INTRODUCTION

Pelvic organ prolapse (POP) is a prevalent problem which affects a woman's quality of life, 50% of parous women with 20% of these being symptomatic. It has been reported that as many as 11% of women in their lifetime required a single operation for POP and stress urinary incontinence ***(Payne et al., 2009)***.

The 4th International Consultation on Incontinence defines pelvic organ prolapse (POP) as an abnormal loss of support of one or more of the pelvic organs leading to prolapse into or outside the vagina. This includes anterior vaginal prolapse (cystocele), posterior vaginal prolapse (rectocele), apical or uterine prolapse, enterocele and perineal descent ***(Milsom, 2009)***.

Women with POP may present with a variety of lower urinary tract symptoms (LTS), such as urinary frequency, urgency, urinary incontinence, and various forms of voiding dysfunction ***(Ellerkmann et al., 2001)***.

Several studies showed that Bladder outlet obstruction (BOO) is a frequent finding in women with severe POP ***(Romanzi, 2002)***. In addition; detrusor overactivity is reported commonly in women with severe POP ***(Nguyen and Bhatia, 2001).***

Stress urinary incontinence (SUI) often coexists with pelvic organ prolapse (POP). However, up to 80 % of women with POP do not complain of urinary incontinence. This is despite clinical and/or urodynamic testing revealing leakage of urine with or without reduction of the prolapse. This phenomenon is described as occult stress incontinence (OSI) ***(Chaikin et al., 2000)***.

Urodynamics try to enhance the understanding of lower urinary tract function and reveal the underlying pathophysiology responsible for the patient's complaints. The information gained from urodynamics may confirm or alter the clinical diagnosis. The AUA Guidelines on Adult Urodynamics have described and supported the utility of UDS testing in the evaluation of various urologic conditions ***(Elizabeth et al., 2013).***

AIM OF THE WORK

To explore the association of anterior pelvic organ prolapse, with voiding dysfunction and; consequently, on urodynamic studies. Then, assessments of the significance of surgical repair of pelvic organ prolapse, to cure or improve voiding symptoms and urodynamic results.

Chapter 1

ANATOMY OF FEMALE PELVIC FLOOR

The pelvic organs have no static or fixed form, structure or strength. Normal function of these pelvic organs is directly dependent on the integrity of the pelvic floor structure defined as: bones, muscles and ligaments which contribute to normal pelvic floor function ***(Raizada and Mittal, 2008).***

Levels of Vaginal Support:

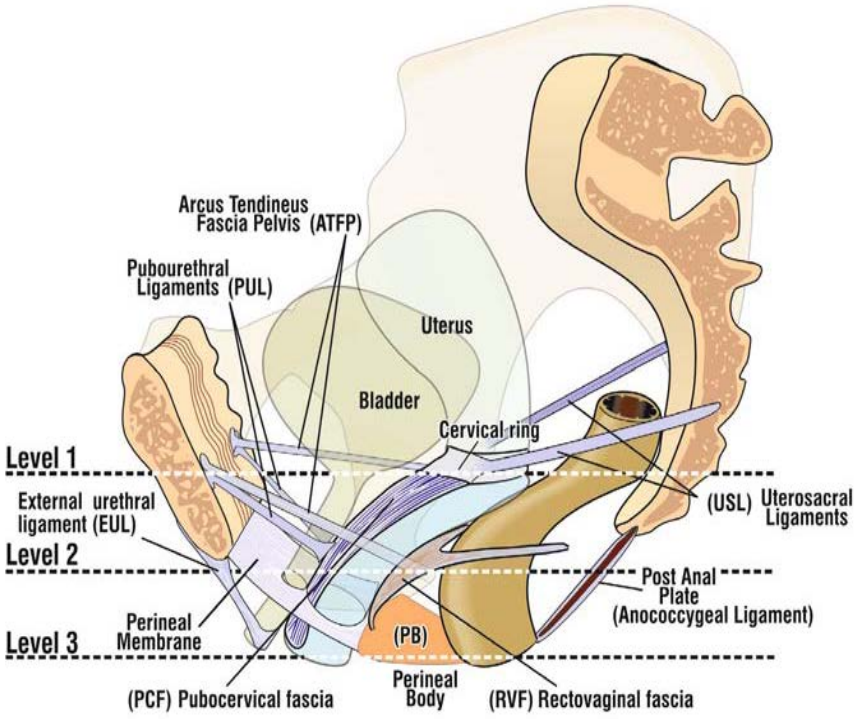

Figure (1): Levels of vaginal support ***(Delancey, 1992).***

Delancey in 1992, described the connective tissue supports of the vagina in three levels *(Fig. 1)*

