Levator Trauma After Vaginal Delivery

Hans Peter Dietz, PhD, and Valeria Lanzarone, MB

OBJECTIVE: To date, the evidence on pelvic floor injury in labor remains sketchy due to a lack of prospective studies comparing pelvic floor imaging before and after childbirth. We intended to define the incidence of major trauma to the pubovisceral muscle.

METHODS: A total of 61 nulliparous women were seen at 36–40 weeks of gestation in a prospective observational study. The assessment included an interview and 3-dimensional translabial ultrasound and was repeated 2–6 months postpartum.

RESULTS: Fifty women (82%) were seen postpartum. Of the 39 women delivered vaginally, levator avulsion was diagnosed in 14 (36%, 95% confidence interval 21–51%). Among those delivered vaginally, there were associations with higher maternal age ($P = .10$), vaginal operative delivery ($P = .07$), and worsened stress incontinence postpartum ($P = .02$).

CONCLUSIONS: Avulsion of the inferomedial aspects of the levator ani from the pelvic sidewall occurred in approximately one third of all women delivered vaginally and was associated with stress incontinence 3 months after childbirth.

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LEVEL OF EVIDENCE: II-3

What we call ‘the pelvic floor muscle’ is, as far as it is clinically relevant for pelvic floor dysfunction in gynecology, the pubococcygeus–puborectalis complex or pubovisceral muscle, a component of the levator ani muscle. This muscle complex forms a V-shaped sling running from the pelvic sidewall toward the anorectal junction, surrounding it posteriorly and back toward the contralateral pelvic sidewall. It is palpable vaginally and the main structure defining vaginal anatomy and function. The levator hiatus, ie, the space between the arms of the V, contains the urethra anteriorly, the vagina centrally and the ano-rectum posteriorly. The area of the levator hiatus in young nulliparous women varies from 6 to 36 cm² on Valsalva maneuver.² The area of the average fetal head in the plane of minimal diameters measures 70–90 cm² (equating to a head circumference of 300-350 mm), requiring marked distension and deformation of the levator complex, in some women by more than one order of magnitude.

Computer modeling based on magnetic resonance imaging (MRI) has shown that the most inferior and medial parts of the levator complex (ie, the pubovisceral muscle) have to increase in length by a factor of 3.5 during crowning of the fetal head.³ Given this degree of acute distension, it is remarkable that many women seem to go through childbirth without sustaining disruption of the muscle and its insertion. However, some do sustain such trauma, and from the above one would expect it to occur mainly to the most inferomedial aspects of the levator ani, because it is those fibers that come under the most marked mechanical strain.

There is very little evidence to date on the incidence and extent of levator trauma in labor. Although anal sphincter trauma is well defined and of proven clinical relevance,⁴ there have been no imaging studies in the published literature comparing the state of the pelvic floor musculature before and after childbirth. All data currently available is limited to describing postnatal appearance,⁵⁻¹⁰ although it has been shown that appearances suggestive of trauma are limited to parous women.⁹

Most morphologic abnormalities have indeed been observed in the inferomedial aspects of the pubovisceral muscle,⁹ as predicted by the above-quoted modeling. The commonest finding seems to be an avulsion injury to the inferomedial aspects of the pubovisceral muscle, ie, a detachment of this muscle from its insertion on the arcus tendineus fasciae pelvis.⁹ Most authors understandably assume that such defects arise during vaginal childbirth, prob-
ably at the time of crowning of the fetal head.\textsuperscript{9–11} However, proof for this hypothesis has been lacking due to the inherent limitations of magnetic resonance imaging and the logistic problems of performing MRI in young asymptomatic nulliparous pregnant women in late gestation. As a result of recent technological developments, 3-dimensional and 4-dimensional pelvic floor ultrasound is now capable of demonstrating the pubovisceral muscle complex at little cost and with minimal inconvenience to the patient.\textsuperscript{12} Figure 1 shows the location of relevant planes in a standard midsagittal ultrasound representation of the pelvic floor, and Figure 2 demonstrates a comparison of MRI and 3-dimensional pelvic floor ultrasound imaging in a young, asymptomatic nulliparous woman.

In this prospective study we aimed to estimate the incidence of major trauma to the inferomedial aspects of the levator muscle and to correlate such trauma with clinical data.

**MATERIALS AND METHODS**

In a prospective observational study undertaken at a tertiary obstetric unit, 61 nulliparous women were seen at 36–40 weeks of gestation. They were recruited between January and June 2004 as part of a larger study of pelvic floor function in antenatal clinic and through mailouts. Inclusion criteria were an uncomplicated singleton pregnancy, with both mother and caregivers planning a vaginal delivery. Minor pregnancy complications such as bleeding in early pregnancy, hyperemesis gravidarum, prior admissions for threatened premature labor, and gestational diabetes were not exclusion criteria unless they had resulted in medical advice to deliver electively, and unless this advice had been communicated to the patient.

