



A practical ligament-based diagnostic system for cure of pelvic symptoms and prolapse

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Contributions: (I) Conception and design: All authors; (II) Administrative support: All authors; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: The Integral Theory Paradigm (ITP) has a 25-year track record of successfully treating bladder/bowel/pain symptoms caused by laxity in specific ligaments, even when the prolapse is minimal. The ITP-based treatment involves ligament support and can be nonsurgical or daycare surgical. An accurate diagnostic protocol is required. The Integral Theory Diagnostic system is performed in an outpatient setting. It a step-by-step “how to” resource for clinicians who wish to learn a practical anatomical diagnostic method which can quickly and accurately identify a ligament cause for bladder/bowel/pain symptoms, and therefore, potentially cure them. The structured ITP diagnosis flow chart uses symptoms to diagnose anatomical defects. It comprises 4 related steps. The ITP is holistic, and bladder, bowel, pain symptoms co-occur. The first step, therefore, is to establish all possible symptoms for transfer to the Diagnostic Algorithm which is the second step. Because patients complain of one main symptom, other symptoms must be located by direct questioning, using the Diagnostic Algorithm as an aide memoire, or a questionnaire to locate bladder, bowel, pain symptoms. Second step: symptoms are placed into 3 anatomical zones: anterior zone, pubourethral ligament (PUL) [stress urinary incontinence (SUI)]; middle zone, cardinal ligament (CL) (transverse defect cystocele); posterior zone, uterosacral ligament (USL) (uterine prolapse and enterocele). The third step is a vaginal examination to confirm the ligament damage (prolapses) in the three zones predicted by the algorithm. The fourth step is “simulated operations” (mechanical support of specific ligaments per vaginam) to validate the particular ligament indicated by the diagnostic algorithm, is indeed causing that symptom. For SUI, a hemostat test at midurethra supports PUL vaginally to stop urine loss on coughing; the lower blade of a bivalve speculum gently inserted into the vagina can relieve urge and pain.

Keywords: Diagnostic algorithm; pelvic organ prolapse (POP); pelvic symptoms; vaginal examination; simulated operations

Submitted Jul 12, 2023. Accepted for publication Jan 31, 2024. Published online Apr 18, 2024.

doi: 10.21037/atm-23-1759

View this article at: <https://dx.doi.org/10.21037/atm-23-1759>

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Introduction

The key points of the article are summarized in the video abstract (Videos S1-S3).

“It is not sufficient to describe an anatomical structure. An answer is required to the question, what is it for.”—Salvador Gil-Vernet (1892–1987) Famous Spanish Anatomist and Urologist and Nobel Prize nominee.

The Diagnostic System of the Integral Theory Paradigm (ITP) (1,2) is a practical guide designed for everyday clinical use (Figure 1). It is structured, anatomical, and symptom-based.

Why the ITP structured diagnostic system is different?

The ITP flow chart (Figure 1), is the only diagnostic system for diagnosing the anatomical causation of bladder/bowel/pain symptoms in existence. It is a 4-step comprehensive diagnostic system.

Why is a structured diagnostic system necessary?

Simply stated, patients complain of only one main problem, the “tip of the iceberg” (3) (Figure 2). Only a structured questionnaire can identify all patient symptoms. In Figure 2, the main complaint in 198 women (3) was chronic pelvic pain (CPP). The other pelvic symptoms were “under the surface” and were diagnosed by the use of the Integral Theory Symptom Questionnaire (ITSQ) (4). The structured diagnostic system (Figure 1 flow chart), located

many other bladder/bowel/pain symptoms which were present “below the surface”, but were not volunteered by the patients.

The structured assessment diagnostic system is summarized in a diagnostic flow chart

It is a comprehensive clinical assessment, recording and testing tool to determine ligamentous causes of pelvic symptoms and prolapse.

Figure 1 comprises 4 parts: (I) the validated ITSQ, locates symptoms; for the (II) diagnostic algorithm for initial diagnosis of ligament causation; which guides the (III) vaginal examination to confirm specific prolapses and ligament damage; which guides performance of (IV) “simulated operations” to confirm ligament pathogenesis: hemostat test to (i) relieve urine loss on coughing, speculum test to relieve urge and chronic; (ii) CPP, which more securely guides surgical or nonsurgical treatment.

Part I of the flow chart—the validated patient questionnaire (ITSQ)

With reference to the diagnostic flow chart (Figure 1), the Structured Assessment System begins with a completed questionnaire (4) (Figure 3) which uses an actual clinical case as an example: a parous woman with symptoms of stress urinary incontinence (SUI), overactive bladder (OAB) (urge, frequency, nocturia), abnormal emptying, CPP, and 4th degree cystocele and uterine prolapse.

Please note: the same clinical case example in the questionnaire [1], is used for the Algorithm [2] and for the examination sheet [3]. The results from pubourethral ligament (PUL) and uterosacral ligament (USL) surgery are written in red in the questionnaire.

How to use the ITSQ

The ITSQ (Figure 3) is a validated questionnaire and was designed to be self-administered (4). However, experienced clinicians advise more clarity of the answers can be achieved by direct questioning by the physician. “Sometimes” answers are ticked in the algorithm columns, even when incidence is low.

A,M,P (A_{anterior} , M_{middle} , $P_{\text{posterior}}$), on the left side of the questionnaire, indicate zones of connective tissue (ligament) looseness. The appropriate columns, A,M,P, are ticked in the algorithm (see marked example, Figure 4). “TVS” on

Highlight box

Key findings

- A practical diagnostic system which diagnoses ligamentous causation of bladder/bowel/pain symptoms.

What is known and what is new?

- Many bladder/bowel/pain symptoms are said to have unknown pathogenesis and to be, in the main, incurable.
- A holistic, comprehensive, step by step practical method for locating and guiding the repair of ligaments to cure or improve bladder/bowel/pain symptoms.

What is the implication, and what should we change now?

- The algorithm indicates which ligaments may cause bladder/bowel/pain symptoms, which can be confirmed by simple outpatient tests.
- Adoption of the diagnostic algorithm, as a standard assessment tool in women with bladder/bowel/pain symptoms, accurately guides ligament causation and helps guide decisions for surgery.

