

Prediction of Success in External Cephalic Version for Breech Presentation at Term

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OBJECTIVE: To design a clinically based predictive model for the likelihood of successful external cephalic version (ECV).

METHODS: This single-center retrospective study was conducted from February 2016 to July 2018 and included all candidates for ECV between 36 and 41 weeks of gestation. Variables with a potential effect on ECV success were collected. These variables include: body mass index, amniotic fluid index, gestational age, parity, location of placenta, fetal trunk posture, time in breech presentation before the procedure and the ultrasonographically measured size of the amniotic fluid preceding the fetal presenting part (fore-bag). Variables' association with ECV success was evaluated using a multivariate logistic regression and a decision tree predicting ECV outcome was developed using 75% of the patients and validated on the remaining 25%.

RESULTS: Overall, 250 pregnant women were identified and opted for a trial of ECV by a single operator, with a success rate of 64.8%. Body mass index, size of fore-bag, and parity were independent determinants of the version success, whereas other variables had no statistically significant effect on the success rate. Our decision tree model divided the cohort into five subgroups according to various combinations of the three variables.

When evaluated on the internal validation set, the C-Index of the tree was 0.933 (0.863–1) and the prediction accuracy was 91.9% (86.5%–97.3%).

CONCLUSION: A prediction model composed of three easily measurable variables enables accurate prediction of successful ECV at term. Fore-bag was identified as the most important discriminator. Our model holds in internal validation and it can be used to support patient counseling and decision making for ECV but should be externally validated.

(*Obstet Gynecol* 2019;133:857–66)

DOI: 10.1097/AOG.0000000000003196

Between 3% and 4% of all full-term singleton pregnancies result in breech presentation at birth, and a large portion of them are delivered by cesarean delivery.^{1,2} An external cephalic version (ECV) is an obstetric procedure carried out to avoid breech presentation, thus obviating cesarean delivery and its associated complications, such as endometritis, wound infection, hemorrhage, pelvic organ injury, and thromboembolic disorders.¹

The reported chance for a successful ECV are highly variable and range from 35% to 86%,^{1,3} depending on the selection of patients and the population studied. The uncertainty of success rates in addition to the reputation of versions as painful and hazardous procedures have led many patients (up to 76%) to decline undergoing it.^{4,5} The effectiveness of ECV in reducing the rates of cesarean delivery is supported by a 2015 systematic review of eight randomized trials of ECV at term (N=1,308 women). Compared with women with breech fetuses who had no attempt at ECV, women who attempted ECV reduced the risk of cesarean delivery by approximately 40%.³

External version has been associated with several sequelae, such as stillbirth, placental abruption, emergency cesarean delivery, cord prolapse, transient abnormal fetal heart rate changes, vaginal bleeding, rupture of membranes, and fetomaternal transfusion.² External version may also be painful, as reported in

See related editorial on page 855.

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Presented as a poster at the Society for Maternal-Fetal Medicine's 39th Annual Pregnancy Meeting, February 11–16, 2019, Las Vegas, Nevada.

Each author has confirmed compliance with the journal's requirements for authorship.

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Financial Disclosure

The authors did not report any potential conflicts of interest.

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ISSN: 0029-7844/19



studies using visual analogue pain scales, with mean scores of 4.6–8.5 out of 10. Some authors have used neuraxial analgesia for ECV, leading to reduced pain scores and increased success.⁶ However, neuraxial analgesia itself may be associated with maternal hypotension, sedation, and a prolonged hospital stay for a procedure that can be performed on an outpatient basis.⁷

The ability to predict the outcome of an ECV attempt may improve the rates of patient consent and prevent the performance of many unpleasant procedures with low chance for success. Modern scoring systems have been developed to predict success and to counsel patients before an ECV, but their predictive values were only poor-to-fair, with a maximal area under the curve (AUC) of 0.71.^{8,9}

This study aims to identify possible determinants of success of an ECV using both statistical inference and machine learning methods based on maternal, fetal and uterine parameters collected near term. The model will represent an intuitive flowchart for clinicians and may be a useful tool in counseling women considering an ECV.

METHODS

We conducted a retrospective cohort study of pregnant women with singleton pregnancies and breech presentations who opted for an ECV attempt at a single, tertiary, university-affiliated medical center from February 2016 to July 2018. The study was approved by the Tel Aviv Sourasky Medical Center's institutional review board (TLV-0749-18). The study group consisted of healthy pregnant women at 36–41 weeks of gestation with breech presentation and without contraindications to ECV (eg, placental abruption, placenta previa, uterine malformations, and any contraindication for vaginal delivery). Excluded from the study were women with an amniotic fluid index (AFI) below 8 cm, evidence of nuchal cord, regular contractions, prelabor rupture of membranes, and nonreassuring fetal heart rate patterns during a routine tracing performed before the procedure. The primary outcome was successful ECV and the secondary outcome was the route of delivery.

