Original article

An EMG needle technique for validation of external opening of urethra by levator plate during micturition

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Abstract: Background: At present, the commonly accepted notion is that the pelvic floor muscles relax, allowing micturition and defecation to take place. Significant observational x-ray data evidence indicates that there is an active striated mechanism which opens out both the urethra and anorectum during micturition. Micturition studies with an EMG cylindrical electrode positioned in the posterior vaginal fornix demonstrated that these contractions preceded the onset of urine flow. In the 1990 Integral Theory publication and subsequently, it was hypothesized that both levator plate and conjoint longitudinal muscles of the anus activate this external opening mechanism. However, this has never been demonstrated by direct needle EMG. *Aim* to develop EMG methodology to measure levator plate contraction, thought to be a key element of this active opening mechanism. *Methods:* Using ultrasound guidance, an EMG needle was inserted halfway between the anus and coccyx, 1.5cm laterally from the midline position to a depth of approximately 1.5 cm. *Results:* The needle EMG showed that muscle contraction preceded urine flow. *Conclusions:* The technique, though successful, is not easy to perform accurately and requires ultrasound guidance for accurate needle placement. Further studies are proceeding.

Key words: EMG; Levator plate; Micturition; Pelvic floor contraction.

INTRODUCTION

In 1990, the Integral Theory of Female Urinary Incontinence[1] hypothesized that the urethral closure on stress and opening during micturition were activated by an external striated muscle mechanism, directional muscle forces stretching the surrounding tissues (Figures 1-3). Closure was activated by 3 striated muscle vectors, forward (m.pubococcygeus), backwards (levator plate) and downwards (conjoint longitudinal muscle of the anus) (Figure 2). Micturition was almost the same except that the forward vector (m.pubococcygeus) relaxed, while the posterior vectors (levator plate and the conjoint longitudinal muscle of the anus) contracted (Figures 1, 3); this causes the urethra to funnel, lowering the resistance to flow by the expulsive action of the detrusor.

All hypotheses require objective testing. Only the distal closure mechanism (Figure 2) was demonstrated in 1990. Abdominal ultrasound testing demonstrated distal urethral closure from behind on straining and coughing.[1] Video x-ray proof for closure and micturition was offered in 19932 and again in 1997.[3,4] In 1997, a cylindrical EMG located in the posterior vaginal fornix showed evidence of pelvic floor contraction during coughing and micturition, in the latter, preceding urine flow (Figure 3).[3,4] Video x-ray studies indicated that contraction of levator plate was also most likely a critical part of anorectal closure and evacuation[5] (Figures 1, 3). A finite element model based on known stretch extension characteristics of the components of the vagina and urethra indicated that the pressure generated by the detrusor during micturition was deficient by at least two orders of magnitude as regards opening pressure.[6]

Though highly suggestive of an external striated muscle action during closure and micturition, none of these investigations were able to definitively demonstrate contraction of the levator plate as hypothesized.

