Four-dimensional sonographic evaluation of avulsion of the levator ani according to delivery mode

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ABSTRACT

Objective To determine the percentage of avulsion of the levator ani muscle in primiparous women according to delivery mode, using introital four-dimensional ultrasonography.

Methods We performed a prospective observational study at a tertiary obstetric unit. One hundred and eighty primiparous women were included and divided into three groups: normal vaginal delivery without episiotomy, forceps delivery and Cesarean section groups. Between 40 and 120 days after delivery, four-dimensional ultrasonography was performed in order to evaluate the integrity of the levator ani muscle. The operator was blinded to all clinical data and was not aware of delivery mode. The influence of other variables associated with delivery such as birth weight, body mass index, maternal age and use of epidural anesthesia was also studied.

Results Avulsion of the puborectalis component of the levator ani muscle was detected on ultrasonography in 61.7% of women who had undergone a forceps delivery, compared with 13.3% for normal vaginal delivery and 0% for Cesarean section. Bilateral avulsion was observed in 12/60 (20.0%) of the forceps group and in 2/60 (3.3%) of the normal vaginal delivery group ($p < 0.001$). Other variables did not seem to influence prevalence.

Conclusions Forceps delivery is associated with an increased rate of avulsion of the puborectalis component of the levator ani muscle. The effect of forceps use is independent of other delivery-related variables.

KEYWORDS: avulsion; delivery; forceps; levator ani; ultrasound

INTRODUCTION

During vaginal delivery, injury to the puborectal fascicle of the levator ani muscle may occur. This condition may be an etiological factor for pelvic floor pathologies such as uterine prolapse, cystocele and rectocele. During delivery, distension of the levator ani allows the hiatus to widen during crowning of the fetal head, and increases in size by between 25 and 245%. This may result in macroscopically visible and microscopic/ultrastructural damage to the puborectal fascicle of the levator ani muscle. Instrumental delivery by forceps is one of the most likely causes.

The use of ultrasonography to study pelvic floor pathology is increasing. Two-dimensional (2D) ultrasonography is able to assess bladder neck mobility as an indicator of stress urinary incontinence and the integrity of the pubofascial fascicle of the levator ani muscle. However, with the emergence of three-dimensional (3D) ultrasonography, the study of the levator ani muscle has become much easier thanks to the ability of this technique to visualize the axial plane; previously, this plane could only be accessed using magnetic resonance imaging. The low cost and the ease of a functional and dynamic study using four-dimensional (4D) ultrasonography offer clear advantages for the study of pelvic floor pathology. The technique has made possible conclusive identification of injuries of the levator ani that in the past could only be macroscopically visible and microscopic/ultrastructural.

3D ultrasound evaluation of the lesion of the levator ani and its association with instrumental delivery was first documented by Dietz and Lanzarone. Our main objective was to determine the percentage of avulsion of the puborectalis fascicle of the levator ani.
muscle in normal vaginal delivery, forceps delivery and Cesarean section in our population. We also aimed to examine the influence of other variables on the prevalence of avulsion, such as maternal age, body mass index (BMI), birth weight, gestational age at delivery, administration of epidural anesthesia and induction of labor.

METHODS

This was a prospective observational study of primiparous women only. Women were recruited by telephone in October 2010 after consulting the register of deliveries of our hospital, a tertiary institution with 1874 births in 2010. Women who had given birth between June and September 2010 were considered for inclusion. During this period 659 deliveries were recorded, of which 19.4% were instrumental (Kjelland’s forceps being used in 11.8%, vacuum extractor in 7.3%, Thierry’s spatulas in 0.3%). In all, 18.4% of deliveries were by Cesarean section and 62.2% were normal vaginal deliveries.

