Hypothesis

A hypothesis for urinary stream divergence in the female: unilateral dislocation of the pubovisceral muscle

KAY U. SCHEFFLER[1], PETER E. PETROS,[2] AND OLIVER W. HAKENBERG[1]

[1]*Dept. of Urology, University of Rostock, Rostock, Germany*
[2]*University of NSW, St Vincent's Medical School, Sydney*

Abstract: Objective: Cure of diverted urinary stream with TFS tensioned minisling pubovisceral muscle re-attachment Aim and hypothesis: To surgically correct a urinary stream divergent to the left side hypothesized to be caused by right pubovisceral muscle (PVM) avulsion. *Patient and Methods*: The patient presented with a divergent urinary stream to the left side with deficient right PVM attachment to the symphysis. Micturating cystography confirmed diversion of bladder neck and proximal urethra to the right side during micturition. A TFS U-Sling was used to re-attach the dislocated PCM to the tissues behind the pubic symphysis. *Results:* The direction of the stream returned to normal , the USI was cured and both conditions remained cured at 12 months review. *Conclusion:* We hypothesize that the TFS U-Sling works by penetrating the PVM fascia to "reglue" it to the tissues near ATFP origin, restoring the insertion point of the right backward urethral opening vectors and therefore, urinary stream direction.

Key words: Diverted Urinary Stream; Pubovisceral Muscle Dislocation; TFS U-Sling; Minisling.

INTRODUCTION

Pelvic floor trauma during delivery followed by age-related alterations of collagen /elastin distribution can lead to dysfunctional symptoms in women such as incontinence, abnormal emptying, urge and chronic pain.[1] More recently, avulsion of the pubococcygeus/puborectalis complex, now known as the "pubovisceral muscle" (PVM), at childbirth has been reported as an association of anterior vaginal wall prolapse.[2]

A complex case is reported in which a right-sided tear of the PVM was symptomatic with a urinary stream diverging to the left. Ethics approval was not required as this patient was treated according to standard hospital care. Informed consent for the surgery was obtained as was the patient's permission for publication of her case.

MATERIALS AND METHODS

A 69 year old woman reported with a poor urinary stream which diverted to the left side. On average, she had 3 incontinence episodes per day, especially when coughing but no urgency.

There was moderate laxity of the suburethral vaginal hammock but no urine loss with coughing. Palpation of the pubovisceral muscle attachments to the pubic bone showed a gap in the muscle layer on the right side which was located just next to the bladder neck. This spot was also very tender on palpation.

Video-urodynamic study: Normal bladder capacity (610 ml), early bladder filling sensation (80 ml), no detrusor hyperactivity, normal compliance. On micturition, the bladder neck and proximal urethra moved towards the right pelvic wall (Figure 1), the maximum flow rate was 8 ml/sec, the residual volume 40 ml. The urine stream diverted to the left.

SURGERY

We hypothesized that the left-sided stream deviation was caused by dislocation of the PVM. The aim of surgery was therefore to re-attach the collagenous insertion point of the PVM to the posterior aspect of pubic symphysis. We accomplished this by using the Tissue Fixation System (TFS) "U-sling" procedure (Figure 2). A full thickness incision was made in the anterior vaginal wall between bladder neck and the hysterectomy scar. The bladder was dissected off the vagina. A channel was dissected below the descending pubic ramus to the insertion point of the ATFP. The anchor was inserted and the tape was tightened to restore the laterally displaced tissues to their correct position more medially.

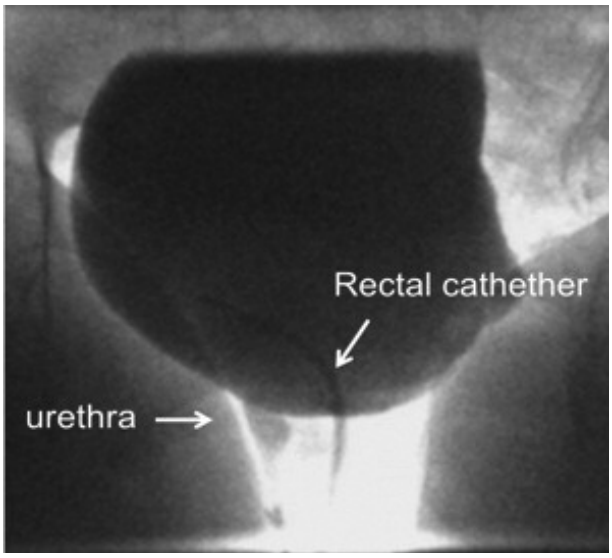

Figure 1. – Fluoroscopy at the start of micturition shows a rapid and marked movement of the proximal urethra towards the right pelvic wall.

