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ORIGINAL RESEARCH

Determinants of Successful Vaginal Birth After Cesarean Section: A Retrospective Cohort Study in Southeast China

Ying-Ling Xiu, Bing-Qing Lv

Department of Gynecology and Obstetrics, Fujian Maternal and Child Health Hospital, Fuzhou, Fujian Province, 350000, People's Republic of China

Correspondence: Bing-Qing Lv, Department of Gynecology and Obstetrics, Fujian Maternal and Child Health Hospital, No. 18 of Daoshan Road, Gulou District, Fuzhou, Fujian Province, 350000, People's Republic of China, Tel +86 18950330039, Email Lvbingqing2024@163.com

Objective: This study aimed to identify factors influencing the success of a trial of labor after cesarean section (TOLAC) and to evaluate associated maternal and neonatal outcomes.

Methods: A retrospective analysis was conducted on data from women with a prior cesarean section who underwent TOLAC at Fujian Maternity and Child Health Hospital in Southeast China between January 2016 and January 2018. Of the 1179 women who attempted TOLAC, 1038 achieved vaginal birth after cesarean (VBAC) while 141 experienced unsuccessful trials. Sociodemographic and clinical characteristics were compared between the successful and unsuccessful TOLAC groups using the *t*-test for normally distributed data, non-parametric tests for non-normally distributed data, and the χ2 test, corrected chi-square test, or Fisher's exact test for categorical variables, as appropriate. Logistic regression analysis was performed to identify factors independently associated with successful TOLAC, with the results expressed as Odds Ratios (ORs) and corresponding 95% Confidence Intervals (CIs).

Results: Multivariable logistic regression analysis revealed that maternal height (OR = 1.09, 95% CI = 1.05–1.14), abdominal circumference (OR = 0.95, 95% CI = 0.91–0.98), ultrasound-estimated fetal weight (OR = 0.99, 95% CI = 0.99–1.00), and history of vaginal delivery (OR = 9.62, 95% CI = 2.33–39.67) were independently associated with successful TOLAC. No significant differences were observed between the successful and unsuccessful TOLAC groups in terms of neonatal asphyxia, postpartum hemorrhage, placental abruption, or bladder injury.

Conclusion: Maternal height, abdominal circumference, ultrasound-estimated fetal weight, and history of vaginal delivery were identified as influential factors for VBAC success. Clinical evaluation of these factors may enhance the selection criteria for TOLAC candidates, potentially increasing VBAC rates and reducing cesarean section rates overall.

Keywords: pregnancy outcome, prior cesarean delivery, trial of labor after caesarean section, vaginal birth after caesarean section

Introduction

Cesarean delivery rates have risen significantly from 28.8% in 2008 to 34.9% in 2014, further reaching 36.7% in 2018 in China, with geographic variation ranging from greater than 60% in some supercities to less than 10% in some rural areas.[1] The recent rise in cesarean delivery rates has become a worldwide phenomenon, the rate in U.S.A has increased to 29.1%, England 21.5%, and in Latin American nations 40%.[2] This upward trend in cesarean delivery (CD) appears persistent, showing no signs of slowing down.[3] The repeat cesarean deliveries contribute considerably to these statistics, although implementation of the two-child policy has presented new challenges to reducing repeat cesarean deliveries.[4–6] There is a significant increase in the risk of uterine rupture in subsequent pregnancies in women with a prior cesarean section, and this too can escalate the rate of repeat cesarean deliveries.[7]

While cesarean sections can reduce the risk of dystocia and adverse events during childbirth, they are associated with an increased risk of complications, including postoperative infection, hemorrhage, and uterine rupture, which may adversely affect maternal and neonatal health. Recent advancements in medical technology have led to the development of numerous guidelines for trial of labor after cesarean section (TOLAC) both in China as well as in other countries

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across the world.[8] Xing et al reported that the success rate for vaginal birth after cesarean (VBAC) can reach about 60% to 80%.[9] However, there is few systematic research on the indications and risk factors of TOLAC in the southeast of China. In this context, a retrospective analysis was conducted on data from pregnant women who underwent a cesarean section at the Fujian Maternity and Child Health Hospital located in Southeast China to examine the indications for TOLAC as well as pregnancy outcomes of trial deliveries to provide a reference for improving pregnancy outcomes in such cases.

