Research paper

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An assessment of the relationship between urethral hypermobility as measured by ultrasound and the symptoms of stress urinary incontinence in primiparous women 9–18 months postpartum

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ultrasound; birth; urethra; bladder neck; stress urinary incontinence

Abstract

Aim: The aim of the study was to estimate the relationship between bladder neck hypermobility as assessed by ultrasound and the occurrence of stress urinary incontinence as measured with the UDI-6 questionnaire in primiparous women 9–18 months postpartum. **Materials and methods:** The study included 100 women 9–18 months after their first delivery, 19% of whom (study group) presented with urethral hypermobility. Ultrasound was used to determine the position and mobility of the bladder neck in order to assess the urethral hypermobility. A vector of ≥15 mm was defined as urethral hypermobility. Symptoms of stress urinary incontinence were assessed using question 3 of the UDI-6 questionnaire, in which the presence of symptoms was defined as a response rated from 1 to 4. **Results:** We demonstrated a statistically significant relationship between urethral hypermobility and the symptoms of stress urinary incontinence with a statistical significance level of $p < 0.002$. **Conclusions:** Stress urinary incontinence is a common disorder in women, the pathophysiology of which is not fully understood. It has adverse effects on the quality of life, perception of one's own body and sexual function. Impairment of urethral fixation may play an important role in the pathophysiology of this common form of urinary incontinence. The study showed that urethral hypermobility, as assessed by ultrasound, contributes to stress urinary incontinence, as measured with the UDI-6 score. Although stress urinary incontinence is a multifactorial disorder influenced by anatomical changes and congenital anatomical features, it is easily diagnosed. Suburethral slings are an effective surgical technique; however, the incidence of postoperative voiding dysfunction or recurrent stress urinary incontinence is 10–20%. Therefore, an assessment of anatomical changes in stress urinary incontinence may help individualize the surgical strategy.

Introduction

Stress urinary incontinence (SUI) is a common condition in women, the pathophysiology of which is not fully understood. It disturbs the quality of life, perception of one's own body and sexual function[(1)]. Even though it does not pose a threat to life, it is considered by patients as a serious disability and often contributes to social isolation, lower self-esteem, shame, poor sexual life and even depression among women[(2)]. SUI is caused by a sudden increase in intra-abdominal pressure during sneezing, coughing, walking or jumping, which results in urine leakage. This condition may be associated with anatomical changes in the pelvis and urethral sphincter following pelvic organ prolapse (POP) as a result of tissue weakening and prolonged labor[(3)]. Many authors have observed a relationship between the route of delivery and the risk of SUI. This risk is estimated at 13% in the population of women after vaginal delivery, 26.4% in those after caesarean section and 30.3% in the group of women after forceps delivery[(4)]. Tähtinen *et al.* also showed that vaginal delivery is associated with a two-fold risk of SUI compared to caesarean section, with an overall increase in risk of 8%[(5)]. In turn, Groutz showed that the incidence of postpartum SUI was similar after vaginal delivery (10.3%) and cesarean section due to obstructed labor (12%). However, SUI was significantly less common after elective cesarean section without attempting vaginal birth (3.4%, $p < 0.05$)[(6)]. According to Derewiecki *et al.*, the most important risk factors contributing to the onset of urinary incontinence

(UI) are age (35.64%), previous pregnancies (27.72%), physical labour (12.87%), urinary tract infections (11.88%), genetic conditions (8.91%) and overweight (2.97%)[7].

Many authors have concluded that urethral dysfunction is the dominant factor in the pathogenesis of SUI[8]. According to Delancey's „hammock theory" and the integral theory proposed by Petros and Ulmsten, normal voiding control mechanisms depend on the proper function of the urethral sphincter, as well as on the bladder neck, urethra, and the supporting and surrounding anatomical structures[9]. Hyper- or hypomobility of organs indicates an abnormal structure of the pelvic floor. Damage to the levator ani muscle or pubourethral fascia causes weakening of the vaginal pressure on the urethra and the inability to maintain the pressure closed in the normal urethra, which leads to SUI [10,11]. Ultrasound of the pelvic floor is gaining popularity in the assessment of urogynecological patients. Many studies have been devoted to the static and dynamic assessment of the pelvic floor using pelvic floor sonography with transvaginal probe (PFS-TV). Its advantages include, among others, availability of equipment (especially among gynecologists), minimum area of pressure exerted by the transducer on the urethra (which helps minimize measurement errors), real-time assessment, and high repeatability. Although PFS-TV does not allow for a comprehensive assessment of the pelvic floor in one image, it is characterized by good repeatability of urethral mobility assessment[12].

