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Vaginal birth after Cesarean section and levator ani avulsion: a case–control study

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KEYWORDS: ballooning; childbirth trauma; levator ani avulsion; levator hiatus; transperineal ultrasound; urogenital hiatus; vaginal birth after Cesarean; VBAC

CONTRIBUTION

What are the novel findings of this work?
This is the first study to report on the incidence of levator ani muscle avulsion following vaginal birth after Cesarean section. Our data showed that vaginal birth after Cesarean section is associated with an increased risk of levator ani muscle avulsion.

What are the clinical implications of this work?
Levator ani muscle avulsion increases the risk of developing pelvic organ prolapse later in life and the risk of its recurrence after reconstructive surgery. The findings of our study show that women who delivered vaginally after a Cesarean section are at an increased risk of having levator ani muscle avulsion compared with primiparous women who had a vaginal delivery.

ABSTRACT

Objective *The aim of this study was to explore the risk of levator ani muscle (LAM) avulsion and enlargement of the levator hiatus following vaginal birth after Cesarean section (VBAC) in comparison with vaginal delivery in primiparous women.*

Methods *In this two-center observational case–control study, we identified all women who had a term VBAC for their second delivery at the Departments of Obstetrics and Gynecology at the Faculty of Medicine in Pilsen and the 1st Faculty of Medicine in Prague, Charles University, Czech Republic, between 2012 and 2016. Women with a repeat VBAC, preterm birth or stillbirth were excluded from the study. As a control group, we enrolled a cohort of primiparous women who delivered vaginally during the study period. To increase our control sample, we also invited all primiparous women who delivered vaginally in both participating units between May and June 2019 to participate. All participants were invited for a four-dimensional pelvic floor ultrasound scan to assess LAM trauma. LAM avulsion and the area of the levator hiatus were assessed offline from the stored pelvic floor volumes obtained at rest, during maximum contraction and during Valsalva maneuver. The laterality of the avulsion was also noted. The cohorts were then compared using the* χ^2 *test and Wilcoxon's two-sample test according to the normality of the distribution.* $P < 0.05$ *was considered statistically significant. Multivariate regression analysis, controlling for age and body mass index (BMI), was also performed.*

Results *A total of 356 women had a VBAC for their second delivery during the study period. Of these, 152 (42.7%) attended the ultrasound examination and full data were available for statistical analysis for 141 women. The control group comprised 113 primiparous women. A significant difference was observed between the VBAC group and the control group in age (32.7* vs *30.1 years;* $P < 0.05$*), BMI (28.4* vs *27.4 kg/m*^{2}*;* $P < 0.05$*) and duration of the first and second stages of labor (293.1* vs *345.9 min;* $P < 0.05$ *and 27.6* vs *35.3 min;* $P < 0.05$*, respectively) at the time of the index birth. The LAM avulsion rate was significantly higher in the VBAC compared with the control group (32.6%* vs *18.6%;* $P = 0.01$*). The difference between the groups was observed predominantly in the rate of unilateral avulsion and remained significant after controlling for age and BMI (adjusted odds ratio 2.061 (95% CI, 1.103–3.852)). There was no statistically significant difference in the area of the levator hiatus at rest (12.0* vs *12.6 cm*^{2}*;* $P = 0.28$*)*

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or on maximum Valsalva maneuver (18.6 vs *18.7 cm^2; P = 0.55) between the VBAC and control groups. The incidence of levator hiatal ballooning was comparable between the groups (17.7% and 18.6%; P = 0.86).*

***Conclusions** VBAC is associated with a significantly higher rate of LAM avulsion than is vaginal birth in nulliparous women. The difference was significant even after controlling for age and BMI.*

INTRODUCTION

After a first delivery by Cesarean section (CS), many women choose to attempt a vaginal delivery for their second child[1]. In the USA, a uterine scar contributes to almost a third of Cesarean delivery indications[2]. Hence, vaginal birth after CS (VBAC) is currently an important and effective intervention for curtailing the rising CS rate[3–5]. Opponents of VBAC point out that the policy of trial of labor after CS is associated with a low success rate, an increased risk of uterine rupture and potential adverse events[6]. However, serious complications associated with the trial of labor after CS are rare, and the success rate is acceptable provided that a standardized evidence-based labor management protocol facilitates intrapartum care and decisions[7].

