

## The integral theory and its tethered vagina syndrome revisited: vaginal scarring may cause massive urinary incontinence

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### Introduction

Total urinary incontinence (UI) in women after successful obstetric fistula surgery is very common but has received very little attention with regard to its aetiology. Centres repairing obstetric vesico-vaginal fistulae commonly report a 95% fistula closure but fail to mention that up to 55% remain incontinent [1]. Reports of pain and UI following vaginal mesh insertion to cure pelvic organ prolapse brought a warning from the USA Food and Drug Administration (FDA) in 2011. The great majority of these women with these widely disparate conditions remain untreated because the mechanism has not been understood. The pathogenesis of these conditions has a common origin, scar tissue fibrosis of the anterior vaginal wall (Fig. 1).

With regard to closed obstetric fistula but persistent UI, trans-vaginal ultrasonography and urodynamics testing by the senior author did not help elucidate the cause of the UI. Treatment with anticholinergics and bladder drill showed some minor improvement in some patients with mixed detrusor instability and stress UI, but not sufficient to continue. The use of a Martius fat graft has not stood the test of time and suburethral slings have not been an effective treatment.

To understand what has happened to these obstetric fistula women and those with UI after pelvic mesh surgery the 'Integral Theory' of urinary continence first described by Petros and Ulmsten [2] in 1990 must be revisited. This was treated with derision at the time by many urologists who could not understand it and did not know what to do about it.

### Integral Theory

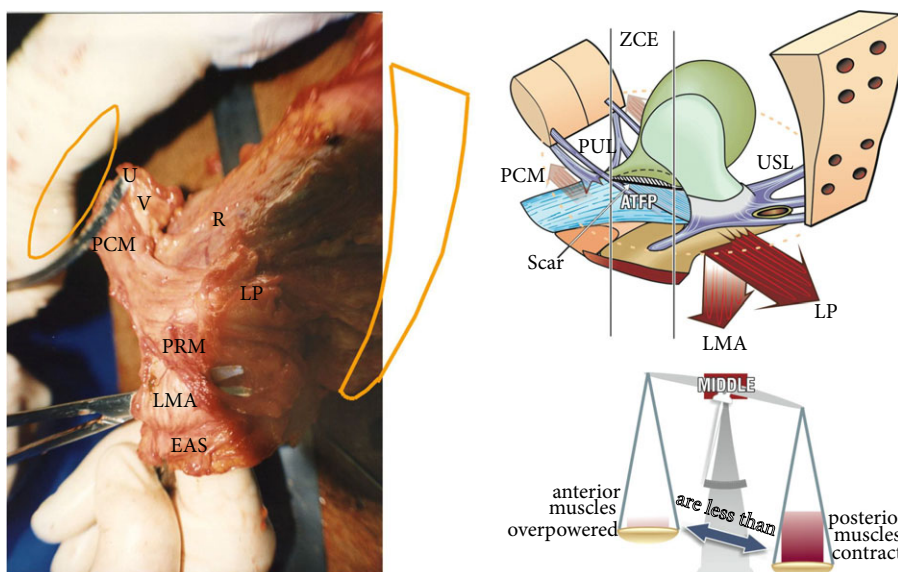
The Integral Theory evolved from anomalies discovered during the development of the midurethral sling operation

[2]. It states: oppositely acting striated muscle vector forces contract against competent pubourethral ligaments to enact two separate mechanisms for closure, the first at the distal urethra and the second at the bladder neck (Fig. 1). To allow them to act separately, these closure vectors require adequate elasticity in the bladder neck area of the vagina, the 'zone of critical elasticity' (ZCE; Fig. 1). If vaginal elasticity at the ZCE is compromised in any way, e.g. by mesh sheets inserted behind the vagina for prolapse, excision of vagina by 'native tissue repair', over-elevation by Burch colposuspension, and especially, necrosis and scarring in patients with obstetric fistulae, severe uncontrollable UI may occur. This condition was described as the 'tethered vagina syndrome' (TVS) [2,3] and it was cured by insertion of a skin graft in the anterior vaginal wall [3]. The mechanism for UI with TVS is mechanical (Fig. 1); the backward-acting vectors, overcome the weaker forward-acting vectors, forcibly opening the posterior urethral wall [2,3]. The classic symptom of TVS is massive uncontrollable urine loss immediately on getting out of bed in the morning. In severe cases, such as after obstetric fistula repair the UI is total, day and night. Cure requires surgical restoration of elasticity in the anterior vaginal wall by a skin graft [3–5] plus reconstruction of the pubourethral ligament, as this is inevitably severed during preliminary urethrolysis.