Candidates for an ECV underwent a preliminary ultrasound scan by an obstetrician to provide information on fetal lie, type of breech, fetal position, placental location, estimated fetal weight, AFI, and estimation and size of the fore-bag. The fore-bag is the size of the pocket of amniotic fluid (in centimeters) preceding the fetal presenting part measured by abdominal ultrasound scan, in centimeters, from the internal os to the low-most fetal breech (in the

midline) (Fig. 1). Candidates were instructed to fast for at least 6 hours before the procedure in case an emergency cesarean delivery became necessary. All the patients received 30 mg nifedipine sublingually 40–120 minutes before the procedure to achieve uterine relaxation. A single obstetrician with experience of more than 500 ECVs performed the versions. The performer of the versions was not aware of the data previously collected and thus was not influenced by them.

The session was terminated under any one of the following conditions: 1) the fetus was successfully inverted to vertex, 2) 30 minutes of fetal manipulation had elapsed, 3) the patient asked to stop the procedure owing to pain or any other reason, or 4) the practitioner decided that continuing the procedure would be of no benefit. Fetal well-being was monitored during the ECV procedure by ultrasound scan that focused on fetal heartbeats and movements. Fetal lie was confirmed by ultrasound scan 1 hour after the version, and fetal heart rate tracing was performed for a period of at least 20 minutes after the procedure before discharge.

The study group was divided into successful versions (group A) and unsuccessful ones (group B). Maternal demographic and obstetric data were collected, as were potential determinants of the likelihood for successful version as detailed below. Two authors (L.R. and S.M.) entered and double-checked all the data by validation in two separate databases. A one-sample proportion power analysis determined

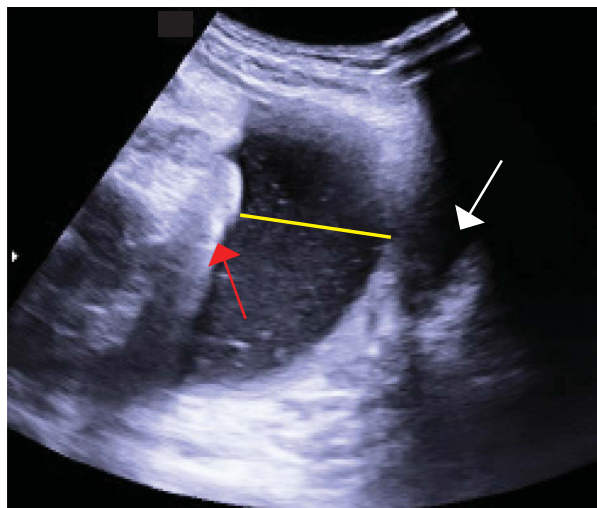


Fig. 1. Ultrasonographic appearance of a forebag. Red arrow indicates fetal breech; yellow line indicates forebag of 2.3 cm; white arrow indicates bladder.

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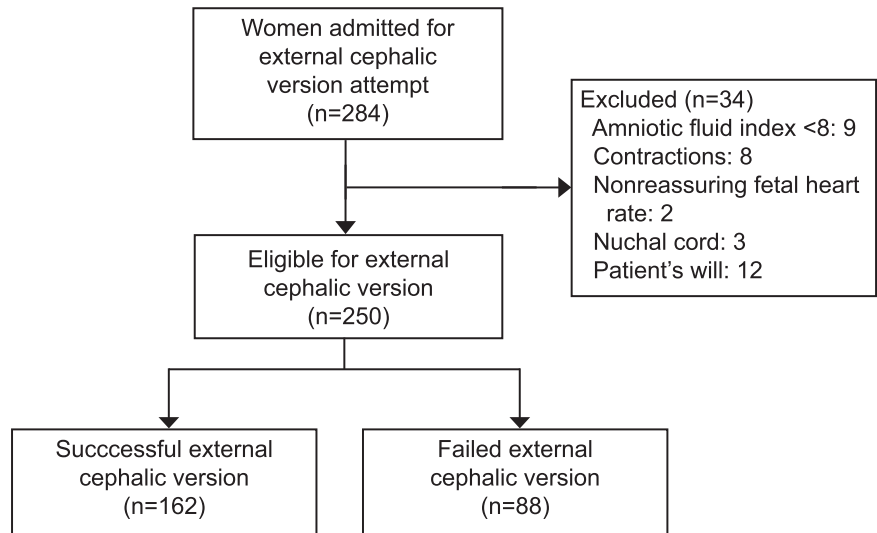


Fig. 2. Study design.

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that given $N=250$ patients, our study had the power to detect even a small-sized effect (0.185) corresponding, for example, to an increase in accuracy from 80% to 87% with type I error probability of 0.05 and type II error probability of 0.1. Between-group comparisons of patient characteristics were performed using a two-tailed Student's t test for continuous variables, a Pearson χ^2 test for categorical variables and the Kruskal–Wallis test for continuous nonnormal variables. $P \leq 0.05$ was considered significant. Power calculations for proportion tests with one sample were performed using accuracy as the tested proportion. Correlation between variables was tested using the Spearman's rank correlation test. Multivariate logistic regression was used to assess the association between the various collected variables and ECV attempt outcome. Fore-bag size, BMI, age, parity, estimated fetal weight, and time in breech presentation were all included as continuous variables and the remaining variables as categorical. All statistical analyses were performed using R 3.5.2 (<http://www.r-project.org>).

