CHAPTER 3

Anatomical and functional changes in the lower urinary tract following spontaneous vaginal delivery

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ABSTRACT

Objective To assess the incidence of urinary incontinence in pregnancy and after spontaneous vaginal delivery and its relation with changes in the static and dynamic function of the pelvic floor.

Design Prospective longitudinal study.

Setting University Hospital and Martini Hospital Groningen, the Netherlands.

Population A cohort of 62 women before and after spontaneous vaginal delivery at term and 27 nulliparous non-pregnant controls.

Methods Urinary incontinence was measured by a questionnaire and by a 24-hour pad test. The position and mobility of the urethro-vesical junction were measured by perineal ultrasound and related to simultaneously measured abdominal pressure changes. Serial investigations were done at 38 weeks gestational age and at 6 weeks and 6 months after delivery.

Main outcome measure Urinary incontinence and its relation with the position of the urethro-vesical junction at rest and with the mobility of the urethro-vesical junction during Valsalva and during coughing, indicated by the displacement/pressure coefficient and with obstetric variables.

Results After delivery, reported urinary incontinence was reduced from 26% at 38 weeks of gestation to 16% and 15% at six weeks and six months after delivery, respectively. Even lower rates were measured by the 24-hour pad test which revealed a decrease from 14% at 38 weeks to 10% and 5% at 6 weeks and 6 month postpartum, respectively. Six weeks and 6 months after delivery the angle of the urethro-vesical junction at rest was significantly increased compared to the non-pregnant control women. Compared to the antenatal measurements, the displacement/pressure coefficients during coughing and during the Valsalva manoeuvre were significantly increased six weeks after delivery. Six months after delivery, only the coefficient for coughing was still significantly greater than the antenatal value and the value in the non-pregnant control group. No relations were found between urethro-vesical junction measurements and obstetric variables and subjective or objective urinary incontinence parameters.

Conclusion Though pregnancy and spontaneous vaginal delivery significantly increased the degree of bladder neck descent and permanently affected the function of the pelvic floor during coughing, urinary incontinence, quite common during pregnancy, disappears post partum in most women.
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*INTRODUCTION*

Pregnancy and delivery cause transient urinary incontinence in a considerable number of women. Until now, it is not clear to what extent pregnancy itself or vaginal delivery contributes to the development of urinary incontinence. Following vaginal delivery neuromuscular damage and bladder neck hypermobility, indicating a change in pelvic floor function, has been confirmed. Nevertheless, in the great majority of women the incontinence has disappeared six months after delivery. This prompted us to investigate in a longitudinal study the effects of pregnancy and delivery and puerperium on pelvic floor function in nulliparous women. Using perineal ultrasound, the position and mobility of the urethro-vesical junction were serially investigated. In a previous study, we examined changes in the position and mobility of the urethro-vesical junction during pregnancy in relation to incontinence in a group of nulliparous women.

In the present study we investigated those women of the previous study who had a spontaneous vaginal delivery. We describe how spontaneous vaginal delivery affects the position and mobility of the urethro-vesical junction in relation to incontinence and whether these effects were still present after 6 months.

*METHODS*

This study is part of a larger prospective study on the effect of pregnancy and delivery and puerperium on changes in pelvic floor mobility and urinary incontinence. Recently, we reported the effects of pregnancy. Of the 117 nulliparous women, initially recruited for the study at the University Hospital Groningen and at the Martini Hospital Groningen, 62 had a spontaneous vaginal term delivery with vertex presentation. The median (range) duration of the first stage of labour was 430 (95-2340) minutes, while the median active stage of labour was 39 (6-147) minutes. A total of 16/62 (25%) women had an intact perineum; 22/62 (35%) had an episiotomy; 24/62 (39%) had perineal lacerations of several degrees, 22 1st and 2nd degree tears, two 3rd degree tears. The median (range) birth weight was 3487 (2100-4410) gram. The median (range) head circumference was 34 (31-37) centimetres. The effect of spontaneous vaginal delivery was investigated by serial analysis of data obtained antenatally at 36-38 weeks gestation, and at 6 weeks...
postpartum. To study the effect of the puerperium measurements were taken 6 months postpartum. All women were nulliparous, with singleton pregnancies and none of them had a history of incontinence, pelvic operations or neurological disease before pregnancy. Data from 27 nulliparous non-pregnant women from the infertility outpatient clinic without a history of incontinence were included. These non-pregnant controls were subjected to the same study protocol, but only once. Written informed consent was obtained from all participating women. The medical ethical committees of both hospitals approved the study.