Our aim was to develop a repeatable method for location

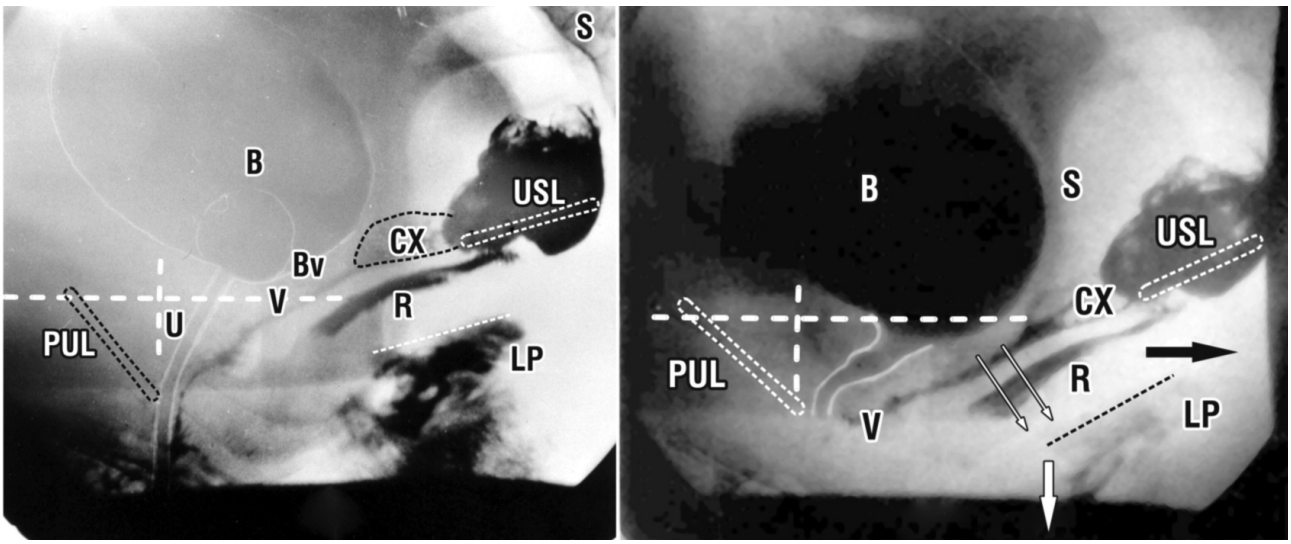

Figure 1. – **Left side.** Bladder (B) in resting position. Patient sitting. Slow twitch contractions angulate the urethra (U), vagina (V) and rectum (R) around the pubourethral ligament (PUL). 10ml dye has been injected into the levator plate (LP). CX=cervix; USL=uterosacral ligament. S=sacrum. Vertical and horizontal broken lines indicate bony co-ordinates.
Right side. Micturition. The urethra has moved backwards suggesting relaxation of the forward vector (cf. fig. 2). Vagina and rectum appear to have been stretch backwards by a backward vector (arrow) . The anterior part of LP has been angulated downwards, seemingly pulling open the posterior urethra.

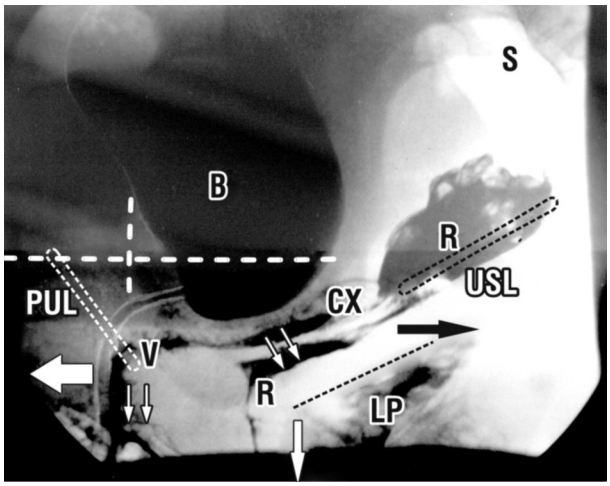

Figure 2. – **Patient straining.** Same patient and labeling as fig1. Exactly the same directional movements have occurred as in micturition: backward/downward stretching of bladder base, vagina & rectum around PUL to 'kink' the proximal urethra and anorectal angle. The distal urethra and vagina have been pulled forwards of PUL beyond the vertical co-ordinate.

and testing of levator plate contraction so as to allow us to challenge both theories[1,5] for truth or falsity. The experiment was performed under the umbrella of existing IRB approval from Nanjing University for needle EMG studies of the pelvic floor.

PATIENT AND METHODS

The EMG test was performed on a 57 year old para 1 patient who presented with chronic constipation but no urinary symptoms of incontinence or evacuation. We used the technique described by Berglas and Rubin.[7] The patient was digitally examined and asked to strain. A spot was marked halfway between the coccyx and anus. The needle was inserted 1.5 cm laterally from the midline position to a depth of approximately 1.5 cm. Its exact location was monitored initially with a 6MHz curvilinear transperineal ultrasound probe, then with a 6 MHz intravaginal probe. The position was checked on the EMG monitor by asking the patient to cough. Because of concerns for displacement of the needle, the variables were kept to a minimum for this first testing, in that the patient was asked to micturate into a commode, with no urodynamic monitoring of detrusor pressure or flow. Prior to initiating micturition, the needle position was confirmed by coughing. The initial loss of urine was marked on the graph, and the experiment was repeated on a 2nd patient.

RESULTS

The EMG (Figure 5) shows clearly that levator plate contraction precedes urine loss during micturition. We found the EMG signal was more concentrated during micturition rather than during resting, but it was weaker than the straining contraction and cough maneouvre registered.

DISCUSSION

This is the first report of levator plate contraction demonstrated directly during micturition. We found that use of the ultrasound probe was essential for accurate placement of the EMG needle. Movement of the needle during an activity was a major concern, as the patient had to come off the bed onto a commode. This issue, movement of the needle, caused us to vastly simplify our original intended methodology which was to test all the elements deemed essential for finally proving the complex series of events hypothesized to occur during micturition.[1]

Ideally, this would consist of placing an EMG needle into the anterior portion of pubococcygeus to confirm its relaxation during micturition. Also a needle needs to be located into the conjoint longitudinal muscle of the anus (LMA) to confirm its contraction. Ideally, a double transducer would also be needed in the urethra and bladder so simultaneous measurements pressure could be taken.

Adding another two EMG needles and urodynamics would have exponentially increased the complexity of measurement. As the EMG and urethral components of the pressure measurement are highly sensitive to movement, we felt that complex measurements at the initial testing were not possible. Therefore, we felt it was not possible to monitor more than one variable.