Video TFS minisling surgery for 4th degree prolapse log onto www.integraltheory.org

RESULTS

First Follow up: This was done at four weeks after surgery. The urinary stream was now straight (normal) and the stress urinary incontinence was cured (no pad use). The anterior vaginal wall prolapse was entirely cured.

Post-operative Voiding Cystography showed a slight rotation of the bladder base, much less than before, with a straight urinary stream.

One year later pelvic re-evaluation was repeated, with identical results. The urinary stream remained straight.

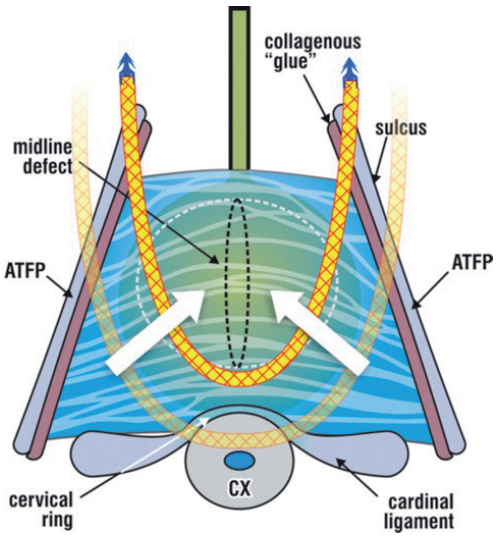

Figure 2. – U-sling procedure using the TFS, which re-attaches connective tissue structures, in this case, the aponeurotic fascia covering of the pubovisceral muscle (PVM) to the origin of the ATFP. As the tape is tightened, the tissues are restored to their more medial position (white arrows), closing the herniation, and reinforcing the anterior vaginal wall.

DISCUSSION

To the best of our knowledge this is the first case report of successful surgical cure of a divergent urine stream. It is also the first application of the TFS tensioned minisling for re-attachment of an avulsed pubococcygeus/puborectalis ("PVM") to its attachment point to the symphysis pubis. We used the "regluing" principle reported in the animal experiments which preceded the prototype midurethral sling operation : the tape created an artificial pubourethral neoligament and glued the tape to everything it came into contact with. In this case, the TFS applicator penetrated the connective tissues adjacent to the avulsed muscle and advanced it towards the posterior surface of the pubic symphysis where it penetrated tissues in the general area of the origin of the ATFP.

Other than a description of "splitting",[3] we could find no reference to incidence, causation or management in the female.

Pubovisceral muscle re-attachment operations Dietz et al[4] described 15 patients where they attempted to re-attach the displaced PVM using sutured mesh, with, however, a 74 % prolapse recurrence rate. Rostamina et al.[5] recently reported re-attachment of a dislocated PVM using ultrasound guided microsurgery, successful at 6 months. Our methodology does not rely on sutures to maintain the integrity of the anatomical restoration. The TFS anchor has a 2.5Kg pull out force which we consider sufficient to maintain PVM re-attachment during the healing period. We see a technical problem with the Rostamina method: any muscle tissue deficiency will make it impossible to re-attach the ruptured PVM with sutures. The TFS tape overcomes the "gap" problem as it creates a collagenous neoligament around the tape, using the same principle as the original TVT operation.

As regards the divergent urinary stream, we attribute this to the unbalanced action of the pubococcygeus/levator plate complex. In 1993, video xray studies demonstrated posteriorly acting directional muscle forces acting during micturition.[1] These were attributed to the levator plate muscle, which is the fused product of the lateral pubococcygeus muscle as they sweep behind the rectum to form the levator plate. We attribute restoration of the urinary stream direction to re-attachment of the right muscle to its retropubic attachment point.

We believe that rupture of the right PVM and right pubourethral ligament (PUL) resulted in the right PVM remnant pulling the urethra and bladder base to the right against an intact left PUL at the commencement of micturition. At micturition, the urethra is shortened and opened out (funneled) by bilateral backward/downward acting muscle vectors acting against PUL (see appendix). If the right muscle is ruptured, only the left side of the urethra can be tensioned, shortened and pulled open. The urinary stream diverges to the left.

Strengths of our paper. Description of a reproducible single incision minimally invasive operation for re-attachment of dislocated PVM muscles.

Weakness of our paper. The dislocation, though clinically obvious, was not confirmed by MRI.

CONCLUSION

We have described cure of a diverted urinary stream using a minimal technique which re-attaches the pubovisceral muscles and an anatomical rationale for causation of a diverted stream. Hopefully this will open the door to further research on a problem about which very little is known.