Childbirth trauma and its possible consequences should be taken into account when counseling women about their second delivery after CS. Although VBAC is an extensively studied subject, to date, few studies have focused on pelvic floor trauma after this mode of birth[8–12] and none of them studied the risk of levator ani muscle (LAM) avulsion. LAM avulsion is a relatively frequent complication following a vaginal delivery, with a reported prevalence ranging from 13% to 36%[13,14]. It leads to reduced contractility of the pelvic floor and increased vaginal laxity[15,16]. The trauma plays an important role in the pathophysiology of pelvic organ prolapse, increasing its lifetime risk 4-fold and hence negatively impacting on the woman's quality of life and sexuality[17–19].

VBAC has been associated with an increased risk of perineal[8,10] and cervical trauma[11]. It has been postulated that the combination of a vaginally nulliparous pelvic floor, a larger fetus and more powerful uterine contractility may result in an increased likelihood of pelvic floor trauma[11,20]. Therefore, we hypothesized that the risk of LAM avulsion at the time of the first vaginal delivery is higher in women having a VBAC compared with that in nulliparous women. Consequently, the magnitude of enlargement of the levator hiatus was expected to be greater in women after VBAC. The aim of the study was to test these hypotheses.

METHODS

In this observational case–control study, we identified all women who had a term VBAC for their second delivery at the Department of Obstetrics and Gynecology, Faculty of Medicine in Pilsen and the Department of Obstetrics and Gynecology, 1st Faculty of Medicine in Prague, Charles University, between 2012 and 2016. Women with a repeat VBAC, preterm birth or stillbirth were excluded from the study. We aimed to recruit primiparous women who delivered vaginally as our control group. We initially attempted to recruit controls with a length of follow-up comparable with that of the cases. This was achieved by approaching every primiparous woman who had a singleton vaginal birth subsequent to each of the included VBAC cases. However, this approach yielded a small number of women who had not had a further delivery in the meantime. Therefore, to increase the number of controls, we invited all women who had their first vaginal delivery in both participating units between May and June 2019 for an ultrasound examination at least 2 months postpartum. The hospital electronic clinical databases of the two participating units were used to identify eligible women, and their individual health records were used for data collection (age, body mass index (BMI), gestational age, birth weight, duration of the first and second stages of labor, perineal trauma, episiotomy, vaginal laceration, operative vaginal delivery). Women who were eligible were contacted and invited to participate in the study.

Women were assessed in the supine position after bladder emptying using four-dimensional (4D) ultrasound (GE Voluson E8, GE Healthcare, Zipf, Austria) with 8–4-MHz curved array volume transducer with an 85° angle of acquisition. Volume acquisition was performed on maximum Valsalva maneuver for the assessment of the dimensions of the levator hiatus and on maximum pelvic floor muscle contraction for diagnosis of LAM avulsion. The acquired volumes were analyzed offline on a desktop PC using the proprietary software 4D View version 18.0 (GE Healthcare). The assessors who performed the ultrasound analysis were blinded to all the patients' data.

Tomographic ultrasound imaging (TUI) was used for the diagnosis of LAM avulsion, with slices obtained in the axial plane at 2.5-mm slice intervals using the plane of minimal hiatal dimensions and the two slices immediately above that plane. The plane of minimal hiatal dimensions was defined in the mid-sagittal plane as the minimal distance between the hyperechogenic posterior aspect of the symphysis pubis and the hyperechogenic anterior border of the LAM just posterior to the anorectal muscle. LAM avulsion was diagnosed if the distance between the center of the urethra and the LAM insertion (levator–urethra gap) was $\geq$ 25 mm in all three central slices[21,22] (Figure 1). The laterality of the avulsion was also recorded. Hiatal dimensions were measured in an axial cross-section at the plane of minimal hiatal dimensions[23]. Hiatal area at rest and during the third maximum Valsalva maneuver was measured. The distensibility of the levator hiatus was described by the difference in its area at rest and on maximum Valsalva and the frequency of ballooning, which was defined as area of the levator hiatus > 25 cm^2 during maximum Valsalva[24]. The volumes were analyzed offline by