Materials and Methods

Research Participants

This cohort study involved a retrospective analysis of the clinical data of 8472 pregnant women with a previous cesarean section at the Fujian Maternity and Child Health Hospital between January 2016 and January 2018. Of these, 1179 women underwent TOLAC, resulting in 1038 achieving successful VBAC and 141 unsuccessful trials. The remaining 7162 women opted for an elective repeat caesarean section (ERCS) without attempting labor. A flowchart illustrating the enrolment of participants for the study is shown in Figure 1.

Evaluation of Delivery Method

Inclusion and exclusion criteria were assessed by investigators, according to the guidelines for Vaginal Birth After Cesarean (VBAC) reissued by the American College of Obstetricians and Gynecologists (ACOG, 2019),[10] the Society of

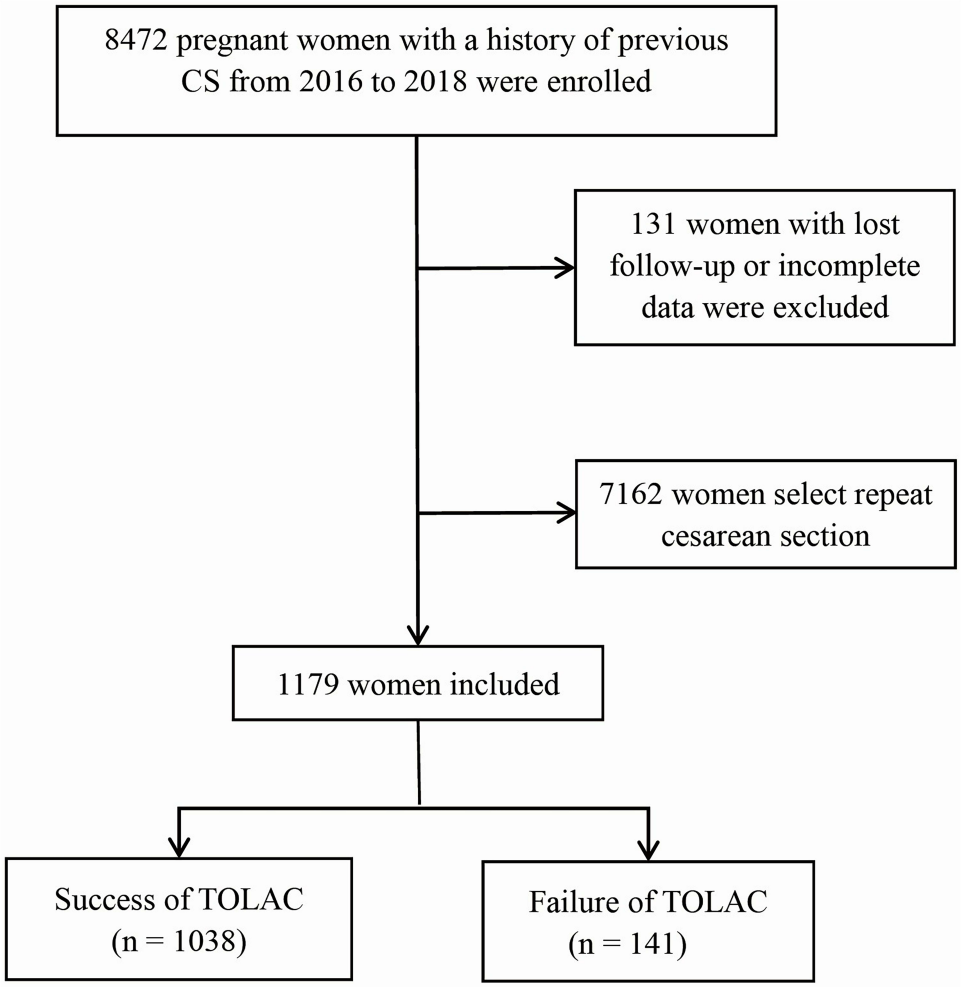

Figure 1 Flowchart of the enrolled patients.

