

INTRA-ABDOMINAL DYNAMICS AND MECHANICAL PRINCIPLES INVOLVED IN THE CAUSE OF BACKWARD AND DOWNWARD DISPLACEMENTS OF THE UTERUS¹

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IN the study of this subject one should not be content with mere theory, but should have some practical knowledge regarding pressure within the abdomen under varying conditions, in the active or passive state and in normal or abnormal health. To determine these points, the writer made some experiments that seem to have been successful in arriving at a working basis.

An apparatus was made consisting of two rubber bags, one placed within the other, and to prevent over-distention and rupture a silk sack was placed between them. The triple bag thus arranged was connected by tubing to a Faught's blood-pressure apparatus for the purpose of correct reading (Fig. 1). When testing intra-abdominal pressure the collapsed bag was placed within the inverted sack of suitable post-operative or other hernias which were free from obstructive adhesions, and a quantity of air sufficient to

inflate the bag without undue pressure was pumped into it. The pressure was not enough to elevate the recording mercury column more than a few mm. above the level of its fellow. The zero mark of the graded scale was placed opposite the mercury level and changes in the reading carefully recorded as tests were made. Of the many points of interest which developed a few relating to this subject are briefly recounted here.

In the normal subject abdominal pressure is *nil* when the patient is lying upon the back, but on assuming the sitting or standing position it increases to 18 mm. Tension of the abdominal wall in maintaining the upright position is sufficient to account for the change, the weight of the intestines not being great enough to produce the effect. The squatting position causes compression of the viscera, which increases the pressure to 20 mm. Inspiration in the recumbent position

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shows 5 mm. In the passive state the abdominal walls are more or less relaxed and yield to diaphragmatic displacement; the reading, therefore, indicates normal muscular tonicity. When sitting or standing the muscles are tense, resist the force of the diaphragm to a great degree, and cause in these two positions 18 to 30 mm. of pressure respectively. On the other hand, expiration in all postures mentioned failed to show any pressure whatever. In coughing or straining at stool the muscles are more rigid and diaphragmatic contraction is greater; here registration shows 30 to 40 mm.

If the testing bag is placed in the vagina beneath the cervix it will indicate 20 mm., less pressure than the abdomen indicates before the pelvic floor begins to bulge; but when full distention occurs the reading on the scale reaches the maximum (average 80 mm.).¹ The interpretation of this is that the uterine ligaments sustain 25 per cent of intra-abdominal strain; beyond that they stretch sufficiently to transmit it to the levator muscle and its contiguous fascia.

In lacerations of the perineum with cystocele and rectocele little or no force is registered unless firm counter-pressure is made with perineal pad or until the patient sits upon some hard substance. In such circumstances the full force from the abdomen is measured in the vagina at the site of the lacerated perineum. If the abdominal walls are much relaxed the pressure is less, for diaphragmatic displacement is dissipated before the abdominal muscles are put upon strain sufficient to create resistance. With the abdomen firmly bandaged and perineal counter-pressure employed the test will show vaginal pressure equal to abdominal.

ANATOMY

Wherever there is force there is resistance, and this brings us first to a brief review of the arrangements and anatomy of the supports of the organs contained within the pelvis. For instance, the lumbar, transversalis, and iliac fasciæ line the abdomen external to the peritoneum and, extending downward, become continuous with the pelvic fascia, which

¹Hard coughing.

lines the pelvic cavity. The fascia is attached to the bony framework of the pelvis; in front, to the body of the pubic bone as far forward as the lower border of the symphysis; on the sides, to the ileopectineal line; posteriorly, just above the attachment of the pyriformis; and is finally lost on the anterior surface of the sacrum. In its descent the fascia divides into several layers, the principal ones being the obturator and rectovesical. The latter passes downward over the inner surface of the levator ani muscles to join the fascia of the opposite side, thus effectually closing the lower end of the immense fibrous bag.

One layer of the rectovesical fascia is reflected over the bladder and becomes its fibrous coat. Another layer is reflected on to the uterus and curves backward external to the pouch of Douglass and is firmly attached to the ischial spine on either side. In its descent in the pelvis the pelvic fascia forms a true and a false bottom to the fibrous bag above referred to. The true bottom contains the several sheets in the pelvic floor — the deep pelvic, the triangular ligaments, and the rectovesical fascia in its relation to the levator ani muscle, etc. The false bottom is formed by the reflected sheets of the rectovesical and deep pelvic, which support the bladder, uterus, and rectum, and contribute to the component parts of certain ligaments of the pelvic organs.