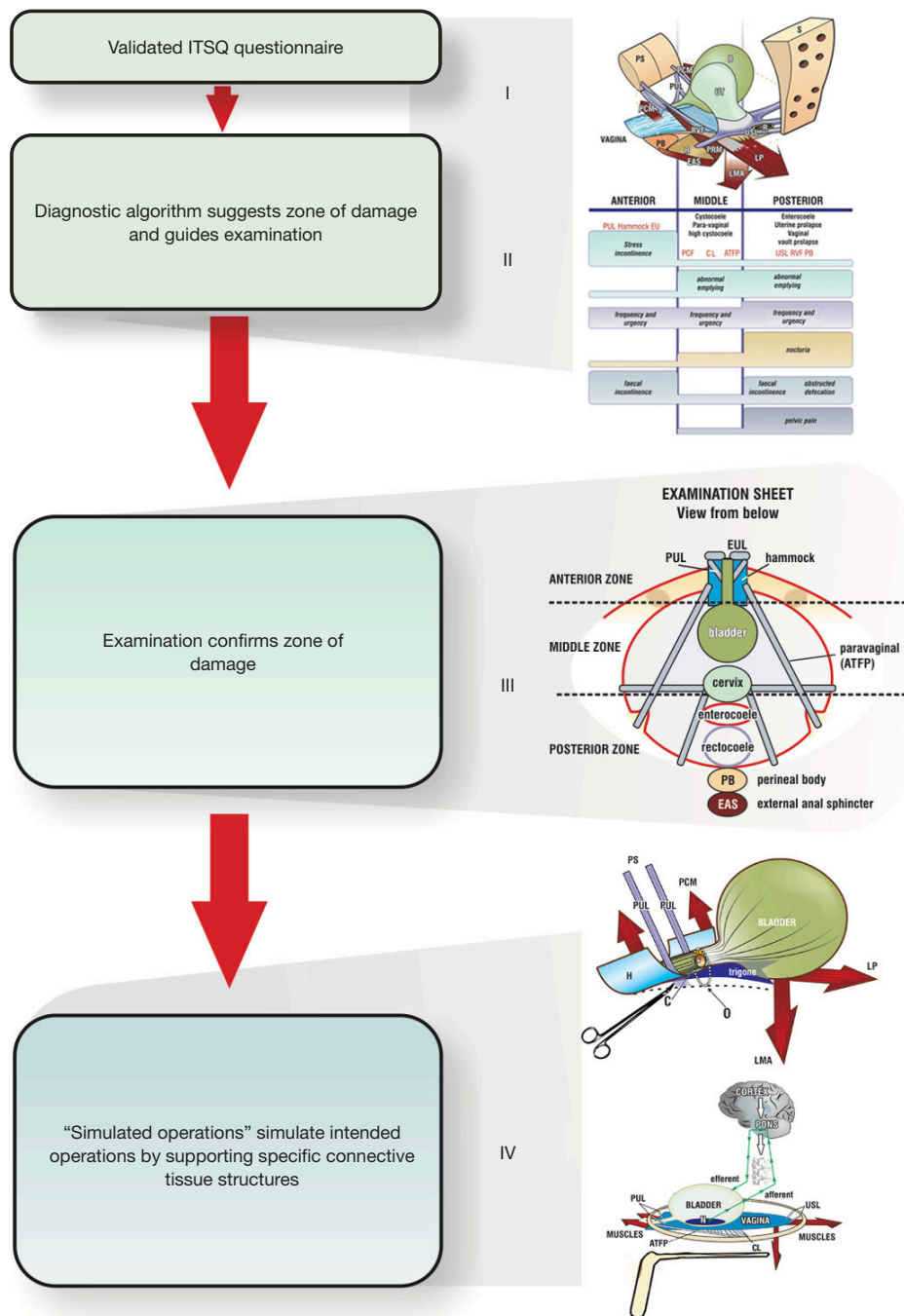


Figure 1 The diagnostic system flow chart has 4 parts: (I) the validated patient questionnaire ITSQ; (II) the pictorial diagnostic algorithm; (III) vaginal examination; (IV) simulated operations. Reused from (1). With permission from Peter Petros; retains ownership of the copyright. ITSQ, Integral Theory Symptom Questionnaire; S, sacrum; B, bladder; PS, pubic symphysis; PCM, pubococcygeus muscle; PUL, pubourethral ligament; UT, uterus; R, rectum; USL, uterosacral ligament; RVF, rectovaginal fascia; PB, perineal body; PRM, puborectalis muscle; EAS, external anal sphincter; LMA, conjoint longitudinal muscle of the anus; LP, levator plate; EUL, external urethral ligament; PCE, pubocervical fascia; CL, cardinal ligament; ATPF, arcus tendineus fascia pelvis; H, suburethral vaginal hammock; C, closed; O, open.

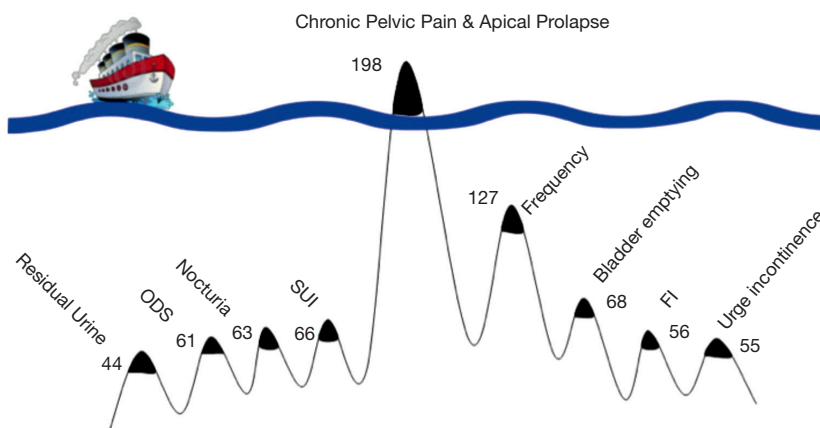


Figure 2 The Pescatori Iceberg diagram applied to CPP. Reused from (3). Copyright 2017, with permission from the *Pelviperrineology*. The presenting symptom was CPP. Symptom prevalence is graphically indicated in the iceberg diagram. Latent symptoms are below the waterline, are numbered according to their prevalence and were derived from the ITSQ (4). CPP, chronic pelvic pain; ITSQ, Integral Theory Symptom Questionnaire; ODS, obstructive defecation syndrome; SUJ, stress urinary incontinence; FI, fecal incontinence.

the left side signifies the question relates to the Tethered Vagina Syndrome (TVS), a condition caused by scarring or tightness in the bladder neck area of the vagina (middle zone), usually iatrogenic.

The diagnosis of ligament looseness and prolapse is then visually read off from the algorithm (see marked example, *Figure 4*).

The numbers 1–11 in the left column of the questionnaire explain the anatomical basis of the questions. This part is for the physician only and is located at the end of each questionnaire (see *Appendix 1*). The red writing shows the post-operative symptom results from midurethral and uterosacral sling operations.

Part II of the flow chart—the diagnostic algorithm

With reference to the diagnostic flow chart (*Figure 1*), answers from the questionnaire have been marked in each of the three columns (zones) of the algorithm (*Figure 4*). The algorithm indicates that the patient has four potentially damaged ligaments, PUL, cardinal ligament (CL), USL, perineal body (PB), and potential prolapses in all three zones:

- ❖ Anterior zone: suburethral vaginal hammock and external urethral ligament (EUL);
- ❖ Middle zone: cystocele;
- ❖ Posterior zone: uterine/apical prolapse and enterocele.

A diagnosis of ligament causation of symptoms and prolapse is indicative of pathogenesis, but it has to be

checked by vaginal examination and “simulated operations” (*Figure 1* flow chart).

Adoption of the diagnostic algorithm as a standard assessment tool in women with bladder/bowel/pain symptoms accurately guides ligament causation and helps guide decisions for surgery (see *Appendix 2* for a clear copy of the diagnostic algorithm).

The algorithm used as a stand alone diagnostic tool

The diagnostic algorithm (*Figure 4*) can be used by itself, as a simple stand-alone diagnostic tool as part of every vaginal operation. The clinician uses the algorithm as an “aide memoire” and asks the questions directly. The algorithm is sufficiently accurate from a diagnostic perspective, and it ensures that every symptom and every prolapse is searched and recorded (see *Table 1*).

Part III of the flow chart: vaginal examination

This is a “how to” instruction of what the ligament defects and prolapses predicted by the algorithm in each zone look like. At the end of the vaginal examination, the clinician completes the examination sheet for each individual patient, where the clinician records the findings for all the three zones. The examination sheet records ligament defects and degree of prolapse. It also serves as an aide memoir to ensure all three zones are examined.

Patient Questionnaire

Self administered patient questionnaire

Part I Personal Details

Name: _____ Date: _____
 Address: _____ Date of birth: 20/5/82
 Telephone: _____
 Weight: _____ kg
 Number of vaginal deliveries (3)
 Number of caesarean sections (0)

Part II Symptoms

Describe in your own words your main urinary symptoms and duration:
 I can't hold on. Get up 4-5 times a night.
 I lose urine on coughing.
 I have pain in my lower abdomen.

All sections: tick appropriate square. Write extra details if you wish.

A. Stress Incontinence (SI) Symptoms

	No	Yes some-times	Yes 50% or more
Do you lose urine during:			
(A) Sneezing	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> *
(A) Coughing	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> *
(A) Exercise	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> *
(A) (1) Walking	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(A) (2) Stooping, squatting or getting up from a chair	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<i>dry</i>			
(P,M) Symptoms of deficient emptying			
(3) Do you feel that your bladder isn't emptying properly?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(3) Do you ever have difficulty starting off your stream?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(3) Is it a slow stream?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(3) Does it stop and start involuntarily?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<i>good stream</i>			

Ant & post sling 31-1-08 rectocolle P/B Post-op 8-7-08

(P)(10) Pelvic pain

	No	Yes some-times	Yes 50% or more
Do you have deep pain on intercourse?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you have a pain down at the bottom of your spine?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Do you have a pain down at the bottom of your abdomen?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(11) Do you have pain at the entrance to your vagina?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

pain cured 100%

Quality of life grading

Please circle a grading between 1 and 5 to describe the effect that incontinence has on your normal activities. 1 is low impact, 5 is high impact.

1 = normal
 2 = mild, no effect on lifestyle
 3 = can't drink, must locate toilets on going out
 4 = always wears pads, very restricted social life
 5 = totally housebound.

