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SOME THOUGHTS ON THE MECHANICAL ANATOMY OF THE FEMALE PELVIS[1]

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THE BONY PELVIS

The obstetric significance of the female bony pelvis lies firstly, in its role during pregnancy wherein it protects the pelvic viscera and provides the point of attachment for the muscles of the abdominal walls, and secondly, during labour when the bony pelvis is the "immovable object" through which must pass the more pliable and compressible foetus.

The mature female bony pelvis is made up of four bones: the sacrum, the coccyx, and two innominate bones — which are formed by fusion at puberty of the ischium, ilium and pubic bones about the acetabulum.

Ideally the bony pelvis should be of such dimensions that at least one diameter of each of its three obstetrically significant planes (the plane of the pelvic inlet or brim, of the mid-pelvis, and of the pelvic outlet) is large enough to accommodate the widest diameter of that part of the foetus which presents to the pelvis during labour. Normally the presenting part is the vertex of the foetal skull — the part bounded anteriorly and posteriorly by the two major fontanelles, and laterally by the parietal eminences. The average widest diameter of this presentation is 9.5 cm. Thus the anteroposterior, oblique, or transverse diameter of each of the three planes of the bony pelvis must exceed 9.5 cm. if vaginal delivery is to be safe for the baby.

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Clinically, one is limited in the precise assessment of these diameters by the intervening soft tissues, but certain observations can be made which are a guide to the normality of the bony pelvis, *viz:*

Plane of the pelvic inlet: Vaginal examination in the normal female pelvis will show a nicely rounded forepelvis at this level. The posterior portion of the brim, including the sacral promontory, cannot be felt in the normal pelvis.

Plane of mid-pelvis: The ischial spines should not project unduly into the pelvic cavity and above and behind the ischial spines lies the greater sciatic notch with the ischiococcygeal ligaments running from ischial spine to coccyx on either side. In the normal pelvis it should be possible to place three fingers on these ligaments. The side walls of the pelvis should be almost parallel.

Plane of pelvic outlet: Ideally, the subpubic angle should be obtuse and there should be ample room to accommodate four knuckles between the ischial tuberosities. The sacrum should be nicely hollowed and there should be mobility of the sacrococcygeal joint so that backward angulation of the coccyx can occur during the delivery of the baby — thus temporarily increasing the anteroposterior diameter of the pelvic outlet.

THE LIGAMENTS AND JOINTS OF THE PELVIS

The four bones of the pelvis are united at four joints: The symphysis pubis — in the midline anteriorly, the sacrococcygeal joint, and the right and left sacro-iliac joints.

It is as well to consider the joints and their associated ligaments at the same time.

Symphysis pubis

There is normally very little movement in this secondary cartilagenous joint. A fibro-cartilagenous disc with a small central "disc space" unites the articular surfaces of the two pubic bones and there is no joint capsule or synovial membrane. This joint has two supporting ligaments — anteriorly there are short transverse fibres reinforced by the aponeuroses of the rectus abdominis muscles and the external oblique muscles — and inferiorly there is an arcuate pubic ligament. In pregnancy there may be some mobility in this joint.

Sacrococcygeal joint

This synovial hinge joint allows movement backwards and forwards at the articular surfaces. There are reinforcing ligaments anteriorly, posteriorly and laterally joining the bodies of the fifth saccral and the first coccygeal vertebrae, and the intercornual ligaments posteriorly also. The external anal sphincter muscles and levatores ani muscles are attached to this joint which becomes lax during pregnancy, and may be damaged by excessive backward extension during delivery.

Right and left sacro-iliac joints

These are the most important pelvic joints and normally are subjected to great stresses and strains associated with weight bearing in the erect position, which stresses they transmit to the lower limbs.

The fascinating scientific description of these joints is "Diarthrodial hetero-morphic, atypical hinge joints". Diarthrodial — synovial joint allowing movement; hetero- morphic — the articular surfaces are not alike: atypical hinge — allows movement in a vertical and horizontal direction.

The stability of the joints depends on:

(a) the interlocking mechanism of the articular surfaces of sacrum and ilium;

(b) the ligaments binding the joints anteriorly and posteriorly, and

(c) the accessory ligaments not intimately involved with the joints but helping to stabilize them.

The anterior sacro-iliac ligaments prevent undue forward movement of the sacrum on the ilium and consist of short transverse fibres running from the sacral wings, or ala, to the adjacent sulcus or groove on the ilium. The posterior sacro-iliac ligaments run in a fan shape from the back of the sacrum across to the iliac crest and posterior superior and inferior iliac spines.