The decision tree algorithm chosen for predicting whether a given version will be successful was the conditional inference classification tree.¹⁰ This algorithm performs an unbiased, recursive division of the study population into subgroups according to the independent variables. The underlying algorithm incorporates formal testing of statistical hypotheses to choose which variables to include, determine their discriminatory value, and the order in which they occur in the tree. A variable is chosen to be incorporated into the decision tree only if it is significantly associated with the outcome. Association is tested by univariate analysis according to the variable tested

(analysis of variance and χ^2 for numeric and categorical variables, respectively).

The tree-based model was trained to predict the outcome of an ECV attempt given maternal and ultrasonographic features collected before the attempt. A positive result was defined as cephalic presentation after version attempt, and a negative result was defined as breech presentation after version attempt. The entire cohort was initially randomly divided into two groups. The first group termed “training set,” comprised of 75% of the patients and was used for model development. The second group, termed “internal validation set,” comprised of the remaining 25% and was used for performance evaluation. Cross validation was used during model development to estimate model performance under different parameter settings. Briefly, for each tested parameter value, the training set was randomly divided into 10 sections. One section was put aside, and a classification tree was built on the combined remaining nine sections. The performance of the constructed tree was estimated on the isolated section that was not used during model development. This form of evaluation tests how well a developed model performs on new datasets. This process was repeated five times, and the average of the combined estimates was recorded. The parameter setting with the best mean performance estimated by cross validation was used in the final decision tree model which was then used for internal validation on the remaining 25% of participants. Performance was compared between different values of the minimal 1- P -value used to decide whether a variable will be added to the tree (eg, min-criterion). The final model was developed using



