Introduction

The female pelvis contains three major tracts that lie on and traverse the pelvic floor. These are the urinary bladder and the urethra anteriorly, the female genital tract in the middle, and the rectum and anal canal posterior. The pelvic floor consists of the pelvic floor muscles, mainly the levator ani muscles, and connective tissues and ligaments. The relative contributions to the structural support of the pelvic floor and its functions have been the subject of controversy. With increasing age, women can develop voiding troubles as urgency, overactive bladder frequency, nocturia, and stress urinary incontinence (SUI). Other concomitant troubles, which occur, are genital prolapse, fecal incontinence and pelvic pain. All of these symptoms can be associated, to a greater or lesser extent, with pelvic floor defects ***(Liedl et al., 2012).***

It is believe that the first vaginal birth is especially associated with the development of prolapse, whereas additional vaginal births do not show significant increases in the odds of prolapse. We believe that multiple and frequent childbirth does not allow time for regenerative repair to occur and make the trouble worse. We believe that every organ has a strong collagen frame (chassis) which help the organ to keep its proper shape and to do its

function. The pelvic organs have their strong collagen frame (chassis) which is a main factor in their continence, function and configuration. Childbirth trauma cause invisible lacerations of the strong chassis of the pelvic organs and subsequent abnormal shape position and malfunction ***(El Hemaly et al., 2013).***

Urinary continence depends on two main factors: a- high urethral pressure b- an intact healthy IUS, the high urethral pressure (Pura) which depends upon two factors: one inherent and one acquired.

1- The inherent factor is the tough strong collagen layer constituent of the internal urethral sphincter (IUS), that creates the high wall tension necessary for keeping high urethral pressure (Pura). The IUS is a collagen-muscle tissue cylinder that extends from the bladder neck to the perineal membrane in both sexes.

2- The acquired factor, which is high alpha-sympathetic tone at the IUS gained from learning and training in early childhood, keeps it contracted and the urethra closes all the time until there is a need or a desire to void as social circumstances allow. Injury to one or both factors leads to urinary incontinence.

(El Hemaly et al., 2012).

The vagina is a cylinder of collagen-elastic-muscle tissues. The strong tough collagen sheet is responsible for the upright position of the vagina. The main function of the pelvic ligaments is to assign the pelvic organs to their anatomical site and keeps the pelvic organs in situ. Childbirth trauma damages the collagen layer due to overstretching of the vagina and leads to flabby and redundant vaginal walls with subsequent vaginal prolapse. When the pelvic ligaments suffer most of the trauma, the insult will lead to weakness of the pelvic ligaments, leading to vault and uterine prolapse ***(El Hemaly et al., 2013).***

Classically, many theories are put forward to explain the factors that control urinary continence e.g.

1- Equal transmission of pressure: this is the classic gold standard theory of urinary continence. It is the presence of the bladder neck and the upper part of the urethra above the pelvic floor so that there is a direct and equal influence of intra-abdominal pressure on the bladder; bladder neck and the intra-abdominal part of the urethra ***(Stevens and Smith, 1937).***

2- Mucous membrane cooptation.

3- The presence of a special cavernous vascular plexus in the lamina propria pushing the mucous membrane to act as a seal.

The above mentioned two theories suggest that the mucosal and vascular tissues that surround the urethral lumen provide a hermetic seal ***(Stoker and Wallner, 2008).***

4- The "intergral" theory of urinary continence by Petros and Ulmsten: they mentioned urinary continence depends on the action of: (a) the pubococcygeus muscles lift the anterior vaginal wall anteriorly to compress the urethra, specially the mid third, against the pubis; (b) the pelvic floor muscles draw the hammock upwards closing the bladder neck; and (c) the anterior vaginal wall must be tough and not lax ***(Ulmsten and Petros, 1995).***

5- The "hammock theory" of de Lancey: the pelvic floor muscles and fasciae act as a hammock supporting the bladder neck, and the upper part of the urethra. The supportive hammock under the urethra and bladder neck provides a firm backstop against which the urethra is compressed during increases in abdominal pressure to maintain urethra closure pressure (UCP) above rapidly increasing bladder pressure. The supporting layer consists of the anterior vaginal wall, the pelvic fascia (especially the tendinous arch) that attaches it to the pelvic bones and the levator ani muscles ***(DeLancey, 1994).***