Women were selected according to their type of delivery: normal vaginal delivery without episiotomy (with first-level tear maximum), use of Kjelland’s forceps or delivery by Cesarean section. Recruitment continued until a minimum of 60 patients was reached per group. Two hundred and eighteen patients were contacted by telephone in order to recruit the 180 patients needed for the study. Subjects who enrolled gave verbal consent, and no economic incentives were given. Ethical approval was obtained from the Clinical Research Ethics Committee (ref. 05/09 May 27, 2009). Compliance with the study was high, because of the patients’ awareness of the significance of pelvic floor pathology and because of the high motivation of the staff involved in recruitment.

All women underwent introital 4D ultrasound scanning using a GE Voluson E8 BT09 (GE Medical Systems, Zipf, Austria) with 4.0–9.0-MHz convex volume probe RIC5-9-D (acquisition angle 120°). Data were analyzed on a computer using proprietary software (4D View, Version 9.1; GE Medical Ultrasound Kretz GmbH). Women were scanned between 40 and 120 days after delivery. The volume was acquired with the patient in the lithotomy position and with an empty bladder. The operator was blinded to all clinical data and was not aware of delivery mode.

A sagittal section of the pubic symphysis, urethra, vagina, anal canal and the lower portion of the levator ani muscle was obtained on 2D ultrasonography (Figure 1). From this plane, 4D ultrasonography was activated and the patient was told to perform a Valsalva maneuver and a maximum contraction of the pelvic floor muscle (PFMC). Using the cine (4D) function of the system, volumes at resting, maximum Valsalva and maximum PFMC were obtained. The hiatal area was determined in the axial plane of minimal hiatal dimensions, defined as the distance between the hyperechogenic posterior aspect of the symphysis pubis and the hyperechogenic anterior border of the pubovisceral muscle just posterior to the anorectal angle at rest, maximum Valsalva and maximum PFMC. Avulsion of the levator ani was assessed at maximum PFMC. A discontinuity in the fibers of the puborectal fascicle of the levator at the site of its insertion in the os pubis was considered evidence of avulsion (Figure 2). Lesions were recorded as unilateral or bilateral.
Tomographic ultrasound imaging (TUI) was used to calculate the depth of the lesion, with slices obtained in the axial plane at 3-mm slice intervals (Figure 3). Lesion depth was calculated according to the number of slices affected: in the case of a single affected slice a depth of 3 mm was estimated, and each further affected slice added 3 mm to lesion depth.

Sonographic, demographic and pregnancy data were recorded in an Excel database and statistical analysis was performed with SPSS version 15.0 (SPSS, Chicago, IL, USA). The comparison of means between groups was performed by Student’s *t*-test, after checking for normal distribution of the variables; otherwise a Mann–Whitney *U*-test was used. For the study of categorical variables, Fisher’s exact and chi-square tests were used when possible. Factors independently associated with levator injury were identified by multivariable logistic regression, using as predictors those variables that were identified as significant on univariate analysis or that were considered to be possible confounders, given their clinical relevance. For all tests, an *α* of 0.05 was considered statistically significant.

**RESULTS**

One hundred and eighty women participated in the study, with a mean age of 29.7 (SD 4.13, range 20–40) years and a mean BMI of 24.9 (SD 4.1, range 16–40) kg/m². The mean gestational age at delivery was 39 + 6 (SD 1 + 3, range 34 + 1 to 41 + 6) weeks. Epidural anesthesia had been administered to 93.3%. Labor had been induced in 32.8%; the most common reason for induction was rupture of membranes without uterine contractions (52.4%).

Demographic characteristics, mode of onset of labor, anesthesia and neonatal data for the three groups are presented in Table 1. Statistically significant differences were found between the groups for the variables BMI, birth weight and epidural administration. There were no significant differences in the indication for induction.

Avulsion of the puborectalis muscle was detected in 45 (25.0%) of the 180 women. This trauma was identified in eight (13.3%) of the 60 women with normal deliveries without episiotomy, and in 37 (61.7%) of the 60 women who had a forceps delivery (Figure 4). Bilateral avulsions were observed in 12/60 (20.0%) in the forceps group, but in only 2/60 (3.3%) patients in the normal vaginal delivery group (*P* < 0.001). There was a preponderance of right-sided lesions: four vs. two left-sided after normal vaginal delivery, and 18 vs. 7 after forceps. The average

![Figure 3](image-url)  
**Figure 3** Tomographic ultrasound image showing left-sided avulsion of the puborectalis component of the levator ani muscle (arrows).