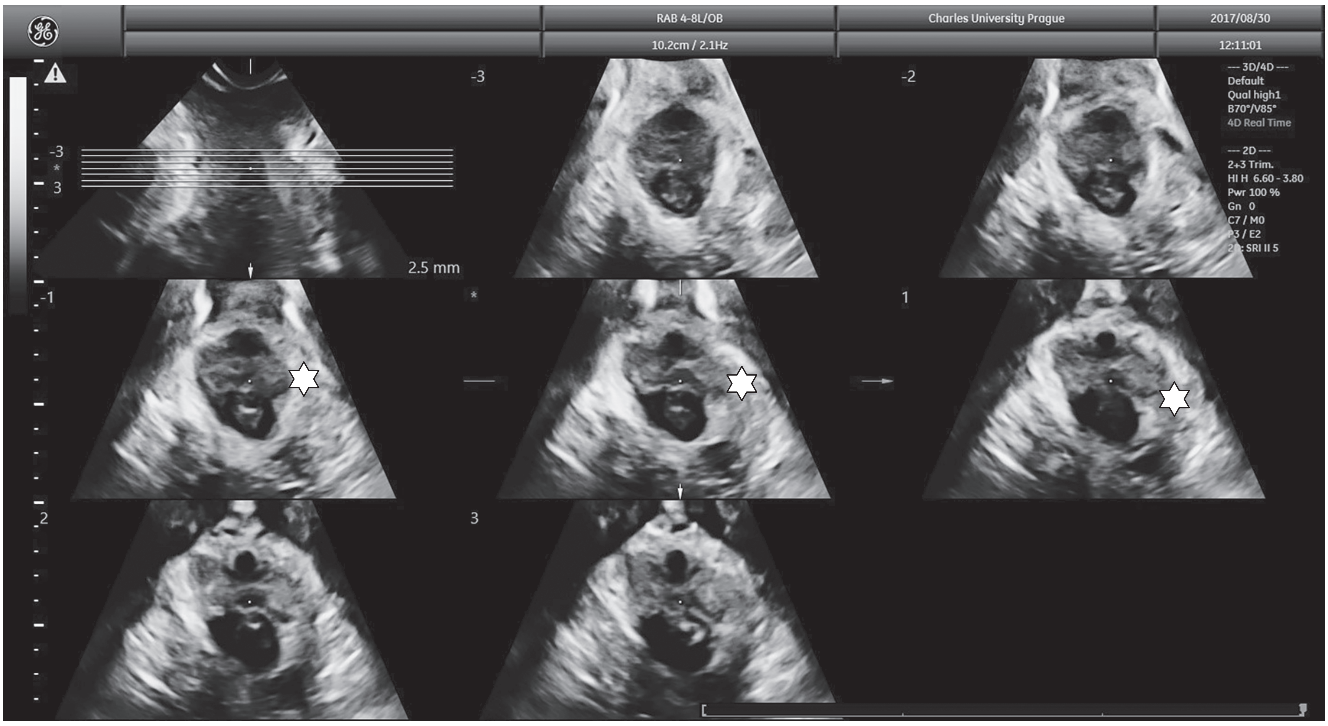

Figure 1 Left-sided levator ani muscle avulsion (✡) diagnosed by tomographic ultrasound imaging.

an assessor blinded to any childbirth trauma information using TUI to identify unrecognized anal sphincter injury[25].

Statistical analysis was performed using SAS 9.4 statistical software (SAS Institute Inc., Cary, NC, USA). Comparison of variables between the two study groups with respect to the normality of their distribution was performed using the non-parametric two-sample Wilcoxon test. Categorical variables were analyzed using the χ^2 test or Fisher's exact test, as appropriate, and described by contingency tables; $P < 0.05$ was considered to indicate statistical significance. Additional multivariate logistic regression analysis was performed to control for age and BMI.

The study was approved by the local ethics committees of both participating units (ethics committee of the University Hospital in Pilsen and Faculty of Medicine in Pilsen, Charles University – number 92/2017, date of approval 2nd March 2017, and ethics committee of the General University Hospital in Prague – number 100/17, date of approval 19th October 2017). Prior to enrollment, all women provided signed informed consent. The study was registered at ClinicalTrials.gov (NCT03420001) prior to its commencement.