At each visit, all the women completed a questionnaire on symptoms of incontinence. They were also given pads to be worn for 24 hours preceding their visit. The outcome of the 24-hour pad test was recorded as the weight gain of the pad at each visit. A cut-off level of 9 g was used to classify a woman as incontinent.

Figure 1: Schematic representation of perineal ultrasound scanning of the UVJ with the woman in the lithotomy position. S = symphysis, U = uterus and US = ultrasound probe.

Perineal ultrasound was performed with Aloka 600 equipment with a 3.5 MHz convex transducer and the woman in the lithotomy position (Fig. 1). Bladder volume varied from 100-300 ml. The position of the urethro-vesical junction was recorded continuously during coughing and during the Valsalva manoeuvre. Simultaneous abdominal pressure changes were recorded by the insertion of a microtip pressure transducer (Gaeltec) high in the posterior fornix of the vagina. During the Valsalva manoeuvre and during coughing, sets of time-related data were obtained on the
displacement of the urethro-vesical junction and the change in abdominal pressure. A graph was plotted of these two simultaneously recorded variables to show the relation between displacement of the urethro-vesical junction and abdominal pressure changes (Fig. 2). The slope of the line connecting the starting point and the point of maximum pressure was considered to be a characteristic index of pelvic floor function. We called this the displacement/pressure coefficient; it is expressed as displacement of the urethro-vesical junction in degrees per abdominal pressure change in cm H$_2$O. A more extensive description of the methods can be found in a previous article.

**Figure 2:** Cross plot of intra-abdominal pressure and urethro-vesical junction (UVJ) angle measurement. $A_0$ is the resting angle, the rotation angle at rest, pressure is minimal. $A_{max}$ is the maximal angle, the rotation angle at maximal pressure during Valsalva, or coughing. The lower part of the curve reflects the UVJ angle at increasing pressure whereas the upper part of the curve reflects the angle during decreasing pressure. The slope of the line connecting the starting point and the point at maximum pressure is defined as the displacement/pressure coefficient, a characteristic index of the pelvic floor, expressed as the displacement of the urethro-vesical junction in degrees per abdominal pressure change in cm H$_2$O.

**STATISTICAL ANALYSIS**

The Kolmogorov-Smirnov test was used to assess if the data had a Gaussian distribution. For the weight gain in the pad test and for the UVJ measurements, the Mann-Whitney U test was used and for 2 * 2 frequency tables Fisher’s exact test.
To identify significant relationships between variables the Spearman correlation test was used.

Table 1: Serial measurements of UVJ-mobility, pad-test and reported incontinence.

<table>
<thead>
<tr>
<th></th>
<th>38 weeks pregnancy</th>
<th>6 weeks postpartum</th>
<th>6 months postpartum</th>
<th>Nulliparous Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting angle UVJ $\alpha_0$</td>
<td>67</td>
<td>66</td>
<td>57**</td>
<td>44.5***</td>
</tr>
<tr>
<td>Coefficient $c_{\text{cough}}$</td>
<td>0.20</td>
<td>0.25*</td>
<td>0.24**</td>
<td>0.16***</td>
</tr>
<tr>
<td>Coefficient $c_{\text{Valsalva}}$</td>
<td>0.30</td>
<td>0.39*</td>
<td>0.35</td>
<td>0.30</td>
</tr>
<tr>
<td>Positive pad-test</td>
<td>7/51</td>
<td>4/41</td>
<td>2/40</td>
<td>1/27</td>
</tr>
<tr>
<td>Reported incontinence</td>
<td>16/62</td>
<td>10/62</td>
<td>9/62</td>
<td>-</td>
</tr>
</tbody>
</table>

Resting angle in degrees; Coefficient, displacement/pressure coefficient in degrees per cm H$_2$O for cough end for Valsalva; positive pad-test, i.e. pad-test more than 9 grams. * significant difference 6 wks pp compared to 38 wks, **significant difference 6 months pp compared to 38 wks, *** significant difference controls compared to 6 months pp. Level of significance, p< 0.05.

