



● Clinical Note

STRAIN ELASTOGRAPHY AS A NEW METHOD FOR ASSESSING PELVIC FLOOR BIOMECHANICS

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Abstract—Strain elastography (SE) is a new technique of parametric imaging that allows quantification of the elasticity of tissue. The aim of our study was to determine if the elasticity of para-urethral tissue correlates with urethral mobility and urinary incontinence (UI). Ninety-nine unselected women were investigated with SE. They were given a standardized interview about UI, and SE raw data for the para-urethral tissue were acquired in a sagittal standard urethra-symphysis view while being stimulated by a coughing fit. We placed one region of interest (ROI A) in the tissue between the urethra and vagina at midlevel of the urethra bordering the urethral wall. The second ROI (ROI B) was set at the level of the os urethra internum in the tissue of the bladder neck in one line to ROI A. We measured elasticity in both ROIs with TDI-Q (Tissue Doppler Imaging-Quantification Software) and calculated the ratio between ROI A and ROI B (A/B). Mobility of the urethra was quantified by measuring the angle between a line parallel to the urethra and a line parallel to the bladder neck during stress and rest. SE analysis was feasible in all cases. A/B was found to be correlated with the incidence of urethral mobility ($p < 0.001$). The incidence of UI was associated with an increase in urethral mobility ($p = 0.04$). No correlation between UI and A/B could be shown ($p = 0.24$). We observed a correlation between urethral mobility and elasticity of the para-urethral tissue. In case of increasing urethral mobility, the para-urethral tissue close to the bladder neck seems to be more elastic, and the patients reported about more symptoms of UI. No noticeable correlation between UI and urethral elasticity was shown. SE may be a useful technique for direct quantification of tissue elasticity and assessment of pelvic floor biomechanics. (E-mail: Jana-g@muenster.de) © 2016 World Federation for Ultrasound in Medicine & Biology.

Key Words: Urinary incontinence, Doppler ultrasound, elastography, strain, para-urethral tissue.

INTRODUCTION

Transurethral urinary incontinence (UI) affects 25% of women, and its prevalence increases with age (Hannestad et al. 2000). The most common types of UI are stress incontinence, urge incontinence and mixed incontinence, which are commonly defined as loss of urine with physical activity, an urge to urinate or both, respectively (Hunskar et al. 2003). Although stress incontinence is caused by urethral hypermobility resulting from lack of support at the level of the bladder neck (Hammock hypothesis) (DeLancey 1994) and deficiency of the urethral sphincter (DeLancey et al. 2008), the latter of these factors may be more strongly associated with the

condition according to functional testing by DeLancey et al. (2008). Pirpiris et al. (2010) reported that mobility of the mid-urethra—and, therefore, an impairment of the mid-urethral fixation—seems to be an important mechanism in the pathophysiology of stress urinary incontinence. Transvaginal ultrasound is a time- and cost-efficient method for diagnosing anatomic defects related to UI. Moreover, it allows for dynamic examinations of the pelvic floor, especially measurements of urethral hypermobility (Costantini et al. 2006; Miller et al. 2001). Tapp et al. (2005) defined urethral hypermobility as a cotton-tipped swab angle of $\geq 30^\circ$ from the horizontal. Another method for quantifying urinary incontinence is to measure the maximum urethral closure pressure (MUCP). The cutoff point for diagnosis of intrinsic sphincteric deficiency was determined as a MUCP < 20 -cm water column (Krissi et al. 2005).

To date, however, no sonographic technique has been developed to quantify pelvic floor biomechanics

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directly. Strain elastography (SE) is a new technique of parametric imaging that allows measurement of tissue deformation and, therefore, tissue elasticity (Nesbitt et al. 2009). Tissue deformation is measured as strain (Wojcinski et al. 2013). Soft tissue is more compressible than harder tissue and thus has a higher strain. Today, clinical relevance is given for diagnosis of breast tumors (Stoian et al. 2016) and prostate cancer (Good et al. 2014) and differential diagnosis of benign and malignant lymph nodes (Ryu et al. 2016) and thyroid gland tumors (Menzilcioglu et al. 2016).