Obstetricians and Gynecologists of Canada (SOGC, 2019),[11] and the Royal College of Obstetricians and Gynecologists (RCOG, 2015),[12] and considering the expert consensus on VBAC management released in China in 2016,[13] our hospital has established VBAC management standards tailored to the specific conditions of our country.

(1) Criteria for TOLAC: inclusion criteria were as follows: a. no contraindications to labor trial; b. normal maternal pelvic structure; c. an interval of more than two years since the previous cesarean delivery; d. pregnant women who voluntarily choose vaginal delivery; and e. informed consent provided by the woman and her family members. The following were the exclusion criteria: a. a history of uterine rupture; b. prenatal ultrasound showed placenta attached to the scar site; c. general contraindications to cesarean delivery; and d. severe pregnancy-associated complications.

(2) Criteria for cesarean delivery: a. an interval of less than two years since the previous cesarean section; b. pregnant women with a history of two or more uterine surgeries; c. prenatal ultrasound showed that placenta was attached to the scar; and d. social factors (eg, maternal request for cesarean delivery).

Method

(1) Clinical information for pregnant women with a prior cesarean delivery was obtained from the electronic medical records of the hospital. Details included maternal age, height, gestational week, gravidity, parity, pregravid maternal weight, pregravid maternal body mass index (BMI), maternal weight at delivery, ultrasound-estimated fetal weight, the interval between the ultrasound examination and vaginal delivery, maternal BMI at delivery, maternal weight at delivery, inter-delivery interval, delivery method, abdominal circumference, fundal height, pregnancy complications, number of fetuses, scar thickness, birth weight and fetal prenatal data (fetal position, fetal distress, and placenta characteristics). The fundal height and abdominal circumference of pregnant women are recorded from the prenatal examination measurements taken at the time of admission. As for the prenatal ultrasound measurements, the most recent examination results prior to delivery are selected.

(2) Pregnancy and neonatal outcomes for pregnant women with a previous cesarean delivery were collected. Outcomes data included information on placental abruption, uterine muscle layer rupture, neonatal intensive care unit (NICU) admission, postpartum hemorrhage, bladder injury, birth weight, and neonatal asphyxia.

Statistical Analysis

Excel (Microsoft® Excel® 2010) was used for data collection and storage during the study design phase. Statistical analysis was performed using the R software package (V3.6.2). SPSS (23.0) was used to draw Q-Q plots for normality tests of continuous variables. The measurement data that conforms to the normal distribution were expressed as mean ± standard deviation ($x \pm s$) and the difference in means between groups was compared by *t*-test. For measurement data that does not conform to the normal distribution were expressed as the median (interquartile range) [M (P 25, P 75)] and the non-parametric test (Mann–Whitney *U*-test) was used to compare the differences between the two groups. Count data were expressed as n (%) and analyzed using the $\chi 2$ test, corrected chi-square test or Fisher's exact probability method. The indications for trial vaginal delivery and repeat cesarean section among pregnant women with a previous cesarean delivery were analyzed using logistic regression. A P value of < 0.05 was considered statistically significant.

Ethical Considerations

The Ethics Committee of the Fujian Maternity and Child Health Hospital approved this cohort study. The requirement for ethical approval and written informed consent was waived due to the study's retrospective design and because the study did not involve any interventions in patient care at any stage.

Results

Univariate Analysis between Successful and Failed TOLAC Groups

Compared to women in the failed TOLAC group, those in the successful TOLAC group exhibited significantly smaller abdominal circumference, lower fundal height, and reduced ultrasound-estimated fetal weight and greater maternal height. ($P < 0.05$). There were no significant differences between the two groups in terms of the interval between the ultrasound examination and vaginal delivery, age, scar thickness, pregravid maternal weight, pregravid maternal BMI,

maternal weight at delivery, maternal BMI at delivery, parity, or duration of labor ($P > 0.05$). Additionally, women in the successful TOLAC group had a higher rate of prior vaginal deliveries than those in the unsuccessful TOLAC group ($P < 0.05$). However, there were no significant differences between the two groups with respect to history of vaginal trials, hypertensive disorders of pregnancy, gestational diabetes, or premature rupture of membranes ($P > 0.05$) (Table 1).