SUPPLEMENTARY MATERIAL

1. The Appendix details the anatomical basis for the hypothesis of urinary diversion.
2. The video demonstrates the TFS U-Sling operation. The video is of 2005 vintage. Nevertheless, the principles of the technique remain unchanged.

CONFLICT OF INTEREST

Scheffler, Hakenberg nil. Petros invented the TFS sling, infracoccygeal sacropexy operation and co-invented the TVT.

CONTRIBUTIONS OF EACH AUTHOR

Scheffler performed the assessment, diagnosis and postoperative followup. All authors participated in the decisions for surgery, the surgery and the writing of the manuscript.

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APPENDIX

The anatomical basis for the hypothesis

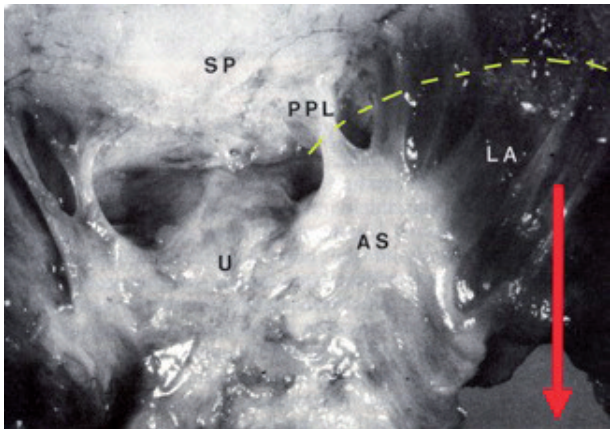

Figure 3. – The divergent insertions of the pubourethral ligament (PUL) into symphysis pubis (SP) and levator ani muscle (LA) and its aponeurotic sheet (AS). LA is equivalent to pubococcygeus muscle (PCM), but not necessarily pubovisceral muscle (PVM), as PUL does not insert into puborectalis which with PCM forms part of PVM. The PCM muscles sweep around the rectum to join and form part of levator plate, which contracts during micturition (red arrow).
The yellow line represents dislocation of LA from SP. During micturition, LA muscle still contracts (large red arrow), but against the left PUL, so the urethra and bladder base are pulled to the right. Photo from Zacharin RF, by permission.

In this next section, we provide the flow mechanics background for our hypothesis. In essence, it involves active opening out of the urethral outflow tract by an external musculoelastic mechanism driven by two striated muscle vectors, backward, levator plate and downward, conjoint longitudinal muscle of the anus. This has been validated by EMG and video X-ray studies.[1,2]

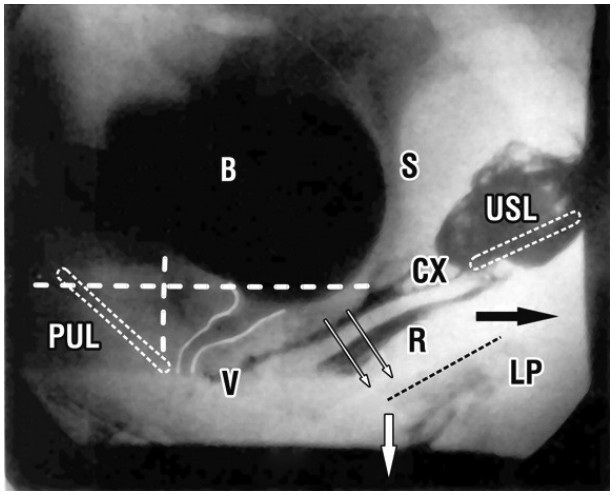

Figure 4. – Micturition X-ray. Levator plate (LP) vector pulls the bladder base and urethra backwards; the downward vector (white arrow) pulls downward on the posterior wall of the urethra opening it out "funneling". This action effectively shortens the urethra. This action also relies on LP being tensioned from pubic symphysis to sacrum. If the right side of LP is ruptured, only the left side can be tensioned, so only the left side is shortened. This scenario explains urinary stream divergence to the left and "spraying", as there will be a smoother flow of urine on the left side and much more turbulent flow on the right side. The important factor here is that the frictional resistance between the urine flow and the urethral wall is exponential, inversely to the 5th power of the radius.

$$\Delta P = P_{ves} - P_0 = \frac{8\rho Q^2 Lf}{\pi^2 d^5} + \frac{1}{2}\rho V^2 - \rho g \Delta h$$

This explains descriptions of a good stream on one side, with "splitting", a dribble on the other side