The structures entering into the formation of the pelvic floor are designated as the buoyant supports, while the false bottom in connection with the ligaments is the suspensory support of the pelvic organs. Nature has in this way made double protection against the stress of intra-abdominal strain, and provided for its gradual dispersion to the side walls and floor of the pelvis, thus eliminating the shock of sudden contact with the unyielding surface and the liability to laceration of ligaments, peritoneum, etc., that might occur under the influence of violence. With these this paper will deal briefly, attention being confined principally to the ligaments of the uterus.

Deaver describes them as being of two kinds; false and true. The first are peritoneal folds, so well known that they need not be mentioned here. The latter, the round, uteropelvic, and the uterosacral ligaments

are made up of fibrous and muscular tissue, and on that account concern us most. They are unstripped, muscular prolongations from the uterus, and, therefore, are affected and behave in a manner not unlike the uterine muscularis. They become softened and relaxed in similar circumstances and suffer the effects of puerperal infection when it extends to the peritoneum or parametrium. They may even become thickened or hypertrophied in pregnancy and in chronic inflammatory (vascular) conditions of the cervix, such as carcinoma, and be mistaken for an extension of the disease. In health the muscle lends elasticity to the ligaments — not the contractility that is characteristic of voluntary muscle, but resiliency. It contributes to motion and rebounds and assists in controlling physiological mobility of the uterus. But one of its main uses is its capability of hypertrophy and participation in bearing the increasing weight in the early months of pregnancy.

These ligaments in pairs possess individual functions. The round ligaments running from the cornua upward, outward, and forward to the inguinal canal are so placed that they cannot effect a sustaining influence upon the uterus in the normal position, nor are they put upon severe strain until the cervix protrudes from the vagina; for the uterus in backward and downward displacement describes an arc, the radius of which is represented by this pair of ligaments — and the radius of an arc is constant (Fig. 1+). The function of the round ligaments is to hold the fundus forward and to maintain its even balance in the pelvis. But when imperfectly developed, relaxed, or elongated they fail in this specific function; then, from the effect of posture or excessive distention of the bladder, etc., retroflexion occurs.

The superior uteropelvic ligaments, extending from a point below the attachment of the fallopian tubes to the uterus, outward to the lateral walls of the pelvis, possess a limited range of utility. They are extremely small, and from their points of attachment and from the naturally relaxed state of the upper border of the broad ligaments, cannot directly hold up the pelvic organs. Like the round ligaments they act as guys to the top of the womb.

The inferior uteropelvic ligaments, being attached to the side of the cervicocorporeal junction and walls of the pelvis above the obturator muscle and lying in the plane of the broad ligaments, exert an upward and lateral traction and have a tendency to prevent downward and backward motion of the uterus in the direction of its long axis (Fig. 2 and Fig. 2+). They do not act as aids to the uterosacrals in holding the cervix in the posterior section of the pelvis except as counter tractors. A line passing along one of the inferior uteropelvic muscles, through the cervix and up the other, would form an angle at the point where it traverses the neck of the uterus. The cervix, therefore, may be said to be sitting in a swing formed by these two bands of muscular tissue, and, so far as the control of these bands is concerned, it might swing back and forth with little restraint. They do not hold the neck of the uterus in the hollow of the sacrum, as claimed by some authors, as is proved by the relations here described. If the lateral traction is sufficient to exert such an influence it is so limited that very slight relaxation of the muscles will permit the lower segment of the uterus to advance to the vaginal orifice¹ (Fig. 2+).

Anatomists with few exceptions describe the uterosacral ligaments in common, and agree that they are flat, muscular bands extending from the junction of the body and cervix of the uterus to the articulation of the second and third sacral bones or to the sacrum opposite the lower border of the sacro-iliac joint. "The muscular fibers which run in the uterosacral ligaments are more or less continuous, not only with the fibers of the uterus, but with the muscular fibers about the region where the ureters enter. There are also muscular bundles running from the sides of the bladder — below where the ureter enters — to the vagina, and again from the vagina to the walls of the rectum."²

Motion imparted to the uterus by superimposed force puts the utero-sacral ligaments upon a strain in the direction of their longest dimensions. The neck of the uterus cannot

¹ The diagram drawn to scale illustrates this feature conclusively.