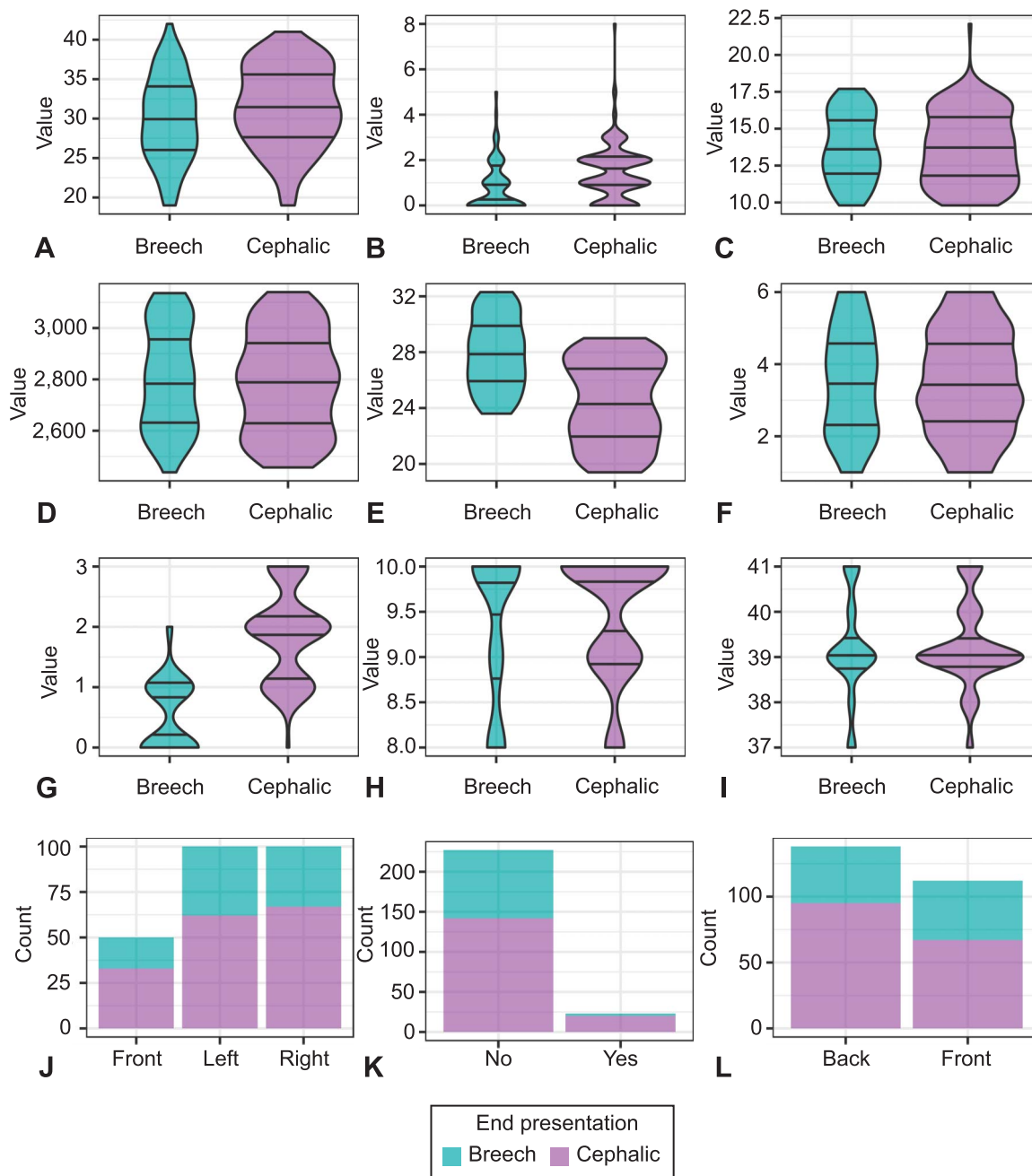


Fig. 3. Distribution of collected clinical and ultrasonographic characteristics in the successful external cephalic version attempt (purple) and the failed attempt (teal). Age (A), number of births (B), amniotic fluid index (C), estimated fetal weight (D), body mass index (E), time in breech (F), fore-bag size (G), 5-minute Apgar score (H), weeks of gestation at birth (I), back direction (J), previous cesarean delivery (K), and placenta position (L).

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a mincriterion of 0.938. Because the outcome groups were comparable in size, the overall accuracy (ie, the sum of correct ECV outcome predictions divided by the total number of predictions) was used for performance estimation. The C-index was calculated as an additional measure of performance on both the train-

ing and the validation set. All accuracy and C-index values are reported together with a 95% CI. C-indices were compared using DeLong's test for two correlated receiver operating characteristic curves.

Finally, model performance was validated on the internal validation set (the remaining 25%) that was



Table 1. Demographic, Clinical, and Ultrasonographic Characteristics

	Endpoint Breech Presentation	Endpoint Cephalic Presentation	P
n	88	162	
Age (y)	29.92±5.34	31.43±5.19	.031
Parity	0.00 (0.00–1.00)	1.00 (1.00–2.00)	<.001
Amniotic fluid volume index	13.71±2.29	13.65±2.44	.838
Direction of fetal back			
Front	17 (19.3)	33 (20.4)	.745
Left	38 (43.2)	62 (38.3)	
Right	33 (37.5)	67 (41.4)	
Estimated fetal weight (g)*	2,807±198	2,788±196	.458
BMI (kg/m ²)	27.95±2.59	24.35±2.97	<.001
Previous cesarean delivery			
No	85 (96.6)	142 (87.7)	.035
Yes	3 (3.4)	20 (12.3)	
Placental implantation			
Posterior	43 (48.9)	95 (58.6)	.176
Anterior	45 (51.1)	67 (41.4)	
Time in breech presentation (wk) [†]	3.53±1.49	3.49±1.48	.838
Fore-bag (cm)	0.52±0.59	1.90±0.75	<.001
Birth type			
Cesarean	28 (31.8)	55 (34.0)	.626
Normal	51 (58.0)	96 (59.3)	
Vacuum	9 (10.2)	11 (6.8)	
5-minute Apgar score	9.38±0.83	9.49±0.68	.25
NICU admission			
No	70 (79.5)	147 (90.7)	.021
Yes	18 (20.5)	15 (9.3)	
Gestational week	39.20±1.11	39.25±0.92	.747

BMI, body mass index; NICU, neonatal intensive care unit.

Data are mean±SD, median (interquartile range), or n (%) unless otherwise specified.

* The ultrasonographic estimated fetal weight at the time of the external cephalic version.

[†] The time between the last ultrasound-confirmed breech presentation to performing external cephalic version.

not used during model development. Model development and testing were performed using R 3.5.2 with the party and caret package.¹¹

RESULTS

After excluding 34 patients who were not suitable for a trial of version (nine owing to AFI lower than 8, eight owing to contractions, three owing to evidence of nuchal cord, two owing to nonreassuring fetal heart rate, and 12 women changed their minds just before the procedure), a total of 250 women underwent an ECV trial during the study period (Fig. 2). The overall ECV success rate in this cohort was 64.8%. Clinical and ultrasonographic characteristics of groups A and B are presented in Figure 3. The mean maternal age was higher in the successful ECV group compared with the unsuccessful ECV group (31.4±5.2 vs 29.9±5.34 years, respectively, $P=.031$) as was the number of previous cesarean deliveries (12.3% vs 3.4%, respectively, $P=.035$). The neonatal intensive care unit admission rates were lower in the successful ECV group. There was no significant group difference

in the AFI, fetal back direction, estimated fetal weight, placental location, time in breech presentation, or gestational age at delivery (Table 1).