The accessory stabilizing ligaments are the sacro-tuberous and sacro-spinous ligaments — thick tough straps of connective tissue acting as anchor ropes to counter the downward thrust of the forces due to assuming an erect posture acting on the upper sacrum.

THE PELVIC MUSCLES

The pelvic floor consists of a muscular diaphragm together with its enveloping fascia. It is concave superiorly, and, acting as a sling, it separates the pelvic cavity above from the perineal space below.

There are two openings in this sling — a larger anterior gap, the urogenital hiatus (which allows the urethra anteriorly and vagina behind it to emerge at the vulva) and a smaller posterior rectal hiatus. The muscular bridge between these two openings is the perineal body.

The two muscles involved in the formation of the pelvic floor are:

The *coccygeus (ischiococcygeus):* This is a triangular muscle arising on the narrow ischial spine and inserted into the lower lateral part of the sacrum and the upper lateral part of the coccyx. The sacro spinous

ligament, which runs in the same direction, is probably its aponeurosis. The function of coccygeus in tailed animals is to wag the tail — in women its action is stabilization of lower sacrum and coccyx.

Levator ani.

This paired muscle is sometimes subdivided into four parts — iliococcygeus, pubococcygeus, puborectalis and pubovaginalis.

The line of origin of the levatores ani is lateral on the side wall of the pelvis and the insertion is central — to fuse with its fellow of the other side. The line of origin from front to back is: the posterior aspect of the pubis, the "white line" of pelvic fascia over the obturator internus muscle, and the ischial spine. From this line of origin the fibres sweep downwards, backwards and medially, to be inserted into the lower vagina, the perineal body, anal canal, anococcygeal body, lateral border of coccyx, and lower part of sacrum.

The nerve supply to the levatores ani muscles comes from S2, 3 and 4, via the inferior haemorrhoidal nerve and the perineal branch of S4.

In primitive tailed animals the levatores function to depress the tail; in woman they provide a muscular shelf on which sit, from front to back, bladder and urethra; uterus, cervix and vagina; fallopian tubes and ovaries; rectum and anus.

Other functions of the pelvic floor are to maintain the intra-abdominal pressure, to act as a sling and sphincter for the vagina, as a sling and auxiliary sphincter for the rectum, and to stabilize the sacrum.

THE PERINEUM

This is the diamond shaped area of the trunk below the level of the pelvic floor and its boundaries are: anteriorly, the symphsis pubis; posteriorly, the tip of the coccyx; antero laterally, the inferior ischio pubic rami; postero laterally, the sacro tuberous ligaments.

This diamond shape in fact comprises two triangles separated by the superficial and deep transverse perineal muscles — the anterior or urogenital triangle and the posterior or anal triangle.

Urogenital Triangle

This area is penetrated by the urethra and vagina and contains:

(1) the ischio-cavernosus muscles which run forward from the underside of the inferior ramus of the ischium on either side to ensheath the crus of the clitoris on that side. The function of this muscle is to compress the crus during sexual excitation, blocking off the venous blood flow thus making the clitoris erect.

(2) The bulbo-cavernosus muscle on either side. These muscles combine posteriorly with the external anal sphincters and form a figure-8 around the anus and vagina. The bulbo-cavernosus arises from the central point of the perineum, runs around the side of the lower vagina where it forms a weak sphincter and surrounds the vascular bulb of the vestibule and is then inserted into the clitoris. Its function is also compression of veins during sexual excitation causing engorgement and swelling of the labia with associated increase in secretion of lubricating fluid from the Bartholin's glands contained therein, to facilitate penetration during coitus.

There are two "pouches" formed by the two layers of the urogenital diaphragm — a fibrous sheet pierced by urethra and vagina as it runs from ischiopubic ramus to ischiopubic ramus.

(a) The superficial perineal pouch is covered by Colles' fascia — a continuation of Scarpa's fascia of the anterior abdominal wall — and this pouch contains the muscles, vestibular bulbs and Bartholin's glands.

(b) The deep perineal pouch lies under the deep layer of the urogenital diaphragm and contains the membranous urethra and the external urethral sphincter which is continuous with the transverse perineal muscles; and the blood vessels and nerves of the clitoris and labia.

The Anal Triangle

This area consists of the termination of the anal canal and its external sphincters; the anococcygeal ligament and the ischiorectal fossa on each side with the vessels and nerves of this area.

The ischiorectal fossa on each side is roofed over by the levator ani, has obturator internus for its lateral wall, the transverse perineal muscles form its floor anteriorly and the gluteus maximus muscles posteriorly. The obstetrically important pudendal nerve runs in Alcock's canal along its lateral wall behind the ischial spine — which is the commonest site of anaesthetic block of this nerve to facilitate delivery.