RESULTS

Urinary incontinence (Table 1)

Postpartum, the number of women reporting incontinence was reduced from 16/62 (26%) at 38 weeks of pregnancy to 10/62 (16%) at 6 weeks postpartum and to 9/62 (15%) at 6 months postpartum.

A positive pad test result, i.e. a weight gain of nine grams or more, was found in 7/51 (14%), 4/41 (10%) and 2/40 (5%) at the three consecutive measurements. De novo post partum incontinence was reported by 3 of the 9 women at 6 months after delivery. All the women with a positive pad test at 38 weeks gestation became negative 6 month post partum, whereas only two women with a negative test ante partum revealed a positive test at 6 months post partum. All the women who had a positive pad test at 38 weeks of pregnancy were also tested at 6 weeks and 6 months postpartum, whereas only 34 out of 44 of the women with a negative pad test antenatally turned in their pads post partum. Therefore the number of positive pad tests may be over represented. Moreover 33/35 women with a positive questionnaire (cumulative for three measurements) turned in their pads according to the protocol, whereas 103/151 women with a negative questionnaire did. Figures 3 and 4 show the sequential results of the subjectively reported incontinence and the pad tests from 38 weeks gestation to 6 months post partum.
Measurements of the urethro-vesical junction (Table 1)

The resting angle of the urethro-vesical junction (A₀) remained hardly unchanged 6 weeks after vaginal delivery, but decreased significantly at six months postpartum, from 67 to 57 degrees, respectively. This value is significantly greater than the 44.5 degrees in the non-pregnant control group.

The effects of coughing and of the Valsalva manoeuvre on the mobility of the urethro-vesical junction were investigated by calculating the displacement/pressure coefficient. During coughing, the displacement/pressure coefficient increased significantly from 0.20 at 38 weeks of pregnancy to 0.25 at 6 weeks postpartum. At 6 months, the median coefficient was 0.24, which is still significantly higher than the antepartum value at 38 weeks. During the Valsalva manoeuvre, the median coefficient increased significantly from 0.30 at 38 weeks gestation to 0.39 at 6 weeks postpartum. At six months, the median coefficient was 0.35, which was not significantly different from the antepartum value at 38 weeks and also not different from that of the non-pregnant control group of 0.30.

None of the UVJ measurements were correlated to subjective or objective incontinence data.

Obstetric variables

None of the obstetric variables, i.e. duration of the first stage of labour, duration of the active stage of labour, intact perineum, episiotomy, lacerations of several
degrees, birth weight and head circumference, were correlated with the incontinence outcome measurement or with measurements of the UVJ, or with changes in the individual outcome of these measurements.

Figure 4: Longitudinal course of incontinence diagnosed by the pad test. The figures in the circles represent the number of women.

**DISCUSSION**

The results of the present study show a marked reduction in the incidence of urinary incontinence six weeks after delivery, as compared to 38 weeks of gestation. This holds for the reported as well as for the objectively measured incontinence by the pad test.

De novo post partum incontinence was reported by 3 of the 9 women affected at 6 months after delivery. All the women with a positive pad test at 38 weeks gestation became negative 6 months post partum, whereas only two women with a negative ante partum test revealed a positive test at 6 months post partum. Apparently incontinence during pregnancy is a different entity than urinary incontinence during the postpartum state.

The mostly temporary incontinence in pregnancy can be interpreted as a result of interaction between predisposing hereditary factors and uterine pressure upon the bladder, in combination with hormonal effect upon the suspension ligaments of the urethra\(^9\). Persisting incontinence post partum is mainly the result of changes
of the pelvic floor function and anatomy, due to delivery. The (partial) irreversibility of these changes may indicate why stress incontinence appearing for the first time after vaginal delivery has a more serious prognosis than incontinence developing during pregnancy.