Level I: Uterosacral ligaments (USL), arcus tendinius fasciae pelvis (ATFP) and pubocervical fascia (PCF)

Level II: Pubourethral ligaments (PUL) and rectovaginal fascia (RVF)

Level III: Perineal body (PB), perineal membrane, post-anal plate and external ligament of the urethra (EUL) ***(Apte et al., 2012).***

The level I support comprises the uterosacral/cardinal ligament complex. It is an intricate three-dimensional connective tissue structure that originates at the cervix and upper vagina and inserts at the pelvic sidewall and sacrum. It serves to maintain vaginal length and keep the vaginal axis nearly horizontal in a standing woman so that it can be supported by the levator plate. *Loss of level I support contributes to prolapse of the uterus and/or vaginal ape* ***(Apte et al., 2012)***.

Level II support: suspended the vagina laterally to the arcus tendinous fasciae pelvis (ATFP), there are the paravaginal attachments, at the location of the ischial spine. The distal half of the posterior vaginal wall fuses with the aponeurosis of the levator ani muscle from the perineal body along a line referred to as the arcus tendinous rectovaginalis. It converges with the ATFP at a point approximately midway between the pubic symphysis and the ischial spine *Detachment of these lateral*

supports can lead to paravaginal defects and prolapse of the anterior vaginal wall ***(Leffler et al., 2001).***

Level III support is provided by the perineal membrane, the muscles of the deep perineal space, and the perineal body. These structures support and maintain the normal anatomical position of the urethra and the distal third of the vagina, which is perpendicular to the floor in a standing woman. At level III, the vagina fuses with the urethra anteriorly and with the perineal body posteriorly. *Disruption of level III anteriorly can result in urethral hypermobility and stress incontinence, and disruption posteriorly may result in rectocele, enterocele, and perineal descent* ***(Shafik et al., 2007)*** *(Fig. 2).*

Bones, muscles and connective tissue, consisting of ligaments and fascia, are the main structural components of the pelvis. We are going to review in more details.

1- Bones:

The bony pelvis is the rigid foundation to which all of the pelvic structures are ultimately anchored. The bony pelvis is composed of the sacrum, ileum, ischium, and pubis. It is divided into the false (greater) and true (lesser) pelvis by the pelvic brim, bounded by the sacral promontory; the anterior ala of the sacrum; the arcuate line of the ilium, the pectineal line of the pubis and the pubic crest that culminates in the symphysis pubis. The female pelvis has a wider diameter and a more

circular shape than that of the male, the wider outlet predisposes to subsequent pelvic floor weakness ***(Barber, 2004).***