² McKay, p. 223.

move forward without relaxation, or unless the pressure is sufficient to stretch these ligaments. They, therefore, limit the motion of the lower pole of the uterus and maintain it in a more or less fixed position in the posterior part of the pelvis. They preserve the balance and equalize the strain in front and behind the uterus, maintain the normal size of Douglass' pouch, and help to turn the body and fundus of the uterus forward in such a way that intra-abdominal pressure is exerted upon its posterior surface with a tendency to antevert the organ.

The principal parts of the buoyant supports or the pelvic floor are the levator ani muscle (including the coccygeus), the rectovesical and deep pelvic fasciæ, the triangular ligaments, and the coccyx.

The periphery of the levator muscle, being attached to the sides of the pelvis and its central portion to the coccyx, is deeply concaved, and resembles a bowl with its rim tilted forward and upward, the plane of which cuts the horizon at an angle of about forty-five degrees. The central point of its concaved bottom is behind the anus; and the bowl-like muscle, therefore, is represented as lying upon its side, through which the rectum and vagina pass. These two canals incline upward and backward at sharp angles to the side of the muscular bowl, and lie directly upon its inner surface. The uterus and the bladder rest upon both of them. The uterus, inclined as here described, lies nearly parallel to the puborectal portion of the muscle and quite parallel to the external margins of the vaginal orifice. Its anterior surface is then presented to the sides of this muscular bowl and the vaginal outlet.

Under excessive strain the uterus would be driven down upon the bladder and vagina, and, in turn, would force these organs upon the levator muscle and into the vaginal introitus, covering the latter with its broadest dimensions and not with its wedge-like extremity (the cervix), and would effectually block its own expulsion. The pelvic floor is so constructed that it becomes the greatest support of the pelvic viscera, taking 75 per cent of the strain.

PHYSICAL FEATURES

Having set up the principles of force and resistance, the physical features involved now require attention.

Pressure contained within a cavity exerts its influence in all directions equally, and can be no greater than the weakest point of the container, for it seeks the direction of least resistance. If a ball be placed in a closed cylinder surrounded with water or other fluid, and subjected to pressure, the force will be distributed equally over the surface of the ball. If, in place of water, the ball be surrounded by numerous rubber bags or tubes containing water and air, the effect will be the same. If, in place of the ball, the uterus be substituted, the pressure within the container would be expended upon it in identically the same way. Further, if the closed cylinder be substituted by the abdominal and pelvic cavities, and the intestines be represented as taking the place of the rubber tubes, it will be apparent that the effect of pressure within the abdominal cavity is not unlike that exerted upon the ball in the cylinder; that is, an equal distribution of pressure above, behind, and in front of the uterus — or upon all of its exposed parts. (Fig. 3.)¹

If the pelvic supports were absolutely rigid, it would be contrary to any known law of physics for intra-abdominal pressure to disturb the position of the uterus. But, as such is not the case, and since it has been shown that abdominal dynamics do influence the pelvic organs, some change in the position or relation of the structures below and external to the pelvic peritoneum must take place before this force can alter the balance of the uterus. Then, as the tendency of abdominal pressure is to drive the pelvic organs and floor of the pelvis directly before it, the weaker parts become the most impressed while the more fixed tissues suffer the least displacement.

In changing conditions the surface of the uterus exposed to pressure varies, which circumstance necessitates a comparison of the dynamic influence on different parts of that organ. This we can do by relative expressions

¹The illustration for Fig. 3 was made with an adjustable or movable picture that is too complicated to put in print.