(P) AFTER INSERTION OF TAMPONS

	CHANGE IN SYMPTOMS		
	None	Yes 25%	Yes 50% or more
1. Feeling of urgency		<input checked="" type="checkbox"/>	
2. Bladder pain			
3. Pelvic or vaginal pain			<input checked="" type="checkbox"/>
4. Nocturia (write the number of times)			
3 (previously 5)			

Figure 3 Self-administered patient questionnaire. A,M,P (A_{anterior}, M_{middle}, P_{posterior}), on the left side of the questionnaire, indicate zones of connective tissue (ligament) looseness. The numbers 1–11 in the left column of the questionnaire explain the anatomical basis of the questions. This part is for the physician only and is located at the end of each questionnaire (see Appendix 1). The red writing shows the post-operative symptom results from midurethral and uterosacral sling operations. Reused from (1). With permission from Peter Petros; retains ownership of the copyright.

Figure 5 is the actually completed examination sheet record of the ligament defects and degree of prolapse found in each of the three zones of the patient's ITSQ completed questionnaire (Figure 3, see Appendix 3 for a clear copy of the examination form, see Appendix 4 for a clear copy of the questionnaire form).

Typical examination findings of anatomical defects in the 3 zones

The Figures 3–5, which are generic figures, demonstrate what to look for in the vaginal examination; they are not necessarily related to the ITSQ patient example given previously.

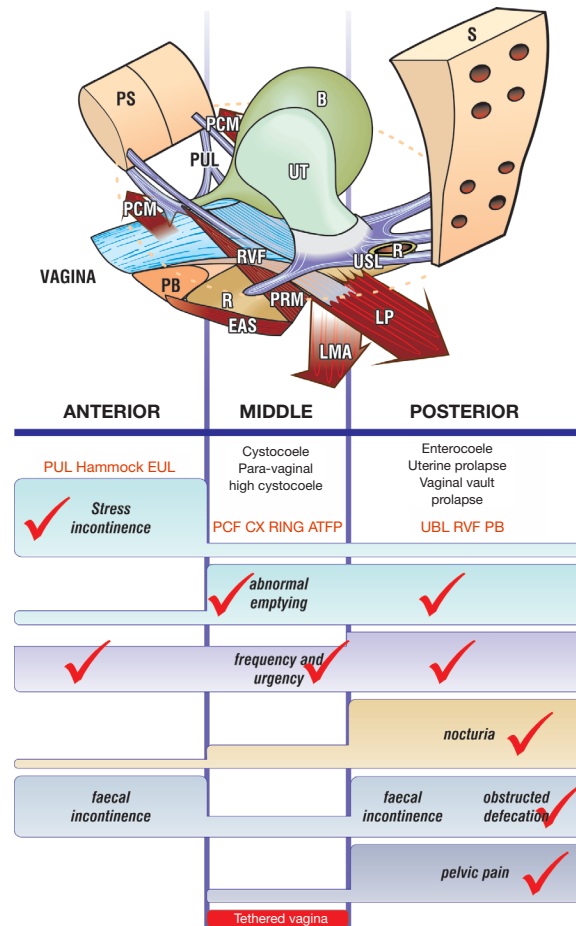


Figure 4 Patient algorithm has three zones of causation (ligament damage). It is marked with ITSQ answers. The prolapses in the algorithm correlate with ligament damage in the columns. Symptom groupings in the columns help deduce which ligaments cause which symptoms. Anterior zone runs from the external meatus to the bladder neck, and comprises EUL, PUL, suburethral vaginal hammock, and dislocated collagenous insertion of PCM also known as “levator avulsion”. Middle zone runs from the bladder neck to the anterior cervical ring and comprises PCF, CL, and ATFP. Posterior zone runs from the cervix to the PB. It comprises USL, RVE, and PB. Reused from (1). With permission from Peter Petros; retains ownership of the copyright. S, sacrum; B, bladder; PS, pubic symphysis; PCM, pubococcygeus muscle; PUL, pubourethral ligament; UT, uterus; R, rectum; USL, uterosacral ligament; RVE, rectovaginal fascia; PB, perineal body; PRM, puborectalis muscle; EAS, external anal sphincter; LMA, conjoint longitudinal muscle of the anus; LP, levator plate; EUL, external urethral ligament; PCF, pubocervical fascia; CX RING, cervical ring; USL, uterosacral ligament; ITSQ, Integral Theory Symptom Questionnaire; CL, cardinal ligament; ATFP, arcus tendineus fascia pelvis.

Anterior zone examination for PUL damage

PUL laxity, the main cause of SUI, cannot be visually confirmed by the presence of a prolapse. It can only be confirmed by the hemostat test (Figure 6).

The patient is asked to cough; if urine loss during coughing is prevented by a hemostat gently pressed upward immediately behind the pubic bone, in the position of the midurethra, a diagnosis of lax PUL can be made (Figure 6) (see Video S4). This is recorded along with findings for

vaginal hammock and the EUL.

Unilateral hemostat support, immediately behind the symphysis at the origins of the PUL, prevents the causative elongation of the PUL to “L”, and so controls urine loss on coughing (Video S4).

Anterior zone examination for EUL damage, and hammock laxity

The function of these structures is to seal the urethra.

Table 1 How to use the diagnostic algorithm as a stand-alone tool

Instructions

- (I) Tick symptoms in every box where they occur, even if they occur only “sometimes”
- (II) Visually read off the prolapse and connective tissue structures which are potentially causing the symptom

Conditions

Nocturia, chronic pelvis pain and ODS occur only with USL laxity

Note: this simplifies diagnosis of USL causation and repair thereof

SUI of major degree is always caused by PUL weakness

Note: a midurethral sling or repair will or improve SUI and 50% urge symptoms, if it is mixed incontinence

Some symptoms, for example, urge and frequency, abnormal emptying, occur in more than one column and so may have more than one single causation

Adapted from Petros P (1). With permission from Peter Petros; retains ownership of the copyright. ODS, obstructive defecation syndrome; USL, uterosacral ligament; SUI, stress urinary incontinence; PUL, pubourethral ligament.

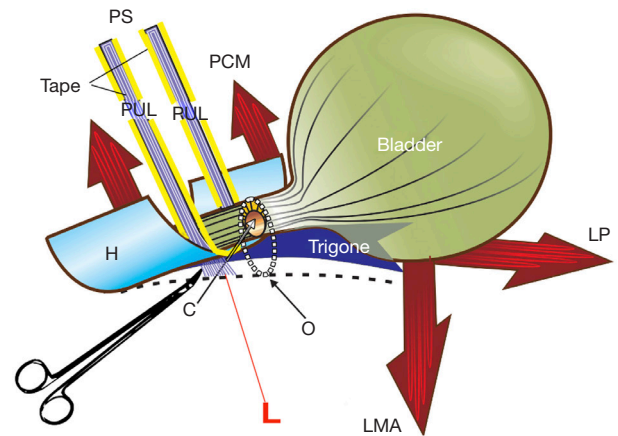


Figure 6 Anterior zone: Hemostat test. The hemostat test mechanically prevents elongation of the PUL in the same way as a midurethral sling. This is a 3-dimensional sagittal view of the bladder base and trigone supported by the vagina below (broken lines); PUL laxity “L”, allows PUL to stretch downwards; in the absence of a firm PUL anchoring point, the normal LP/LMA contraction which closes the bladder neck now forcibly opens the posterior wall of the urethra, from “C” (closed) to “O” (open), so urine is lost on effort. The hemostat mechanically prevents extension of the PUL, exactly as does a midurethral tape, so the bladder neck and distal urethra are closed as per normal. With permission from Peter Petros (1); retains ownership of the copyright. PUL, pubourethral ligament; PCM, pubococcygeus muscle; LP, levator plate; LMA, conjoint longitudinal muscle of the anus; H, suburethral vaginal hammock; C, closed; O, open; PS, pubic symphysis.

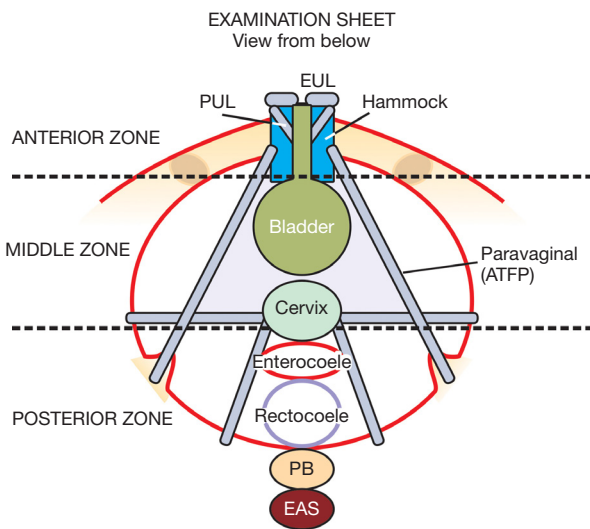


Figure 5 Completed examination sheet record. Completed examination sheet record for anatomical defects found in each of the three zones (for the completed ITSQ patient questionnaire). Reused from (1). With permission from Peter Petros; retains ownership of the copyright. ITSQ, Integral Theory Symptom Questionnaire; EUL, external urethral ligament; PUL, pubourethral ligament; PB, perineal body; EAS, external anal sphincter; ATFP, arcus tendineus fascia pelvis.