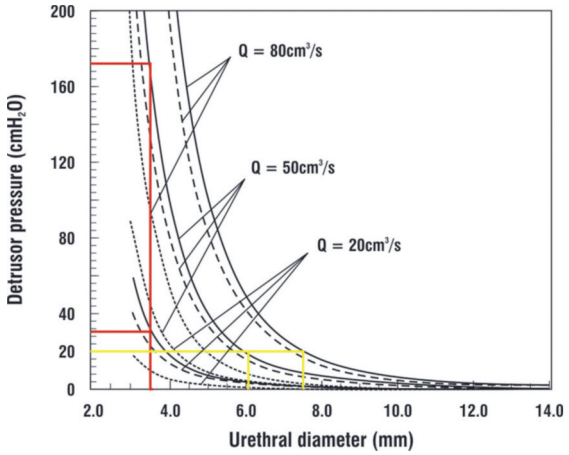

Figure 5. – Figure 5. The pressure flow curve is exponentially determined. Detrusor pressure as a function of the urethral diameter. For a tube length of 4 cm . . . . . , frictional component; - - - - - , dynamic component; _____ , total. A detrusor pressure of 30cm H2O is required to drive the urine out of a smooth tube 3.5cm in diameter at a flow rate of 20ml/sec . 170 cm pressure is required to achieve a flow rate of 50ml/sec.

"Splitting" and a diverted urinary stream are different.

The frictional and dynamic components of urethral resistance are exponentially determined and they apply to the right and left walls of the urethra. Inability to stretch one wall explains a good stream on one side and dribble on the other. Diversion is different. It requires rupture of the pubourethral ligament also.

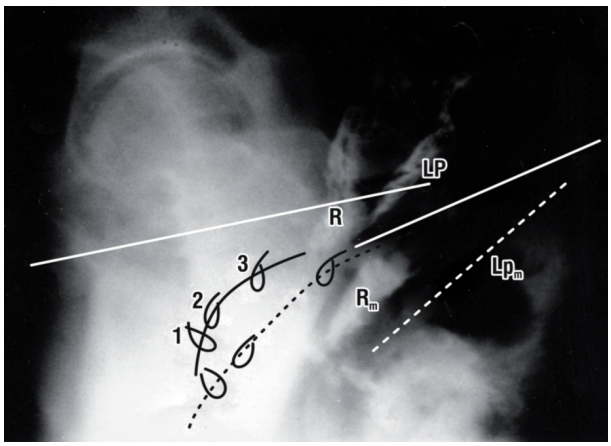

Figure 6. – Upper figure X-ray proof of an external musculoelastic mechanism pulling open the posterior urethral wall. Micturition (broken lines) X-ray superimposed on resting X-ray (unbroken lines). Clips have been applied to the anterior vaginal wall, '1', midurethra, '2' bladder neck, '3' bladder base. Note downward/backward displacement of clips '1,2&3'. The levator plate (LP) and rectum (R) are angulated downwards. Downward movement of clip '1' may indicate active contraction of the lower level muscles of the pelvic floor, such as bulbocavernosus and ischiocavernosus, opening out the posterior wall of the distal urethra. Clips 1 & 2 also indicate the movement of the distal half of urethra which is closely attached to the vagina. The broken lines and the subscript 'm' indicates the position of the LP and R during micturition. Vascular clips on anterior vaginal wall were stretched apart backwards and downwards. Intraabdominal forces are said to cause downward movement, but they could never initiate the backward stretching seen in figure 2. Only a muscle contraction can achieve this.

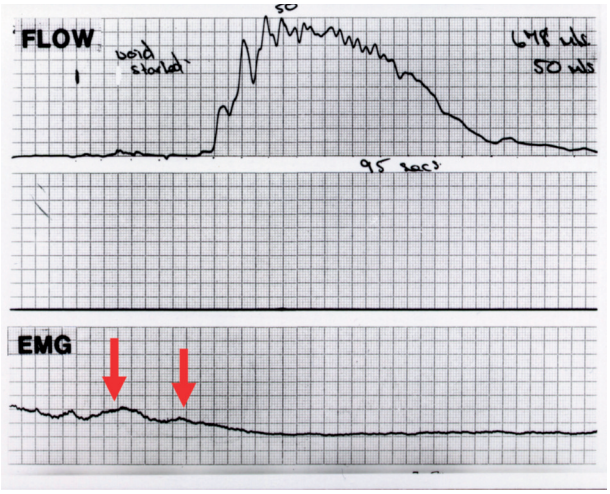

Figure 7. – Lower figure EMG in the posterior fornix of the vagina demonstrates commencement of muscle contraction (arrows) prior to commencement of voiding. This observation is consistent with active opening out of the outflow tract so as to decrease resistance to flow.

APPENDIX REFERENCES

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Correspondence to:

Prof. Peter Petros
Email: pp@kvinno.com