![Figure 4](image-url)  
**Figure 4** Bar graphs demonstrating the number of patients with intact puborectalis muscle ( ), unilateral avulsion ( ) and bilateral avulsion ( ) according to the type of delivery.

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**DISCUSSION**

We determined the frequency of avulsion of the puborectalis portion of the levator ani muscle in three groups of primiparous patients defined by their mode of delivery and attempted to define injury size and location. The three delivery modes chosen for this study are the commonest forms of childbirth in our practice. According to recently published data on obstetric practices in public hospitals in Catalonia, Cesarean sections are performed in 22% of primiparous women and 31% of vaginal deliveries are instrumental, mainly involving the use of forceps. The present study was carried out at a hospital in which the rate of instrumental delivery is lower than average for this geographical area.

Corroborating previously published data, we found that the frequency of levator injury occurred exclusively after vaginal delivery. Avulsion was observed in 13.3% of women after normal vaginal delivery without episiotomy, and in 61.7% of cases with forceps use associated with episiotomy. These results are similar to those obtained by Krofta et al., who found an injury rate of 63.6% after forceps delivery. The percentage of women in whom avulsion was detected following forceps delivery is also similar to that reported (59.5%) in a previous study by our group that was designed to demonstrate general sonographic changes by comparing nulligravid women, primigravid women in late pregnancy and primiparous women at 1 and 9 months postpartum with very restrictive inclusion criteria. In the multivariable analysis, the only variable that was associated independently with avulsion was forceps delivery, with a highly significant odds ratio of 10.47 with respect to the normal vaginal delivery group. A recently published study of intrapartum risk factors for levator injury found that forceps delivery was an independent risk factor, with an OR of 3.83 (95% CI, 1.34–10.94).7 The authors noted that rotational forceps deliveries are very rare in their practice. In a sample of 488 women, there were only 54 cases of instrumental delivery (vacuum or forceps) and of these only 20 involved forceps; instrumentation was used in 14% of all vaginal deliveries.

Other authors have studied other potential intrapartum risk factors, such as epidural analgesia, the duration of the second stage of labor, head circumference and birth weight. Unlike in other studies in which epidural

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**Table 1** Demographic and pregnancy data of study groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cesarean section (n = 60)</th>
<th>Normal vaginal delivery (n = 60)</th>
<th>Forceps delivery (n = 60)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>29.6 ± 4.5 (20–39)</td>
<td>29.4 ± 4.1 (21–40)</td>
<td>30.2 ± 3.6 (22–39)</td>
<td>0.523</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.9 ± 4.6 (18–40)</td>
<td>23.9 ± 3.6 (17.7–34.9)</td>
<td>25 ± 4 (16–35.4)</td>
<td>0.035</td>
</tr>
<tr>
<td>Gestational age at delivery (weeks)</td>
<td>39.5 ± 1.4 (34.1–41.6)</td>
<td>39.5 ± 1.3 (36–41.6)</td>
<td>39.7 ± 1.2 (38.5–41.6)</td>
<td>0.530</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3377 ± 506.7 (2140–4380)</td>
<td>3142 ± 442.4 (1980–3900)</td>
<td>3357 ± 401.9 (2315–4500)</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Data shown as mean ± SD (range) or %. BMI, body mass index.