Laxity (Figure 7, right) needs to be repaired otherwise patients may say that SUI is cured but they still leak small amounts of urine, feeling like a bubble escaping.

Middle zone examination for transverse cardinal (CL) defect cystocele

A transverse cardinal defect cystocele usually has rugae and prolapses lateral to the cervix (Figure 8A).

Pathogenesis of transverse defect cystocele

The CL attachment onto the anterior cervix is stretched or torn and prolapses downwards, lateral to the cervix, taking the prolapsed vagina with it (Figure 8A). The vaginal prolapse is caused by tearing of the pubocervical fascial (PCF) attachment to the CL (Figure 8B). The pubocervical layer and the underlying vagina descend downwards like a trapdoor as a transverse defect or “high”

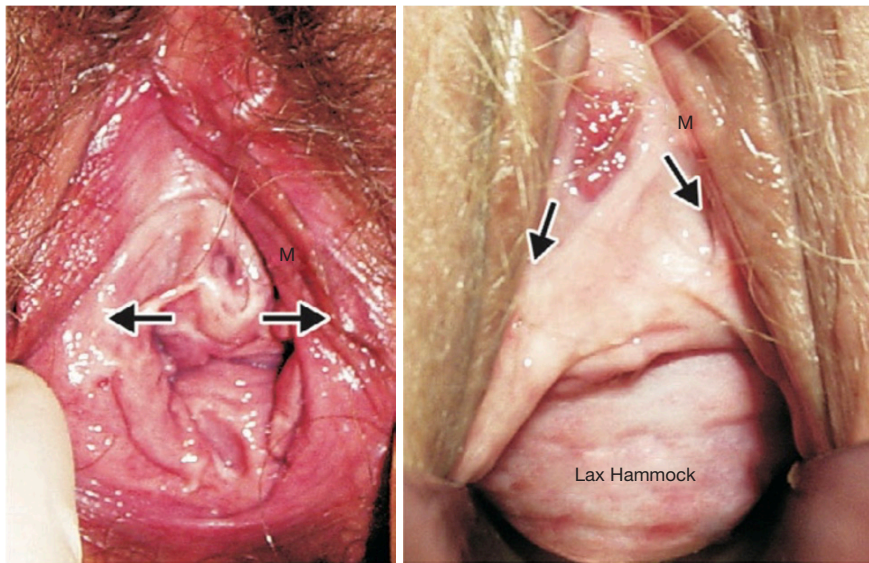


Figure 7 Anterior zone: EUL defect. Left: normal EUL. The urethral meatus (M) is well supported horizontally by the EUL (arrows) which attach it to the anterior surface of the symphysis. The hammock is in the normal plane. Note: the external urethral ligament is also called, “anterior pubourethral ligament”. Right: lax EUL and hammock. The urethral meatus (M) is lax and has caused the urethral mucosa to become everted. The lateral EUL supports are seen “drooping” downwards (arrows). The hammock is lax and angulated downwards. “Simulated operation”. Gentle mechanical support of EULs (“simulated operation”) will usually cause the everted mucosa to retract. With permission from Peter Petros (1); retains ownership of the copyright. EUL, external urethral ligament.

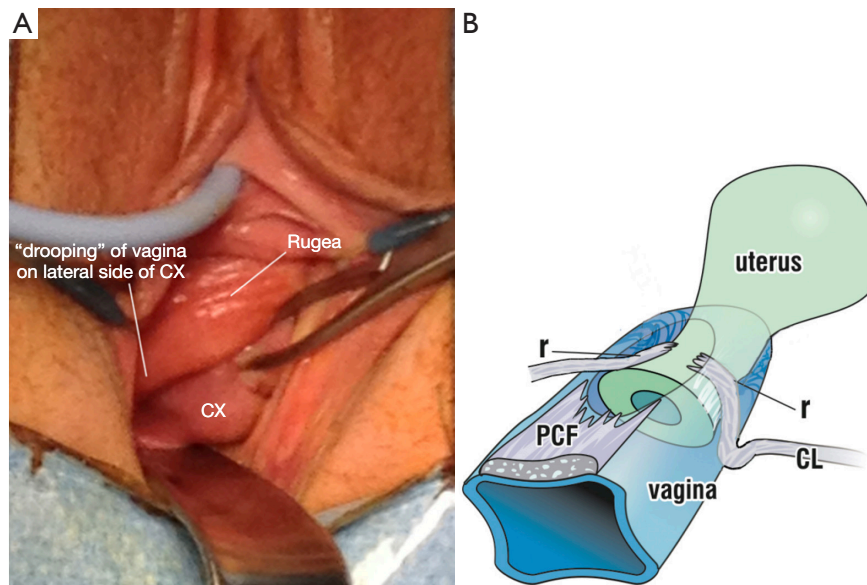


Figure 8 Middle zone: transverse defect. Findings of prolapsed vagina lateral to the CX, confirms CL dislocation or tearing. With permission from Peter Petros (1); retains ownership of the copyright. (A) Vaginal prolapse lateral to the cervix contains prolapsed “CL” as per (B); (B) pathogenesis: the vagina’s PCF, is torn from the “CL” and, now unsupported, prolapses down like a trapdoor as a “lateral defect” or “high” cystocele. r, rupture of the “CL”; PCF, pubocervical fascial layer; CL, cardinal ligament; CX, cervix.

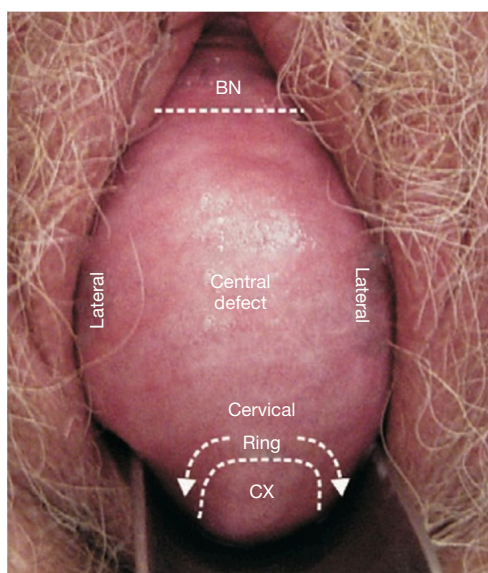


Figure 9 Middle zone: central defect cystocele and uterine prolapse. A large central defect (4th degree) extends laterally. Prolapse of the dislocated CL is seen around the CX (curved arrows), characteristic of CL/cervical ring defect. The central cystocele invariably has shiny vaginal epithelium. It is most likely caused by dislocation of the PCM from the symphysis. The central defect remained after the Allis forceps test to approximate displaced CLs and restore transverse defect. Posterior zone: uterine prolapse and cystocele, both 4th degree. The uterus is totally externalized. A dislocated CL is seen around the CX (curved arrows), characteristic of CL/cervical ring. With permission from Peter Petros (1); retains ownership of the copyright. BN, bladder neck; CX, cervix; CL, cardinal ligament; PCM, pubococcygeus muscle.

cystocele. The examination results are recorded in the examination sheet.

Clinical test for CL dislocation cause of transverse defect cystocele

With two Allis forceps, very gently grasp each side of the prolapsed vagina, lateral to the cervix (*Figure 8*), and approximate them to the midline of the cervix. The cystocele disappears.

Caution: this test must be performed with extreme gentleness so as not to cause pain.

Middle zone examination for central cystocele

Characteristically, there is a large bulge with shiny vaginal epithelium, with no obvious rugae. Invariably, there is also a transverse defect (*Figure 9*, see curved arrows, “cervical ring”).

