ≥3	Score ≥4	Kalok et al.
Sensitivity, %	85.4	76.7	81.0
Specificity, %	18.4	28.7	52.3
Positive predictive value, %	55.3	56.0	84.6
Negative predictive value, %	51.6	51.0	46.0
Negative likelihood ratio	0.792	0.811	NA
AUC of ROC (95% CI)	0.835 (0.774–0.897)	0.740 (0.667–0.813)	0.700

AUC: area under the curve; CI: confidence interval; ROC: receiver operating characteristic

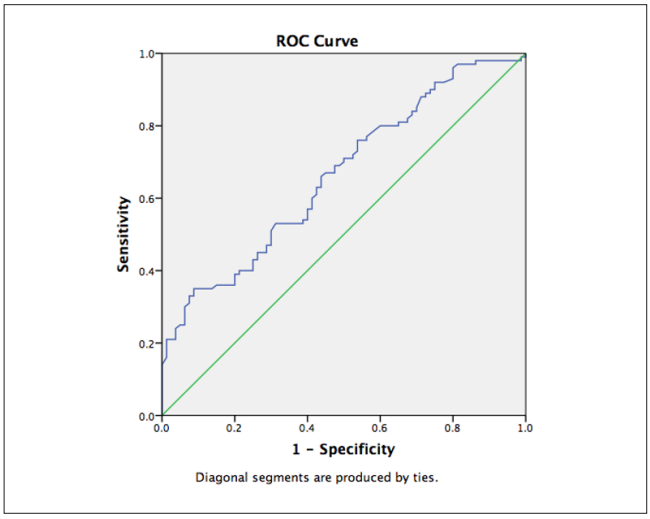

Fig. 2. Receiver operating characteristic (ROC) curve for the prediction of vaginal birth after caesarean section success using Grobman nomogram. The area under the curve is 0.664 (95% confidence interval 0.585–0.742).

when compared to actual published statistics in the development of the Kalok system. A score of 3 or more to indicate a successful VBAC appears to have a higher AUC of ROC (0.835) than when a score of 4 or more is used (AUC 0.740) (Fig. 3).

DISCUSSION

The VBAC success rate in our study population was 54.2%. This was lower compared to other institutions with rates of 60–80%.[12,13] The lower VBAC rate may be related to the institutional practice where prostaglandin induction or augmentation with oxytocin is not favoured in VBAC patients. Induction and augmentation improve VBAC success rates, but also increase the risk of uterine rupture. Many factors have been found to affect the success of VBAC. They are commonly included in VBAC scoring systems to identify patients who are good candidates for trial of labour after caesarean section. However, these models differ in

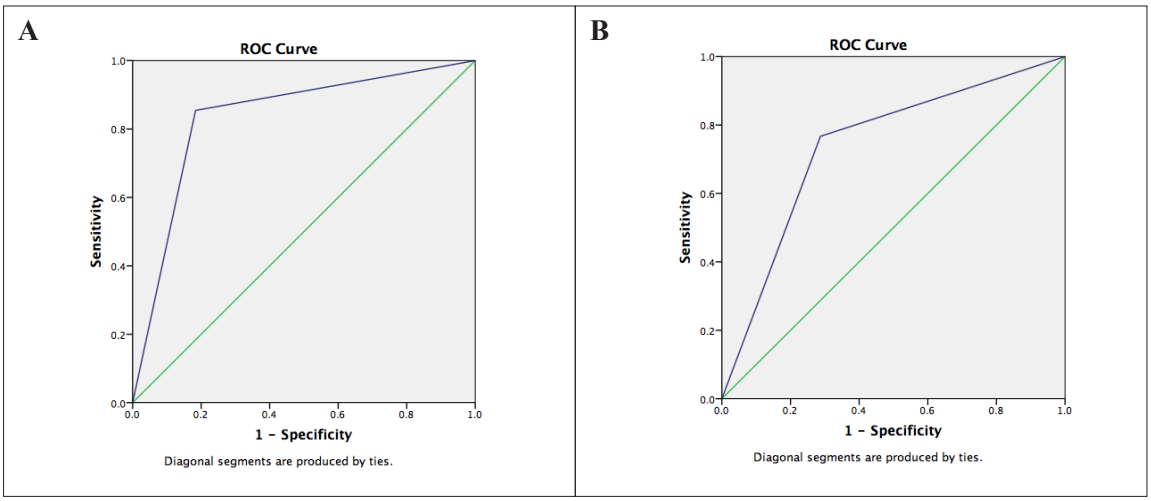

Fig. 3. Receiver operating characteristic (ROC) curves for the prediction of vaginal birth after caesarean section success using Kalok scoring system.
(A) Score of ≥3 predictive of successful VBAC, area under the curve 0.740 (95% confidence interval [CI] 0.667–0.813). (B) Score of ≥4 predictive of successful VBAC, area under the curve 0.835 (95% CI 0.774–0.897).

their performance to consistently predict the success of VBAC.

