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Original Article

Development of a regression model for the prediction of a success of external cephalic version

Lianghui Zheng, Rongxin Chen, Rongli Xu, Jianying Yan, Qin Han, Lin Lin

Department of Obstetrics and Gynecology, Fujian Maternity and Child Health Hosptial, Affiliated Hospital of Fujian Medical University, No. 18 Daoshan Road, Gulou District, Fuzhou 350001, China

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Abstract: Background: The success of external cephalic version was affected by a series of factors. Development of a regression model incorporating multiple important factors will help prediction of success of external cephalic version. Here, we describe the development of a logistic regression model for predicting the success of external cephalic version for breech presentation in pregnancy. Methods: We retrospectively reviewed the records of 100 pregnant women who were pregnant with breech presentation during 37-40 weeks of gestation, and who were admitted in Fujian Provincial Maternity and Children's Hospital affiliated Hospital of Fujian Medical University from Jan 2016 to Jan 2017. They were without other indications for cesarean section and ready to receive external cephalic version. The clinical data of the subjects were subjected to univariate analyses for selecting variables to be included in the logistic regression model. AUC of the regression model was calculated for estimate of the accuracy of the model. Independent variables with P≤0.1 in the multivariate analysis were selected for establishment of a scoring system of risk factors. External cephalic version success rate was compared between groups that were divided according to a scoring system. ROC curve analysis was employed to convert the quantitative variables into bi-categorical variables to be included as independent variables in the multivariate logistic regression model. Results: The success rate of external cephalic version was 62% (62/100), and 48 cases (80%) underwent vaginal delivery at the end. The following variables were included in the regression model: parity, the sum of uterine height and presentation height, amniotic fluid volume, spontaneous transposition times during pregnancy and fetal head holding. The AUC of the model was 0.929 (95% CI: 0.878-0.981). The comparison between groups divided by scoring revealed groups with higher scores had higher success ECV rate. Conclusion: Our regression model showed a good performance for predicting ECV success for breech presentation in single pregnancy.

Keywords: Regression model external, cephalic version, ECV rate

Introduction

The incidence of single breech position pregnancy was 3%-4% [1, 2]. Due to the difficult fetal head delivery and birth injury after vaginal delivery of breech presentation, 50%-94% of full-term pregnancies with breech position choose cesarean section [3, 4]. External cephalic version (ECV) refers to a series of operations performed in the abdomen of a pregnant woman to convert the presentation of the fetus from the breech (or feet) to head first. It is recommended by the American Association of Obstetricians and Gynecologists as one of the most effective clinical interventions to reduce the rate of cesarean section [5-7]. It is an effective method to revise breech presentation. At present, ultrasound, fetal electronic monitoring and the tocolytics have improved the safety of external inversion to a certain extent. There are several factors reported to be associated with success of ECV [5-7]. This is an effective way to modify the breech performance. At present, ultrasound, electronic fetal monitoring and contractions inhibitors improve the safety of external inversion to a certain extent. Several factors have been reported to be associated with the success of ECV [8]. Development of a prediction model based on those important clinical factors can provide guidance in performing ECV. In this study, a retrospective study was conducted to explore the factors influencing the success of external cephalic inversion. A multivariate logistic regression model was established according to five important factors in univariate analysis, and the risk factors scoring system was established based on the regression model.

Population and methods

Subjects

The clinical data of 100 pregnant women with single pregnancies with breech presentation, underwent external inversion in Fujian Provincial Maternity and Children's Hospital from Jan 2016 to Jan 2017, and were retrospectively analyzed. The inclusion criteria included the following: single pregnancy, breech presentation confirmed by ultrasound, no absolute indication of cesarean section, and willingness to a vaginal trial of labor. The exclusion criteria included the following: severe uterine malformation, multiple fetus pregnancy, premature rupture of membranes, prenatal hemorrhage, abnormality detected by fetal monitoring or the presence of absolute cesarean section indications. However, young gestational age coupled with abnormal Doppler flow, preeclampsia, oligohydramnios, severe fetal malformations and scarred uterus were categorized as relative contraindications of external cephalic inversion. The age of the pregnant women included in the study ranged from 21 to 41 years. The gestational age ranged from 37.14 to 39.57 weeks. There were 61 cases of primipara and 7 cases of transverse presentation.