Logistic Regression Analysis of TOLAC Success in Pregnant Women with a Previous Cesarean Delivery

A multivariable logistic regression analysis was performed to identify factors associated with the success of TOLAC. Variables that were either significantly associated with success of TOLAC in the univariate analysis or known to influence TOLAC outcomes were included in the regression model (Table 2). The analysis showed that maternal height

Table 1 Comparison of Clinical Characteristics Between Women in the Success of TOLAC Group and Failure of TOLAC Group

	Failure of TOLAC (n = 141)	**Success of TOLAC (n = 1038)**
Age (years)	31.95±3.60	31.65±3.92
Scar thickness (mm)	1.43±0.37	1.39±0.35
Maternal height (cm)	158.54±4.81	159.79±4.83
Pre-gravid maternal weight (kg)	53.23±6.99	53.86±6.67
Pre-gravid maternal BMI (kg/m2)	21.17 ±2.60	21.09±2.45
Maternal weight at delivery (kg)	65.98±7.59	66.17±7.31
Maternal BMI at delivery (kg/m2)	26.24±2.69	25.91±2.63
Abdominal circumference (cm)	99.27±4.85	97.61±5.68
Fundal height (cm)	34.04±2.03	33.01±2.55
Ultrasound estimated fetal weight (g)	3136.43 ±402.48	2888.38±590.65
Interval between ultrasound examination and vaginal delivery	3.44±1.98	3.35±2.01
Advanced maternal age# (n (%))	30 (21.3)	229 (22.1)
Gestational age at delivery (wk GA)	38.88±1.52	37.83±2.80
Gravidity	2.00 [2.00, 3.00]	3.00 [2.00, 4.00]
Parity	1.00 [1.00, 1.00]	1.00 [1.00, 1.00]
Duration time of labor (years)	5.09±2.64	5.26±2.89
History of vaginal trial delivery	58 (41.1)	364 (35.1)
History of vaginal delivery (%)	2 (1.4)	116 (11.2)
Hypertensive disorder of pregnancy (n (%))	2 (1.4)	21 (2.0)
Gestational diabetes (n (%))	29 (20.6)	219 (21.1)
Premature rupture of membranes (n (%))	32 (22.7)	289 (27.8)
Polyhydramnios (n (%))	0 (0.0)	2 (0.2)

Note: #Advanced maternal age refers to a pregnant individual who is 35 years or older at the time of delivery.
Abbreviations: TOLAC, trial of labor after caesarean section; BMI, body mass index.

Table 2 Multivariate Logistic Regression Analysis of the Success Rate of TOLAC

Co-variable	OR	95% CI of OR	
		Low Limit	Upper limit
Height (cm)	1.09	1.05	1.14
Abdominal circumference (cm)	0.95	0.91	0.98
Gestational age at delivery (wk GA)	0.89	0.77	1.02
Ultrasound estimated fetal weight (g)	0.99	0.99	1
History of vaginal delivery (%)	9.62	2.33	39.67

Abbreviation: TOLAC, trial of labor after caesarean section.

(OR = 1.09, 95% CI = 1.05–1.14), abdominal circumference (OR = 0.95, 95% CI = 0.91–0.98), gestational age at delivery (OR = 0.89, 95% CI = 0.77–1.02), ultrasound-estimated fetal weight (OR = 0.99, 95% CI = 0.99–1.00), and history of vaginal delivery (OR = 9.62, 95% CI = 2.33–39.67) were associated with successful TOLAC (Table 2).