Pelvic floor US allows for a precise and dynamic assessment of the damage and movement of the pelvic organs. This imaging modality enables a more accurate assessment of the function and location of pelvic organs and muscles, and thus obtaining detailed information on the anatomical structure and movements of pelvic organs for the purposes of diagnosis and treatment[13]. The analysis of diagnostic criteria in women with postpartum SUI and the estimation of the relationship in ultrasound examination, which is important for the clinical diagnosis, will contribute to increased diagnostic rates, which is of great importance for the early detection of SUI. UDI-6 (Urinary Distress Inventory) helps assess the severity of UI symptoms. It consists of 6 questions on voiding disorders rated from 0 to 4, depending on the severity of symptoms. UDI-6 question 3 refers to the presence and severity of SUI. Ultrasound assessment of bladder neck mobility is made based on the location of point C, which determines the position of the bladder neck in relation to the pubic symphysis at rest and during the Valsalva maneuver.

Aim

The aim of the study was to estimate the relationship between bladder neck hypermobility, as assessed by ultrasound, and the occurrence of SUI, as measured with UDI-6, in primiparous women 9–18 months postpartum.

Materials and methods

The research was approved by the Bioethics Committee of the Medical University of Lodz on January 15, 2019 (No. RNN/40/19/KE), and was financed from own sources. The study was conducted in a group of 100 patients over 18 years of age, who were 9–18 months after their first childbirth by means of forceps delivery, physiological delivery, elective cesarean section or full dilation cesarean section. The research was conducted at the Department of Perinatology of the Medical University of Lodz from March 12, 2019 to December 1, 2021. Participation in the study was voluntary. The patients were informed about the nature and purpose of the research and gave written consent for participation. The study group included 19 patients with urethral hypermobility, which was assessed based on an ultrasound to estimate the position and mobility of the bladder neck. The control group included 81 patients who did not present with urethral hypermobility on ultrasound. Exclusion criteria included age below 18 years, multiple pregnancies, congenital defects and chromosomal aberrations in the fetus, severe maternal diseases such as asthma, chronic obstructive pulmonary disease, upper and/or lower respiratory tract infection, chronic cough, nicotine dependence, pharmacotherapy for hypertension based on angiotensin-converting enzyme inhibitors (so-called ACEI inhibitors), and severe fetal diseases, as well as neurological conditions, pelvic surgery, multiparity and another pregnancy during the study.

Tab. 1. Voiding symptoms (UDI-6)

Do you	NO	YES
1. Urinate frequently?	0	1234
2. Usually experience urine leakage related to urgency?	0	1234
3. Usually experience urine leakage related to coughing, sneezing, laughing?	0	1234
4. Usually experience minor urine leakage (small amounts, drops)?	0	1234
5. Usually experience difficulty emptying your bladder?	0	1234
6. Usually experience pain or discomfort in your lower abdominal, pelvic, or genital area?	0	1234

Age of ≥18 years, Caucasian race, singleton pregnancy, first delivery, physiological delivery and delivery ended with forceps surgery, elective cesarean section or full dilation cesarean section were the inclusion criteria.

UDI-6 question 3, i.e. "*Do you usually experience urine leakage related to coughing, sneezing or laughing*?", was used to assess the presence of SUI symptoms.

UDI-6 is a questionnaire used to assess the type and severity of UI, including SUI, consisting of 6 questions addressing voiding disorders. The symptoms are rated from 0 to 4, depending on their severity (Tab. 1).