Material and methods

Preparation for external cephalic inversion

(1) Outpatient ultrasound physicians preliminarily assessed fetal position; surgeons made assessments and informed the pregnant women of the pelvic condition, explained the benefits and related risks of external cephalic inversion, hospitalized those who did consent to receive external cephalic inversion and obtained a signed informed consent for operation. (2) Recheck with ultrasound examination to determine fetal position; the feasibility of external cephalic inversion was evaluated by the surgeon and the fetal ultrasound physician. (3) Routine examinations were made before operation, including improved routine blood work and coagulation, and liver and kidney function and infection. (4) Fetal heart rate monitoring was made before inversion; only subjects with non-responsive to stress tests received ECV. (5) Measurments of fetal presenting height: fetal sacrum and mother's sciatic spine were made as indicators; trained obstetricians measured the distance between fetal sacrum and mother's sciatic spine within the vagina; 1, 2, 3 and 4 cm above sciatic spine were counted as -1, -2, -3 and -4 cm respectively and fetal sacrum was expressed as 0 cm above sciatic spine.

External cephalic inversion

(1) External cephalic inversion was performed in the operating room. All pregnant women used lubricants and terbutaline to relax uterine tension. Epidural anesthesia was performed if the pain of the pregnant women was intolerable. (2) Pregnant women emptied their bladder and took a supine position. Buttocks were properly padded and the abdomen was smeared with the appropriate amount of lubricant to alleviate the pregnant women's discomfort and facilitate intraoperative ultrasound monitoring. (3) The surgeon stood on the side of the pregnant woman, lifted the fetal buttocks on the pubic symphysis and gradually pushed the fetal buttocks out of the pelvic cavity. Assistants help to fix the fetus in the current position, and then surgeon gradually pushed the fetal head to the pelvic entrance according to the axis of the fetal spine. (4) All external cephalic inversion was performed by the same two trained surgeons. Ultrasound was used to monitor the fetal heart rate during inversion process. If abnormal changes occurred in the fetal heart rate, the operation was put on hold, and could be tried again after recovery of fetal heart rate. External cephalic inversion can be completed in multiple steps. Assistants assisted in fixing the fetal position between each step. If one inversion fails, the inversion may be attempted for the opposite direction. When the second attempt failed, it was regarded as ECV failure.

Management after external cephalic inversion

(1) Non-stress testing was performed immediately after inversion. Monitoring was prolonged for non-responders, and continuous monitoring for fetal heart rate was provided when necessary. (2) Ultrasound examination was performed on the first day after inversion. (3) Artificial rupture of membranes or intravenous

injection of oxytocin could be administered to induce labor if pregnancy complications or induced labor indications existed.

Analysis indicators

Head position delivery after external cephalic inversion was regarded as successful outcome of ECV. ECV failure refers to the presence of the fetus with the buttocks first during delivery. The factors influencing the success of external cephalic inversion were analyzed.

Statistical analysis

Quantitative data were tested for normality. When they followed a normal distribution, quantitative data were described as mean ± SD (standard deviation). Independent sample *t* test was used for comparison between the two groups. When a normal distribution was not found, P50 (P10, P90) was employed for statistical description. Mann-Whitney U test was used for comparison between the two groups. Qualitative data were described as frequency and percentage (%), and χ^2 test was employed for comparison between groups. Among the index with P<0.05 in univariate analysis, five factors were selected according to clinical importance to be included in multivariate logistic regression analysis, and the AUC of the regression model was used to evaluate its accuracy. The independent variables with P≤0.1 in the multivariate analysis were selected to establish the risk factor scoring system, and the scoring system was analyzed statistically. ROC curve analysis was used to determine the optimal boundary point, and quantitative variables were converted into binary variables by the optimal boundary point. Binary variables were used as independent variables of multivariate logistic regression analysis. ROC curve analysis and AUC calculation were made with MedCalc13.0, and any other statistical analysis was made with SPSS 25.0.