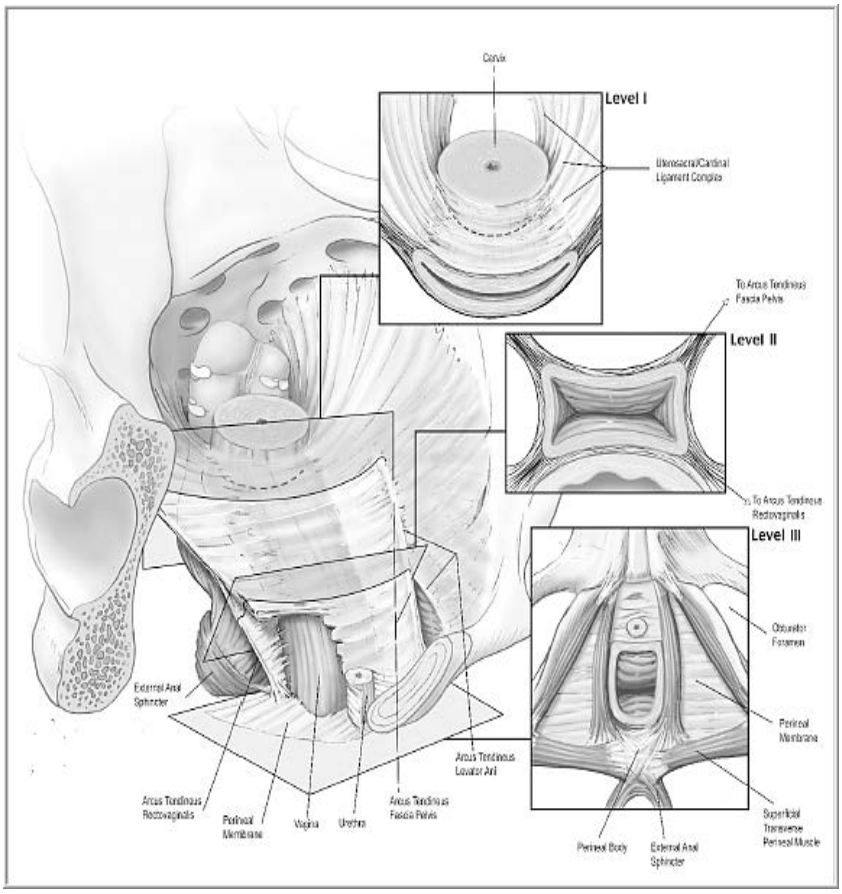

Figure (2): The anatomy of the three compartments of the pelvis viewed from above (from Hulka and Reich, Textbook of Laparoscopy).

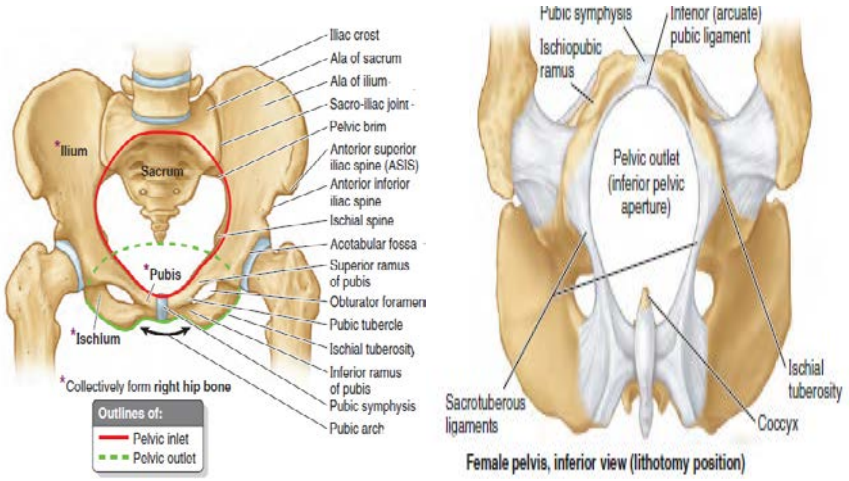

Figure (3): Bony pelvis inlet and outlet ***(Clinically oriented anatomy / Keith L. Moore, Arthur F. Dalley, Anne M.R. Agur. 2014, 7th ed. P329).***

In the standing woman, the pelvis is oriented such that the anterior superior iliac spine and the front edge of the pubic symphysis are in the same vertical plane, perpendicular to the floor, and the pelvic inlet is tilted anteriorly and the ischiopubic rami and genital hiatus are parallel to the ground, the bony arches of the pelvic inlet are oriented in an almost vertical plane. This directs the pressure of the intra- abdominal and pelvic contents toward the bones of the pelvis, *(fig.4)*, instead of the muscles and endopelvic fascia attachments of the pelvic floor ***(Mattox et al., 2004).***

For these reasons, variations in the orientation and shape of the bony pelvis, such as a loss of lumbar lordosis and a less vertically oriented pelvic inlet, have been associated with the development of pelvic organ prolapse ***(Nguyen et al., 2004).***