RESULTS

The database search identified 356 women who had a first VBAC during the study period and who met the *a-priori* set inclusion criteria. Of these, 54 were excluded owing to an ongoing pregnancy or another delivery, 149 were uncontactable or declined to participate in the study and one woman had had perineal surgery since her delivery. The remaining 152/356 (42.7%) women were recruited into the study as cases, and all attended for the ultrasound assessment. Eleven women were additionally excluded owing to incomplete or missing ultrasound data (Figure 2). In addition, 113 primiparous women delivering vaginally were enrolled as a control group. The group comprised 25 case-matched women with the same length of follow-up as the VBAC group, as well as a cohort of women who delivered consecutively in a 2-month period who attended for pelvic floor ultrasound examination. In total, 88/355 (24.8%) women who delivered in this period agreed to participate and attended for the ultrasound assessment (Figure 2). The mean follow-up was 3.5 years in the VBAC group and 1 year in the control group.

The demographic details and birth outcomes of the groups are summarized in Table 1. There was a statistically significant difference in age (32.7 *vs* 30.1 years; $P < 0.05$) and BMI (28.4 *vs* 27.4 kg/m^2; $P < 0.05$) between the VBAC and control groups. Furthermore, compared with controls, the VBAC cohort had significantly shorter duration of the first and second stages of labor (293.1 *vs* 345.9 min; $P < 0.05$ and 27.6 *vs* 35.3 min; $P < 0.05$, respectively). Obstetric anal sphincter injury (OASI) was observed in six women in the VBAC group, while none of the controls was affected ($P = 0.03$). The groups did not differ in the frequency of other degrees of perineal or vaginal trauma (Table 1). Very few women ($n = 4$ per group) had an operative vaginal delivery, which was by vacuum extraction in all cases.

LAM avulsion occurred in 32.6% of women in the VBAC group (Table 2) and was more frequent on the right side, however, the difference in laterality did not reach statistical significance (right-sided, 14.9%; left-sided, 9.2%; bilateral, 8.5%; $P = 0.2$). The LAM avulsion rate was significantly higher in the VBAC group than in controls (32.6% *vs* 18.6%; $P = 0.01$), and this difference remained significant even after controlling for age and BMI. The adjusted odds ratio (OR) was 2.1 (95% CI, 1.1–3.9) and did not differ substantially from the crude OR. The relative risk of LAM in the VBAC group was 1.35 (95% CI, 1.1–1.7). The observed difference between the VBAC and control groups was present only in the rate of unilateral, but not bilateral, avulsion (Table 2). No statistically significant difference in the area of the levator hiatus at rest (12.0 *vs* 12.6 cm^2; $P = 0.28$) or on maximum Valsalva maneuver (18.6 *vs* 18.7 cm^2; $P = 0.55$) was observed. Similarly, the incidence of levator hiatal ballooning was comparable in the VBAC and control groups (17.7% and 18.6%; $P = 0.86$) (Table 2).