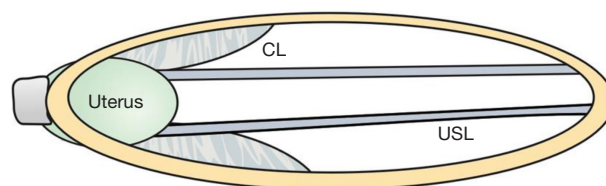


Figure 10 Posterior zone: 3rd degree uterine prolapse. Damage or weakening of the USL and CL at the entry to the birth canal contribute to uterine prolapse. Elongation of USLs also causes them to spread laterally, to cause an enterocele. It is important to remember that USLs attach to the lateral wall of the rectum with fine ligaments. As the uterus prolapses down, the anterior rectal wall may descend also, often as an intussusception. Surgical shortening and reinforcement of the USLs will also restore both the uterine prolapse and also, the intussusception (6). With permission from Peter Petros (1); retains ownership of the copyright. USL, uterosacral ligaments; CL, cardinal ligaments.

Pathogenesis of central defect is essentially unknown

Repair of dislocated pubococcygeus muscles to cure a diverted urinary stream with a USling (5), cured a central cystocele. Repeated confirmation of cure of a central cystocele as in *Figure 9*, by a USling, by several surgeons, caused us to hypothesize that its pathogenesis may be pubococcygeus muscle dislocation from the symphysis.

Posterior zone examination for USL laxity

In *Figures 9,10*, uterine prolapse of 4th degree is evident. *Figure 10* also shows that with a large degree of uterine prolapse, the CL must also be stretched equivalently. More difficult to confirm is minimal prolapse, 1st and 2nd degree, which often has the worst symptoms, and is usually only confirmed in the OR by pulling down the cervix. Clinical confirmation of such cases is by elevating the anterior vaginal wall with a speculum and asking the patient to strain down. Appearance of an enterocele confirms USL elongation. Not diagnosable by vaginal examination is the frequent co-occurrence of anterior rectal wall intussusception with uterine/apical prolapse which requires diagnosis by X-ray proctogram (6) or by ultrasound (see “Simulated operations” paper in this series).

Video S5 demonstrates that the CL plays a causative role equivalent to the USL, in 4th degree uterine prolapse, as indicated in *Figure 10*. Note in *Video S5*, how there was significant restoration of the uterine prolapse when Professor Sekiguchi tightened the CL TFS tape. Professor Sekiguchi’s restoration of uterine prolapse and cystocele by shortening

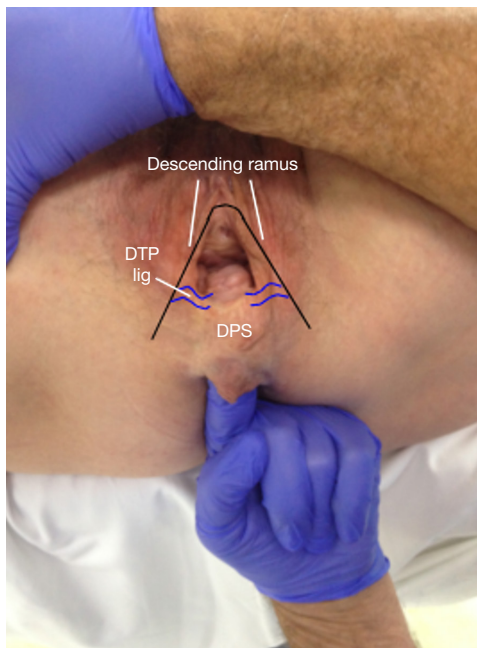


Figure 11 Posterior zone: rectal examination. DTP ligaments insert behind the junction of the upper 2/3 and lower 1/3 of the descending rami to suspend the perineal body. Reused from (1). With permission from Peter Petros; retains ownership of the copyright. DPS, descending perineal syndrome; DTP, deep transversus perinei.

and reinforcing the CL and USL (*Figure 10*), is, in fact, a more modern version of Fothergill’s Manchester Repair operation (*Video S5* is by permission of Professor Sekiguchi). **Diagnosis of minimal USL laxity**
In the outpatient clinic, lifting up the anterior vaginal wall with a speculum, and asking the patient to strain down hard can provoke an enterocele bulge in the posterior wall to confirm USL laxity.

Posterior zone examination for perineal body damage

There is a considerable bulge of the perineum on straining (*Figure 11*) (see *Video S6*). Rectal examination usually confirms that there is very little tissue between the vagina and the rectum.

Pathogenesis of perineocele and descending perineal syndrome

Rectal examination confirms flattening and lateral displacement of the perineal bodies which are usually to be found below the ischial tuberosity. The cause is elongation of the deep transversus perinei (DTP) ligaments (*Figure 12*). The lateral displacement of these structures allows

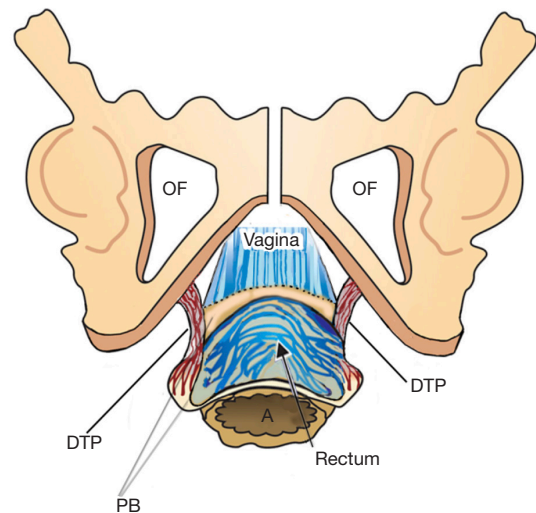


Figure 12 Posterior zone: pathogenesis of perineocele and descending perineal syndrome. Overstretching of the perineum at delivery may cause elongation of the DTP ligaments, with consequent displacement of the perineal bodies to below the ischial tuberosity. The rectum protrudes in the space of the displaced “PBs” and if the rectum’s muscular and serosal layers are ruptured, the rectal mucosa, often 1-mm thick, may adhere closely to the vagina, “PB” and pubic rami. Reused from (1). With permission from Peter Petros; retains ownership of the copyright. DTP, deep transversus perinei; OF, obturator fossa; PB, perineal body; A, anus.

protrusion of the rectum into the central space which presents as a low rectocele or perineocele. Often the serosal layer of the rectum has been breached. This allows the rectal mucosa to spread laterally and to adhere to the vagina, DTP ligaments and even the pelvic bones. If the damage is sufficient, the perineal body itself descends as “descending perineal syndrome” (7,8).

How accurate was the algorithm in predicting examination findings?

Figure 13 compares the examination sheet findings (*Figure 5*) with the algorithm predictions from *Figure 4*, (both from the ITSQ patient example):

- ❖ Anterior zone prediction—SUI confirmed by hemostat supporting the PUL.
- ❖ Middle zone prediction—cystocele confirmed.
- ❖ Posterior zone prediction—uterine prolapse, enterocele, lax perineum confirmed.

What this means: a clinician experienced in the diagnostic system can figure out fairly accurately which ligaments may

