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Does levator avulsion increase urethral mobility?

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ABSTRACT

Objective: It is often assumed that stress urinary incontinence may be due to abnormal pelvic floor muscle function or anatomy. This may be mediated through urethral hypermobility. The aim of the study was to determine the association between major levator ani defects ('avulsion') and urethral mobility.
Study design: Three hundred and five women were referred to a tertiary referral service for lower urinary tract and prolapse symptoms between December 2006 and July 2008. All patients had undergone an interview, clinical examination, multichannel urodynamic testing and 4D transperineal ultrasound. Ultrasound volume datasets of 198 women were analysed retrospectively. Tomographic ultrasound imaging was used to diagnose levator avulsion at the time of the original assessment. To determine urethral mobility, data analysis was performed on a desktop PC using proprietary software several months later. The urethra was divided into 5 equal segments with 6 points marked evenly along the urethra from the bladder neck (Point 1) to the external meatus (Point 6) as identified in the mid-sagittal view. Measurements of vertical and horizontal distances from the dorsocaudal margin of the pubic symphysis of these 6 points were taken in the mid-sagittal plane, using volume datatsets obtained at rest and on maximal Valsalva. Mobility vectors of these 6 points were calculated using the formula SQRT $((x_{valsalva} - x_{rest})^2 + (y_{valsalva} - y_{rest})^2)$ and were correlated with levator status using two sample *T* tests.
Results: Levator avulsion was found in 18% of patients ($n = 35$). Except at the bladder neck which almost reached significance (32.5 mm in those with defects vs. 28.9 mm in those without, $P = 0.07$), there was no significant association between urethral mobility and avulsion (all $P \geq 0.17$).
Conclusion: Major levator trauma does not seem to substantially affect urethral mobility, with the possible exception of the bladder neck.

1. Introduction

The prevalence of urinary incontinence in community-dwelling women is thought to range between 20 and 40% [1,2]. Stress urinary incontinence (SUI) is the most prevalent type [1] accounting for $1.3 billion treatment cost per annum in the United States [3]. Despite its high prevalence the pathophysiology of SUI is not well defined. It is generally believed that intact urethral support and a normal urethral sphincter mechanism are important for the maintenance of urinary continence.

The levator ani muscle may play a role in urinary continence. It may be involved in stabilising the urethra, especially during rises in intra-abdominal pressure. In John DeLancey's 'hammock hypothesis', an intact connection of the vaginal wall and endopelvic fascia to the arcus tendineus fasciae pelvis and levator ani muscles is thought important for urethral support [4]. This functional unit is thought to provide a hammock against which abdominal pressure compresses the urethra to preserve continence during intra-abdominal pressure rises. Changes in neurological function, fascial or muscular structural defects may theoretically lead to failure of urethral support, compromising pressure transmission and leading to SUI. A visible defect of the levator ani muscle on magnetic resonance imaging (MR) was seen twice as often in women with new onset SUI after a first vaginal birth compared to those without [5].

The importance of the levator ani muscle in the maintenance of SUI has recently been questioned however. Levator avulsion diagnosed with 3D/4D pelvic floor ultrasound and on MR was found not to be associated with symptoms of SUI or urodynamic stress incontinence (USI) [6–8]. These findings are intriguing as they contradict commonly held expert opinion. In order to further elucidate the role of levator ani muscle defects in the pathogenesis of SUI, we performed a study to determine the relationship between avulsion and the urethral motion profile (UMP), a recently developed method to study urethral mobility [9]. As it is believed that the levator ani muscle is important for urethral support and fixation, one would expect to see altered urethral mobility in women with evidence of major levator trauma. Our hypothesis

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was defined as follows: 'Levator avulsion is associated with altered urethral mobility as determined by UMP'.

2. Materials and methods

We included 305 consecutive women referred for multichannel urodynamic testing (Neomedix Acquidata, Neomedix, Hornsby, NSW, Australia) and 4D pelvic floor ultrasound imaging between December 2006 and July 2008 in this study. All patients had undergone an interview, a clinical examination (ICS POP-Q) [10] and 4D transperineal ultrasound. The ultrasound was performed in the supine position after bladder emptying using a GE Voluson 730 Expert system (GE Medical Systems, Zipf, Austria) equipped with 8–4 MHz curved array volume transducer with acquisition angle of 85° as previously described [11,12]. Volume acquisition was performed at rest, on maximum Valsalva and on pelvic floor muscle contraction. At least three Valsalva maneuvers were performed for each patient. Volume data of the Valsalva resulting in the greatest degree of pelvic organ descent was for the assessment of urethral mobility.

Levator status was determined at the time of the original assessment. Volumes on pelvic floor contraction (or at rest in those patients unable to contract) were utilised for the assessment of muscle integrity. Tomographic ultrasound imaging (TUI) was used to diagnose levator avulsion as previously described [13]. Image slices were obtained in the axial plane at 2.5 mm slice intervals, from 5 mm caudal of the plane of minimal hiatal dimensions (defined as the minimal distance between the posterior aspect of the symphysis pubis and the anterior border of the levator ani in the mid-sagittal plane) to 12.5 mm above that plane, in order to encompass the entire puborectalis muscle (see Fig. 1). A complete avulsion was diagnosed if the reference slice as well as the two slices cranial to the reference slice showed an abnormality of the muscle insertion on the inferior pubic ramus (i.e., slices 3–5 in Fig. 1), a methodology that has been validated against pelvic organ support [14]. Good repeatability of the sonographic diagnosis of levator avulsion (kappa ≥0.7) has been demonstrated by the authors and others [6,13,15].