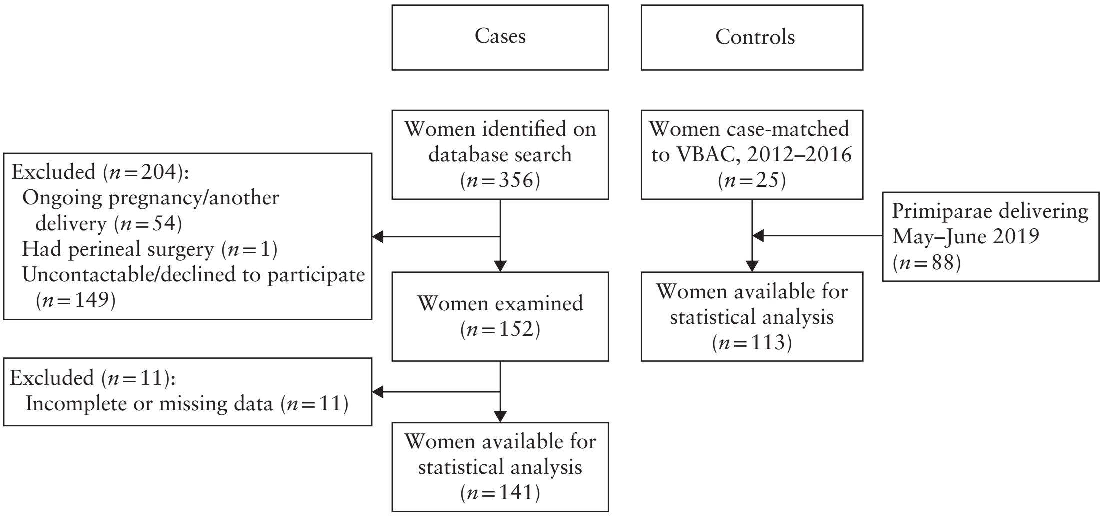

Figure 2 Flowchart summarizing study population.

Table 1 Demographic characteristics and birth outcomes of women with vaginal birth after Cesarean section (VBAC) and primiparous women with vaginal delivery (controls)

Parameter	*VBAC* (n = *141*)	*Controls* (n = *113*)	P
Age (years)	32.7 ± 3.6	30.1 ± 4.6	0.0001*
Body mass index (kg/m^2)	28.4 ± 4.3	27.4 ± 6.0	0.0236*
Gestational age at delivery (weeks)	39.6 ± 1.2	39.4 ± 1.2	0.45*
Birth weight (g)	3372.2 ± 401.9	3307.9 ± 467.5	0.28*
Duration of first stage of labor (min)	293.1 ± 139.3	345.9 ± 129.0	0.0004*
Duration of second stage of labor (min)	27.6 ± 19.3	35.3 ± 28.1	0.02*
Operative vaginal delivery	4 (2.8)	4 (3.5)	1.00†
Intact or minimal perineal trauma	29 (20.6)	24 (21.2)	0.91‡
First-degree tear	15 (10.6)	11 (9.7)	0.80‡
Second-degree tear	16 (11.3)	14 (12.4)	0.81‡
Obstetric anal sphincter injury	6 (4.3)	0 (0)	0.03†
Mediolateral episiotomy	74 (52.5)	51 (45.1)	0.23‡
Vaginal tear ≥ 5 cm	24 (17.0)	18 (15.9)	0.80‡

Data are presented as mean ± SD or *n* (%). *Wilcoxon two-sample test. †Fisher's exact test. ‡χ^2 test.

Table 2 Findings on pelvic floor ultrasound in women with vaginal birth after Cesarean section (VBAC) and primiparous women with vaginal delivery (controls)

Parameter	*VBAC* (n = *141*)	*Controls* (n = *113*)	P
Any LAM avulsion	46 (32.6)	21 (18.6)	0.01*
Unilateral LAM avulsion	34 (24.1)	11 (9.7)	0.003*
Bilateral LAM avulsion	12 (8.5)	10 (8.8)	0.92*
Levator hiatal area (cm^2)			
At rest	12.0 ± 3.4	12.6 ± 3.7	0.28†
On maximum Valsalva maneuver	18.6 ± 7.3	18.7 ± 6.3	0.55†
Increase from rest to maximum Valsalva maneuver	6.6 ± 6.2	6.1 ± 4.5	0.83†
Hiatal ballooning	25 (17.7)	21 (18.6)	0.86*

Data are presented as *n* (%) or mean ± SD. *χ^2 test. †Wilcoxon two-sample test. LAM, levator ani muscle.

DISCUSSION

In this case–control ultrasound study of LAM trauma after VBAC, we found that women who had VBAC are at an increased risk of LAM injury than are primiparous women after a vaginal birth. Women with VBAC were older at the time of delivery and had a higher BMI, but their LAM avulsion rate was higher when compared with controls, even after controlling for these confounders. The size of the levator hiatus and the ballooning rate were comparable between the VBAC and control groups despite the difference in the avulsion rate. Urogenital hiatus enlargement probably occurs later in life[26]. Furthermore, only a small proportion of ballooning of the levator hiatus can be explained by LAM injury at the time of childbirth[27].

The main risk factors for LAM avulsion include age, primiparity, birth weight, head circumference, length of the second stage of labor and forceps delivery[28–30]. Although most of these risk factors are commonly associated with VBAC, the difference between the groups in this study remained significant even after controlling for age and BMI, suggesting that VBAC represents an additional risk factor. Although only speculative, the faster progression of labor in the VBAC cases, allowing less time for adaptation of the pelvic floor, could lead to an increased risk of its injury.