The aims of our study were (i) the correlation between the elasticity of the para-urethral tissue measured by SE and urethral mobility; (ii) the correlation between urethral mobility and UI; (iii) the correlation between the elasticity of para-urethral tissue and UI.

METHODS

Study population

Ninety-nine unselected women aged between 21 and 76 y were prospectively investigated during routine examination in the Department of Obstetrics and Gynecology, University of Münster. The study was designed according to the Declaration of Helsinki. Informed consent was obtained from all patients. The patients were asked standardized questions about symptoms of UI. No distinction between urge and stress incontinence was made. Patients were marked as positive for UI if reporting UI symptoms during all day activities. When no symptoms of UI were described, patients were marked as negative for UI.

Ultrasound examination

For ultrasound, we used a 9-MHz vaginal probe (PVT-681-MV, Aplio XG, Toshiba Medical Systems Europe, Zoetermeer, Netherlands). After emptying the bladder, patients reclined in a supine position. The probe was placed parallel to the urethra on the external level without pressure. SE data sets were obtained during a coughing fit and static elastography data were analyzed with TDI-Q (Tissue Doppler Imaging-Quantification Software, Toshiba Medical Systems Europe, Zoetermeer, Netherlands).

Raw data analysis

For raw data analysis, Lagrangian strain preset was chosen, and angle correction was activated. Two 7-mm-diameter circular regions of interest (ROIs) were placed parallel to the urethra in the posterior urethral tissue. We used this standardized ROI size to cover a representative region of the posterior para-urethral tissue. We placed one ROI (ROI A) in the tissue between the urethra and the vagina at the midlevel of the urethra

bordering the urethral wall. The second ROI (ROI B) was set at the level of the os urethra internum in the posterior tissue of the bladder neck at a distance of about 3 mm from ROI A (Fig. 1). This standardized distance results in placement of ROI A at the midlevel of the urethra, which has an average length of about 3 cm. SE was measured as peak strain in both ROIs by TDI-Q. To achieve a stress-independent evaluation, we calculated the ratio between ROI A and B (A/B).

Two picture files of the ultrasound examination were stored, one during rest and one during stress. The angle between the urethra during rest and the urethra during stress was measured with Axio Vision software (Zeiss, Germany) (Fig. 2).

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics 20 for Windows (IBM, Armonk, NY, USA). Descriptive statistics are expressed as the mean $\pm$ standard deviation (SD). Urethral mobility was divided into a hypermobility group and a low-mobility group. To test the association between A/B and the urethral mobility, the Mann–Whitney U -test for two independent samples was applied. To test for normal distribution of the data, the Kolmogorov–Smirnov test was performed. A one-way analysis of variance for data from multiple independent groups was used to test whether the group means for a specific dependent variable differ significantly. Inferential statistics are intended to be exploratory (hypotheses generating), not confirmatory, and are interpreted accordingly. The local significance level was set at 0.05. No adjustment for multiple testing was performed. Therefore, an overall significance level is not determined and cannot be calculated. p Values are considered noticeable in cases where $p < 0.05$ and highly noticeable in cases where $p \leq 0.01$.

RESULTS

Analyses were feasible in all cases. The mean $\pm$ SD age of the population was 51 ± 16 y (Table 1). Forty-seven (47.5%) women were marked as negative for UI and 52 (52.5%) as positive for UI. Twenty-six degrees of urethral mobility, half of the measured maximal urethral mobility, was determined as the cutoff point for comparing two groups. One was named low-mobility group ($<26^\circ$, UM1), and the other, the high-mobility group ($\geq 26^\circ$, UM2). The median urethral mobility was 17 (4–25) for UM1 and 30 (26–52) for UM2. The incidence of UI was found to be associated with an increased urethral mobility during stress ($p = 0.04$).

The UM1 group had noticeably higher values for A/B compared with the UM2 group (0.3 ± 1.6 vs.

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