The present study demonstrates that spontaneous vaginal delivery causes transient as well as long-lasting changes in the lower urinary tract. It seems likely that the long-lasting changes that we observed six months after delivery will be permanent. Parturition alters urethral support and as a consequence, the position of the bladder neck at rest becomes permanently descended. These findings are in agreement with the results of Peschers et al. who found that the bladder neck was significantly lower at rest in women after vaginal delivery than in nulligravid controls. The changes in pelvic floor reaction to coughing, as measured by an increase of the displacement/pressure coefficient, indicates reduced pelvic floor stiffness due to coughing. This finding adds to the effect of pregnancy, where we observed already a significant decrease in pelvic floor stiffness during coughing. These findings are most likely the consequence of impaired muscle contraction due to muscular or nerve fibre tissue changes. However, it is also possible that we measured an altered effect of normal muscle contraction primarily resulting from connective tissue defects.

Peschers et al. found an increased reaction to the Valsalva manoeuvre six to ten weeks after vaginal delivery and conclude therefore that vaginal delivery alters vesical neck mobility. However we found that parturition has only a transient influence on the pelvic floor reaction to the Valsalva manoeuvre. This transient increase in the displacement/pressure coefficient means a decrease in resistance to deformation, e.g. decreased stiffness of the pelvic floor. As the pelvic floor can be considered as a composition of collagen tissue and neuromuscular tissue, transient changes in the collagen tissue conditions are most likely to be responsible for this phenomenon, because during Valsalva, neuromuscular activity from the pelvic floor is negligible. Landon described this phenomenon as stress relaxation, molecular reorganisation and fibre movement leading to the necessary adaptation of collagen tissue to permit physiological stretching during pregnancy and parturition.

Our findings confirm the results of Howard et al., who found that the cough stiffness of the pelvic floor in nulliparous women was significantly greater than that in the primiparous continent women, whereas stiffness during Valsalva did not differ between these groups.

King et al., also using perineal ultrasound, found that antenatal bladder neck
mobility was greater in primigravid women with postpartum incontinence than in women who were continent postpartum. They suggest that collagen susceptibility to changes during pregnancy, measured by changes in bladder neck mobility, may predict post partum incontinence. Keane\textsuperscript{18} proves that collagen tissue defects in nulliparous women are indeed related to genuine stress incontinence. Therefore we focussed especially on the relation between antenatal bladder neck mobility and post partum stress incontinence. Although we did find increased bladder neck mobility in early pregnancy\textsuperscript{8} and near term (this study), we could not confirm the results of King. Neither at the various stages of pregnancy, nor at 6 weeks and 6 months post partum. Neither for objective nor for subjective incontinence. This might be due to the small number of women with post partum stress incontinence in our study. Moreover we used the displacement pressure co-efficient, they measured UVJ displacement at a standardised Valsalva manoeuvre for all patients, i.e. a pressure of 40 cm H\textsubscript{2}O.

We did not find any relation between incontinence measurements, urethro-vesical junction measurements and obstetric variables. This concurs with evidence found in other large clinical studies that obstetric factors do not form independent risk factors for postpartum incontinence\textsuperscript{19-21}. In a recently published paper on urodynamics in pregnancy and after delivery, obstetric variables did not have any consistent effects on objective bladder function\textsuperscript{22}.

Delivery, especially vaginal delivery, is thought to play a major role in the aetiology of urinary stress incontinence. Parturition is thought to cause damage to the structure and function of the pelvic organs\textsuperscript{1,23,24}. However, incontinence generally disappears within 3 months postpartum\textsuperscript{1,3,6,7}. Later in life, particularly after repeated delivery and after menopause, incontinence may recur\textsuperscript{3,24,25}. Owing to this time lag between delivery and the late onset of urinary incontinence, it is almost impossible to prove a causal relation. In addition, the relation is troubled by lifetime experiences that can influence a woman's chance of developing urinary incontinence.

\textbf{CONCLUSION}

It is concluded that pregnancy and spontaneous vaginal delivery significantly permanently alter the static condition of bladder neck descent. The dynamics of the pelvic floor are affected as well. This effect is temporary for Valsalva and
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permanent for coughing. Urinary incontinence, quite common during pregnancy, disappears post partum in most women. No evidence was found for a significant association between pelvic floor function measurement and urinary incontinence, nor at 6 weeks, nor at 6 months postpartum. As the onset of symptoms of urinary incontinence later in life is thought to be due to the combined effect of occult trauma during pregnancy and delivery and the progression of neuropathy during lifetime4,24 the persistent anatomical and functional changes in the lower urinary tract that we found, could play an important role in the aetiology of urinary stress incontinence later in life.

**Reference List**