Other important factors are considered such as the urethral length, the presence of urethro-vesical angel of about 90 degrees, and the absence of funneling of the bladder neck. Also the role of the urethral sphincters in controlling the urine with no overall agreement on which sphincter that plays the main role, whether it is the internal urethral sphincter (IUS), the external urethral sphincter (EUS) or a third mid urethral sphincter?***(El Hemaly et al., 2012).***

Conditions blamed for causing SUI are deficiency in urethral length, descent of the bladder neck and the proximal urethra below the pelvic floor (prolapse) with failure of transmitting increased intra-abdominal pressure to the bladder neck and proximal urethra during stress; and/or abnormalities in the urethro-vesical angles. However, SUI can be present despite the absence of genital prolapse. Amputation of the distal urethra does not lead to SUI. ***(El Hemaly et al., 2012).***

Imaging of the pelvic floor and pelvic organs is done in the investigations to diagnose the pathology and troubles that affect pelvic organs. Imaging includes ultrasound, MRI and X-ray pictures plain and with dye. The new modalities in U/S are 3-4 dimension ultrasounds. The new modalities offer stereoscopic picture of the different organs, showing the damage in a more clear way ***(El Hemaly et al., 2014).***

Perineal ultrasound especially has provided a good visualization of the bladder, bladder base, urethrovesical (UV) junction, urethra and the symphysis pubis ***(Virtanen and Kiilholma, 2002).*** It has been used as an alternative to conventional radiological techniques to assess the dynamic changes of the urethrovesical junction and proximal urethra for two decades ***(Chen et al., 2006)***.

Aim of the Work

The aim of work is to determine the effectiveness of three dimension transvaginal ultrasound in diagnosis of stress urinary incontinence in comparison to urodynamic study.

Chapter (1)

Female Pelvic Floor Anatomy

The effective management of stress urinary incontinence (SUI) requires knowledge of the pathophysiologyic mechanisms behind the disorder. Key to identifying these mechanisms and providing proper treatment to women with stress urinary incontinence (SUI) is an understanding of the anatomy and function of the female pelvic floor and its supporting structures ***(Herschorn, 2004).***

The pelvic floor includes all the structures closing the pelvic outlet from the peritoneum superiorly to the skin inferiorly. It consists of three strata. The strata are the pelvic peritoneum superiorly; then the pelvic diaphragm, which consists of the endopelvic fascia, the pelvic ligaments (the utero-sacral., the cardinal transverse cervical and pubo-cervical ligaments), and the pelvic diaphragm muscles. The third stratum is the perineum with its muscles, perineal membrane and the skin inferiorly. The pelvic diaphragm is a funnel shaped fibro-muscular partition in the pelvis; it is composed of the levator ani and the coccygeus muscles along with their superior and inferior fascia ***(Herschorn, 2004).***

A basic knowledge of pelvic floor anatomy is fundamental to the imaging interpretation and understanding of dysfunction. The pelvic floor is classically divided into three compartments: anterior, middle, and posterior, to which a fourth compartment, the peritoneal cavity and fascia, is sometimes added. This segregation reflects historical boundaries between the various professional groups involved and is, to a large extent, artificial, because the pelvic floor structures are closely interrelated and patients with abnormalities in one compartment often have disorders in others ***(Stoker et al., 2001).*** The term pelvic floor is used broadly to include all the structures supporting the abdominal and pelvic cavity ***(El Sayed, 2012).***

Conceptually, pelvic floor anatomy is commonly divided into passive and active structures **(Fig. 1).** The passive structures are (1) the pelvic bones and (2) the supportive connective tissue of the pelvis, which consists of ligaments and endopelvic fascia. The active support structures are the pelvic floor muscles, with their neurological wiring that results in sustained (tonic) and intermittent voluntary muscle contractions during activity. ***(Altringer et al., 1995; El Sayed, 2012).***