Data analysis was performed on a desktop PC using the proprietary software 4D View version 5.0 (GE Medical Ultrasound Kretz GmbH, Zipf, Austria) by the second author several months after the original assessment, blinded to any clinical or ultrasound data. Volume datasets obtained at rest and during the most effective Valsalva maneuver were used for numerical evaluation. The urethra was divided into 5 equal segments with 6 points (Point 1–6) marked evenly along the urethra from the bladder neck (Point 1) to the external urethral meatus (Point 6) as identified in the mid-sagittal view. Measurements of the point coordinates were taken at rest and on maximal Valsalva. Mobility vectors of the 6 points were calculated using the formula SQRT $((x_{\text{valsalva}} - x_{\text{rest}})^2 + (y_{\text{valsalva}} - y_{\text{rest}})^2)$ as previously described (x = vertical distance from the dorsocaudal margin of the pubic symphysis; y = horizontal distance from the dorsocaudal margin of the pubic symphysis) (see Figs. 2 and 3) to determine the urethral motion profile (UMP). Our method of studying the UMP has been shown to have good to excellent repeatability [9].

As the manual determination of UMP coordinates is very time consuming, a semi-automated program was developed utilizing an Excel macro allowing automatic determination of x and y coordinates of the 6 points relative to the dorsocaudal margin of the symphysis pubis on a bitmap imported from 4D View. A test–retest series of 120 mobility vectors performed by the first and

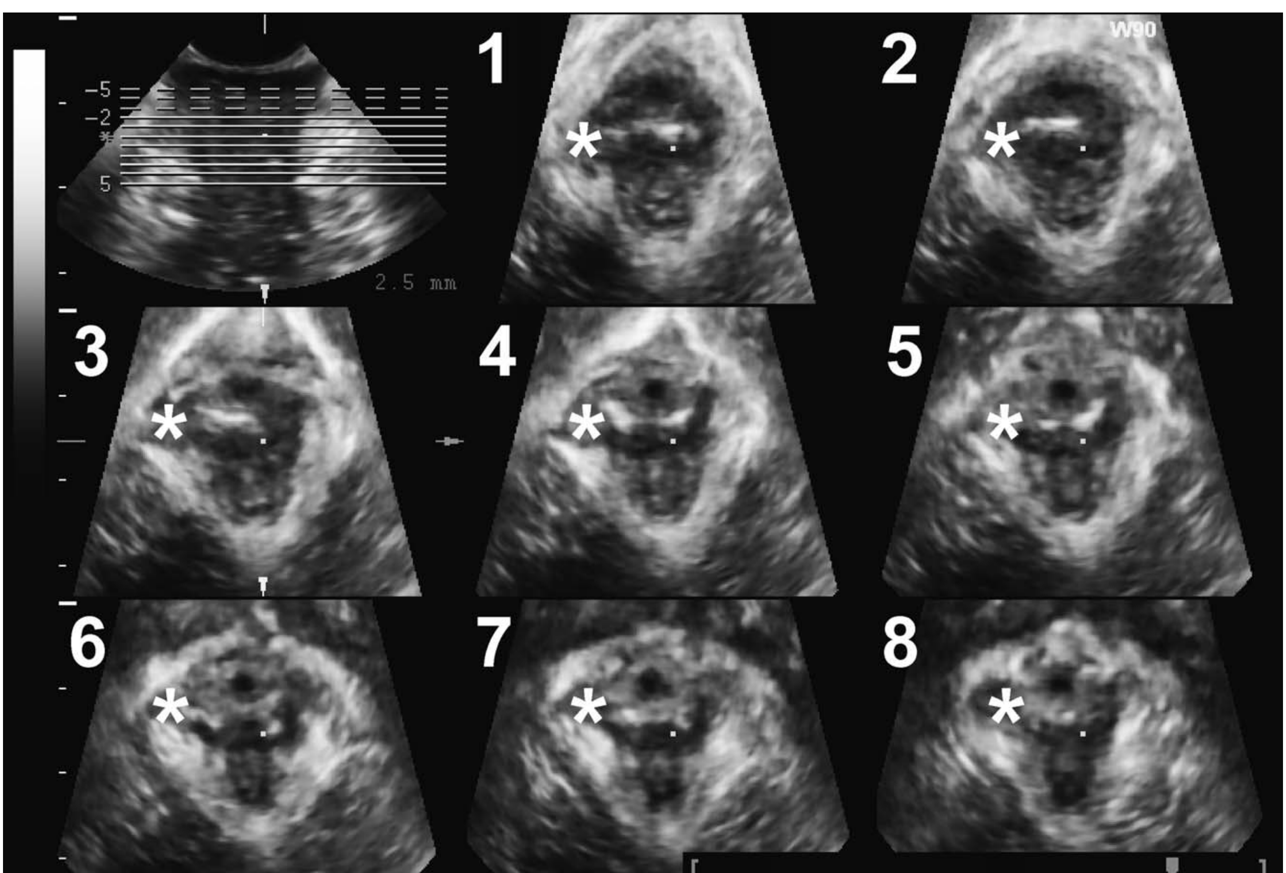

Fig. 1. Tomographic ultrasound imaging (TUI) showing a right-sided levator avulsion. The defect is marked with '*'.