STRESS INCONTINENCE IN THE HUMAN FEMALE. AN OPERATION FOR ITS CURE.

THESIS

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by

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INTRODUCTION.

The stimulus for this work is grounded in a series of cases observed by the writer during some years of general practice. These patients presented various degrees of prolapse of the uterus, bladder and rectum.with varying severity of stress incontinence. On passing these cases on for treatment by consultants one was struck by the apparent "sameness" of the operations performed. The names appended to these procedures were: Vaginal repair; vaginoplastic; repair of cystocele and rectocele; Manchester; Fothergill.

It was noticed, however, that rarely did these procedures consist of more than the removal of triangular pieces of mucosa from the anterior- and posterior surfaces of the vagina, followed by suturing of these wounds with or without some plication of the exposed submucous tissues. Some of these cases did feel better for a few months but the stress incontinence invariably was not cured and in some

instances procidentiae followed within one to two years.

The operation presented here has proved to be effective for up to eight years post-operatively so far in stress incontinence irrespective of the causal origin of this distressing condition— and even in those cases that have had more than one failing procedure. This is mainly due to the fact that the mechanism of this cure does not depend solely upon the function of the organs normally involved in the closure of the bladder, but mainly on a new activity whose shutting off of the bladder-neck is complete and absolute. The patient herself cannot prevent this closure during intra-abdominal stress even if she wishes to.

In an operation for this condition the following equation particularly applies - as it may well do in most surgical procedures:

$$R = \frac{O\,P}{T}$$

Where R = Recovery of function.

O = Correctness of operation chosen.

P = Post-operative care effectiveness.

T = Technical defects in the operation.

It is essentially a reconstructive procedure that is required, and while in cases where a diseased organ has to be removed, and even very poor technique may on occasion yet give a good result, in the treatment of stress incontinence every detail is of great importance and its neglect may lead to failure.

The whole problem can be likened to a building of which the roof, ceiling, walls and floor are in a state of partial collapse. The reconstruction of the edifice with the original damaged material is surely a more formidable problem than a replacement with new parts. This task is still more complicated when one or more previous procedures for repair had failed. In this observer's operation, although the damaged tissues in the pelvic floor, around the vaginal vault, bladder neck and urethra all have to be repaired as far as possible, two reliable inverted arches or slings are provided as re-inforcement in the form of tissue from the abdominal wall.

To place the problem and its treatment in perspective, a brief description is first given of the

relevant history, embryology, anatomy and physiology.

A special apparatus has been devised and constructed for the study of pressure changes in the bladder and in the urethra. It is called a cysto-urethromanometer.

As a kind of by-product of some investigations of the function of the bladder, a method was developed for the cure of abnormal frequency of micturition that follows on longstanding cystitis which causes inability of the bladder to dilate to normal capacity. This is merely a form of distension of the bladder with increasing quantities of normal saline, repeated several times a week until dilation to normal capacity is restored.

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DEFINITION.

Stress incontinence in the human female is defined as the involuntary loss of urine through the urethral canal during the sudden increase of intra-abdominal pressure, while there may be normal control at rest.

The increased pressure may be caused by such acts as coughing, laughing, sneezing and physical exertion as bending or walking up or down staircases.

HISTORICAL REVIEW.

As stress incontinence is only one of the symptoms of weakening of the pelvic floor with consequent descensus of some of, or all the pelvic organs and concomitant postural derangement of the bladder and associated organs, with resultant impairment of the sphincteric function of the bladder neck and urethra,— the study of its history means the consideration of the approach that scientists had towards prolapse throughout the years.

This approach can be divided into two main phases which can be called the pre-Fothergill and post-Fothergill periods. The first period began in 1834 when a "Practical Treatise on the Diseases of the Uterus and Appendages" by Mme. Veuve Boivin and A. Duges was published and translated by G. O. Heming.

Heming[1], in 1831 carried out operations on the anterior vaginal wall and was soon followed by Kilian, Marion Sims and others. Results, however were poor as anaesthesia was still unknown and suture material

primitive— strips of quill being mainly used.