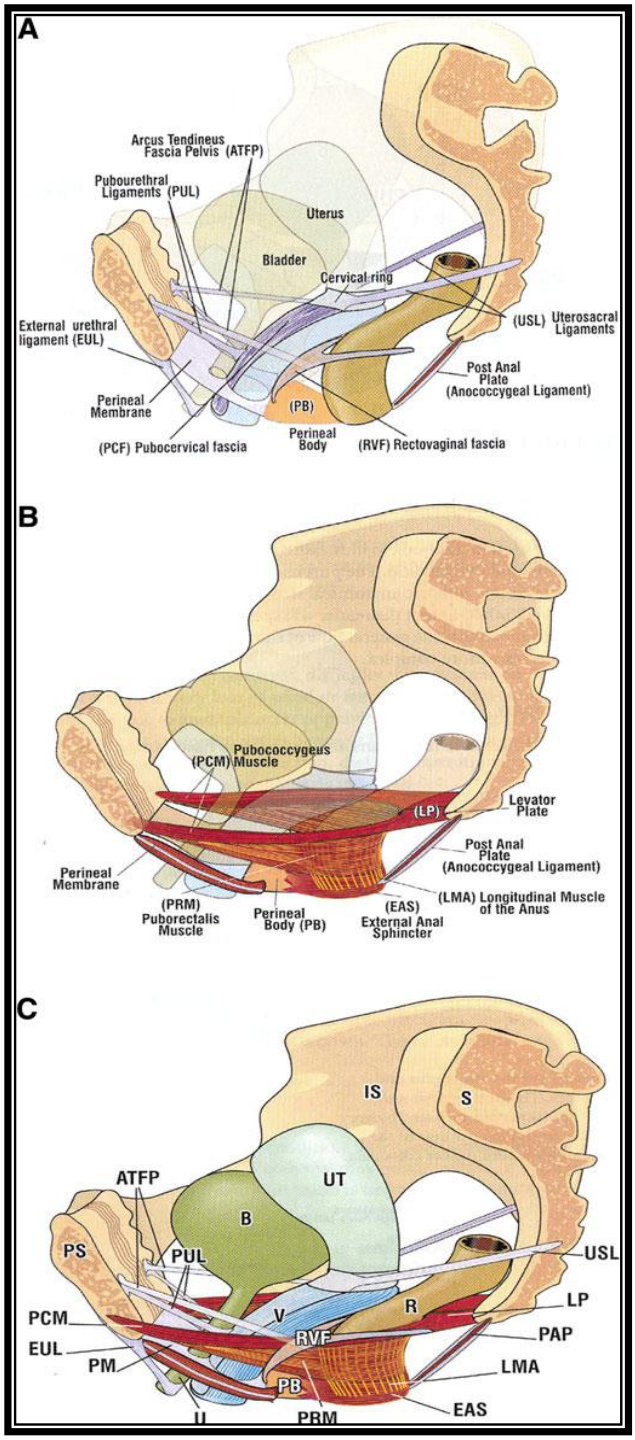

Fig. 1: Passive and active structures of the pelvic floor: A Pelvis with organs and connective tissue. The ligamentous and membranous structures are indicated by shades of gray, and the fascial thickenings of the vagina (PCF, RVF) are darker. B Pelvis with organs and muscles (muscles are brown with striations). C The relationship of the pelvic muscles to organs, ligaments, and fascia. ***(Petros, 2007).***

These passive and active components of the pelvic floor function as an integrated multilayer system **(Fig. 2).** From cranial to caudal, it consists of the endopelvic fascia, the pelvic diaphragm, and the urogenital diaphragm ***(El Sayed, 2012).***