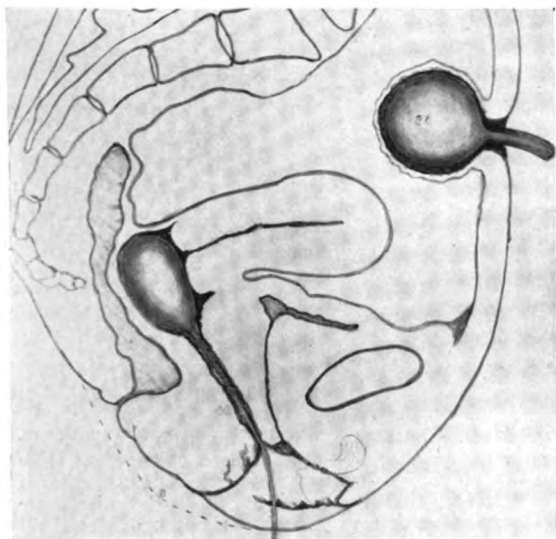


Fig. 1. When testing intra-abdominal pressure the collapsed bag was put within the inverted sack of suitable post-operative or other hernias which were free from obstructive adhesions.

only, on account of inability accurately to measure the surface of the pelvic peritoneum, and accordingly a system of units has been adopted to take the place of customary notations in pounds, ounces, etc.

In this matter effects must be reckoned with respect to the center around which the uterus rotates in backward and downward displacements. It is located near the internal os at the attachment of the uterosacral ligaments; its axis lies transversely in the base of the broad ligaments. I have called it the pivotal point. As the uterus is balanced on this point by reason of its posterior ligamentous attachments, comparison of pressure upon its lower and upper poles must be made with this center as a line of demarcation between the two extremities.

Parts of the uterus exposed to pressure coincide with its peritoneal coverings. Its area on the lower pole is represented by units 1, 2, and parts of 0 and 3, while 4, 5, 6, 7 (Fig. 4), stand for the upper pole, there being one unit excess on the latter. It is the longest, and its forward tilting has been described as a lever-like action. This action is much increased when the superior borders of the broad ligaments are sufficiently relaxed

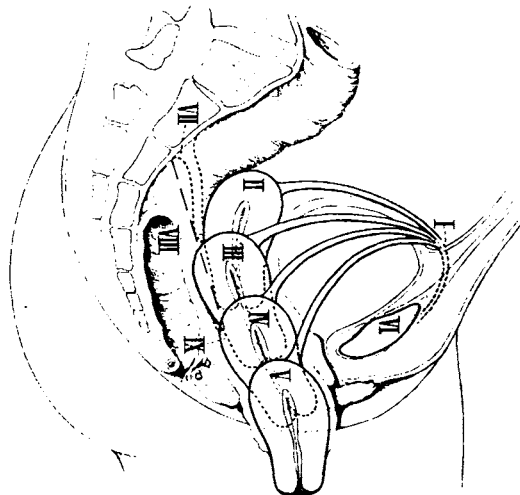


Fig. 1+. The uterus in backward and downward displacement describes an arc, the radius of which is represented by the round ligaments — and the radius of an arc is constant. Their function is to hold the fundus forward and to maintain its even balance in the pelvis.

to let the corpus uteri lie upon the bladder, for the pressure area of these ligaments is greater behind than in front; stress, therefore, would force the body of the uterus and bladder against the levator muscle and over the vaginal orifice. But when the bladder is distended, or when the intestines lie between it and the uterus, abdominal pressure is transmitted through them to the anterior part of the uterus; then the four units, 10, 11, 12, and 13 (exerting a lifting effect) neutralize units 4, 5, 6, and 7 behind the corpus. The lever-like action is reversed, for pressure in the cul-de-sac — 1, 2, and parts of 0 and 3 — carries the lower pole forward, and the upper pole moves to the rear. This clearly indicates the use of the round ligaments, for without them to hold the fundus in position the difference of pressure favoring forward inclination of the uterus might be overcome easily.¹

Inspection of Fig. 5 discloses the fact that, no longer occupying the anterior segment of

¹It also explains the reason girls and young women with immature development or slight infantilism are so frequently subject to retrodisplacements. And I may add that the lack of development in the body of the uterus results in decrease of pressure area behind the corpus and coincidentally a relative increase of pressure bearing surface in the pouch of Douglass, or a reversal of normal status.