**Table 2** Univariable and multivariable logistic regression for the prediction of avulsion of the levator ani

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Univariable</th>
<th>Multivariable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index (kg/m²)</td>
<td>0.350</td>
<td>0.302</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>0.370</td>
<td>0.397</td>
</tr>
<tr>
<td>Maternal age (years)</td>
<td>0.580</td>
<td>0.751</td>
</tr>
<tr>
<td>Normal vaginal delivery group</td>
<td>0.006</td>
<td>1.15 (1.04–1.27)</td>
</tr>
<tr>
<td>Forceps group</td>
<td>&lt; 0.001</td>
<td>2.60 (1.30–2.50)</td>
</tr>
<tr>
<td>Epidural anesthesia</td>
<td>1.000</td>
<td>0.181</td>
</tr>
</tbody>
</table>

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anesthesia seemed to have a protective role for injury of the levator ani, we did not observe this effect, perhaps owing to the very high rate of epidural administration in our population. A head circumference of 35.5 cm or more and a longer second stage of labor beyond 110 min are factors independently associated with lesions of the levator ani. In our study, fetal birth weight was not identified as an independent risk factor.

Maternal age has been identified as a possible risk factor for levator injury. However, in a recent publication Shek and Dietz did not confirm maternal age as an independent risk factor, although the authors noted in their discussion that this finding may have been because of the low average age of the women studied (25.9 range, 17.7–45 years). In our study we did not identify maternal age as a risk factor either, although the average age of our group was 29.7 (SD 4.13) years. Nor did we identify an association between BMI and avulsion. The impact of an avulsion of the pubococcygeus muscle is emphasized by the differences we observed in the hiatal area between patients with and without trauma, an effect that has been demonstrated by others. The fact that we observed larger injuries and more bilateral trauma in the forces group suggests that forces use not only increases the risk of avulsion, but also results in more extensive injuries.

There are several limitations of our study that should be mentioned. As we did not obtain ultrasound volume datasets prior to childbirth, peripartum changes in individual patients could not be analyzed. Furthermore, this was not a cohort study, and so we are unable to give estimates of overall prevalence of levator trauma in our population. We performed our examinations relatively early in the postpartum period, which means that some patients may still have presented changes that were potentially reversible, such as those due to transient neuropathy. Another limitation of our study is that our definition of an avulsion as the presence of one abnormal 3-mm slice on TUI means that the incidence of lesions was relatively high. The presence of three or four abnormal slices on TUI will be of greater clinical relevance than the presence of only one or two. However, lesions of 3 mm depth may be important in the future, and long-term follow-up is required to establish their true significance and chances of recovery.

Despite these shortcomings, our analysis supports the hypothesis that forceps delivery is a strong risk factor for levator trauma. It has been hypothesized that the increased risk of injury to the levator is due to the mechanical effect of forceps placement, which increases the effective diameter of the fetal head.

Since forceps delivery is a risk factor independent of variables such as maternal age, BMI, fetal weight and type of anesthesia, it seems reasonable to propose that other forms of instrumental delivery with a lower associated risk of pelvic floor injury should be used whenever possible, as long as this does not pose a risk to fetal well-being.

ACKNOWLEDGMENTS

We would like to thank all the women who participated in this study and the Residents from the Department of Obstetrics and Gynecology for helping in recruitment.

REFERENCES


on pelvic floor muscle according to the type of delivery. Int Urogynecol J Pelvic Floor Dysfunct 2011; 22: 1011–1018.


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AQ1 Please check that all affiliations are correct and complete.

AQ2 The term ‘single blind’ did not seem quite right in this context, so I have removed this and added ‘The operator was blinded to all clinical data and was not aware of delivery mode’ towards the end of this paragraph, ok? (OS)

AQ3 “Among deliveries using forceps, 61.7% subjects presented a lesion of the levator compared with 13.3% in normal vaginal deliveries and 0% in cesarean section” reworded to ‘Avulsion of the puborectalis component of the levator ani muscle was detected on ultrasonography in 61.7% of women who had undergone a forceps delivery, compared with 13.3% for normal vaginal delivery and 0% for Cesarean section’, ok? I’ve added “the puborectalis component” as this is mentioned in the Conclusions, ok? (OS)

AQ4 “Forceps delivery increases the rate of avulsion of the puborectalis component of the levator ani muscle” changed to ‘Forceps delivery is associated with an increased rate of avulsion of the puborectalis component of the levator ani muscle’, as the study was observational, ok? (OS)