We developed a classification tree algorithm that predicts whether a given ECV will result in cephalic presentation using three parameters: fore-bag size, BMI, and number of deliveries (Fig. 4). The C-Index for the final tree during model training was 0.928 (0.924–0.931) and the accuracy for correctly predicting version outcome was 92.2% (91–93.4%). Evaluating the performance of the developed tree on the internal validation subgroup yielded a C-Index of 0.933 (0.863–1) and the prediction accuracy was 91.9% (86.5–97.3%), which was significantly better than the no information rate of 64.8% ($P<.001$). Sensitivity for predicting successful versions was 0.975 (0.87–1), specificity was 0.818 (0.6–0.95), the positive predictive value was 0.947 (0.74–1) and the negative predictive value was 0.907 (0.78–0.97). Reviewing the decision tree, patients with no fore-bag had a predicted probability of 2.6% and 10% for successful version in the training and internal validation cohorts,



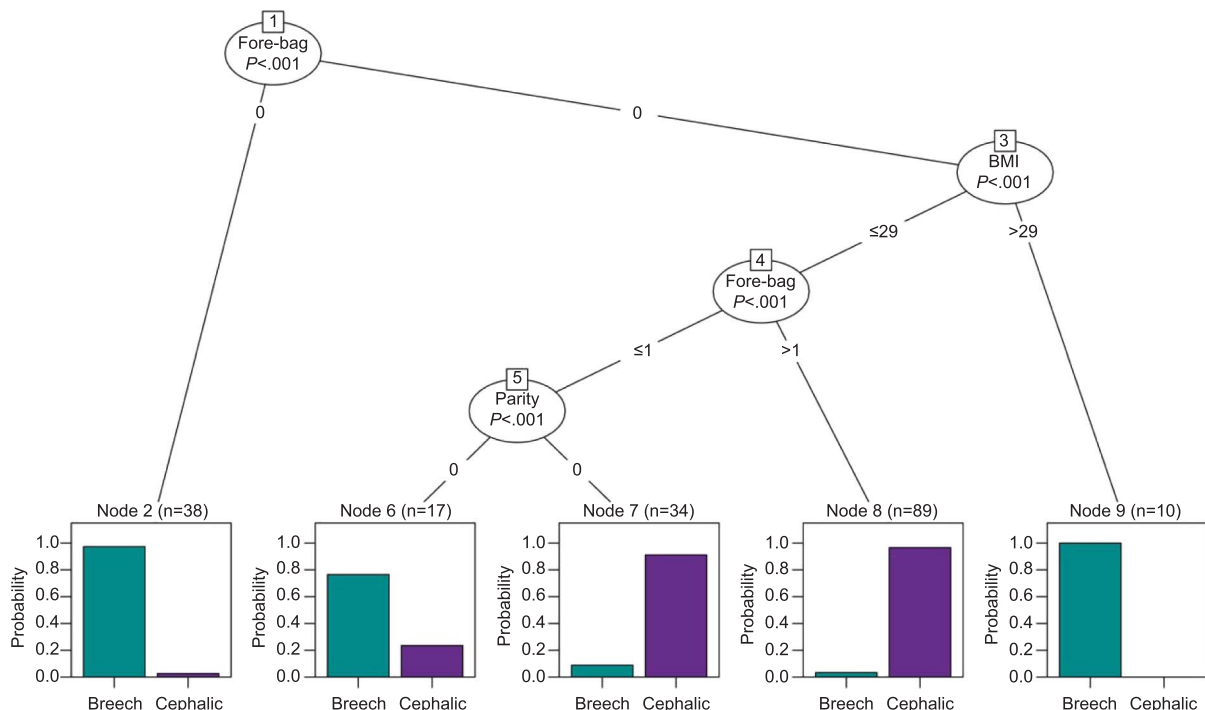


Fig. 4. Decision tree for estimating the probability of a successful external cephalic version attempt (cephalic presentation after version). BMI, body mass index.

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respectively. Patients with BMI greater than 29, had a low probability for version success, regardless of fore-bag size. The version outcome in patients with a BMI of 29 or less was significantly associated with the fore-bag size. When fore-bag size was higher than 1 cm, versions were likely to succeed (97% and 96.3% in the training and internal validation cohorts, respectively). When fore-bag size was 1 cm, outcome dif-

fered between nulliparous and multiparous patients, with nulliparous patients having a much lower probability of success (24% vs 91% and 0% vs 81% in the training and validation cohorts, respectively). As decision tree models may oversimplify variable-outcome relations, a multivariate logistic regression-based model was generated using the training set as well (Table 2). Three variables were identified to be