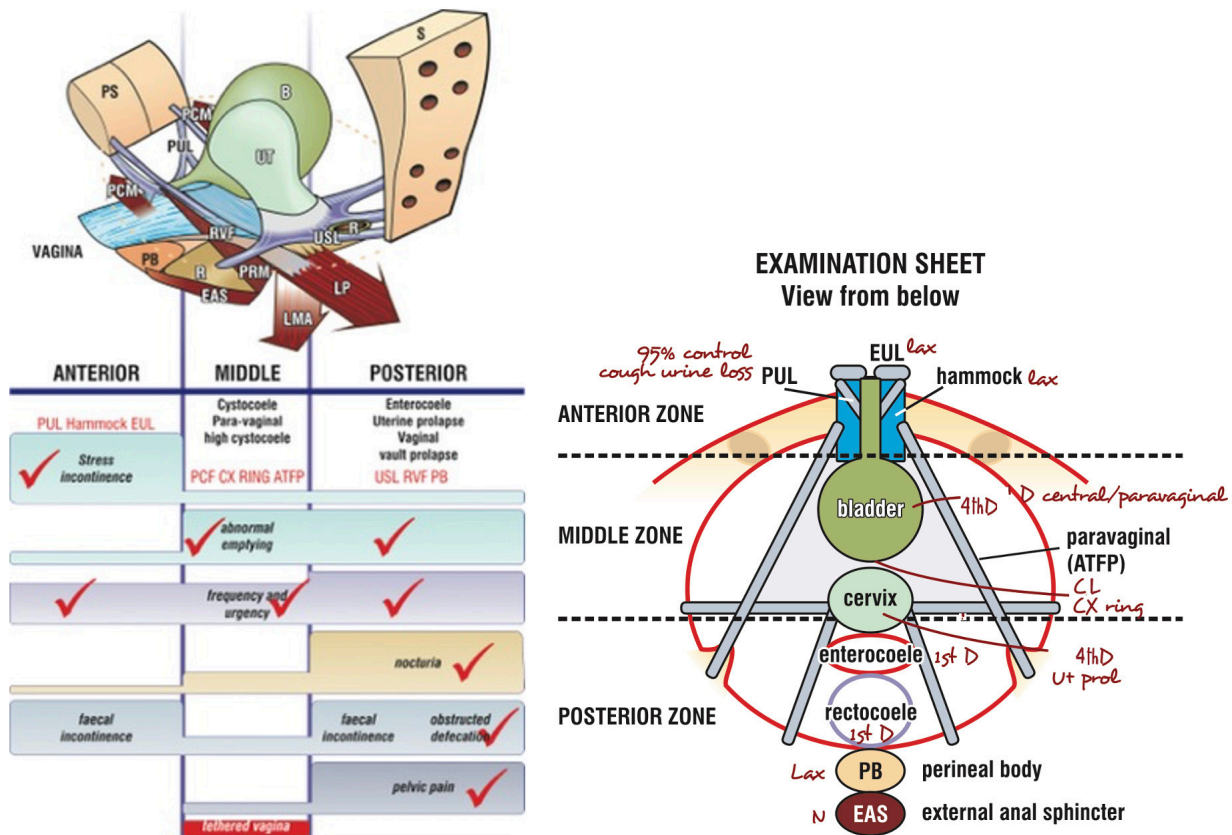


Figure 13 Testing symptom predictions of ligament damage. Comparing algorithm, *Figure 4* (left) with vaginal examination, *Figure 5* (right). Reused from (1). With permission from Peter Petros; retains ownership of the copyright. USL, uterosacral ligament; PUL, pubourethral ligament; EUL, external urethral ligament; ATFP, arcus tendineus fascia pelvis; CL, cardinal ligament; LMA, conjoint longitudinal muscle of the anus; LP, levator plate; S, sacrum; B, bladder; PS, pubic symphysis; PCM, pubococcygeus muscle; PRM, puborectalis muscle; RVE, rectovaginal fascia; UT, uterus; PCF, pubocervical fascia; EAS, external anal sphincter; PB, perineal body; R, rectum; CX, cervix.

be causing patient problems purely from the symptoms, especially where there is minimal prolapse. For example, SUI = PUL damage; pain and nocturia = USL damage; bladder emptying/retention = USL or CL, often both.

Part IV of the flow chart—simulated operations

Though simulated operations follow vaginal examination in the flow chart (*Figure 1*), they are actually performed during the vaginal examination. Specific structures such as PUL and USL, and bladder base, are mechanically supported and the change in symptoms of stress incontinence, urge and pain are observed. Many simulated operations are possible, and these are presented in detail in this Annals of Translational Medicine series in the paper, “Simulated Operations apply mechanical support to structures to confirm symptom causation”. Simulated operations for

PUL and USL, are presented here, as they have become part of a standard vaginal assessment.

Simulated operation for stress and mixed incontinence

A hemostat applied behind the symphysis mechanically supports a weak PUL and prevents PUL elongation on coughing or straining, as in *Figure 6*. If it prevents urine loss on coughing, it predicts a midurethral sling should cure or improve SUI. If the hemostat test reduces urge also, it can be predicted that the urge component of “mixed incontinence” (stress plus urge) will also be cured or improved in 50% of such women.

Confirming urinary urge and CPP objectively:speculum test (simulated operation)

The speculum test (*Figure 14*) is a simple and available test

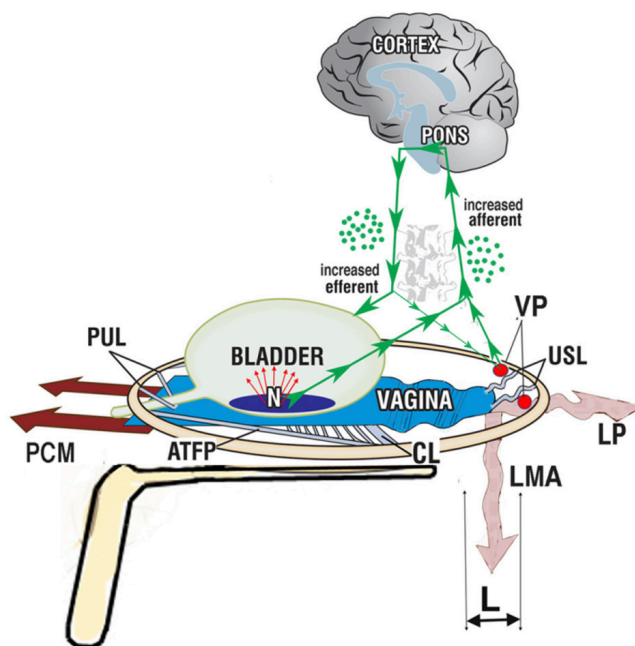


Figure 14 Speculum test (simulated operation). Gentle insertion of the speculum mechanically supports stretch receptors “N” to control urge. The speculum also supports lax USL and the VP to control pain. This test relieves pain and urge in 70–80% of women who have these symptoms. The pink wavy lines indicate weakened muscle forces, a consequence of the “LP” and “LMA” contracting against weakened USLs (L). Reused from (1). With permission from Peter Petros; retains ownership of the copyright. USL, uterosacral ligament; VP, visceral plexuses; PUL, pubourethral ligament; PCM, pubococcygeus muscle; ATFP, arcus tendineus fascia pelvis; CL, cardinal ligament; LMA, conjoint longitudinal muscle of the anus; LP, levator plate.

for determining USL pathogenesis of CPP and urgency.

Confirming nocturia objectively

Shkarupa *et al.* (9) successfully used a gauze roll inserted during the day and overnight to test eligibility of patients with OAB symptoms for CL/USL plication (9) (see [Appendix 5](#) for further references which surgically validate the predictive value of the diagnostic system).

Adding objective testing to clinical assessment

Objective investigative assessment is essentially the same as the four-part clinical assessment but adds more investigative information and objective tests. Examples in *Figure 15*, are patient diaries, pad tests (10) 2D or 3D transperineal ultrasound (11), specific urodynamic tests such as “interventional urodynamics” which mechanically support a ligament during urodynamic testing while observing the changes in the graphs (12,13). Such objective testing is standard practice in many tertiary academic centres. In some cases, such as TVS, tests such as 2D ultrasound

monitoring during straining, add a substantial layer of diagnostic certainty.

With the caveat of variability inherent in all short objective tests such as diaries, urodynamics, pad tests, the protocols detailed in *Figure 15* could be used as a starting base for a future “evidence-based” artificial intelligence (AI) diagnostic system. For example, the prototype Bayesian Network learning model (*Figure 6*), is potentially configurable for an individual demographic. *Figure 15* is a more expanded assessment tool than the clinical Structured Assessment System (1) (*Figure 1*).

Future directions: AI/Bayesian network learning

The Decision Tree Diagnostic System (*Figure 16*), contains percentage probabilities for specific input parameters. The decision tree worked accurately in the specialist referral environment where it was created. So as the decision could be more generally applied to other clinics which may have a different patient clientele, a machine learning system based on Bayesian networks which could be trained for a different