Ultrasound assessment of the position and mobility of the bladder neck was used to estimate urethral mobility. Ultrasound assessment of bladder neck mobility is based on the location of point C, which determines the position of the bladder neck in relation to the pubic symphysis at rest and during the Valsalva maneuver. The vector was calculated according to formula (1) used by Viereck[14] as the hypotenuse of a right triangle whose sides are ΔD and ΔH (Fig. 1):

$$\text{Vector} = \sqrt{(\Delta D\ 2 + \Delta H\ 2)}\ (1)$$

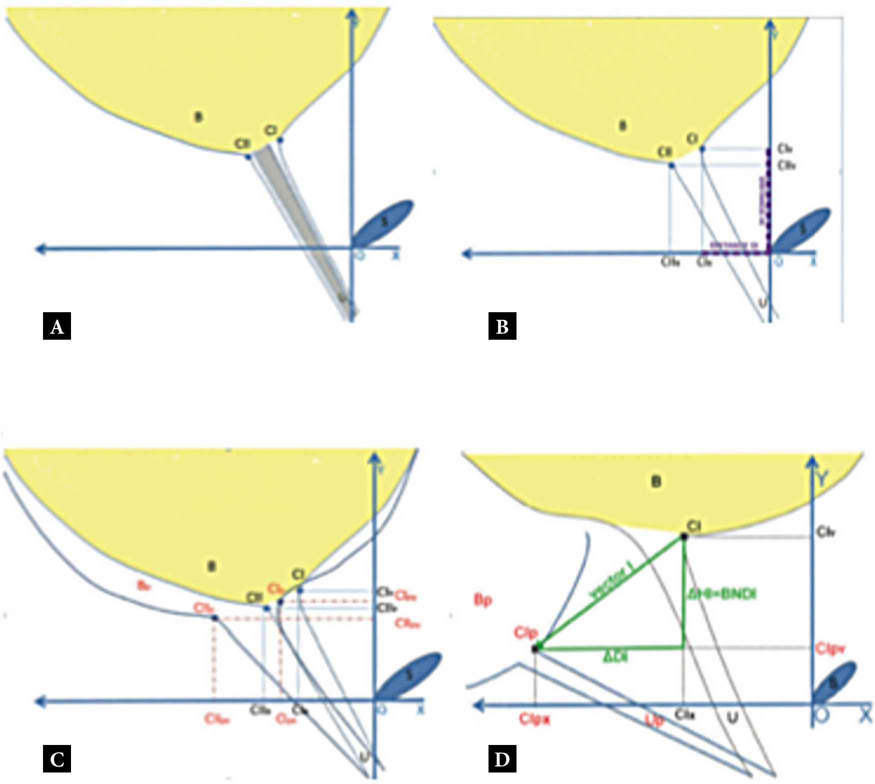

Fig. 1. *A diagram showing ultrasound parameters of the internal urethral opening at rest and during the Valsalva maneuver.* ***A.*** *Location of CI and CII points within the internal urethral opening.* ***B.*** *Location of points CI and CII on the OY and OX axes.* ***C.*** *Location of points CI and CII (at rest), as well as Ci p and CII p (during the Valsalva maneuver) on the OY and OX axes.* ***D.*** *Calculation of bladder neck descent parameters: BND and vector; S – pubic symphysis; B – urinary bladder; U – urethra; CI and CII – points referring to the internal urethral opening at rest; CI x and CII x – projection of CI and CII points on the OX axis; CI y and CII y – projection of CI and CII points on the OY axis; B p – urinary bladder at maximum pressure; Ci p and CII p – points locating the internal urethral opening during the Valsalva maneuver; CI px and CII px – projection of the points CI p and CII p on the OX axis; CIpy and CII p – projection of CIp and CIIp points on the OY axis; ΔHI – BND for the CI point during the Valsalva maneuver; Vector I – vector for the CI point during the Valsalva maneuver*

where ΔH is calculated using the following formula:

$\Delta H = H - H\,p$ (2)

and where ΔD is calculated using the following formula:

$\Delta D = D - D\,p$ (3)