Table 2. Univariate and Multivariate Regression Analysis

	Univariate		Model 1		Model 2	
	OR	P	OR	P	OR	P
BMI (kg/m ²)	0.64 (0.55–0.73)	<.001	0.61 (0.43–0.80)	<.001	0.63 (0.46–0.8)	<.005
Fore-bag (cm)	23.6 (8.77–63.6)	<.001	154 (31.5–1,439.3)	<.001	124.9 (27.8–1,037)	<.005
Parity	1.67 (1.22–2.28)	<.005	6.01 (2.6–17.34)	<.005	4.88 (2.51–11.1)	<.005
Age (y)	1.03 (0.98–1.09)	.265	0.93 (0.78–1.1)	.4		
Amniotic fluid volume index	1.02 (0.90–1.16)	.726	0.97 (0.73–1.31)	.828		
Fetal back—left	0.91 (0.40–2.01)	.819	0.34 (0.04–2.12)	.264		
Fetal back—right	1.00 (0.43–2.25)	.993	0.82 (0.13–5.02)	.824		
Estimated fetal weight (g)	1.00 (1.00–1.00)	.601	1.00 (1.00–1.00)	.787		
Previous cesarean delivery	4.19 (1.12–29.6)	.031	2.55 (0.06–149.1)	.673		
Placental implantation—front	0.56 (0.30–1.03)	.062	0.54 (0.12–2.23)	.394		
Time in breech presentation	1.03 (0.83–1.26)	.807	1.19 (0.73–1.97)	.484		

OR, odds ratio; BMI, body mass index.

Model 1—Includes all of the variables.

Model 2—Includes only BMI, fore-bag, and parity.



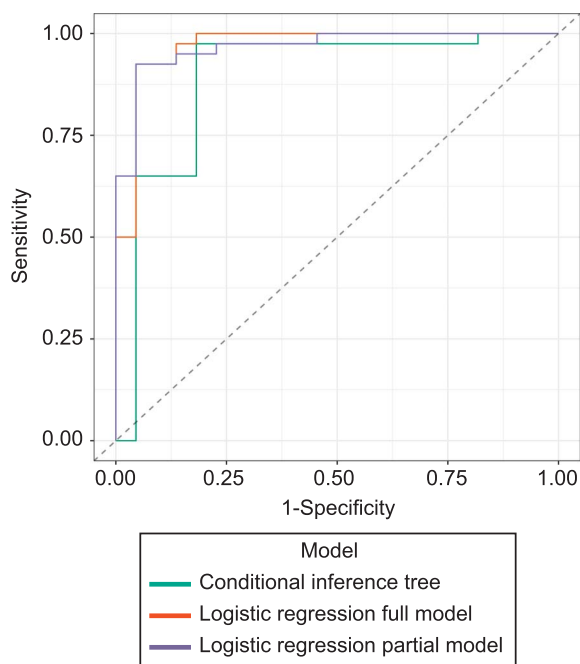


Fig. 5. Model performance on internal validation set.
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significantly associated with successful ECV: A one-centimeter increase in fore-bag size was associated with better odds of successful ECV attempt (odds ratio [OR] 153 [31.5–1,439.4]). A one-unit increase in BMI results in reduced odds of success (OR 0.6 [0.4–0.8]), whereas the number of previous deliveries increases the odds (OR 6 [2.6–17.3]). An additional logistic regression model was developed using only these three variables. When tested on the internal validation set, the accuracies of the complete and partial models were 91.9% and 90.3%, respectively and the C-indices were 0.969 and 0.967, respectively (Fig. 5).

A four-stage hierarchical multiple regression was conducted with fore-bag entered at stage one, BMI entered at stage two, parity at stage three, and all remaining variables at the last stage. The hierarchical multiple regression revealed that adding fore-bag, BMI, and parity contributed significantly to the regression ($\chi^2(1, N=186)=126.2$ $P<.005$, $\chi^2(1, N=185)=27.8$ $P<.005$, $\chi^2(1, N=184)=26.9$ $P<.005$, respectively). Finally, the addition of the remaining variables to the regression model did not result in a significant improvement of the model ($\chi^2(1, N=176)=3.5$ $P=.9$).

We continue to check which of the collected variables are significantly associated with the secondary outcome of final route of delivery. A multivariate logistic regression analysis including all the collected

variables identified post ECV attempt cephalic presentation to be the only variable significantly associated with a vaginal route of delivery (OR 864 [95–14,848]).

Figure 4 summarizes the decision tree for estimating the probability of a successful ECV attempt (cephalic presentation after version). Model training and development was performed using 75% of the original cohort (training set). The final tree divides the cohort into five subgroups. Each subgroup is represented as a terminal node. Node size is indicated above each terminal node. A multiple-testing-adjusted P -value was given for each split, specifying the strength of association between the predictor and the outcome variable conditioned on the previous splits. The fore-bag was identified as the best discriminator among all the tested variables.

DISCUSSION

External version is a simple and effective procedure that can reduce the cesarean delivery rate, but counselling patients on the risks and success rates of version is challenging owing to the lack of validated models to predict success. In the era of shared decision-making, women should be provided unbiased nondirective information on the advantages, disadvantages, and expected risks and outcomes of an ECV. Here, we describe a retrospective study aimed at identifying the factors associated with successful ECV attempts and developing a prediction model to identify patients with lower likelihood of success. We found that BMI, size of fore-bag, and parity are independent determinants of the final presentation, whereas other variables had no statistically significant effect on the success rate. We developed a decision tree predicting ECV outcome based on those predictors with prediction accuracy of 91.9% (86.5–97.3%).