Results

In total, 62 cases (62%) successfully completed the external cephalic inversion. Among the 62 women, 49 cases underwent spontaneous delivery and 1 case underwent midwifery, thus a total of 50 cases underwent vaginal delivery. The remaining 12 cases underwent cesarean section. Among 38 cases (38%) of pregnant women who failed in external cephalic inversion, 1 case underwent midwifery and the other 37 cases underwent cesarean section.

According to t test analysis, 9 factors were associated with success or failure of ECV, including age, weight gain during pregnancy, BMI growth, the sum of uterine height and presentation height, gestation of finding week breech presentation, cervical Bishop score, amniotic fluid volume, neonatal weight, and neonatal length (P<0.05). The rest of the factors tested may not impact the success of ECV (P>0.05) (**Table 1**). Results of χ^2 test shown that 10 factors of gravidity, parity, presentation height spontaneous transposition times during pregnancy, spontaneous uterine contraction in late pregnancy, fetal head position, fetal head holding, fetal hip holding, anesthesia, and pain of pregnant women were associated with success and failure of ECV (P<0.05). The rest of the factors may not impact the success of ECV (P>0.05) (**Table 2**). Therefore, the univariate analysis had identified 19 factors in total, which may be associated with the success of ECV. Due to the requirement of multivariate logistic regression analysis on the sample size, at most 5 independent variables can be included. According to the clinical importance, the 5 factors of parity, the sum of uterine height and presentation height, amniotic fluid volume, spontaneous transposition times during pregnancy and fetal head holding were included in the multivariate regression model.

ROC curve analysis was made with parity, the sum of uterine height and presentation height, amniotic fluid volume, and spontaneous transposition times during pregnancy as the test variables (**Figure 1**). The optimal boundary point for failure of prediction of the 4 factors were "parity ≤0", "the sum of uterine height and presentation height >30.5", "amniotic fluid volume ≤12.4", and "spontaneous transposition times during pregnancy ≤0". Binary variables were generated according to the optimal boundary points: parity >0 (=0 assigned as 0, >0 assigned as 1), the sum of uterine height and presentation height ≤30.5 (>30.5 assigned as 0, ≤30.5 assigned as 1), amniotic fluid volume >12.4 (≤12.4 assigned as 0, >12.4 assigned as 1), and spontaneous transposition times during pregnancy >0 (=0 assigned as 0, >0 assigned as 1).

Table 1. Comparison of several indexes between External cephalic version success group and failure group by t-test

Index	Success group (n=62)	Failure group (n=38)	t	P
Age	30.72±4.08	26.42±3.09	5.570	0.000
weight before pregnancy	52.44±8.59	52.26±8.11	0.104	0.918
Weight in ECV	64.91±8.80	66.90±8.08	-1.128	.262
Weight increase during pregnancy	12.47±3.48	14.64±3.52	-3.005	0.003
BMI before pregnancy	20.38±2.78	20.04±2.59	0.599	0.551
BMI in ECV	25.27±2.72	25.66±2.33	-0.723	0.472
BMI increase	4.90±1.63	5.62±1.47	-2.219	0.029
Abdominal circumference	96.71±5.91	95.50±7.31	0.904	0.368
Uterine height	33.29±1.27	33.55±1.59	-0.917	0.361
The sum of uterine height and presentation height	29.37±1.72	31.22±1.68	-5.203	0.000
Breech position discovery gestation week	32.61±3.25	29.92±7.64	2.422	0.017
BPD	9.20±0.30	9.21±0.41	-0.208	0.836
HC	33.32±0.95	33.46±0.89	-0.768	0.444
AC	33.10±1.26	32.87±1.51	0.804	0.424
FL	6.92±0.23	7.07±0.49	-1.957	0.053
Weight by ultrasonography	3021.56±257.42	3012.97±330.22	0.143	0.886
Cervical Bishop score	2.72±1.01	3.66±1.80	-3.202	0.002
ECV gestation week	37.25±4.91	38.07±0.79	-1.021	0.310
Delivery gestation week	37.41±10.04	37.66±6.31	-0.138	0.890
Amniotic fluid volume	14.90±3.53	12.18±3.51	3.718	0.000
Neonatal weight	3456.25±352.40	3185.13±392.28	3.551	0.001
Neonatal length	49.98±1.51	48.89±1.52	3.464	0.001