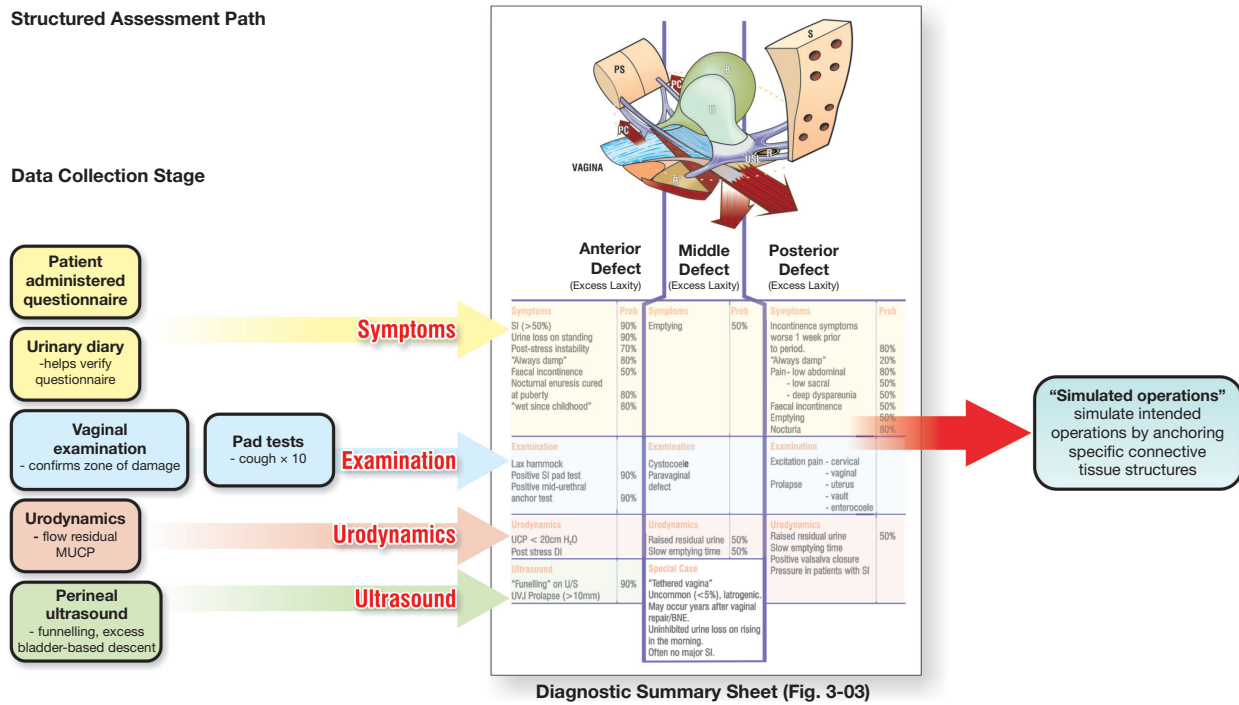


Figure 15 Tertiary referral centre investigative assessment tool. Reused from (1). With permission from Peter Petros; retains ownership of the copyright.

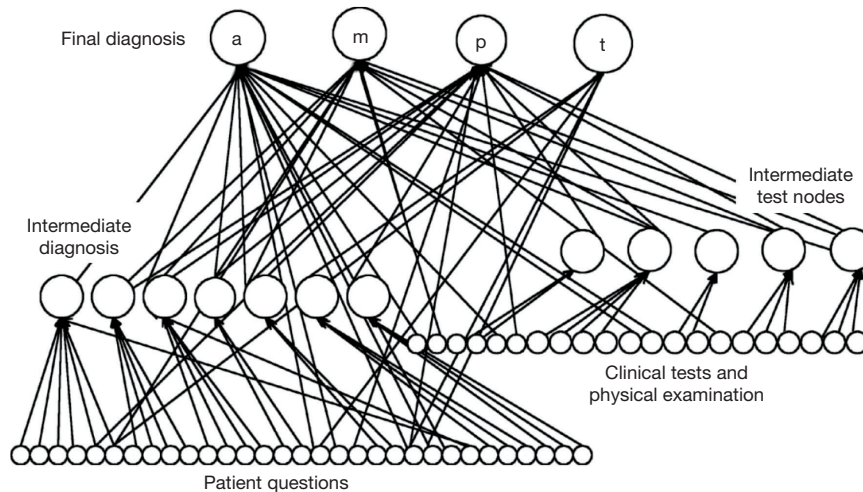


Figure 16 Schema for Bayesian Network output nodes. Top row: predicting the likelihood of defects in the anterior (a), middle (m), or posterior (p) zones, or a diagnosis of Tethered Vagina Syndrome (t). Intermediate diagnosis and test, and patient questions and clinical test nodes are as shown. Reused from (1). With permission from Peter Petros; retains ownership of the copyright.

environment and different clientele was developed by Curtin University School of Engineering, Perth, Western Australia, working with P.P. from Royal Perth Hospital (14). Matlab and the BN Toolbox were used to build the Bayesian networks. The Bayesian networks were trained using a

majority of the data samples and then tested on the balance, ensuring that the test data was unseen by the network during training (14). Tests were also done using the training data. The results obtained by querying the network, for any individual case, were compared with the diagnosis obtained

from the human expert (Peter Petros). These comparisons formed the basis of the evaluation of the system. In most cases, Bayesian networks were found to be at least as accurate as using Decision Trees, for example, *Figure 16*. An advantage of using Bayesian networks is that the accuracy, specificity and sensitivity will improve as the number of test cases available for training increases. In contrast, using Decision Trees is a relatively static process that is not easy to enhance incrementally.

Problems and some possible future directions

Each city, suburb, medical practice will have a different mix of patients. It is envisaged that a Bayesian-based learning machine will be able to train the diagnostic system to be more specific for a location, and, therefore, more accurate.

Conclusions

The ITP has a 25-year track record of curing or improving bladder/bowel/pain symptoms when it can be demonstrated they may be caused by ligament laxity, even when prolapse is minimal. Prior to undertaking any treatment, an accurate diagnostic protocol is required. The structured diagnostic flow chart is entirely clinical. It uses symptoms to diagnose anatomical defects, vaginal examination to confirm damage, and simulated operations to validate that a specific ligament is causing a specific symptom.

Acknowledgments

We would like to express our thanks to Vani Bardetta for her proofreading and administrative services for this article.

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the International Society for Pelviperineology for the series “Integral Theory Paradigm” published in *Annals of Translational Medicine*. Peter Petros (Editor) and Vani Bardetta (Assistant Editor) served as the unpaid Guest Editors of the series. The article has undergone external peer review.

Peer Review File: Available at <https://atm.amegroups.com/article/view/10.21037/atm-23-1759/prf>

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at <https://atm.amegroups.com/article/view/10.21037/atm-23-1759/coif>). The series “Integral Theory Paradigm” was commissioned by the International Society for Pelviperineology without any funding or sponsorship. Peter Petros serves as an unpaid editorial board member of *Annals of Translational Medicine* from October 2022 to September 2024. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All clinical procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for the publication of this article and accompanying images. Human participation in the video was by patient permission on the basis it was deidentified.

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Cite this article as: Petros P, Liedl B, Palma P, Riccetto C, Ding S. A practical ligament-based diagnostic system for cure of pelvic symptoms and prolapse. *Ann Transl Med* 2024;12(2):27. doi: 10.21037/atm-23-1759

Appendix 1 Explanatory notes for the clinician

A, M or P indicate the zone of damage, Anterior, Middle, Posterior.

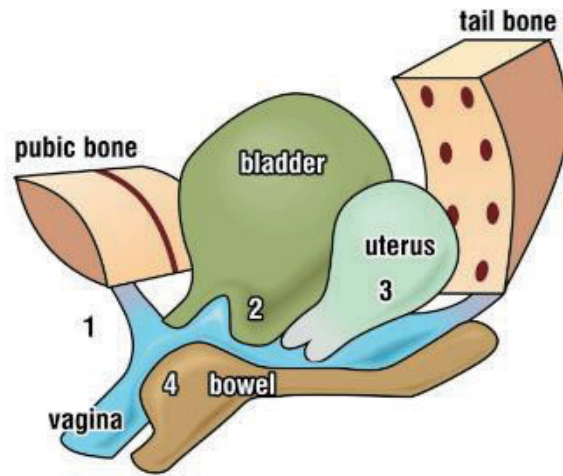
TVS indicates tightness in bladder neck area of vagina “Tethered Vagina syndrome”.

Significance of filters, (none, sometimes, more than 50%)

Symptoms vary: ‘sometimes’ indicates something is wrong; it needs marking as positive when transcribing to the pictorial algorithm.