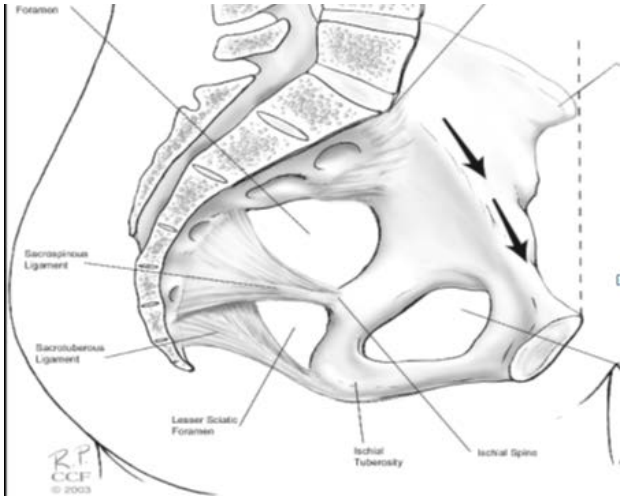

Figure (4): Bones and ligaments of the pelvis (sagittal view).The arrows represent the distribution of weight of the spinal column and abdominal contents and along the ilium ***(The Cleveland Clinic Foundation).***

2- Pelvic Diaphragm muscles (fig.5):

The levator ani muscle is formed by the iliococcygeus, pubococcygeus, and puborectalis. These muscles can be identified as separate parts by their origin and direction ***(Kearney et al., 2004).***

The iliococcygeus originates from the posterior half of the arcus tendinous levator ani (ATLA) -a linear thickening of the fascial covering of the obturator internus that runs from the ischial spine to the posterior surface of the ipsilateral superior pubic ramus- and inserts into the last two segments of the coccyx and in the midline of the anococcygeal raphe. The iliococcygeus forms a sheet-like layer and is often largely aponeurotic. The anococcygeal raphe is the interdigitation of the iliococcygeal fibers from both sides and extends from the

coccyx to the anorectal junction. *The pubococcygeus* originates from the anterior half of the tendinous arc and the periosteum of the posterior surface of the pubic bone at the lower border of the pubic symphysis and inserts on the midline visceral organs (vagina, urethra and anal sphincter complex), the perineal body, the anococcygeal raphe, and the inferior part of the coccyx. The pubococcygeus muscle (also called pubovisceral with the puborectalis) could be further subdivided into the puboperinealis, pubovaginalis, and puboanalis depending on its connections ***(Kearney et al., 2004).***

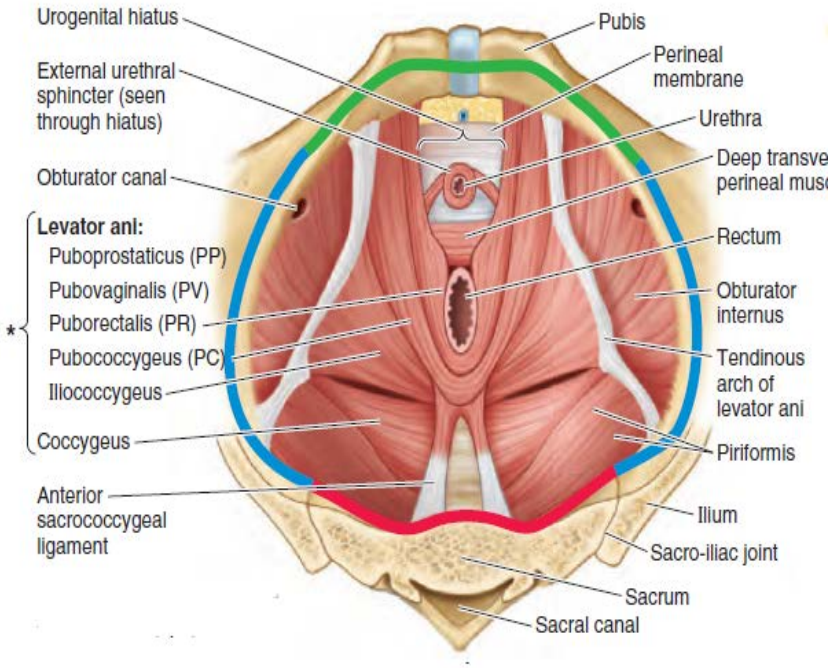

Figure (5): Pelvic view of the levator ani demonstrating its four main components: puborectalis, pubococcygeus, iliococcygeus, and coccygeus ***(Clinically oriented anatomy / Keith L. Moore, Arthur F. Dalley, Anne M.R. Agur. 2014, 7th ed. P340).***

The puborectalis also originates on the pubic bone, but its fibers pass posteriorly and go around the upper part of the anus, where it is attached posteriorly to the anococcygeal ligament, forming a sling around the vagina, the perineal body, and the anorectum and resulting in the anorectal angle. The puborectalis muscle promotes the closure of the urogenital hiatus in cooperation with the pubococcygeus muscle ***(Kearney et al., 2004).***

The coccygeus muscle (also called ischiococcygeus) extends from the ischial spine, courses along the posterior margin of the internal obturator muscle laying on the anterior surface of the sacrospinous ligament, inserts to the lateral part of the coccyx and the lower sacrum, and forms the posterior part of the pelvic diaphragm. The sacrospinous ligament is at the posterior edge of the coccygeus muscle and is fused with this muscle. The proportions of the muscular and ligamentous parts may vary ***(DeLancey et al., 2003)***.