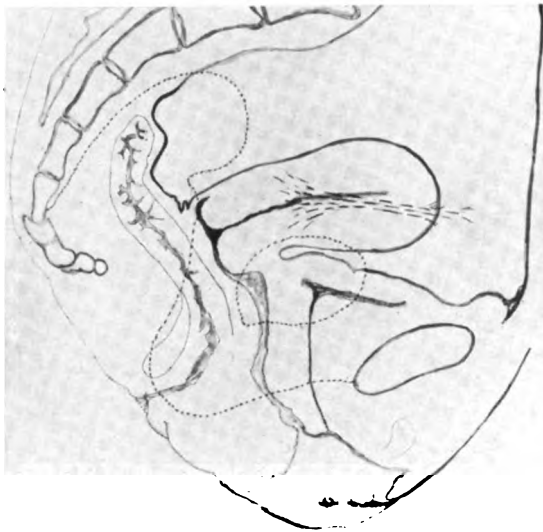


Fig. 2. The inferior uteropelvic ligaments, being attached to the side of the cervicocorporeal junction and walls of the pelvis above the obturator muscle and lying in the plane of the broad ligaments, exert an upward and lateral traction and have a tendency to prevent downward and backward motion of the uterus in the direction of its long axis. They do not act as aids to the uterosacrals in holding the cervix in the posterior section of this pelvis except as counter tractors. (See also Fig. 2+.)

the pelvis, the uterus is not subject to forcible displacement against the bladder and levator ani muscle, nor of imparting to the pelvic floor 75 per cent of incumbent stress, but that its own weight rests upon the broad uteropelvic and uterosacral ligaments. Added to this is the strain of abdominal pressure as indicated by all the units in contact with the peritoneum of the bladder, uterus, and Douglass' pouch (1, 2, 3, 4, 5, 6, and 7). The cumulative effect of these is an over burden far in excess of the normal 25 per cent. The testing bag shows in place of 20 mm. of pressure being sustained by the ligaments that almost the full amount of intra-abdominal pressure is registered in the upper extremity of the vagina. The base of the broad ligaments being no longer restrained by the presence of the corpus uteri between it and the pubic bone swings forward and diverts the greatest strain to the uterosacral ligaments. With forward movement of these ligaments there is an increase in the area of the pouch of Douglass, and a consequent

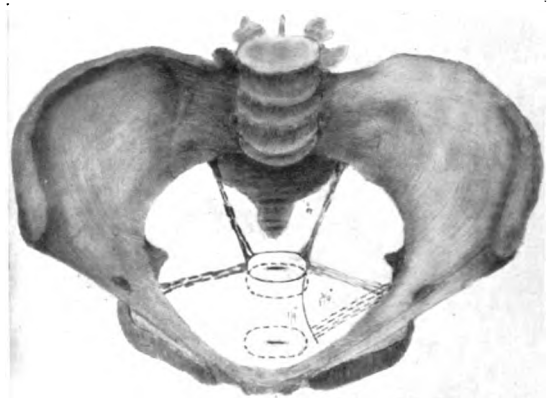


Fig. 2+. The uteropelvic ligaments do not hold the neck in the hollow of the sacrum as claimed by some authors, on account of the relations here described, or if the lateral traction is sufficient to exert such an influence it is so limited that very slight relaxation of them will permit the lower segment of the uterus to advance to the vaginal orifice.

increase of pressure. The larger the pouch grows the greater becomes the force behind the uterus; the increased number of pressure units behind the cervix drive it forward, the inferior uteropelvic ligaments pull the lower pole forward, the posterior ligaments give way, the pivotal point moves downward and advances to a position anterior to the center of gravity of the uterus. Pressure units in front and behind the body neutralize each other, and as the balance of the uterus is thus disturbed it next assumes the position of retroversion.

Figure 6 exhibits the retroverted uterus. In this position the units (1, 2, 3, 4, 5, 6, 7, 8, and 9) cover the entire pelvic peritoneum and indicate that the pelvic organs are subjected to the maximum strain originating in the abdomen. This strain is augmented in the erect position by gravitation. The uterus is in the axis of the vagina (between fifty and sixty degrees to the horizon) and prone to slip almost directly downward.