AQ5 Please explain the statistical test that has been used and the groups that have been compared for the P-values shown for continuous variables in Table 1. t-tests and the Mann–Whitney U-test are mentioned in the Methods section, but these would only test for a difference between two groups. (OS)

AQ6 Table 2: I’ve noticed that the univariable OR for ‘Forceps group’ in Table 2 (2.60) is much lower than that quoted in comparison to the NVD group in the Results section (10.47), could you check these numbers? (OS)

AQ7 Table 2: The multivariable OR for ‘Forceps group’ (0.07) does not look right to me, should this not be a value greater than 1? Please check (OS)

AQ8 “Women who had given birth between June and September 2010 were considered for inclusion”, this sentence has been reworded slightly and moved up from the following paragraph, ok? (OS)

AQ9 Apologies if this is due to a lack of understanding on my part, but I am not sure what is meant by ‘as identified by the oblique horizontal line on the left’, could you clarify this? The term ‘oblique horizontal’ seems to me to be contradictory. Are you referring to one of the two horizontal lines in the left-hand image? (OS)

AQ10 “of the puborectalis component of the levator ani muscle” added to the legends for Figures 2 and 3, is that correct? (OS)

AQ11 “Data were recorded in an Excel database” expanded to ‘Sonographic, demographic and pregnancy data were recorded in an Excel database’, as the additional data were not otherwise mentioned in the Methods section, ok? (OS)

AQ12 “…Fisher’s exact and Chi-Squared tests were used when possible”, I am not sure what you mean by “when possible” here, would ‘as appropriate’ be better? (OS)

AQ13 “Factors independently associated with levator injury were identified by logistic regression, using as dependent variables the variables that were identified as significant on univariate analysis, or were considered as possible confounders, given their clinical relevance” reworded to ‘Factors independently associated with levator injury were identified by multivariable logistic regression, using as predictors those variables that were identified as significant on univariate analysis or that were considered to be possible confounders, given their clinical relevance.’, ok? (OS)

AQ14 Please note that “multivariable” has been used rather than ‘multivariate’ throughout, as ‘multivariate’ refers to analyses with multiple outcome variables, ok? (OS)

AQ15 I’ve interpreted ‘39.6 (SD 1.3, range 34.1–41.6) weeks’ as ‘39 + 6 (SD 1 + 3, range 34 + 1 to 41 + 6) weeks’; i.e. 39 weeks 6 days etc. Is that correct?

AQ16 “There were no significant differences in the indication of induction”, only the overall rates of induction of labor are shown. Could we therefore add ‘data not shown here’? Or do you mean to say ‘There was no significant difference in the rate of induction of labor between groups’ (as is shown in Table 1)? (OS)

AQ17 It’s hard to tell, really, but the number of avulsions for forceps delivery in Fig. 4 looks more like 10 + 24 = 34; could you check?

AQ18 ‘left-sided’ added here; OK?
Queries to Author:

AQ19 “Logistic regression showed that only forceps delivery continued to present an independent statistically significant association with the levator (Table 2)” reworded to ‘On multivariable logistic regression only forceps delivery was found to show an independent statistically significant association with avulsion of the levator ani (Table 2)’, ok? (OS)

AQ20 “This difference was statistically significant when measured at rest, on Valsalva maneuver or during contraction (all P < 0.001)”, ‘all’ added, is that correct? (OS)

AQ21 “with a highly significant odds ratio of 10.47 with respect to the normal vaginal delivery group”, ‘with respect to the normal vaginal delivery group’ added here, as the OR reported here does not seem to be that from the logistic regression analysis, is that correct? (OS)

AQ22 “lesion to the levator” changed to ‘lesions of the levator ani’, ok? (OS)

AQ23 “However, lesions of 3 mm in depth may be important in the future”, do you mean ‘However, lesions of 3 mm in depth may be found to be important in the future’ here? Or perhaps ‘However, lesions of 3 mm in depth may be important in the long-term’? (OS)
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