In the multivariate logistic regression analysis, parity >0, the sum of uterine height and presentation height ≤30.5, amniotic fluid volume >12.4, spontaneous transposition times during pregnancy >0, fetal head holding (untouchable assigned as 0, touchable & un-holdable assigned as 1, fetal head holdable assigned as 2) were set as independent variables, and grouping by ECV success or failure were set as dependent variables (**Table 3**). The analysis result demonstrated that 5 factors of parity >0, the sum of uterine height and presentation height ≤30.5, amniotic fluid volume >12.4, fetal head touchable & unholdable and fetal head holdable were independent factors for success of ECV (P<0.05). Existence of any of the five factors could improve the possibility of ECV success. However, spontaneous transposition times during pregnancy >0 may also improve ECV success rate (regression coefficient >0, *P* value was close to 0.05). If the sample size was increased in following studies, it is possible to obtain P<0.05 for spontaneous transposition times during pregnancy >0. AUC of the model was 0.929 (95% CI: 0.878~0.981), therefore the current regression model has high accuracy in prediction of ECV success (AUC > 0.9).

The factors with P≤0.1 in multivariate regression analysis were scored to establish a scoring system (**Table 3**). The descriptive statistical analysis of the scoring system was shown in **Table 4**. The ECV success rate increased accompanying the increase of scores. Comparison was made among groups divided according to scores (**Table 5**). The three groups were statistically different in ECV success rates (P<0.001). Furthermore, the trend χ^2 test result demonstrated that the ECV success rates in three groups had linear trend (P<0.001). The success rate of the low score group (0-3), medium score group (4-6) and high score group (7-9) presented a linear increasing trend.

Discussion

According to the result of this study, after successful ECV cesarean section rate was 19.35%,

Table 2. Comparison of index between External cephalic version success group and failure group by χ^2 test

Index	ECV success group	ECV failure group	Z/	p
height (m)	1.60 (1.53, 1.65)	1.59 (1.52, 1.67)	-0.339	0.735
gravidity	2.00 (1.00, 4.00)	1.00 (1.00, 3.00)	-3.442	0.001
parity	1.00 (0.00, 1.00)	0.00 (0.00, 1.00)	-4.612	0.000
Presentation height	-4.00 (-5.00, -3.00)	-2.00 (-4.00, 0.00)	-6.081	0.000
spontaneous transposition times during pregnancy			13.162	0.004
0	16 (26.2)	21 (55.3)		
1	29 (47.5)	16 (42.1)		
2	10 (16.4)	1 (2.6)		
3	6 (9.8)	0 (0.0)		
Spontaneous Uterine Contraction in third trimester			9.812	0.007
Frequent spontaneous uterine contractions	7 (11.5)	11 (30.6)		
Occasional spontaneous uterine contraction	45 (73.8)	25 (69.4)		
No spontaneous uterine contraction	9 (14.8)	0 (0.0)		
Has uterine contraction before ECV?			3.238	0.072
Yes	5 (9.4)	8 (23.5)		
No	48 (90.6)	26 (76.5)		
Is contour of uterus clear?			2.662	0.103
No	7 (11.7)	9 (24.3)		
Yes	53 (88.3)	28 (75.7)		
Fetal head position			18.899	0.001
Under xiphoid	10 (16.4)	18 (47.4)		
Fetal head 1-2 o'clock position	33 (54.1)	7 (18.4)		
Fetal head 10-11 o'clock position	14 (23.0)	13 (34.2)		
Fetal head 10-9 o'clock position	2 (3.3)	0 (0.0)		
Fetal head 3 o'clock position	2 (3.3)	0 (0.0)		
Fetal head holding			24.599	0.000
untouchable	1 (1.6)	11 (28.9)		
holdable	54 (88.5)	17 (44.7)		
Touchable & unholdable	6 (9.8)	10 (26.3)		
Breech holding			52.297	0.000
unholdable	0 (0.0)	17 (44.7)		
holdable	53 (88.3)	7 (18.4)		
Touchable & unholdable	7 (11.7)	14 (36.8)		
Cord Around Neck			0.341	0.843
No	33 (56.9)	20 (54.1)		
One circle	22 (37.9)	14 (37.8)		
Two circles	3 (5.2)	3 (8.1)		
Placenta position			4.169	0.384
anterior wall	13 (22.4)	15 (39.5)		
Lateral wall	10 (17.2)	7 (18.4)		
posterior wall	21 (36.2)	10 (26.3)		
fundus	13 (22.4)	6 (15.8)		
Fundus and lateral wall	1 (1.7)	0 (0.0)		
Breech types			3.103	0.684
Frank breech presentation	17 (33.3)	16 (43.2)		
Footling presentation	5 (9.8)	4 (10.8)		
Complete breech	16 (31.4)	13 (35.1)		