### UI after Vesico-Vaginal Fistula Repair

The authors [4] hypothesised this was an extreme form of TVS and that this condition could be repaired using a Singapore skin flap added to standard urethral reconstruction and reconstruction of the pubourethral ligament, optimally performed prophylactically during the fistula repair. There is only one criterion for application of a mesh graft to the vagina. Once the vagina has been fully dissected off the pubic bones and the urethra, the vagina is inspected. If there is a gap between the two sides of vagina, then a skin flap is

**Fig. 1** Mechanism for post-fistula repair leakage. Left - Cadaveric specimen cut away from the skeleton. Bladder and vagina excised at the bladder neck level. The pubococcygeus muscle (PCM) sweeps around behind the rectum to join the contralateral PCM to help form the levator plate (LP), which inserts into the posterior wall of the rectum. The conjoint longitudinal muscle of the anus (LMA) takes fibres from the PCM and LP, and descends vertically to insert into the external anal sphincter (EAS). The puborectalis muscle (PRM) sweeps around the rectum to attach directly onto the symphysis pubis anteriorly. A small 'pimple' directly to the right of the PCM label is the divided pubourethral ligament (PUL); R, rectum; U, urethra; V, vagina; pubic symphysis and sacrum are drawn figuratively in yellow. Right - In the normal patient, the three opposite vectors, PCM, LP, LMA (arrows) are in balance. *Normal distal closure mechanism* – the PCM (forward arrow) contracts forwards against a competent PUL to close the distal urethra. *Normal proximal mechanism (bladder neck closure)* – the LP stretches the distal urethra backwards against the PUL; the downward vector LMA contracts down against the uterosacral ligament (USL) to close the now tensioned urethra at the bladder neck in the manner of a ball valve. The 'zone of critical elasticity' (ZCE) of the anterior vaginal wall extends from the mid-urethra to the bladder base. Adequate elasticity is required at the ZCE to allow the separate action of the opposite vector forces of the PCM and LP (arrows). ATFP, arcus tendineus fasciae pelvis. *Post-fistula repair UI due to TVS* – When scarring occurs, the opposite vectors are joined (tethered). The stronger posterior vectors LP/LMA overcome the weaker forward vector of the PCM to forcibly pull open the posterior urethral wall. The now weakened forward vector of the PCM is indicated by a faint pink arrow. This opening action exponentially decreases the internal resistance to flow. Urine is lost uncontrollably.



required, as any forcible approximation of vaginal tissue will likely lead to the problems of TVS. All the organs, bladder, urethra, ureters, rectum are individually assessed for damage and are appropriately repaired. Any repair has to mimic the anatomy. If a urethra is destroyed, a smooth muscle tube has to be fashioned that connects with the detrusor; a pubourethral ligament-like structure has to be fashioned at mid-urethra to prevent stress UI, and a layer of skin fashioned below the urethra to re-constitute a suburethral vaginal hammock [4].

The initial results from this surgery were dramatic [5]. The technique used consisted of a Singapore flap (a skin graft of groin crease skin with attached blood supply), mid-urethral sling, and urethral smooth muscle reconstruction from detrusor, as required [5]. The results from this technique for the worst cases (those previously considered inoperable, those with huge defects and/or multiple previous operations) are detailed below.

When prophylactically applied at the time of primary fistula repair in 52 women who had an average tissue gap of 2.6 cm,

66% were totally cured [5], with 'cure' defined as 100% dry. As a comparison, historical data from similar cases repaired exactly the same way but without the skin flap, only 19% were cured [5]. In the secondary group of 36 patients who remained incontinent after successful vesico-vaginal fistula repair (average tissue gap 2.2 cm), 83% were completely dry compared to only 23% in the historical series without flaps [5].

### Conclusion

Anterior vaginal wall scarring removes elasticity that is critical for the separate functioning of the two urethral closure mechanisms in the female [2]. This condition is known as the 'tethered vagina syndrome' (TVS) [2–5]. It is a major unrecognised cause of massive UI, particularly in patients with vaginas scarred by mesh sheet or other surgery, and especially successful repair of obstetric fistula. Whatever the cause, cure requires a skin graft to restore vaginal elasticity and pubourethral ligament repair by mid-urethral sling, both being essential for

## Comment

normal urethral closure. It is possible that TVS after prolapse repair may be prevented by not excising the vagina and not implanting mesh sheets, thus preserving elasticity.

## Conflict of Interest

Gordon Williams, Andrew Browning: None. Peter E. Petros: Principal author of the 'Integral Theory' and discoverer of the 'tethered vagina syndrome'.

## References

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**Abbreviations:** TVS, tethered vagina syndrome; UI, urinary incontinence; ZCE, zone of critical elasticity.