The urethral support system during pregnancy and after childbirth

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CHAPTER 1
Introduction
1.1 INCONTINENCE IN PREGNANCY AND AFTER CHILDBIRTH

Pelvic floor dysfunction in women is a major health problem. Symptoms are protrusion of vaginal tissue, voiding difficulties, urinary incontinence, stool problems and sexual dysfunction. Many of these women may eventually require surgery for pelvic floor dysfunction, especially for prolaps and urinary incontinence. This thesis focuses on urinary incontinence and especially on the etiological aspects of pregnancy and childbirth. In a community survey MacLennan reported a prevalence of all types of self-reported urinary incontinence in women is 35.3%. Urinary incontinence increased after pregnancy according to parity and age. The highest prevalence (51.9%) is reported in women aged 70-74 years1-4. Numerous epidemiological studies have associated pelvic floor dysfunction with prior vaginal delivery1;5-15. In contrary there are only a very few prospective studies on the effect of pregnancy and childbirth on the urethral support system16-18, nowadays considered as the important issue in urinary control19.

It is generally accepted that as pregnancy proceeds a growing number of women complains of urinary incontinence. Accidental loss of urine is reported in 17-25% of women in early pregnancy20 and in up to 36-67% in late pregnancy21. Moreover, the degree of incontinence worsens as pregnancy advances21. Urinary incontinence during pregnancy is ascribed to detrusor instability resulting from changes in hormone levels22 and to anatomical changes due to the growing uterus and the engagement of the fetal head in the pelvis23. Others24 have suggested that reduced fascial strength and subsequent weakness of the pelvic supports might contribute to urinary incontinence during pregnancy.

Until now, it is not clear to what extent pregnancy itself or vaginal delivery contributes to the development of urinary incontinence in later life. Following vaginal delivery neuromuscular damage and bladder neck hypermobility, indicating a change in pelvic floor function, has been confirmed25,26. Nevertheless in the great majority of women the incontinence has disappeared six months after delivery13,27.

1.2 THE URINARY CONTINENCE CONTROL SYSTEM

The control system for urinary continence is a complex network with several components. Anatomical it consist of the urethral support system and sphincteric
The sphincteric closing system consists of urethral striated muscles, the urethral smooth muscles, and the vascular elements within the submucosa. The urethral muscles maintain continence in various ways. The striated muscles are well-suited to maintain constant tone as well as allow voluntary increase in tone to provide additional continence protection. Moreover striated muscles are capable to compress the lumen. Smooth muscles may also play a role by surrounding the inner vascular layer, suggesting a role in constricting the lumen.

This sphincteric closing system yields a closing pressure which may deteriorate due to age and neurological injury. Studies on the effect of vaginal birth on the sphincter mechanism reveal decreases in urethral closure pressure as a result of vaginal birth.

The urethral support system consists of all the structures extrinsic to the urethra that provide a supportive layer upon which the urethra rests. The following structures can be distinguished:

1. The connective tissue sheath covering the ventral spect of the urethra and the rhabdosphincter, which may be called ventral urethral fascia, which connects the right and left fasciae of the levator. Contraction of the levator narrows the pre urethral space and an ascending movement of the urethra and the rhabdosphincter.
2. The fasciae of the levator ani muscle, especially the right and left tendineous arch.
3. The strong dorsal structure of the urethra and the rhabdosphincter to the ventral wall of the vagina.

The m. pubo rectalis and the m. pubo coccygeus form a U shape as they originate from the pubic bone on either side of the midline and pass behind the rectum to form a sling. Composed of type 1 striated muscle suited to maintain constant tone. It is this constant tone that keeps the urogenital hiatus closed. The ileococcygeus muscles arise laterally from the arcus tendineus levator ani and form a horizontal sheet that spans the opening in the posterior region of the pelvis, thereby providing a shelf upon which the pelvic organs rest. In this respect the biomechanical properties of the pelvic floor are of great importance, since the pelvic floor must be capable in providing sufficient back pressure for urethral closure.
In a hard cough intra abdominal pressure can increase by about 150 cm H₂O. Ultrasound studies have shown that during coughing the inferior abdominal contents are forced to move caudo dorsally (downwards), presumably due to a simultaneous contraction of the diaphragm and abdominal wall muscles. The proximal urethra and the anterior vaginal wall are intimately connected and attached to the muscles of the pelvic diaphragm and to the arcus tendineus fasciae pelvis. Support of the urethra at rest comes from both its attachments to the arcus tendineus fasciae pelvis and the resting tone of the muscles of the pelvic diaphragm. Therefore, the mobility of the urethro-vesical junction can be used as an index of the mobility of these pelvic floor structures. The downward motion of the bladder neck visible in the ultrasound picture means that its surrounding tissues acquire downward momentum. This downward momentum must than be arrested by stretch resistance of the pelvic floor structures. As the downward momentum of the abdominal contents is slowed by the stretch of the pelvic floor structures, this movement compresses the proximal intra abdominal portion of the urethra against the underlying supportive structures, which is composed of the endopelvic fasciae, the vagina, and the levator ani muscles.
1.3 Definition of the Problem

Overstretching of the hiatus urogenitalis during pregnancy and after childbirth

The ventral fasciae and the fasciae of the levator ani may be separated from the anterior rhabdosphincter. Also, overstretching of the vaginal wall may lead to disruption of the dorsal urethra and rhabdosphincter from the vaginal wall.