Conditions are now changed; the uterus no longer produces the ball-valve action over the vaginal orifice; the pressure-bearing area behind the base of the ligaments is no longer counterbalanced by that anterior to it; but the combined force of the two sections represented by the units or the entire pelvic

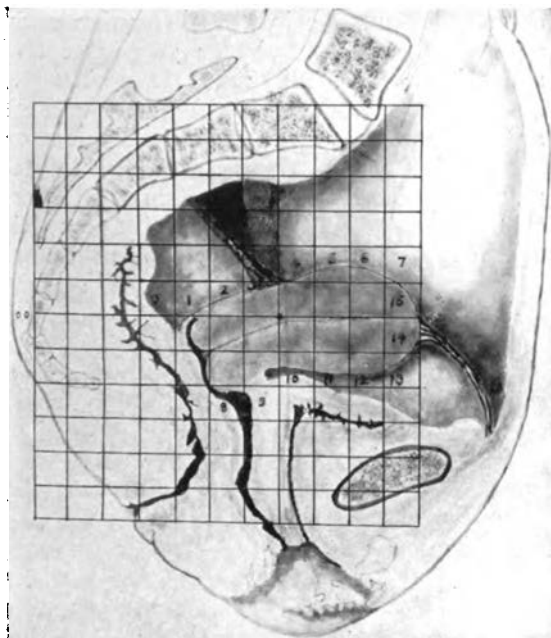


Fig. 4. Parts of the uterus exposed to pressure coincide with its peritoneal coverings. Its area on the lower pole is represented by units 1, 2, and parts of 0 and 3, while 4, 5, 6, and 7 stand for the upper pole, there being one unit excess on the latter.

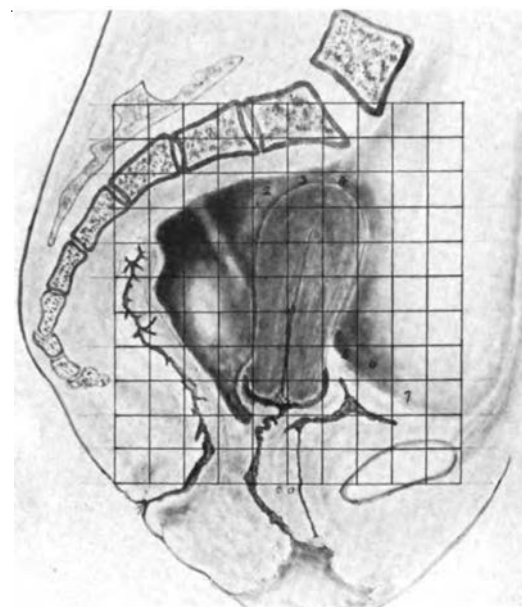


Fig. 5. Added to this is the strain of abdominal pressure, as indicated by all the units in contact with the peritoneum of the bladder, uterus, and Douglas' pouch (1, 2, 3, 4, 5, 6, and 7). The cumulative effect of these is an overburden far in excess of the normal 25 per cent.

area is applied directly to the bladder and anterior surface of the uterus as it lies in the hollow of the sacrum. Change in the tissue, such as softening from relaxation and venous stasis, interfere with nutrition and decrease resistance. The conditions are similar to those of the post-puerperal displacement, except for the effect produced by infection, inflammatory lesions, lacerations, etc. The mucosa, connective tissue, and fascia become œdematous; glandular secretions increase; infection is invited; the result is disease of the endometrium, glandular proliferation, round-cell infiltration, and hypertrophy of mucosa, or perhaps chronic metritis, fibrous deposits, atheromatous vessels, hæmorrhage, etc. The vagina becomes redundant and is thrown into folds; the anterior wall slips down in advance of the uterus and, forcing up the trigonum, passes beneath it into the ostium vaginæ; the lateral ligaments of the bladder become relaxed and, if the suspensory ligaments are much impaired, the neck of the bladder may rotate under the pubic arch in

advance of the developing cystocele. The uterus becomes prolapsed, the uterosacral ligaments effaced, and the broad ligaments are subjected to excessive pressure. The inferior uteropelvic ligaments are now subjected to greatest strain and the round ligaments can offer no restraint until extrusion of the cervix occurs. At this stage the restraining force preventing extrusion devolves upon the overstretched broad ligaments and the peritoneum, and with little effect, for the full force of intra-abdominal pressure is measured at the vaginal orifice.