PELVIC CONNECTIVE TISSUE OF SPECIAL IMPORTANCE

The fascia transversalis of the anterior abdominal wall continues into the pelvis as the endopelvic fascia — also called the extraperitoneal fascia — and consists of two layers — parietal and visceral.

Parietal Endopelvic Fascia

This covers the sacrum and sacro-iliac joints, the pyriformis and obturator internus muscles, and the body of the pubis. It then sweeps downwards to become the deep layer of the urogenital diaphragm.

In places this fascia is thickened to form recognizable "ligaments" radiating from the cervix to the pubis anteriorly, to the arcus tendonaeus or thickened "white line" of origin of the levatores over the obturator internus, and posteriorly to the sacrum from the promontory of S1 down to S5.

These thickened ligaments are known from anterior to posterior as pubocervical, transverse cervical or cardinal, and uterosacral ligaments, and, in fact, form the main support for the bladder, uterus, tubes and ovaries, and rectum.

Visceral Endopelvic Fascia

The reflection of this fascia over all the pelvic organs blends with the smooth muscles of these organs (*e.g.* uterus, vagina) so that it cannot be separated from them.

CHANGES DURING PREGNANCY

The developing conceptus grows progressively heavier during the 40 weeks gestation so that by the time labour commences, the pelvic floor is directly supporting an increased weight of 14 lb. made up as follows:

foetus 7½-8 lb.
uterus 3½ lb. (increase from 2 oz. at conception).
placenta and membranes 1½ lb.
amniotic fluid 1 lb.
increased blood volume in pelvic organs 1 lb.

Healthy muscle reacts to a constant stress of this nature by hypertrophy.

The circulating levels of female sex hormones increase 1,000 times during pregnancy and these have a relaxing effect on ligaments and joints. This effect tends to make the joints unstable so that mechanical disturbances and joint pain may be a problem in later pregnancy.

In addition, the ligamentous areas of the parietal endopelvic fascia may also soften and stretch — relaxing their firm support of the uterus at a time when it is becoming progressively heavier so that some tendency to uterine prolapse may occur.

CHANGES DURING LABOUR

The nett effect of normal uterine contractions is a downward force which drives the foetus down through the bony birth canal while concurrently causing the cervix to dilate to as least 10 cm. diameter to allow the foetus to emerge from the uterus and be delivered.

The first stage of labour is a passive process as far as the mother is concerned and is occupied solely with this cervical dilatation.

However, once the second stage of labour commences (when the cervix is fully dilated), the mother actively assists the expulsive action of the uterine contractions by raising her intra-abdominal pressure to help increase the total downward thrust.

Parturition in this respect resembles defaecation. Contraction of abdominal wall muscles and diaphragm raises intra-abdominal pressure and facilitates expulsion when the foetal head is driven into the urogenital hiatus in the pelvic floor muscle layer, the medial fibres of these levator muscles reflexly relax, allowing the baby to emerge.

During this process, uncontrolled delivery or overdistension of the birth canal may cause tears in the fascial and muscular layers of the pelvic floor. Likewise, if the pelvic floor is rigid, this in turn will cause delay in expulsion of the child.

DELIVERY

It is customary with the delivery of a mother's first infant to perform a median or mediolateral episiotomy. This surgical incision is made to facilitate the emergence of the infant through the urogenital hiatus of the pelvic floor, and the urogenital triangle. As the latter has bony boundaries anterolaterally, and the very vascular vestibular bulb and Bartholin's glands laterally, it is obviously wisest to make the episiotomy incision away from these structures and through less vascular, and more easily repairable, muscle layers.

Thus a mediolateral episiotomy starts at the midline of the vaginal opening posteriorly and cuts through vaginal epithelium and perineal epithelium, the musculo-fascial vaginal envelope, the perineal body (junction of superficial and deep transverse perineal muscles of both sides) and the pubovaginalis fibres of the levatores. If the incision is really extensive it may open into the ischio-rectal fossa of which, you will recall, the levatores ani form the roof.

It is better to surgically incise — and repair — these structures with a first delivery than allow them to tear indiscriminately and heal inadequately leaving a permanent weakness in the musculo-fascial pelvic supports, which may subsequently predispose to utero-vaginal prolapse. During labour and delivery the musculo-fascial vaginal envelope and the fascial ligamentous supports of the uterus may be torn as the baby descends and emerges through the cervix and is delivered, and they will heal without surgical repair. However, such healing may be imperfect and also predispose to subsequent prolapse.

The pelvic floor — being a muscular structure — can be repaired if necessary and exercises, properly supervised, help to restore to normal in the least time this important support of the pelvic viscera.