Our results showed a higher success rate (65%) than the success rates of 53–55% reported in meta-analyses conducted by Kok in 2008 and 2009.^{12,13} This difference may be due to the fact that a single experienced practitioner performed all the version attempts and that the women's mean BMI was lower in our study when compared with the mean BMI in the aforementioned studies. Numerous studies have addressed the prediction of success in ECVs^{14–20} with conflicting results.²¹ Multiple predictive factors were proposed in these studies, including a clinical history and findings of physical and ultrasound examinations. Clinical prognostic factors that have been associated with successful ECVs include multiparity, nonengagement, relaxed uterus, palpable fetal head, and



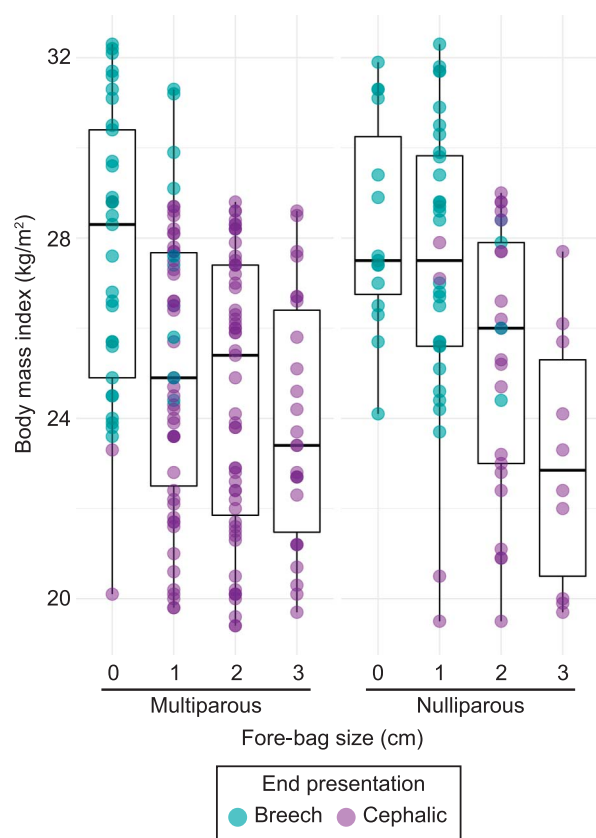


Fig. 6. Interaction of external cephalic version-associated variables.

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a maternal weight below 65 kg.¹² Ultrasound findings that may affect the success of versions are placental location, AFI, and the specific type of breech. One systematic review evaluated the role of the AFI in the success of an ECV attempt¹⁶ and found that an AFI below 10 cm may correlate with lower success rates, although the association was not statistically significant.

Methods of prediction of ECV success were proposed in a number of studies, most of them based on logistic regression analyses. The first clinical score was developed by Newman et al,²² and it includes the variables of parity, estimated fetal weight, placental location, cervical dilatation, and station of presentation. The measurements of cervical dilatation and presentation height, however, are not routinely performed at the week of gestation that ECVs are performed (ie, week 36–40). Moreover, their measurements are usually subjective and, therefore, may introduce bias into the predictive model. Aisenbrey et al¹⁴ developed a scoring system based on uterine tone, fetal spine direction, noncornual placental location,

and breech location out of the pelvis as the independent features. Both studies included relatively small numbers of patients ($n=108^{22}$ and $n=128^{14}$), and neither described an internal validation nor assessed the discriminative capacity of the scoring system. The study by Burgos et al⁹ demonstrated fair performance AUC 0.67 (95% CI 0.62–0.72) and 0.70 (95% CI 0.67–0.74) during internal validation and on the entire cohort, respectively. The model by Kok et al⁸ demonstrated similar performance with AUC 0.71 (95% CI 0.66–0.77) and 0.66 (95% CI 0.60–0.72) in internal validation and external validation, respectively. Hutton et al²³ developed a classification and regression tree based on the engagement of the presenting part and an easily palpable fetal head. The lack of objective determinants, however, makes it difficult to estimate their influence on the success rate and essentially impossible to include them in a scoring system that can be used by obstetricians. Moreover, those authors based their tree on 100% of their data and did not include an internal validation.

The current study describes a prediction model for the outcome of an ECV. We propose a classification tree that was developed on three-quarters of a homogeneous patient population and validated on the remaining one-quarter. Classification trees represent a form of discriminative models much like logistic regression. By identifying the most informative variables and their corresponding cutoffs, decision trees provide several advantages over logistic regression, including: 1) identification of subgroups that have the same outcome of interest, 2) identification of nonlinear relations to the outcome, 3) identification of variable interactions that better stratify the population according to the outcome, 4) easily interpretable models that allow users without statistical background to better understand the variables' association to the outcome and implement the model to predict the outcome of new cases.^{24,25} A major drawback of decision trees is oversimplification of variable-outcome relationships by setting a single cutoff when a continuous relationship is present. To verify that the classification tree-based model does not result in a significant reduction in prediction accuracy and overall performance, we compare the developed model against two multivariate logistic regression-based models. When tested on the internal validation set, the classification tree model demonstrated noninferior accuracy. Next, we tested for collinearity between the three variables identified by the models as most important (BMI, fore-bag, and parity). Body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) was found to be