Our assessment included an interview comprising family and personal medical history and maternal and paternal height, weight, and ethnicity. The examination consisted of a 3-dimensional and 4-dimensional translabial (or transperineal) ultrasound using a Philips HDI 4000 (Philips Electronics Australia, North Ryde NSW, Australia) system with abdominal 7–4 MHz volume transducer. The ultrasound was performed supine and immediately after voiding. Imaging data sets were obtained at rest, on levator contraction, and on valsalva, with at least 3 data sets archived for later analysis. The effectiveness of maneuvers was ascertained by observing a total of at least 3 Valsalvas and pelvic floor contractions on 2-dimensional ultrasound before acquiring volumes. Great care was taken to avoid levator coactivation on Valsalva, which is a major confounder, especially in young and nulliparous women. For a full discussion of the ultrasound methodology used in this study see 2 recent review articles by the first author.\textsuperscript{12,13}

The assessment described above was repeated 2–6 months postpartum in identical fashion plus questions on bladder function, symptoms of prolapse and the subjective strength of a pelvic floor contraction compared with before childbirth. The operator was again blinded to all clinical data until after the assessment. Analysis of ultrasound volume data sets was undertaken 1–3 months later using the software GE Kretz 4D View V 2.1 (GE Medical Systems Kretztechnik, Zipf, Austria),
with the operator blinded against all clinical data, including delivery outcome. The assessment of hiatal dimensions has recently been shown to be highly reproducible, and a test–retest study on 50 patients unrelated to this study yielded a Cohen’s $k$ of 0.825 (95% confidence interval 0.59–1.0, unpublished data) for the diagnosis of avulsion of the pubovisceral muscle. The finding of “avulsion defect” was made when there was a loss of continuity between muscle and pelvic sidewall in all volume data sets. Whenever there was any doubt, a direct comparison of antenatal and postnatal rendered volumes and axial plane single frames was undertaken (Fig. 2, Fig. 3, Fig. 4). Clinical data were obtained from the institutional database and individual records. The parent study and the study extension reported here had been approved by the local Human Research Ethics Committee (reference CSAHS X02-0250).

The sample size for this extension of the parent project was determined by equipment availability; no power calculations were undertaken for this study. Statistical analysis was performed after normality testing (histogram analysis, Kolmogorov-Smirnov testing, or both) of relevant data such as maternal age and bladder neck descent, using Minitab V. 13 (Minitab Inc., State College, PA). Paired $t$ tests and Fisher exact tests were employed. A $P < .05$ was considered statistically significant.

**RESULTS**

Sixty-one women were recruited between 32 and 37 weeks of gestation and attended their first assessment at 37.7 weeks (range 36.1–40.0 weeks) of gestation. All had had verbal pelvic floor muscle exercise teaching, were aware of how to contract the levator ani muscle, and were successful when asked to attempt a contraction as judged by observation on 2-dimensional translabial ultrasound. Table 1 gives demographic data for those 50 women (82%) who returned for their postpartum visit 2–6 months after delivery.

Thirty-nine had been delivered vaginally (27 normal vaginal delivery, 8 vacuum, 4 forceps). One patient had been delivered by elective cesarean delivery for a high head at 38 weeks, the remainder had undergone an emergency cesarean delivery. Six of those were performed before full dilatation ($n = 2$) or failure to progress ($n = 2$). In no case had the head descended below the level of the ischial spines before cesarean delivery.

At the postpartum visit, 15 of 50 (30%) reported stress incontinence, and 1 reported symptoms of prolapse. In 11 women, symptoms of stress incontinence had improved or disappeared, in 10 they had arisen de novo or worsened, and in 3 there had been no change. There was only 1 woman who had developed symptoms of prolapse postpartum. Subjec-

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**Table 1.** Demographic Data (First Visit) for 50 Women Seen at 2–6 Months After First Delivery

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>31.6</td>
<td>22.4–40.1</td>
</tr>
<tr>
<td>Gestation (wk)</td>
<td>37.7</td>
<td>36.1–40.0</td>
</tr>
<tr>
<td>Body mass index</td>
<td>28.6</td>
<td>21.6–38.8</td>
</tr>
<tr>
<td>Caucasian, n (%)</td>
<td>37/50 (74)</td>
<td></td>
</tr>
</tbody>
</table>

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tively, women reported that they considered their pelvic floor muscle to be at 90% strength (range 50% to 130%) compared with before childbirth.