It can be assumed based on the literature that urethral hypomobility is defined as a bladder neck mobility vector of ≤5 mm, normal urethral mobility is in the range of 5–15 mm, and urethral hypermobility is defined as a vector of ≥15 mm[15]. The term itself may be considered erroneous as "hypermobility" means mobility that exceeds the limits that cause a disorder, while in reality these values are not fully understood, and much evidence suggests that hypermobility does not necessarily cause urinary incontinence[16]. Therefore, although patients with SUI should have their intra-abdominal pressure required for Valsalva leak point pressure (VLPP) and urethral mobility described, they should not be classified based on these parameters[17,18]. However, no general consensus has been reached on this issue. A bladder neck vector of ≥15 mm was considered as urethral hypermobility[15].

The examination was performed using a Toshiba Aplio 400 ultrasound unit and a Toshiba PVT-781 VTE (11C3) transvaginal transducer with a frequency of 3.6–10.5 MHz. The examination was performed by one specialist in obstetrics and gynecology.

Vector values ≥15 mm and <15 mm were denoted as 1 and 0, respectively, in order to calculate the relationship between variables. SUI symptoms assessed using question 3 in UDI-6, which defines the presence of symptoms as a response ranging from 1 to 4, were denoted as 1, whereas the answer 0 was denoted as 0. The chi-square test with Yates' correction was used to assess differences in the incidence of SUI symptoms in the study vs control group. Demographic variables were compared between the groups using the Wilcoxon test.

Results

The groups of women included in the study were demographically similar. At the time of the study, the median age of respondents was 30 years (28–32 years) for the total sample, 30 years (27–31 years) in the study group, and 30 years (29–33 years) in the control group. The median body weight during the study was 62 kg (51–70 kg) for the total sample, 65 kg (54–74 kg) in the study group, and 60 kg (56–70 kg) in the control group. The patients has the following BMIs at delivery: 27.31 kg/m^2 (24.68–29.18) kg/m^2 for the total sample, including 25.62 kg/m^2 (24.22–32.25) in the study group

Tab. 2. Demographics for groups: I – study group, II – control group, III – total sample

Variable	Group I	Group II	Group III	*p*-value
Age – median (IQR)	30 (27–31)	30 (29–33)	30 (28–32)	0.1972
Race	Caucasian	Caucasian	Caucasian	
Body weight during the examination – median (kg) (IQR)	65 (54–74)	60 (56–70)	62 (51–70)	0.713
Height (cm) – median (IQR)	169 (163–172)	166 (164–172)	167 (164–172)	0.4694
Body weight at delivery (kg) – median (IQR)	83 (67–90)	74 (70–85)	75 (70–86)	0.3171
BMI at delivery – median (IQR)	25.62 (24.22–32.25)	27.34 (24.68–29.14)	27.31 (24.68–29.18)	0.802
Type of work, *N* (%)				
Manual	3 (16%)	0 (0%)	5 (5%)	
Intellectual	15 (79%)	79 (98%)	94 (94%)	
Housewife	1 (5%)	0 (0%)	1 (1%)	
Education, *n* (%)				
Primary	0 (0%)	0 (0%)	0 (0%)	
Secondary	4 (21%)	7 (9%)	11 (11%)	
Higher	15 (79%)	74 (91%)	89 (89%)	
Pre-delivery SUI	0%	0%	0%	
Child's birthweight – median (g) (IQR)	3500 (3,210–3,895)	3,420 (3,200–3,720)	3,430 (3,200–3,735)	0.3722

BMI – body mass index; IQR – interquartile range; SUI – stress urinary incontinence

and 27.34 kg/m^2 (24.68–29.14) in the control group. The majority of patients (89% of the study sample) were professionally active, performing intellectual work, with higher education declared by 79% and 91% of patients in the study and control group, respectively. Secondary education was declared by 11% of women included in the study, including 21% in the study group and 9% in the control group. None of the respondents had primary education level. Intellectual work was declared by 94% of study participants, including 79% in the study group and 98% in the control group. Manual work was declared by 5% of all study participants, including 16% in the study group and 2% in the control group.