negatively correlated with fore-bag size (-0.39 ; $P<.005$) and parity (-0.178 ; $P<.05$) (Fig. 6). Such collinearity might result in an unstable estimated OR and inflated variance in logistic regression analysis. Because the classification tree algorithm chooses the best variable for each node in the tree, it is less affected by such collinearity. Overall, the classification tree provided an easily interpretable algorithm at the cost of a mild decrease in discriminatory values ($P=.052$ and $P=.06$ for C-index comparison with the full and partial logistic regression models, respectively).

The classification tree automatically selected the most important discriminatory factors (fore-bag, BMI, and parity) and identified the optimal cutoff values for each. The values of those variables could be easily obtained, and they comprise part of routine clinical practice in pregnancy. We examine the size of the fore-bag as a predictive factor, and it emerged as the most important indicator for predicting the outcome of an ECV. The clinical implication of a large fore-bag is a presenting part that is not engaged, which increases the chances for successful ECV.

Multiparity was identified in our study as the major maternal factor associated with the success rate of an ECV, a finding that is widely accepted and also confirmed by a meta-analysis.¹³ This may be due to late engagement (often after the onset of labor) or relative laxity of the maternal abdomen in multiparous women. Maternal BMI was another important determinant of ECV success according to our results. One possible reason for that finding is that a thicker abdominal wall complicates the manipulation of the fetus. Chan et al²⁶ found an association between maternal weight at presentation and ECV success, but no correlation with maternal height. A meta-analysis by Kok et al showed that a maternal weight of less than 65 kg significantly predicted a successful ECV. We contend that the BMI offers a better estimation of the maternal abdominal wall because it considers both height and weight. This is in line with Zandstra et al²⁷ who observed that patients with a higher BMI were less likely to have a successful ECV. The independent association between each of these factors and ECV outcome was also demonstrated using a multivariate logistic regression.

Strengths of this study include the relatively large sample size and good performance of the decision tree. The internal validation of our model adds to the clinical significance of the determinants. The decision tree was developed as a tool to assist the clinician in counseling women before attempting an ECV. The rates of success are usually presented to the patients

but are not always applicable to the specific mother and fetus. Our algorithm enables the obstetrician to predict success of the procedure according to easily obtainable parameters.

Several limitations of this study bear mention. External validation of a prediction model is essential for its implementation in clinical practice. The only model whose performance has been tested in both internal and external validation thus far was the one developed by Kok et al⁸ Unfortunately, external validation of their model had a slight underestimation of the probability for a successful ECV. We recognize that our model needs external validation before it can be used in clinical practice. If it succeeds in passing external validation, the question will then arise as to whether an ECV should be withheld from women with a poor chance of success. Although the low complication rate of the procedure supports attempting ECV even in low likelihood of success, patient discomfort and pain also should be considered and, therefore, a conservative approach might be more appropriate in certain cases. This, in turn, raises the question of complications. It cannot be ruled out that they may be more frequent among women with a low predicted ECV success, bearing in mind the effect of the risk, however small, of an emergency cesarean delivery or even fetal death after an ECV attempt.

Our study was conducted in a single tertiary center, by a single experienced physician and thus it is not clear whether the reported findings can be generalizable to clinical practice. Importantly, the operator was totally unaware of parameters later determined to be predictive of successful version. In addition, by focusing on ECVs performed by a single provider, we were able to offset any bias or effect that might stem from differences in technique or experience by a range of providers. The entire procedure, from the premonitoring phase, the approach to therapy, and the manual rotation maneuver itself was the same for all patients. We therefore believe the advantages of a single performer outweigh the lack of generalization.

The average BMI for the patient population in this study is lower than that in the United States. The mean BMI among pregnant Israeli women is 26.1 with a 95% range of 22–29. The average BMI in our study was similar. We do not have sufficient data to predict the success of ECV in those with a higher BMI. It would certainly be worthwhile and interesting to apply this model in further studies in additional populations.

Women with AFI below 8 cm were excluded from the current study. Several studies addressed the issue of AFI threshold for successful ECV and some



cutoffs had been proposed ranging from less than 10¹⁶ to less than 5, 5–8.²⁸ Because there is no agreement, we have decided on a threshold of AFI below 8 as a reasonable cutoff.

In conclusion, we describe a predictive model for the outcome of an ECV at term that can be used by obstetricians as a simple tool in clinical decision-making. We found that parity, BMI, and size of forebag are variables associated with ECV success. Our model offers an easily interpretable algorithm for the prediction of ECV success.

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PEER REVIEW HISTORY

Received November 14, 2018. Received in revised form January 9, 2018. Accepted January 17, 2019. Peer reviews and author correspondence are available at <http://links.lww.com/AOG/B342>.