Birth imposes a remarkable degree of distension in the muscles and fasciae. If one assumes the diameter of the moulded fetal head (9cm, based on the data from Chitty et al38) is approximately 4 times the initial diameter of the urogenital hiatus (2.5 cm, according to the data of DeLancey and Hurd36) in the levator ani muscles through which the fetal head must pass during the second stage of labour. The theoretically needed stretch ratio is about 9/2.5= 3.6. In a computerized model of the passing fetal head through the hiatus urogenitalis Lien concluded that a maximal stretch ratio of 3.26 was found in the pubococcygeal muscles39. This is 217% of the maximum stretch as defined for non gravid muscles, 1.5.

When damage has occurred in the levator ani muscle and or fasciae the anatomical defect is noted as a tendency towards increased size of the urogenital hiatus and vertical elongation of the levator plate. The increased area of the urogenital hiatus is secondary more to an increase in anterior posterior diameter and less to an increase in transverse diameter. When the ileococcygeus muscle is damaged, the resulting anatomical defect is a tendency towards vertical elongation of the levator plate. This downward sagging of the levator plate increases the size of the urogenital hiatus and results in loss of the valve mechanism that normally prevent pelvic organ prolaps.

As the majority of women has no symptomatic pelvic organ prolaps after vaginal delivery we postulate that both fascia and muscles must have a remarkable accommodation of the level of tissue stretch needed for vaginal birth without major injury of pelvic floor. During childbirth the urogenital hiatus has to adapt to the passing foetus in a limited time. The increase of the perimeter and/or the straining capacities of the tissue (compliance) of the hiatus urogenitalis might facilitate this process.

There is great scarcity of prospective studies on urinary incontinence during pregnancy and after childbirth. The wide variation of the reported prevalence and the uncertainty concerning the changes in the continence control system, prompted us to investigate these issues in a prospective longitudinal study in a homogeneous cohort of nulliparous pregnant women. Dynamic serial perineal ultrasound measurements of pelvic floor characteristics may give us a better understanding of the role and the changes in the continence control mechanism, both during pregnancy and after childbirth.

### 1.4 Aims of the Study

*Assessment of the urethral support system during pregnancy and after childbirth, perineal ultrasonography, compliance and hysteresis*

By analysing the position and the movements of the urethra vesical junction (UVJ) in relation to the changes of the abdominal pressure one analyses the capacity and the stretch resistance of the urethral support system. Generally, tissue distensibility is determined not only by the elasticity of the constituent muscle and connective fibers itself but also by the geometrical arrangement of those fibers. Two parameters
are in use to describe the mechanical properties of tissue: Young’s modulus, or its reciprocal (the compliance), to quantify the pure elastic behaviour of tissue in which the geometrical structure of the fibers remain unaltered, and hysteresis: the failure of tissue to follow the same course during relaxation as it did during distension. The latter parameter is thought to be the result of shifts in the geometrical structure of the fibers with respect to each other, and can be interpreted as a form of internal friction within the tissue. We used perineal ultrasound of the UVJ movements. It can be applied to get on line registration, and can be used freely in pregnancy without radiation, with limited discomfort and great availability. We had experience with the method since 1991, when we first reported on the use of ultrasound in the diagnosis of urinary incontinence. By the use of perineal ultrasound and simultaneous abdominal pressure measurement we were able to measure the displacement and the recovery of the vesical neck in relation to the increase of abdominal pressure during coughing and during Valsalva manoeuvre. In general, deformation under load for tissue is seldomly linear. To quantify such deformation we decomposed deformation into elasticity, approximated by a linear model and hysteresis, estimated by a non linear model. These measurements were made throughout pregnancy and after childbirth resulting in serial measurement of the biomechanical properties of the vesical neck supporting structures during pregnancy and after childbirth.

Assessment of functional changes of the pelvic floor

(Functional) injury of pelvic floor, leading to changes of pelvic floor stretch resistance may lead to pelvic floor dysfunction, which includes urinary incontinence. Part of our study therefore was to measure the incidence of this symptom of pelvic floor dysfunction. Women completed questionnaires and visual analogue scales on symptoms of urinary incontinence, moreover 24-hour pad tests were used to objectify urine loss.

In chapter 2 we assessed the prevalence and the development of urinary incontinence in nulliparous pregnant women, both subjectively and objectively, and we investigated the relation of urinary incontinence with the mobility of the urethro-vesical junction measured by perineal ultrasound.

In chapter 3 we assessed the prevalence of urinary incontinence after spontaneous vaginal delivery and its relation with changes in the static and dynamic function of the pelvic floor.
In chapter 4 we compared women with spontaneous and operative vaginal delivery for urinary incontinence data and for pelvic floor characteristics.

In chapter 5 we focused on displacement and recovery of the vesical neck position during pregnancy and after childbirth, especially we discriminated between compliance of the vesical neck supporting structures with and without pelvic floor contraction.

In chapter 6 we assessed the clinical usefulness of the 24-hour pad test in pregnancy and after childbirth in terms of the relationship between objective urine loss and the self reported symptoms of urinary incontinence.

Chapter 7 is the summary and conclusions and the Dutch summary is in Chapter 8.

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