Although the muscles of the pelvic floor were initially thought to have innervation both from direct branches of the sacral nerves on the pelvic surface and via the pudendal nerve on the perineal surface, recent evidences indicate that these standard descriptions are inaccurate and that the levator ani muscles are innervated solely by a nerve traveling on the superior (intrapelvic) surface of the muscles without contribution of the pudendal nerve The nerve supplying the coccygeus muscle and the levator ani muscles (all three) originates from S3, S4, and/or S5.

Occasionally, a separate nerve comes directly from S5 to innervate the puborectalis muscle independently ***(Barber et al., 2002; Bremer et al., 2003).***

3- Ligaments and fasciae in female pelvic floor:

Fascia is that fibromuscular tissue, composed of smooth muscle, collagen, elastin, nerves and blood vessels and may form part of the wall of the vagina. Fascia is the main structural support of the vagina. Discrete thickenings may be termed *ligaments*. While the role of fascia is to strengthen and support the organs, the role of the ligaments is to suspend the organs and act as anchoring points for *the muscles*. Muscle forces stretch the organs to contribute to their shape, form and strength ***(Norton, 2004).***

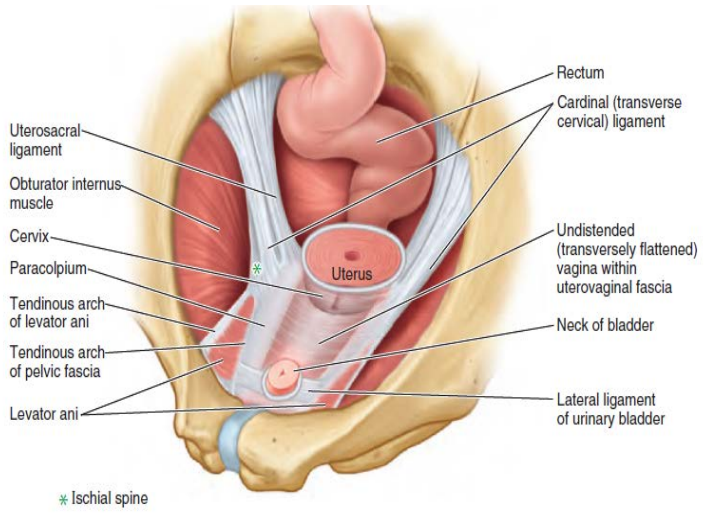

Figure (6): The Key Ligaments of the Pelvic Floor Structure ***(Clinically oriented anatomy / Keith L. Moore, Arthur F. Dalley, Anne M.R. Agur. 2014, 7th ed. P347).***

The key ligaments of the pelvic floor (fig.6):

Those are the pubourethral ligament, the arcus tendineus fasciae pelvis (ATFP) and the cardinal and uterosacral ligaments (USL). The composition of all the suspensory ligaments and fascia is similar. The presence of nerves, smooth muscle and blood vessels indicates that ligaments are active contractile structures, as is the fascial layer of the organs ***(Umek et al., 2004).***

- ***The Pubourethral Ligament***

The pubourethral ligament originates from the lower end of the posterior surface of the pubic symphysis and descends like a fan to insert medially into the midurethra and laterally into the pubococcygeus muscle and vaginal wall.

- ***The Arcus Tendineus Fascia Pelvis (ATFP)***

It is a thickening in the obturator fascia and extends from the pubis anteriorly to the ischial spine, providing attachment to the paravaginal connective tissue. Arising from a similar location on the pubis but extending superior to the arcus tendinous fascia pelvis is a thickening of levator ani fascia called *arcus tendinous levator ani*, which is the origin of the levator ani muscle. The vagina is suspended from the ATFP by its fascia, much like a sheet slung across two washing lines. The muscle force of the levator plate and adjacent muscles makes tension on the ATFP ligament and the vagina itself.