Table 2 shows 2-dimensional ultrasound data on pelvic organ descent, comparing antenatal and postnatal data. For all parameters there was evidence of highly significant increases in pelvic organ mobility postpartum.

Table 3 gives dimensions of the levator hiatus in the axial plane before and after childbirth, and it is evident that vaginal childbirth is associated with an increase in hiatal dimensions on Valsalva maneuver, especially in the coronal plane. This was particularly marked in those women who suffered an avulsion injury. In those the hiatal area on Valsalva increased from a mean (± standard deviation) of 16.54 (± 6.88) to 22.06 (± 5.63) cm² and the coronal diameters from 4.11 (± 0.66) to 5.31 (± 0.78) cm. There was no appreciable increase in dimensions at rest or on pelvic floor muscle contraction. In women delivered by cesarean birth we observed no significant change in any of these parameters.

Before childbirth there were no instances of asymmetry of the pubovisceral muscle, and we did not observe appearances suggestive of avulsion of the muscle from the pelvic sidewall. In the 39 women delivered vaginally, levator avulsion was diagnosed in 14 (36%, 95% confidence interval 21-51%) cases. Defects were on the left (n = 8), on the right (n = 4) or bilateral (n = 2). There was no association between subjectively judged pelvic floor contraction strength and avulsion defects.

There were significant or nonsignificant associations with higher maternal age among those delivered vaginally (P = .1 on t test) and with vaginal operative delivery (P = .07 on Fisher exact test) and worsened or de novo stress incontinence postpartum (4/36 without defects, 6/14 with defects, P = .02 on Fisher exact test). When this analysis was undertaken for the entire cohort of 50 women, defects were significantly associated with maternal age (P = .03), while the association with worsened or de novo stress incontinence became nonsignificant (P = .09). Other obstetric factors, eg, birth weight, were not associated with defects. The increase in bladder neck descent as shown in Table 2 was more marked in those women who showed avulsion defects (+ 7.8 mm compared with + 20 mm, P = .001 on t test). No defects were seen in those 11 women delivered abdominally, and there was no significant increase in bladder neck descent in those women either.

**DISCUSSION**

According to a search of MEDLINE (any language; 1966 to 3rd week of June 2005; keywords [used singly

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**Table 2. Changes in Pelvic Organ Support After Childbirth, 2-Dimensional Pelvic Floor Ultrasound Data**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Antepartum, 36–40 wk (n = 61)</th>
<th>Postpartum, 2–6 mo (n = 50)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder neck descent</td>
<td>17.2 (± 8.6)</td>
<td>28.6 (± 11.3)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Cystocele</td>
<td>12.3 (± 8.9)</td>
<td>2.3 (± 12.3)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Uterine descent</td>
<td>42.5 (± 9.7)</td>
<td>28.5 (± 15.6)</td>
<td>.01</td>
</tr>
<tr>
<td>Rectal descent</td>
<td>24.8 (± 23.9)</td>
<td>0.8 (± 17.7)</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Values are mean (± standard deviation). All changes (increase in bladder neck descent and decrease in position of cystocele, uterus, or rectum) imply increased pelvic organ descent on Valsalva. Differences between means were assessed with paired t-tests.

**Table 3. Changes in Hiatal Dimensions After Vaginal Childbirth, 3-Dimensional Pelvic Floor Ultrasound Data**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Antepartum, 36–40 wk (n = 48)</th>
<th>Postpartum, 2–6 mo (n = 39)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midsagittal hiatal diameter (rest)</td>
<td>5.10 (0.72)</td>
<td>5.06 (0.67)</td>
<td>NS</td>
</tr>
<tr>
<td>Coronal hiatal diameter (rest)</td>
<td>3.67 (0.47)</td>
<td>3.80 (0.56)</td>
<td>NS</td>
</tr>
<tr>
<td>Hiatal area (rest)</td>
<td>11.86 (2.35)</td>
<td>12.23 (2.83)</td>
<td>NS</td>
</tr>
<tr>
<td>Midsagittal hiatal diameter (Valsalva)</td>
<td>5.52 (1.06)</td>
<td>5.68 (1.02)</td>
<td>NS</td>
</tr>
<tr>
<td>Coronal hiatal diameter (Valsalva)</td>
<td>4.04 (0.66)</td>
<td>4.77 (0.90)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Hiatal area (Valsalva)</td>
<td>16.0 (5.35)</td>
<td>19.07 (6.30)</td>
<td>NS</td>
</tr>
<tr>
<td>Midsagittal hiatal diameter (PFMC)</td>
<td>4.34 (0.60)</td>
<td>4.33 (0.67)</td>
<td>NS</td>
</tr>
<tr>
<td>Coronal hiatal diameter (PFMC)</td>
<td>3.42 (0.43)</td>
<td>3.49 (0.59)</td>
<td>NS</td>
</tr>
<tr>
<td>Hiatal area (PFMC)</td>
<td>9.75 (1.84)</td>
<td>10.07 (2.69)</td>
<td>NS</td>
</tr>
</tbody>
</table>