The posterior vaginal wall, coincidentally with the anterior, drops for a short distance, but it is retarded by its attachments to the rectum, and indirectly by its lateral ligaments, when they reach a line between the ischial spines. In this new location they become tense and, not being subjected to much pressure, act as a check on the descent of this part of the vagina. But on further advance these attachments feel abdominal strain and follow the uterus in its outward passage.

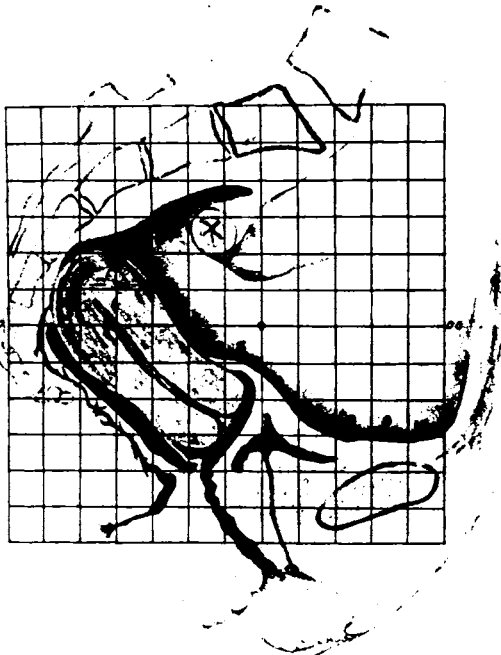


Fig. 6. Diagram exhibiting the retroverted uterus. In this position the units (1, 2, 3, 4, 5, 6, 7, 8, and 9) cover the entire pelvic peritoneum and indicate that the pelvic organs are subjected to the maximum strain originating in the abdomen. This strain is augmented in the erect position by gravitation.

So much for the effects of pressure upon the ligaments of the uterus in ordinary circumstances; but now let us turn to the consideration of cases having their origin in lesions of the floor of the pelvis.

The perineum may be likened to the center stone in an inverted arch, but in place of a crushing force it sustains a tensile strain. The decussating fibers of the levator ani muscle attached to the anterior surface of the anal segment of the rectum, the rectovesical fascia, and the triangular ligament (constituting the most important parts of the perineum) act as a bond holding the two halves of the levator ani muscles together between the rectal and vaginal outlets. Pressure tests show an average of 80 mm. in the abdominal cavity, 60 mm. beneath the cervix, 40 mm. on the inside of the perineum, 20 mm. on its external surface before it reaches full distention, and zero when bulging is complete. Therefore it will be observed that the perineum sustains 40 mm. of pressure, and

actually bears two-thirds of the burden measured beneath the cervix, or 50 per cent of abdominal strain. But *when the perineum is destroyed pressure tests show full intra-abdominal strain at the vaginal orifice.* The reason for this is that the two sides of the levator muscles separate, the abnormally large vaginal orifice offers no resistance, and the pelvic organs are held by their ligaments and other suspensory attachments only (the support below being removed). Normally the levator muscles draw the perineum forward and beneath the bladder until the posterior commissure reaches the trigonum, which covers the outlet like a lid to a box. In lacerations of the perineum this effect is lost. The loose portion of the vesicovaginal septum posterior to the trigonum (that part in which the connective tissue permits the bladder to move easily on the vagina) slips forward and, becoming more or less œdematous, passes beneath the trigonum and protrudes from the vagina. As it develops it draws the neck of the bladder and the uterus downward. If the rectal sheath has been torn when subjected to elongation, coincidentally with distention of the perineum in labor, or if meshing of its fibers has occurred, the rectum rolls forward and outward for the lack of perineal support, as the thin walls of the rectum are unable to sustain the intrarectal pressure, which at times is equal to the abdominal. When dealing with lacerations we must not be unmindful that they are frequently associated with puerperal infection. Inflammatory softening is not confined to the uterus, but it involves the ligaments and arrests the process of involution; they become relaxed and incapable of supporting the uterus. It lies in the hollow of the sacrum; consequently this class of cases frequently begin with retroversion. They, however, follow a similar course to those described, except that changes take place more rapidly and, there being a greater relaxation of fascia, the rectum is disposed to slip forward in advance of the cystocele.

It is not the purpose of this paper to deal with cases having their origin in new growths and other specific pathological lesions, nor is it intended to account for the influence of adhesions to the uterus, etc.