- ***The Uterosacral Ligaments (USL)***

It suspends the apex of the vagina arising from the sacral vertebrate S2, 3, 4 and attaches to the cervical ring posteriorly. Its main vascular supply is the descending branch of the uterine artery ***(Umek et al., 2004).***

Fascial attachment of the vagina:

The vagina is suspended like a trampoline between the two Arcus tendineus Fascia Pelvis (ATFP) ligaments, by lateral fascial extensions; the pubocervical fascia superiorly, and the rectovaginal fascia inferiorly *(fig. 7).*

- ***The Pubocervical Fascia***

The pubocervical fascia (PCF) stretches from ATFP to the anterior part of the cervical ring and the lateral vagina. The anterior part of the cervical ring in turn fuses with the cardinal ligament.

- ***The Rectovaginal Fascia***

Stretches from ATFP to the posterior part of the cervical ring and the lateral vagina the rectovaginal fascia extends as a sheet between the lateral rectal pillars-from the perineal body below to the levator plate above- and the vagina ***(Herschorn, 2004).***

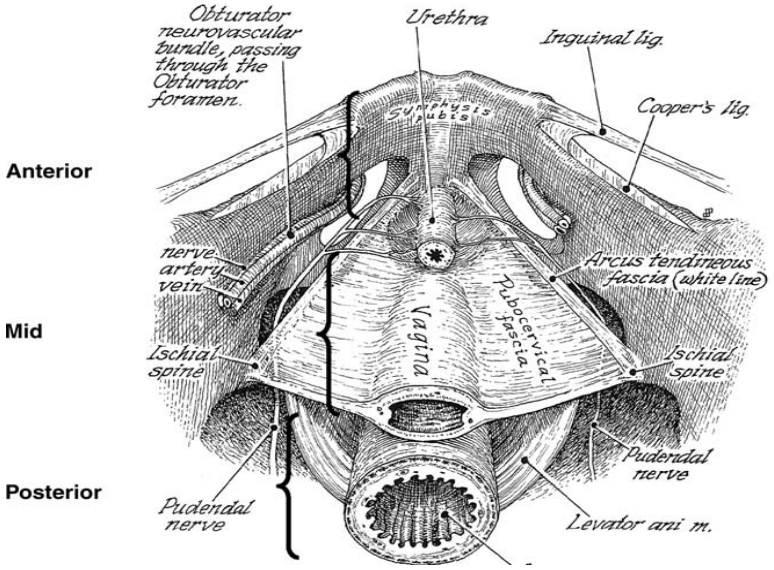

Figure (7): Vaginal attachments to ATFP. The vagina is suspended like a trampoline membrane between the Arcus Tendineus Fascia Pelvis (ATFP) ligaments laterally.

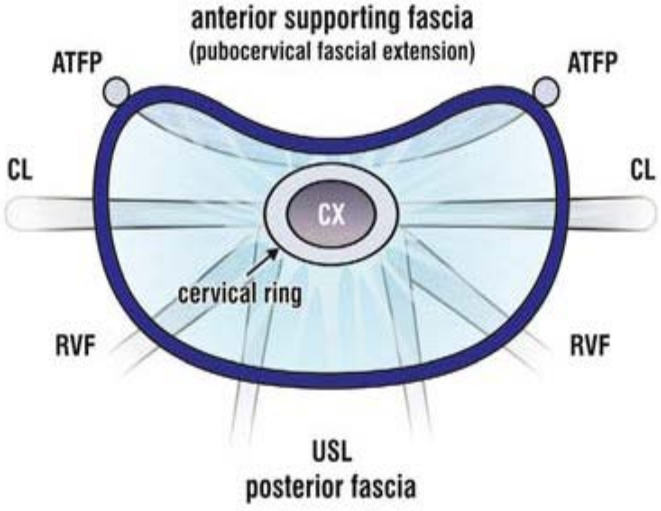

Figure (8): Role of the cervical ring in the connectedness of pelvic fascia. All fascial and ligamentous structures insert directly or indirectly into the cervical ring. Perspective: 3D view, looking into the posterior fornix of the vagina ***(Petros, 2007).***