Comparison of Pregnancy Outcomes between Women in the Successful and Unsuccessful TOLAC Groups

In the unsuccessful TOLAC group, uterine rupture occurred in three pregnant women, all of whom had a lower uterine segment scar thickness of 1.3 mm. There were no significant differences between the two groups in terms of neonatal asphyxia, postpartum hemorrhage, placental abruption, or bladder injury. However, birth weight in the successful TOLAC group was significantly lower than that in the unsuccessful TOLAC group. Additionally, the rate of NICU admissions was significantly higher in the successful TOLAC group compared to the unsuccessful TOLAC group (Table 3).

Discussion

Analysis of Indications for TOLAC and Cesarean Section in Pregnant Women with a Previous Cesarean Delivery

The success rate for TOLAC observed in this study was approximately 88.04%, consistent with findings from previous research.[14,15] Factors influencing the success of TOLAC were comprehensively examined through the collection and analysis of clinical data from hospital medical records. Maternal height, abdominal circumference, ultrasound-estimated fetal weight, and history of vaginal delivery were identified as influential factors for VBAC success. These findings support the potential for early clinical interventions to reduce adverse maternal and fetal outcomes.

Table 3 Clinical Outcomes of the Patients

	Failure of TOLAC (n = 141)	Success of TOLAC (n = 1038)	*P* value
Neonatal asphyxia (n (%))	3 (2.1)	22 (2.1)	1
NICU admission (n (%))	8 (5.7)	173 (16.7)	0.001
Birthweight(g)	3338.79±373.28	3029.01±628.03	<0.001
Rupture of the muscle layer of uterus (n (%))	3 (2.1)	0 (0.0)	<0.001
Placental abruption (n (%))	6 (4.3)	79 (7.6)	0.203
Postpartum hemorrhage (n (%))	2 (1.4)	51 (4.9)	0.096
Injury to the bladder (n (%))	0	0	1

Abbreviation: TOLAC, trial of labor after caesarean section.

In our study, maternal height was found to be positively associated with TOLAC success, the taller the pregnant woman, the higher her success rate of VBAC, which corroborating the results of Rizzo et al that maternal height was independently associated with VBAC in a prospective study.[16] Similar findings were also reported in another retrospective cohort study of over 1066 women in China.[17] Maternal height can serve as an indicator of pelvic conditions; therefore, a detailed assessment of maternal characteristics is essential when determining the optimal delivery method.

As gestational age increases, the uterus becomes excessively dilated, leading to a thinner lower uterine segment, which can increase the risk of scar rupture during delivery. However, evidence confirming higher gestational age as a risk factor for unsuccessful TOLAC remains inconclusive. Our results indicated that gestational age at delivery was significantly higher in the unsuccessful TOLAC group, although this association did not reach statistical significance in the multivariable analysis. Similar results were reported by Levin et al that gestational age at TOLAC was lower in the success group but was not statistically significant in the multivariate analysis.[18] The American College of Obstetricians and Gynecologists (ACOG) noted that although one study showed an increased risk of uterine rupture after 40 weeks of gestation, other studies have not corroborated this association.[19] Therefore, although the likelihood of TOLAC success may be reduced, attempting TOLAC after 40 weeks of gestation remains an option.

Previous studies have consistently identified fetal weight as a key determinant of TOLAC success.[20,21] However, as these studies primarily relied on actual birth weight rather than estimated fetal weight, their applicability to antenatal decision-making regarding delivery mode is limited.[22] In this study, both ultrasound-estimated fetal weight and abdominal circumference were found to be associated with TOLAC success rates. Therefore, a comprehensive evaluation that incorporates both the birth weight from the previous pregnancy and the estimated fetal weight in the current pregnancy is recommended to guide decisions regarding the mode of delivery.

We found that pregnant women with a history of vaginal delivery have a higher success rate of VBAC. In a retrospective study at two large obstetric departments in Germany between 2008 and 2018, Gitas et al found that a prior vaginal birth was positively associated with the likelihood of achieving VBAC.[23] Wu et al reported the same conclusion in a systematic review and meta-analysis.[24] Pregnant women with a history of vaginal delivery tend to have a softened cervical texture, which facilitates vaginal delivery from a physiological perspective. Furthermore, in such women, the second stage of labor is typically shorter than that of primiparous women, reducing the occurrence of complications such as difficult labor caused by prolonged labor and increased risk of scar rupture during lower segment surgeries due to prolonged uterine compression.