PFMC, pelvic floor muscle contraction. Values are mean (± standard deviation). Differences between means were assessed with paired t-tests.
The incidence of avulsion defects in women delivered vaginally was surprisingly high at approximately 1 of 3. This is clearly higher than the prevalence of such defects in parous women as imaged by magnetic resonance and 3-dimensional ultrasound. Of 160 primiparous women of approximately 30 years of age, 29 (18%) showed defects of the pubovisceral portion of the levator ani in an observational MRI study from Michigan.9 No such defects were observed in 80 nulliparas. A larger study on 338 women undergoing urodynamic assessment and 3-dimensional pelvic floor ultrasound (mean age 52.8 years) demonstrated a prevalence of avulsion defects of 15.4% in parous women, with none seen in nulliparas (Steenema A, Dietz HP. What is the clinical relevance of major morphological abnormalities is highly reproducible, the latter with a kappa of 0.825 (95% confidence interval 0.59–1) in unpublished data.

The difference in prevalence between ultrasound and MRI data could be due to differences in imaging methodologies, but it is harder to explain the discrepancy between studies conducted using the same ultrasound methodology. One explanation may be variations in obstetric practice and demographic developments. It has recently been shown that age at delivery is a strong predictor of future stress urinary incontinence, and the average age at first delivery in this study was rather high at 31 years. This is much higher than for women seen in a pelvic floor clinic today (23.6 years in a subset of the study quoted above). One wonders whether the continuing rise in women’s age at first delivery may result in a higher likelihood of pelvic floor trauma such as demonstrated in this study.

As regards obstetric factors, this study clearly did not have the power to investigate delivery-related risk factors for avulsion injury to the levator ani. There was only a nonsignificant association between such defects and vaginal operative delivery and none at all between defects and length of second stage. It is evident that such injuries may occur as a consequence of outwardly normal, uncomplicated deliveries—the shortest second stage among women who suffered an avulsion injury was only 33 minutes, although 6 of 14 had a prolonged second stage over 2 hours.

At the moment there is little information on the clinical significance of the soft tissue trauma documented in this and other studies. While childbirth is associated with pelvic organ prolapse and incontinence in epidemiological studies (see Dietz and Schierlitz14 for a review of current evidence), it is by no means clear whether this is due to delivery-related direct levator trauma. In this study there was a weakly significant association between avulsion injury and worsened or de novo stress incontinence postpartum ($P = .02$), but it is likely that large cross-sectional studied with decade-long follow-up will be required to fully investigate this issue. Own data suggests that avulsion injury of the levator muscle is associated with prolapse of the anterior and central compartment rather than with bladder dysfunction, and this would agree well with the fact that the etiological role of childbirth is much more strongly established for pelvic organ prolapse than for stress incontinence.14

Quite independent of such considerations, the possibility of a changing prevalence of pelvic floor trauma due to demographic developments is particularly intriguing. Women who showed an avulsion after vaginal delivery were older than those without, although this difference did only reach statistical significance when the whole population, including cesarean deliveries, was considered. We know that older age at first delivery is a risk factor for operative delivery, whether vaginal or abdominal.15,16 It is possible that older age at first delivery may be a risk factor for pelvic floor trauma, a hypothesis that is supported by recent epidemiological data from Norway. Rortveit et al showed in a reanalysis of the EPINCONT study that stress incontinence was more likely in women who had had their first baby at an older age (Rortveit G, Hunskaar S. The association between the age at the first and last delivery and urinary incontinence [meeting abstract]. Neurourol Urodyn 2004;23:562-3).

As the age of primiparae in Western societies has risen by about ten years over the last two generations, such observations may have significant public health implications. In addition, women are not just older when they have their first babies, mean birthweight...
has also been increasing steadily—and in some studies birthweight is another risk factor for pelvic floor damage and urogenital prolapse. The current obesity epidemic may further exacerbate such trends. We may well be facing a long-term increase in pelvic floor morbidity due to changing demographics.

In conclusion, this study found that vaginal delivery can cause morphological alterations visible on 3-dimensional pelvic floor imaging. Avulsion of the pubovisceral muscle off the pelvic sidewall is common and can be visualized easily using 3-dimensional and 4-dimensional translabial pelvic floor ultrasound. The clinical significance of such trauma however remains to be established.

REFERENCES