One leg straight one leg bend	6 (11.8)	2 (5.4)		
Transverse presentation	4 (7.8)	1 (2.7)		
Not clear	3 (5.9)	1 (2.7)		
Spinal direction			2.294	0.514
Anterior (left anterior, right anterior and anterior)	36 (60.0)	27 (71.1)		
lateral (left and right)	16 (26.7)	6 (15.8)		
posterior(left posterior, right posterior)	3 (5.0)	3 (7.9)		
transverse, close to xiphoid	5 (8.3)	2 (5.3)		
Heart rate change in ECV?			2.171	0.141
No	53 (91.4)	30 (81.1)		
Yes	5 (8.6)	7 (18.9)		
Anesthesia			22.144	0.000
No	55 (90.2)	18 (47.4)		
Yes	6 (9.8)	20 (52.6)		
Pain of pregnant woman			34.709	34.709
No pain	25 (41.7)	0 (0.0)		
Untolerable	6 (10.0)	22 (57.9)		
Tolerable	29 (48.3)	16 (42.1)		
Neonatal gender			0.680	0.410
Boy	26 (44.1)	20 (52.6)		
girl	33 (55.9)	18 (47.4)		

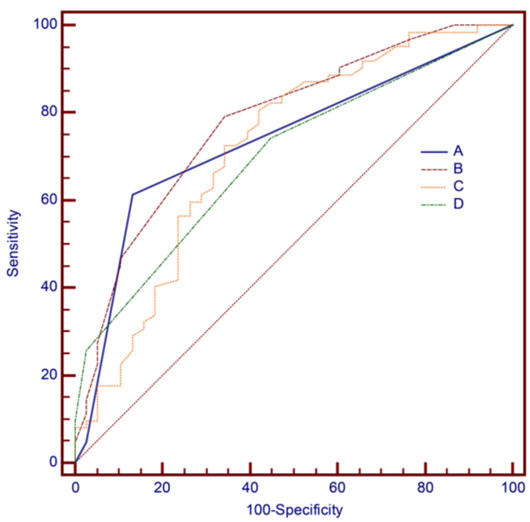

Figure 1. Receiver Operating Characteristic curve analysis. A. With parity external cephalic version outcome: Parity, Sensitivity (%): 61.3, Specificity (%): 86.8, Criterion: >0, AUC (95% CI): 0.736 (0.638, 0.819); B. With the sum of uterine height and presentation height for external cephalic version outcome: The sum of uterine height and presentation height, Sensitivity (%): 79.0, Specificity (%): 65.8, Criterion: ≤30, AUC (95% CI): 0.779 (0.685, 0.856); C. With amniotic fluid volume for external cephalic version outcome: Amniotic fluid volume, Sensitivity (%): 80.6, Specificity (%): 57.9, Criterion: >12.4, AUC (95% CI): 0.719 (0.620, 0.804); D. With spontaneous transposition times during pregnancy for External cephalic version outcome: Spontaneous transposition times during pregnancy, Sensitivity (%): 74.2, Specificity (%): 55.3, Criterion: >0, AUC (95% CI): 0.697 (0.597, 0.785).

therefore successful ECV had greatly decreased cesarean section rate. The success rate of ECV in this study was 62%, higher than 46.9% reported by Vaz de Macedo C etc. [9], and 37% reported by Velzel J [10]. However, this success rate was comparable with that reported by other studies, mainly ranged within 60%-98 [11, 12].