The scoring system by Kalok et al.[11] (AUC 0.740, 95% CI 0.667–0.813) was more accurate than the nomogram developed by Grobman et al.[8] (AUC 0.664, 95% CI 0.585–0.742) as an antenatal tool to predict the success of VBAC in our study population. One possible reason is that Kalok et al. developed the scoring system based on the population of Malaysia, which may have potential similarities with the Singaporean population and also similar clinical practices. One of the 6 antenatal factors included in the Grobman nomogram is race. Women of different geographical regions and hence different ethnicities have differently shaped birth canal,[14] and this can affect the success of VBAC. In Singapore, there are very few patients with a Hispanic or African American background and this may have affected the performance of the nomogram for the local population. The Kalok scoring system was found to have high sensitivity but low specificity. The negative likelihood ratio was as high as 81.1%, which indicated that its predictive value might not be reliable. If a lower score cut off (≥3) had been used for VBAC success prediction, sensitivity and AUC increased but the specificity was lower. Neither scoring system was designed to predict the risk of complications such as uterine scar rupture or a scar dehiscence.

The positive association concluded in this study between previous successful VBAC, lower maternal age and maternal BMI at booking with successful VBAC delivery was generally similar to Grobman's conclusions in his nomogram development. A high maternal BMI predisposes a woman to gestational diabetes and fetal macrosomia, which can result in an unsuccessful trial of VBAC. Similarly, advanced maternal age predisposes women to more obstetric complications such as gestational diabetes, gestational hypertension and pre-eclampsia. For such "high risk" pregnancies, the clinical threshold for obstetric interventions during trial of VBAC may be lowered. This would result in higher rates of emergency caesarean sections. Both high maternal BMI and advanced maternal age are risk factors for dysfunctional labour. The main differences were those of race (P=0.685) and non-recurrent indication for previous LSCS (P=0.244) that were found to be insignificant in our population. These may explain why Grobman nomogram was not sensitive in predicting VBAC success in our study population.

A Chinese study by Xu et al.[15] in 2019 looked at the effectiveness of the Grobman nomogram in their study population, and compared its performance with that of a modified nomogram with 5 new factors including maternal residence instead of maternal race. They found that the Grobman nomogram was suitable for Chinese pregnant mothers, and there were no marked differences between the 2 models of AUC (0.811, 95% CI 0.751–0.870 vs 0.834, 95% CI 0.891–0.886). This implied the presence of other possible reasons, apart from maternal residence, to explain why the Grobman nomogram was not as effective in predicting successful VBAC in the Singapore population. These could include factors such as lack of use of induction or augmentation per local practice and preference. In the study by Xu et al., around 19.5% of participants had induced labour and 19.3% had augmented labour with oxytocin. Only 10% of participants in the current study had induced or augmented labour.

Interestingly, the current study suggested that membrane sweep may be associated with successful VBAC (Table 1). Membrane sweep is a method of non-pharmacological induction of labour that has been found to reduce the need for formal induction of labour.[16] Previous studies[17,18] did not find any significant benefit of membrane sweep in increasing the rate of VBAC.[19] Membrane sweep was not found to be significantly associated with successful VBAC in logistic regression analysis (OR 2.8, 95% CI 0.882–8.892) (Fig. 1). This may be due to the small sample size of participants who had membrane sweep (n=11). Nevertheless, it may be of worth to consider membrane sweep when managing patients keen for VBAC.

This study was limited by its retrospective nature and small sample size. In addition, only the antenatal factors affecting the success of VBAC were analysed. No intrapartum factors were evaluated. The analyses were also limited to term pregnancies and patients with only 1 previous caesarean section. The scoring systems only looked at the success of vaginal birth and were not able to successfully predict outcomes of uterine rupture/dehiscence. Nonetheless, this study serves as a preliminary study for future prospective studies. Further customisation to the current antenatal scoring systems, such as replacing Hispanic or African American background with the 4 ethnic races of Singapore, may be done to develop an antenatal VBAC scoring system specific to the Singapore population to predict the success of VBAC. This study highlights to clinicians the favourable factors (younger age, lower booking BMI and history of successful VBAC) for successful VBAC which can be discussed with the couple in antenatal clinics, before reaching a joint decision regarding the mode of delivery.

CONCLUSION

The current study showed that the scoring system by Kalok et al. was more useful in predicting VBAC success in the Singapore population. However, neither the Grobman nomogram nor the Kalok scoring system had high sensitivity in predicting VBAC, suggesting the need to develop a scoring system tailored for Singapore women. There are limited data available regarding factors that improve VBAC success rate in Singapore. The factors identified in this study (younger maternal age, lower maternal BMI at booking visit and history of successful VBAC) serve as a foundation for the development of an additive prediction model for VBAC in the Singapore population.

Acknowledgements

We thank the Department of Maternal Fetal Medicine, KK Women's and Children's Hospital, Singapore for their assistance, Serene Ong for her administrative assistance and Jiawen Ong for assisting with data collection.

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