It has been suggested that LAM injury is more frequent in women sustaining OASI[31,32]. In agreement with other studies, we observed more OASI in our VBAC cohort[8–10,12]. However, our study was not designed or powered to test this outcome, nor was this one of our objectives.

To our knowledge, there are no other published studies designed to evaluate LAM avulsion rate after VBAC that could be compared with our study. Only one study indicated a possible increased avulsion rate after VBAC and suggested further investigation[20]. The authors hypothesized that 'the combination of a vaginally nulliparous pelvic floor, a larger baby and more powerful uterine contractility may result in an increased likelihood of pelvic floor trauma'. Although women in the VBAC group did not deliver a larger baby in our study, more powerful uterine contractility reflected by shorter first and second stages of labor, when compared with the control group, was observed. The relative shortening of labor could also have been caused by the fact that trial of labor after CS is more likely to be terminated by an iterative CS. However, this approach would be more protective towards the pelvic floor and would not explain the higher avulsion rate.

A review of the literature revealed that 13–36% of women undergoing their first vaginal delivery sustain LAM avulsion[14]; the LAM avulsion rates reported in both groups in our study fall within this range. A very recent review showed an incidence of LAM avulsion after the first spontaneous vaginal delivery of 15%[33]. Caudwell-Hall *et al.*[34] published a large study on the incidence of LAM injury after vaginal delivery, and in their series of 609 women who delivered vaginally, they reported an avulsion rate of 16%. Interestingly, they identified a family history of CS (mother, sister) as a risk factor for LAM avulsion. In our study, a past history of CS was identified as another risk factor for LAM avulsion. The slightly higher avulsion rate in the control group compared with that in the abovementioned studies could be explained by selection bias, since only a quarter of the women in the control group attended the examination. Symptomatic women were more prone to attend in previous studies[35].

The increased rate of LAM trauma after VBAC cannot be explained by a higher operative vaginal delivery rate, as this was comparable between the VBAC and control groups. The slightly higher avulsion rate in the control group compared with the data of the abovementioned studies could be explained by the inclusion of cases with operative vaginal delivery in the analysis. However, this is rather improbable given the negligible proportion of women with an operative vaginal delivery (2.8 *vs* 3.5%; $P = 1.0$). These low numbers are a reflection of Czech obstetric practice, in which the rate of operative vaginal birth is generally very low, with a preference towards the use of vacuum extraction because of the associated lower risk of OASIs and LAM avulsion. The latter was also reported by Friedman *et al.*[13] in their meta-analysis, in which a substantial association between mode of delivery and LAM avulsion was demonstrated.

We acknowledge that our study has some limitations. In spite of the inclusion of women from two tertiary referral centers over a relatively long study period, the number of women with VBAC was still limited. Several women became pregnant or had another delivery after the first VBAC and hence were not included in our analysis. The same issues made it impossible to include enough controls with the same length of follow-up. The retrospective nature of the study is another limitation because it did not allow us to report on the VBAC success rate, as information on trial of labor after CS was not collected in our databases. Similarly, comparison of the area of the levator hiatus before and after delivery was not possible. In contrast, the methodology of the ultrasound assessment is a major strength of the study. The analysis was performed offline by two expert sonographers specializing in pelvic floor ultrasound (K.S., Z.R.), who were blinded to the patients' data, according to the standardized internationally accepted methodology[22]. Furthermore, the inclusion of more than one center increases the external validity of our findings. It eliminates local variations in the management of labor and perineal care provided in the second stage of labor. Comparison of the VBAC cohort with a control group of primiparous women delivering in the same institution constitutes another strength of the study. This design allowed us to study the effects of VBAC because women in the two groups delivered under comparable conditions.

In conclusion, VBAC appears to be associated with an increased risk of LAM avulsion, which remained significant after controlling for age and BMI. Our findings confirm the hypothesis that the combination of a vaginally nulliparous pelvic floor and more powerful uterine contractility in VBAC may result in an increased likelihood of pelvic floor trauma. Based on our observations, women after a CS could be informed about an increased probability of LAM trauma following vaginal delivery, but our results should be validated in a study with a larger cohort.

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