The outcome of ECV was influence by several factors. Previous studies had demonstrated that primipara, anterior placenta, mixed breech position, fat thickness of abdominal wall of pregnant woman, muscle tension of abdominal wall, uterine contraction and pain, amniotic fluid index larger than 100, breech presentation and other factors can affect the success rate of external cephalic inversion [13-17]. Other studies analyzed race, age, parity, BMI, gestational age, fetal weight, breech position, placenta position, amniotic fluid index and found no statistical difference in those indexes, except parity [9]. In this study, the ECV success influencing factors had included 20 factors, which are age, weight gain during pregnancy, BMI growth, the sum of uterine height and presentation height, breech position discovery

Table 3. Multivariate logistic regression analysis for External cephalic version success

Index	Regression coefficient	Standard error	Wald	P	OR (95% CI)	scorin*
Parity	2.071	0.791	6.859	0.009	7.931 (1.684, 37.354)	2
The sum of uterine height and presentation height ≤30.5	1.517	0.698	4.724	0.030	4.558 (1.161, 17.897)	1
Amniotic fluid volume >12.4	2.019	0.698	8.381	0.004	7.534 (1.920, 29.568)	2
spontaneous transposition times during pregnancy >0	1.342	0.706	3.613	0.057	3.825 (0.959, 15.255)	1
Fetal head holding	-	-	-	-	-	-
Touchable & unholdable	3.104	1.520	4.170	0.041	22.277 (1.133, 438.026)	2
Holdable	4.565	1.375	11.019	0.001	96.075 (6.486, 1423.145)	3

*factors with P≤0.1 were included in scoring system. Regression coefficient/1.342 was calculated, and scores were obtained by rounding methods.

Table 4. Descriptive statistical analysis of External cephalic version rate according to scores

Score	Sample size (n=100)	Number of success (n=62)	Success rate
0	2	0	0.0
2	6	0	0.0
3	9	1	11.1
4	13	3	23.1
5	13	6	46.2
6	10	6	60.0
7	19	19	100.0
8	12	11	91.7
9	16	16	100.0

Note: Sample size indicates the exact number of pregnant women in each score. The score in this table means the cervical bishop score and the formula was explained clearly in **Tables 1** and **3**. The formula of success rate = the number of success/the sample size.

gestation week, cervical Bishop score, amniotic fluid volume, neonatal weight, neonatal length, gravidity, parity, presentation height, spontaneous transposition times during pregnancy, spontaneous uterine contraction in late pregnancy, fetal head position, fetal head holding, fetal breech holding, anesthesia, pregnant women's pain and mode of delivery. Among the five variables included in the prediction model, association of parity, amniotic fluid volume, and fetal head holding with ECV success had been confirmed in several studies [16, 18].

First, in this study, the univariate analysis demonstrated that ECV success was not associated with breech types, spinal direction, placenta location. No matter for reason of the breach, whether it was, frank breech, complete breech or foot presentation, once the fetal breech was above the pelvic entrance or was out of pelvic entrance, the fetus can be rotated to increase the success rate. The direction of the fetal spine is related to the direction of inversion. In this study, the fetus was rotated to the opposite side of the spine. If the spine was in the back or front, then fetus was rotated to the side with less resistance. This study had excluded the placenta previa, and the soft placenta tissue in the normal position did not block the fetus's rotation.

Second, this study also showed that, with the absence of statistical differences in gestational weeks (success group vs failure group, 37.41±10.04 weeks vs 37.66±6.31 weeks, P= 0.890), the neonates with larger birth weights had higher inversion success rates (success group vs failure group, 3456.25±352.40 g vs 3185.13±392.28 g, P=0.001). The reason might be that fetus with a larger weight had a large prenatal presentation circumference, so it was more difficlut to enter the pelvis thus increasing inversion success rate.