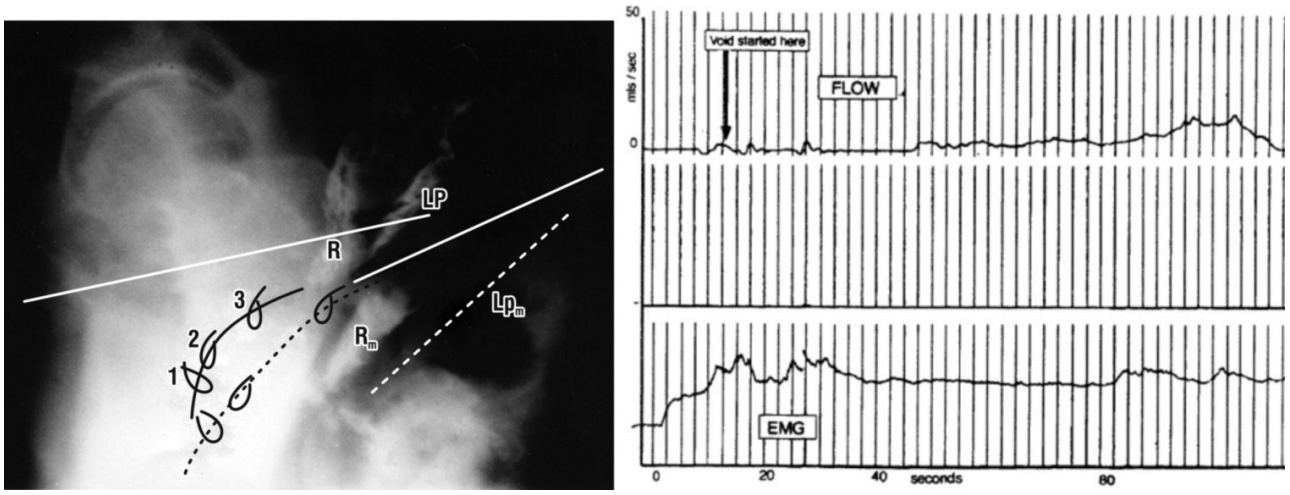

Figure 3. – **Left side.** Micturition x-ray superimposed on resting. Vascular clips have been applied to the midurethra '1'. Bladder neck '2' and bladder base '3'. Radio-opaque dye has been injected into the levator plate LP, which has been angulated downwards during micturion, as has the rectum 'R', which barium paste.
Right side. Surface EMG cylinder placed in the posterior fornix of the vagina simultaneous with uroflowmetry. The EMG shows that muscle contraction precedes urine flow.

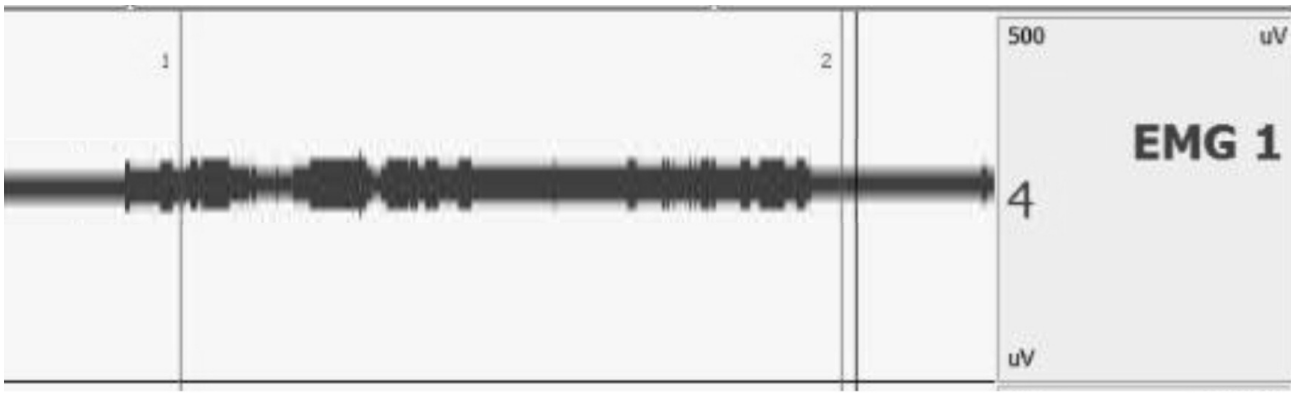

Figure 4. – **Needle EMG during micturition.** Micturition commenced at 1 and finished at 2. EMG contraction preceded urine flow.

CONCLUSION

The technique is the first step in proving the hypothesis proposed by the Integral Theory, that micturition is an active process: relaxation of the forward vector followed by contraction of he backward vector to open out the posterior wall of the urethra. Though successful, levator EMG is not easy to perform accurately. Ultrasound monitoring is an essential part of the methodology. Our initial results appear to demonstrate that levator plate contraction precedes micturition. We are proceeding with more studies which we hope will further elucidate this and other pelvic muscle actions such as coughing, straining and defecation.

There are no conflicts of interest.

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