Analysis of Pregnancy Outcomes

Although there are many contraindications for pregnant women with a previous cesarean delivery, adherence to strict control measures for TOLAC can optimize outcomes. Proper guidance and monitoring of labor progress enable real-time assessment of fetal physical signs, reduce delivery complications, and improve the success rate of vaginal delivery for these women. Some studies have suggested that, during vaginal delivery, the compression of the birth canal facilitates the expulsion of lung fluids in the newborn, potentially reducing the incidence of neonatal respiratory diseases.[25,26] However, cesarean-derived uterine scars typically consist of fibrous connective tissue with reduced elasticity, and pregnancy-related stretching of surrounding muscle fibers may result in their thinning, leading to fatigue in the lower uterine segment, increasing the risk of postpartum hemorrhage. In addition, elevated intrauterine pressure during natural labor in pregnant women with previous cesarean sections may cause different degrees of uterine tears under the stress of contractions. The increased risk of uterine scar rupture and delayed puerperal scar healing following cesarean section deliveries has also been reported.[27]

In our study, the analysis of the pregnancy outcomes for VBAC versus repeat cesarean delivery showed that neonatal birth weights were lower in the VBAC group. There were no significant differences between the two groups in terms of postpartum hemorrhage and neonatal asphyxia, placental abruption, or bladder injury, suggesting that TOLAC does not significantly impact maternal or neonatal outcomes. Therefore, for pregnant women with a previous cesarean delivery, carefully assessing the risk factors for trial vaginal delivery, standardizing labor monitoring, and providing appropriate dietary and exercise management during pregnancy may enhance the safety of trial vaginal delivery.

Strengths and Limitations

Clinical evaluation of influence factors may enhance the selection criteria for TOLAC candidates, potentially increasing VBAC rates and reducing cesarean section rates overall. We are aware of the limitations of our study. First, Birth weight is closely related to both the success rate of TOLAC and pregnancy outcomes. In this study, the difference in birth weight between the successful TOLAC group and the failed TOLAC group was statistically significant, leading to confounding bias in the differences in pregnancy outcomes between the two groups. However, as this study is a real-world clinical cohort study, its results still hold certain reference value. Second, this study is a single-center retrospective cohort study, there may be bias in case selection. Third, the study refers to the Chinese population. Therefore, extrapolations of our results to other populations should be done with caution. However, as a tertiary hospital in Southeast China, the number of patients included in the study is representative, and the results have certain reference value. In the future, we can further conduct prospective and multicenter cohort study to expand the sample size and promote research conclusions.

Conclusion

In conclusion, in this study, factors such as maternal height, abdominal circumference, ultrasound-estimated fetal weight, and a history of vaginal delivery were identified as the factors significantly influencing the success of VBAC. Notably, TOLAC did not appear to increase the risk of complications such as neonatal asphyxia, postpartum hemorrhage, placental abruption, or bladder injury. By rigorously managing the clinical indications for TOLAC, healthcare providers can enhance VBAC rates and contribute to reducing the rate of cesarean sections.

Abbreviations

TOLAC, trial of labor after caesarean section; VBAC, vaginal birth after caesarean section; CD, cesarean delivery; ERCS, elective repeat caesarean section; BMI, body mass index; NICU, neonatal intensive care unit.

Data Sharing Statement

All data used to reach the aforementioned conclusions is available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and consent waiver obtained from the institutional ethics committee of Fujian Maternal and Child Health Hospital. The study was legally approved by the institutional ethics committee of Fujian Maternal and Child Health Hospital and conducted in accord with the guidelines of the Declaration of Helsinki and the rights of all participants were protected.

Consent for Publication

All data were anonymized; therefore, individual consent for publication was not required.

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Disclosure

The authors declare that they have no conflicts of interest in this work.

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