Third, some studies have found that application of epidural anesthesia can increase the success rate of inversion [19]. However, this study found that only 9.8% of pregnancies in the successful inversion group had used epidural anesthesia; 52.6% of pregnancies in the failure group had used epidural anesthesia (P=0.000). The reason might be that in this study those receiving epidural anesthesia were pregnant women with severe pain, these pregnant women had low fetal presentation and high uterine tension, so they were prone to feel pain during inversion. While, a low fetal presentation and uterine tension increased the risk of inversion failure.

Fourth, in this study, it was noted that uterine height was not a factor influencing of the success rate of inversion (success group vs failure group, 33.29±1.27 cm vs 33.55±1.59 cm,

Table 5. Analysis of External cephalic version rate between groups divided according to scores

Group	Sample size (n=100)	Number of success (n=62)	Success rate	χ^2 (P)*	χ^2 (P)#
0-3	17	1	5.9	54.712 (0.000)	53.248 (0.000)
4-6	36	15	41.7		
7-9	47	46	97.9		

*Difference analysis result; #trend χ^2 test result.

P=0.361) while the sum of uterine height and fetal presentation could predict the success rate of inversion (success group vs failure group, 29.37±1.72 cm vs 31.22±1.68 cm, P= 0.000). Because the success of inversion is closely related to the position of the fetal head and whether the fetal head can be held; the fetal head extension and nonholdability decreased the inversion success rate (P<0.05). When the distance between fetal presentation and sciatic spine is equal, if the fetal head is extended below the xiphoid of the mother, then the uterine height is high and the sum of uterine height and fetal presentation is large and thus decreases the inversion success rate, if the fetal head bends to the left or right upper abdomen of the mother, then the uterine height is low and the sum of uterine height and fetal presentation is small and thus increases the inversion success rate.

The differences in the findings from those studies may be contributed the different clinical settings, and physician experience and so on. However, one important reason might be most of those factors had low prediction quality. Single factor is not reliable to predict ECV success.

In this study, we had developed a multivariate regression model incorporating five different variables that showed a high accuracy (AUC-0.929) for predicting ECV success rate. The external validation on the scoring system is based on regression analysis result, demonstrating that the group with the highest scores had high ECV success rate. In comparison, the prediction model for external cephalic version developed by Velzel J et al showed a discriminative ability with a c-statistic of 0.78 (0.75-0.81). We believe that the current regression model might serve as a promising tool for ECV success prediction among pregnancies.

Conclusion

External cephalic inversion can effectively convert breech position to head position, which is suitable for full-term or near-term pregnancy and can reduce the cesarean section rate. There are many factors that can influence the outcome of external inversion. For pregnant women with a single fetus in a breech position, before administration of external cephalic inversion, relevant factors should be fully evaluated. Patients should be strictly screened to improve the success rate of external cephalic inversion. In this study, the prediction model may serve as a promising tool for predicting the success rate of external inversion for pregnant women with breech position.

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Disclosure of conflict of interest

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Address correspondence to: Jianying Yan, Department of Obstetrics and Gynecology, Fujian Provincial Maternity and Children's Hospital, Affiliated Hospital of Fujian Medical University, No. 18 Daoshan Road, Gulou District, Fuzhou 350001, China. Tel: +86-059186329265; E-mail: y_ying007@aliyun.com