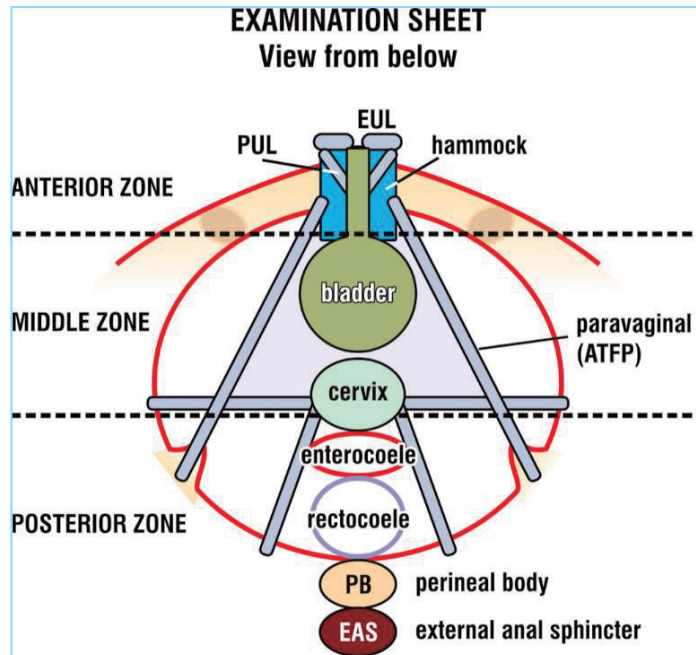
1	May be from lax EUL / hammock (urethral sealing mechanism). If so, often the patients report leakage “like a bubble of air escaping”.
2	Pubourethral ligament damage. In the age group >70 years with no previous surgery, some urine loss may occur on getting off a chair, with minimal loss on coughing, generally due to PUL (pubourethral ligament) atrophy. If previous vaginal surgery or Burch, it can be Tethered Vagina Syndrome. Check Q.5.
3.	USL laxity (enterocele, apical prolapse) may be slight. Cystocele associated with USL laxity, but can occur after excessive bladder neck elevation or an overtight midurethral sling.
4	Exclude UTI; also, cystocele for repeated UTIs, occasionally, chlamydia. Any zone defect may cause urgency: A = “mixed” incontinence (urge plus SUI); M = cystocele (cardinal ligament); P = uterine/apical prolapse (USL laxity). Nocturia and chronic pelvic pain are specific for USL defect.
5.	Exclude Tethered Vagina Syndrome (TVS) which is iatrogenic, middle zone tightness, from previous vaginal surgery or overtight Burch (tight scar at bladder neck). Classical symptom is massive urine loss immediately on getting out of bed in the morning. There is usually minimal SUI with coughing and minimal descent of bladder base on straining with ultrasound; with Burch, look for upward slope of distal vagina. Excess vaginal scarring (TVS) from Obstetric Fistula is a key cause of ongoing massive incontinence after fistula cure.
6.	Congenital PUL weakness - persisting incontinence after bedwetting as a child, also in males. This condition runs in families.
7.	Indicates borderline USL defect worsened by softening of the cervix at onset of menstruation to allow egress of blood loosens USL anchoring point. Other pelvic symptoms may occur (urge, nocturia, chronic pelvic pain).
8a.	Posterior zone defect (USL). If defecation requires digital support of the perineal body, look for low rectocele, perineocele, descending perineal syndrome (DPS). DPS is caused by weak or elongated deep transverse perineal ligaments which attach PB to medial side of descending ramus at the junction of the upper 2/3 and lower 1/3.
8b.	Defective USL and /or anal mucosal prolapse. PUL as cause if patient has BOTH SUI and FI or if cough FI can be controlled by a finger or hemostat applied immediately behind the symphysis.
9.	Hysterectomy. Look for posterior fornix syndrome (PFS) symptoms - PFS often appears in severe form after the menopause.
10.	Chronic pelvic pain is specific for USL defect. It co-occurs in multiple sites, all of which can be relieved at the same time with a positive speculum test.

Appendix 2 Clear copy of the Diagnostic Algorithm of the Integral Theory



Anterior ligaments (PUL & EUL)	Middle ligaments (ATFP & CL)	Posterior ligaments (USL & PB)
	<i>cystocele</i>	<i>rectocele</i>
		<i>uterine/apical prolapse</i>
<i>stress incontinence</i>		
	<i>abnormal emptying</i>	
	<i>frequency and urgency</i>	
		<i>nocturia</i>
<i>faecal incontinence</i>		<i>faecal incontinence</i> <i>obstructed defecation</i>
		<i>pelvic pain</i>
	<i>feathered vagina</i>	

Appendix 3 Clear copy of the examination sheet



Appendix 4 Clear copy of the ITSQ Pelvic Floor Symptom Questionnaire

Date:

Name		Date of birth	
		Weight	
Address			
Telephone		Email address	
Number of VAGINAL Deliveries (N means none)	N/	Number of CAESAREAN Sections (N means none)	N/

Describe in your own words your main symptoms and their duration.

--

FOR ALL SECTIONS mark the appropriate box with an 'x' – Write extra details if you wish.

		No	Yes sometimes	Yes 50% or more
1.	(A) S.I. SYMPTOMS (A) Do you lose urine during sneezing, coughing, exercise?			
	(A) During intercourse?			
	(A) Stooping, squatting or getting up off a chair?			
1b	(A) Walking?			
2	(M,P) SYMPTOMS OF DEFICIENT EMPTYING (M,P) Do you feel that your bladder isn't emptying properly?			
	(M,P) Do you ever have difficulty starting off your stream?			
	(M,P) Is it a slow stream?			
3.	(M,P) Does it stop and start involuntarily?			
	(A,M,P) URGE SYMPTOMS (A,M,P) Do you ever have an uncontrollable urge to pass urine?			
	If so , do you wet before arriving at the toilet?			
	If so , how many times do you wet? (Write the number of times) average day () good day () bad day ()			
	How much? Circle 1, 2, 3 or 4. 1. a few drops 2. teaspoon 3. tablespoon or more 4. Wets floor			
	(A,M,P) FREQUENCY SYMPTOMS How many times do you pass urine during THE DAY ? (Write the number of times) average day () good day () bad day ()			
	(P) How many times do you get up during THE NIGHT to pass urine? (Write the number of times) average night () good night () bad night ()			
	Choose either Yes or No	No	Yes	
4.	INFECTION Do you have pain while passing urine?			

5.	(TV) SUSPECT TETHERED VAGINA			
	(TV) Any previous VAGINAL surgery or BURCH operation? Circle either <i>Vaginal</i> or <i>Burch</i> above. When? ()			
If so, do you lose urine uncontrollably immediately on getting out bed in the morning?				
6.	CONGENITAL			
	(A) Did you have bladder problems as a child? <i>If so, tell us about it.</i>			
(P) Did you have problems of pain or frequency or getting up at night after puberty?				
7.	HORMONAL			
(P) Are your pain, urge, emptying symptoms worse before or during a period?				
8a.	BOWEL SYMPTOMS			
	Constipation			
(P) Do you have difficulty evacuating your faeces?				
(Perin. Body) Do you have to manually assist when you empty your bowels?				
8b.	Faecal incontinence			
	(A,P) Do you ever soil yourself (faeces)? <i>Indicate how often soiling occurs from any of the following in a 24-hour period.</i>			
wind () liquid faeces () solid faeces () each day() each week () each month ()				
9.	(M,P) PROLAPSE			
	(M,P) Do you feel a lump protruding from your vagina without pushing ?			
	Do you feel the lump on pushing coughing or lifting ?			
(P) Have you had a HYSTERECTOMY ? If 'YES' when? ()				
10.	Pelvic Pain	No	Yes Some-times	Yes 50% or more
	(P) Do you have deep pain on intercourse?			
	(P) Do you have a pain down at the bottom of your spine?			
	(P) Do you have a pain down at the bottom of your abdomen?			
	(P) Do you have pain or burning at the entrance to the vagina?			
11.	(QOL) QUALITY OF LIFE			
	(A) Are you 'moist' with urine much of the time?			
	(A,M,P) Do you leave puddles on the floor with urge?			
	(A,M,P) Do you lose urine in bed at night?			
Do you wear a pad or liner on going out? How many pads/liners used per day? (<i>write number</i>) ()				
Grading				
We use a grading of 1-5 to describe limitation of normal activities by your incontinence problem. Circle or indicate the number below which best describes how you feel about this condition.				
1	2	3	4	5
normal	mild No effect on lifestyle	significant Can't drink, must locate toilets when out	restrictive Must always wear pads, very restricted social life	totally housebound

<p>12. In the next section, we ask you to perform a simple test to see if your pain, urge, nocturia are related to loose ligaments in the back part of your vagina.</p> <p>This test is not compulsory, but it can give information about your condition which may help you.</p> <p>Buy some large menstrual tampons from the pharmacy. <i>Without discomfort</i>, insert one or if possible two tampons into the back part of the vagina. It is important that you have a full bladder when the test is done. Then fill in the squares below.</p> <p><i>NOTE: If you get up at night to pass urine more than once (nocturia), go to bed with the tampon inside and see if it makes any difference to your nocturia.</i></p>			
(P) AFTER INSERTION OF TAMPON/S	CHANGE IN SYMPTOMS		
	None	Yes 25%	Yes 50% or more
1. Feeling of urgency			
2. Bladder pain			
3. Pelvic or vaginal pain			
4. Nocturia (write the number of times)			

Appendix 5 Further references which surgically validate the predictive value of the diagnostic system

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