One patient (5%) in the study group was a housewife. The median birth weight was 3,500 g (3,210–3,895) in the study group and 3,420 g (3,200–3,720) in the control group. None of the patients presented SUI symptoms before childbirth (Tab. 2).

The study groups consisted of a total of 100 adult women who were 9–18 months after their first childbirth by means of forceps delivery, physiological delivery, elective caesarean section or a full dilatation caesarean section. The study group (19% of all respondents) presented with urethral hypermobility on ultrasound, with a vector of ≥15 mm accepted as a criterion of hypermobility. The incidence of SUI symptoms, defined based on UDI-6 question 3, was statistically significantly higher in the study group vs. controls: 79% vs. 36% ($p = 0.002$).

Discussion

Pelvic floor ultrasound has been used to evaluate SUI for over 30 years. It seems to be an appropriate tool for estimating urethral mobility as it allows for a panoramic image of the pelvic organs without changing the anatomical relationships between the urethra and other structures of the pelvic floor[19]. When abdominal pressure is increased, the urethra is usually seen to rotate down around the symphysis pubis. Ultrasound allows for the measurement of anatomical changes, such as bladder neck mobility or segmental urethral mobility, with high reliability and repeatability[20]. Real-time anatomical change in the lower urinary tract is important for understanding the etiology of SUI, as urethral hypermobility has been implicated as the main mechanism underlying SUI[21]. The study showed a relationship between bladder neck hypermobility and SUI in patients after vaginal delivery, forceps delivery, elective cesarean section and full dilation cesarean section, with a statistical significance level of $p < 0.002$.

Pirpiris also suggests that the symptoms of SUI are mainly related to segmental urethral mobility[22]. Dietz, in turn, pointed out that bladder neck descent (BND) during the Valsalva maneuver seems to be the main determinant of SUI, and that there is an evident relationship between pelvic organ mobility and SUI. Studies using supine ultrasound imaging have shown that aspects of bladder neck and urethral configuration and mobility, such as bladder neck hypermobility, are significantly correlated with SUI[23]. Wen also showed that urethral hypermobility, midurethral hypermobility in particular, is associated with SUI. It is likely that changes in segmental urethral mobility and urethral alignment may be one of the mechanisms underlying the relationship between POP and lower urinary tract symptoms[24]. Evidence suggests not only that urethral hypermobility is equally common in women with lower urinary tract symptoms and SUI, but also that internal sphincter insufficiency and urethral hypermobility can coexist and do not define distinct classes of SUI patients[25].

It is important to note the limitations of our study. First of all, it was a non-experimental (observational) descriptive study, the potential limiting factor of which was the possibility of activating the pelvic floor muscles during the Valsalva maneuver, which affects the measurements of the location of the bladder neck. Additionally, the lack of standardization of the Valsalva maneuver may also be a confounding factor; however, previous attempts to standardize Valsalva pressures have been largely unsuccessful[26].

Conclusions

Using the UDI-6 questionnaire to assess urinary incontinence symptoms and perineal ultrasound to assess bladder neck mobility, we found a relationship between the location and mobility of the bladder neck and the occurrence of symptoms of postpartum stress urinary incontinence. Impaired fixation of the midurethra may play a significant role in the pathophysiology of this common form of urinary incontinence. Although stress urinary incontinence is a multifactorial disorder influenced by anatomical changes and congenital anatomical features, it is easily diagnosed. Suburethral slings are an effective surgical technique; however, the incidence of postoperative voiding dysfunction or recurrent stress SUI is 10–20%[27,28]. Therefore, an assessment of anatomical changes in stress urinary incontinence may help individualize the surgical strategy[29].

Conflict of interest

The authors report no financial or personal relationships with other individuals or organizations that could adversely affect the content of the publication and claim ownership of this publication

Author contributions

Original concept of study: PMP, GS. Writing of manuscript: PMP. Analysis and interpretation of data: PMP. Final acceptation of manuscript: JK. Collection, recording and/or compilation of data: PMP. Critical review of manuscript: EW, GS.

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