References

[1] Saroha M, Batra P, Dewan P and Faridi M. Genital injuries in neonates following breech presentation. J Neonatal Perinatal Med 2015; 8: 421-425.
[2] Mah MW, Pyper AM, Oni GA and Memish ZA. Impact of antibiotic prophylaxis on wound infection after cesarean section in a situation of expected higher risk. Am J Infect Control 2001; 29: 85-88.
[3] Tan JM, Macario A, Carvalho B, Druzin ML and El-Sayed YY. Cost-effectiveness of external cephalic version for term breech presentation. BMC Pregnancy Childbirth 2010; 10: 3.
[4] Schneider A, Eiermann W, Pfeiffer U and Hepp H. Prognostic factors in the indication for labor induction after previous delivery by cesarean

section. Zentralbl Gynakol 1988; 110: 1086-1091.
[5] Schneider AS, Mennuti MT and Zackai EH. High cesarean section rate in trisomy 18 births: a potential indication for late prenatal diagnosis. Am J Obstet Gynecol 1981; 140: 367-370.
[6] Schmidt S, Norman M, Misselwitz B, Piedvache A, Huusom LD, Varendi H, Barros H, Cammu H, Blondel B, Dudenhausen J, Zeitlin J and Weber T; EPICE Research Group. Mode of delivery and mortality and morbidity for very preterm singleton infants in a breech position: a European cohort study. Eur J Obstet Gynecol Reprod Biol 2019; 234: 96-102.
[7] Xia X, Zhou Z, Shen S, Lu J, Zhang L, Huang P, Yu J, Yang L, Wang P, Lam KH, Jacobsson B, Mol BW, Xia H and Qiu X. Effect of a two-stage intervention package on the cesarean section rate in Guangzhou, China: a before-and-after study. PLoS Med 2019; 16: e1002846.
[8] Liu T, Yang C, Deng X, Li A, Xin Y, Yang J and Xu Y. Clinical characteristics and surgical outcomes of spinal myxopapillary ependymomas. Neurosurg Rev 2019; [Epub ahead of print].
[9] Vaz de Macedo C, Clode N and Mendes da Graca L. Prediction of success in external cephalic version under tocolysis: still a challenge. Acta Med Port 2015; 28: 554-558.
[10] Velzel J, Schuit E, Vlemmix F, Molkenboer JFM, Van der Post JAM, Mol BW and Kok M. Development and internal validation of a clinical prediction model for external cephalic version. Eur J Obstet Gynecol Reprod Biol 2018; 228: 137-142.
[11] Suyama F, Ogawa K, Tazaki Y, Miwa T, Taniguchi K, Nakamura N, Tanaka S, Tanigaki S and Sago H. The outcomes and risk factors of fetal bradycardia associated with external cephalic version. J Matern Fetal Neonatal Med 2019; 32: 922-926.
[12] Prediction of success in external cephalic version for breech presentation at term: correction. Obstet Gynecol 2019; 134: 182.
[13] Ebner F, Friedl TW, Leinert E, Schramm A, Reister F, Lato K, Janni W and DeGregorio N. Predictors for a successful external cephalic version: a single centre experience. Arch Gynecol Obstet 2016; 293: 749-755.
[14] Weiniger CF, Ginosar Y, Elchalal U, Sela HY, Weissman C and Ezra Y. Randomized controlled trial of external cephalic version in term multiparae with or without spinal analgesia. Br J Anaesth 2010; 104: 613-618.
[15] Kok M, Cnossen J, Gravendeel L, Van Der Post JA and Mol BW. Ultrasound factors to predict the outcome of external cephalic version: a meta-analysis. Ultrasound Obstet Gynecol 2009; 33: 76-84.
[16] Olson Koutrouvelis G. Role of external cephalic version in reducing the cesarean delivery rate. Obstet Gynecol 2019; 133: 855-856.
[17] Kok M, Cnossen J, Gravendeel L, van der Post J, Opmeer B and Mol BW. Clinical factors to predict the outcome of external cephalic version: a metaanalysis. Am J Obstet Gynecol 2008; 199: 630, e631-637; discussion e631-635.
[18] Nakayama R, Jagannathan JP, Ramaiya N, Ferrone ML, Raut CP, Ready JE, Hornick JL and Wagner AJ. Clinical characteristics and treatment outcomes in six cases of malignant tenosynovial giant cell tumor: initial experience of molecularly targeted therapy. BMC Cancer 2018; 18: 1296.
[19] Yamasato K, Kaneshiro B and Salcedo J. Neuraxial blockade for external cephalic version: cost analysis. J Obstet Gynaecol Res 2015; 41: 1023-1031.