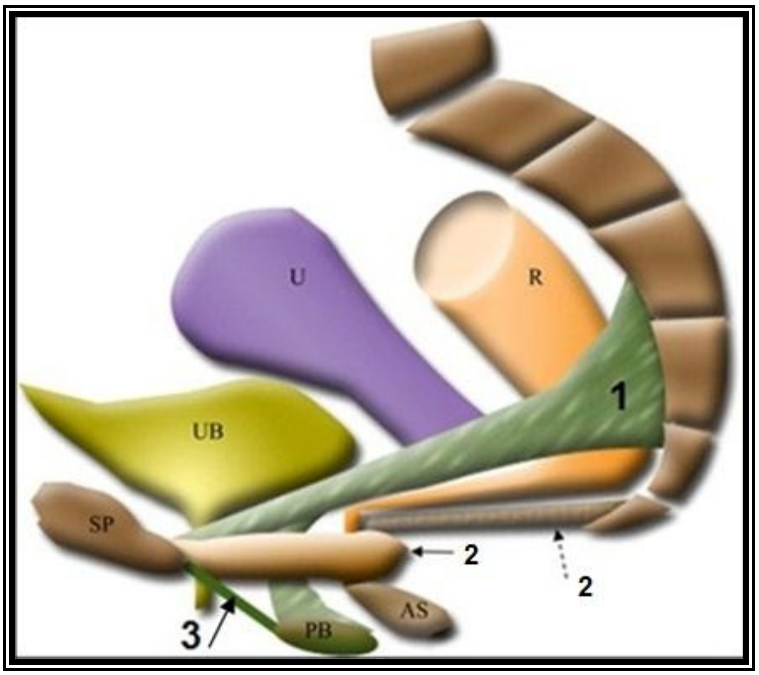

Fig. 2: Three-dimensional schematic of the component of the pelvic floor integrated into a multilayer system, from cranial to caudal., consisting of the following: (1) the endopelvic fascia, giving support to the uterus and upper vagina (light green), (2) the pelvic diaphragm, including the puborectalis (solid arrow) and iliococcygeus (dashed arrow), and (3) the urogenital diaphragm (dark green). AS anal sphincter complex, PB perineal body, R rectum, SP symphysis pubis, U uterus, UB urinary bladder ***(Beco & Mouchel, 2003).***

Bony Scaffolding:

The maintenance of continence and prevention of pelvic organ prolapse rely on the support mechanisms of the pelvic floor. The bony pelvis consists of the 2 innominate bones, or hip bones, which are fused to the sacrum posteriorly and to each other anteriorly at the pubic symphysis. Each innominate bone is composed of the ilium, ischium, and pubis, which are connected by cartilage in youth but fused in the adult. The pelvis has 2 basins: the major (or greater) pelvis and the minor (or lesser) pelvis. The abdominal viscera occupy the major pelvis; the minor pelvis is the narrower continuation of the major pelvis infeiorly. The inferior pelvic outlet is closed by the pelvic floor ***(Herschorn, 2004).***

The female pelvis **(fig. 3)** has a wider diameter and a more circular shape than that of the male. The wider inlet facilitates head engagement and parturition. The wider outlet predisposes to subsequent pelvic floor weakness. Numerous projections and contours provide attachment sites for ligaments, muscles, and fascial layers. Of note is the thin and triangular sacrospinous ligament, which extends from the ischial spines to the lateral margins of the sacrum and coccyx anteriorly to the sacrotuberousm ligament. Its anterior surface is muscular and constitutes the coccygeus; the ligament is often regarded as the

degenerate part of the muscle. The greater and lesser sciatic foramina are above and below the ligament ***(Herschorn, 2004).***

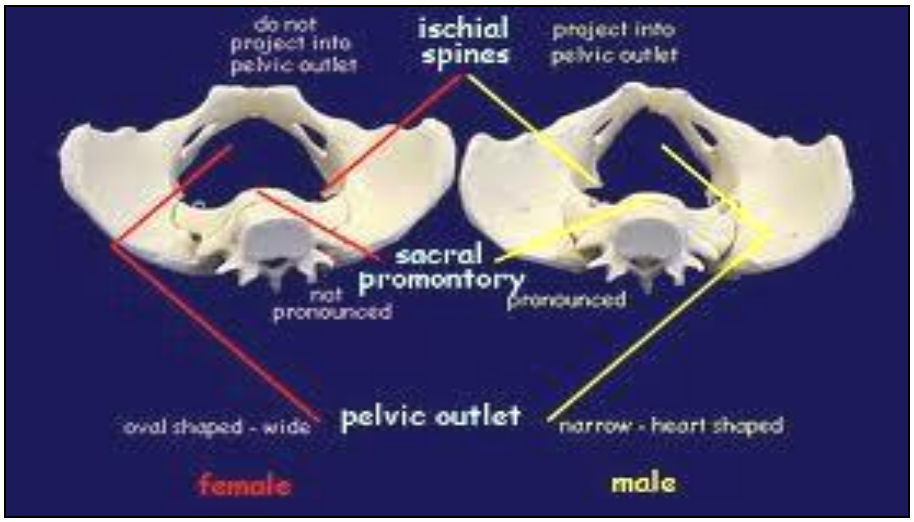

Fig. 3: Female and Male pelvis ***(Herschorn, 2004).***

Muscular supports of the pelvic floor:

Pelvic Diaphragm:

The levator ani and coccygeus muscles that are attached to the inner surface of the minor pelvis form the muscular floor of the pelvis. With their corresponding muscles from the opposite side, they form the pelvic diaphragm **(fig. 4)**. The levator ani is composed of 2 major muscles from medial to lateral: the pubococcygeus and iliococcygeus muscles. ***(Herschorn, 2004).***

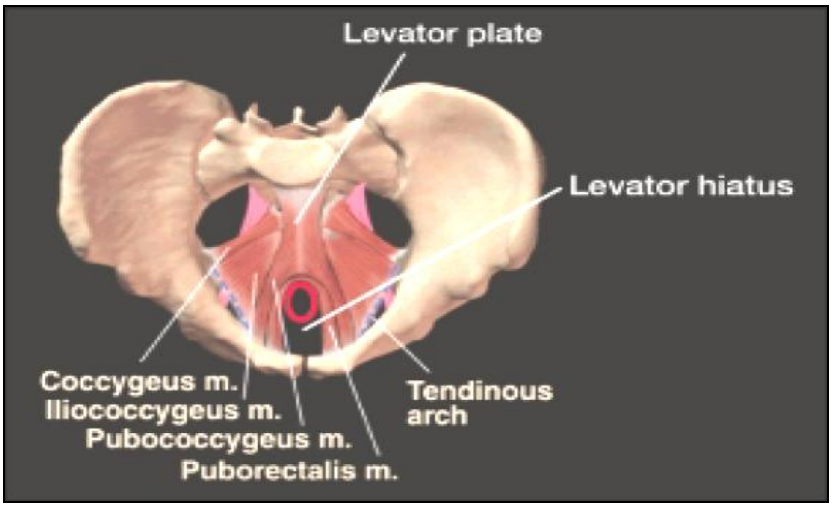

Fig. 4: Pelvic Diaphragm ***(Herschorn, 2004).***

The bulkier medial portion of the levator ani is the pubococcygeus muscle that arises from the back of the body of the pubis and anterior portion of the arcus tendineus. The arcus tendineus of the levator ani is a dense connective tissue structure that runs from the pubic ramus to the ischial spine and courses along the surface of the obturator internus muscle. The muscle passes back almost horizontally to behind the rectum. The inner border forms the margin of the levator (urogenital) hiatus, through which passes the urethra, vagina, and anorectum ***(Herschorn, 2004).***

Various muscle subdivisions have been assigned to the medial portions of the pubococcygeus to reflect the attachments of the muscle to the urethra, vagina, anus, and rectum ***(DeLancey et al., 2001).*** These portions are referred

to by some investigators as the pubourethralis, pubovaginalis, puboanalis, and puborectalis or collectively as the pubovisceralis, because of their association and attachment to the midline viscera. The urethral portion forms part of the periurethral musculature, and the vaginal and anorectal portions insert into the vaginal walls, perineal body, and external anal sphincter muscle ***(Herschorn, 2004)***. The puborectalis portion passes behind the rectum and fuses with its counterpart from the opposite side to form a sling behind the anorectum. Other more posterior parts of the pubococcygeus attach to the coccyx ***(Fielding et al., 2000)***.

Thin lateral part of the levator ani is the iliococcygeus muscle, which arises from the arcus tendineus of the levator ani to the ischial spine. Posteriorly it attaches to the last 2 segments of the coccyx. The fibers from both sides also fuse to form a raphe and contribute to the anococcygeal ligament. This median raphe between the anus and the coccyx is called the levator plate and is the shelf on which the pelvic organs rest. It is formed by the fusion of the iliococcygeus and the posterior fibers of the pubococcygeus muscles. When the body is in a standing position, the levator plate is horizontal and supports the rectum and upper two thirds of vagina above it. Weakness of the levator ani may loosen the sling behind the