In 1832 chloroform was discovered by Soubeiran and Leibig[2] and in 1847 it was introduced as an anaesthetic by Sir James Simpson.[3] Soon after this, in 1852, Baker-Brown[4] could report to the Medical Society of London that he had performed two successful vaginal operations under chloroform. Quill sutures were used and to obtain pressure, the strips of quill were placed through pieces of bougie. To aid healing the patient's knees were tied together for up to a week. The infection incidence was high and the cure rate low.

The outstanding figure that appeared in the pre-Fothergill period was Donald[5] who came to St. Mary's Hospital, Manchester, from Edinburgh in 1885. He was driven to frustration very soon by the way the hospital's Board of Management exercised restrictions over abdominal operations and he therefore turned his attention to relaxed pelvic floors and uterine prolapse. These complaints were very common and were aggravated by the severe working conditions for women

at that time.

In 1888 Donald combined his colpoperineorrhaphy and amputation of the often diseased cervix in a single procedure using silver wire as suture material. Catgut had now become available from Germany[6] but the problem about it was the matter of sterilisation.

The second phase then began with the advent of Fothergill[7] who, in 1906, joined the same hospital and saw for the first time the colporrhaphy operation performed by Donald.

Fothergill immediately set about making a detailed and scientific study of the anatomy involved in the various degrees of prolapse and between 1907 and 1921 he had treated numerous women with his famous operation.[8] The main features of this procedure is that a triangular area of the anterior vaginal wall, with its base about 2 cms. from the edge of the cervix and the apex about 1 cm. below the external meatus of the urethra, is denuded of mucous membrane. The cervix is amputated, the bases of the broad ligaments approx-

mated in front of the remaining base of the cervix, the bladder neck pushed up into an angle by the same kind of plicating sutures that the cystocele is obliterated with and the edges of the triangular area then again sutured together. There are many variations of detail in this procedure and should a rectocele also be present then the posterior vaginal wall is dealt with somewhat similarly, the rectocele reduced with mattress or purse-string sutures and the levator muscle edges approximated.

The Fothergill operation, with minor modifications has held its own in modern surgery for many years, also in North America, and still does. In 1946 Te Linde[9] described in detail how this operation is carried out at Johns Hopkins University. Likewise Montgomery[10] in 1948 described the use of the Manchester-Fothergill operation at Jefferson Medical College. Greenhill[11] of Chicago states "for correcting uterine prolapse I particularly prefer extensive plastic operations like the

Manchester-Fothergill operation".

During the late 30^{s} and early 40^{s}, however, there occurred a general dissatisfaction with the treatment of prolapse and its associated symptoms, least of which was not incontinence of the bladder described until then mainly as exertional incontinence, and by now known by the more scientifically descriptive name of "stress" incontinence, given to it by Holland[12] in 1928. As stress incontinence can exist in patients that have no marked descensus at all and whereas it constitutes the most distressing symptoms of most degrees of prolapse, the aim to cure was shifted more to stress incontinence itself.

And, indeed, few conditions could have stimulated the ingenuity and imagination of gynaecological surgeons more than did stress incontinence. The operations that have been devised are far too numerous even to be listed and therefore a short summary will be given of the nature of those ones only that seem to have contributed to the relief or cure of this most frustrating malady.

During the period in which Fothergill's operation established its worth there was never, however, a paucity of attempts to find an operation that could give more lasting results. The repair of cystocele and plication of the urethra and bladder neck brought temporary relief mainly in those cases (as indeed it does at the present time) in which the condition was related to the injuries of childbirth. This kind of repair is not of value in cases of congenital defects of the sphincter mechanism or of the urethra itself, or where the incontinence is due to lesions of the central nervous system.

The first operation that is known where tissue from an area remote from the bladder was utilised is that of Giordano[13] in 1907 and used successfully and quoted by Deming[14] in 1926. In this operation the distal end of a gracilis muscle was brought up to the urethra and sutured around it. In this method, however, there may be interference with the movements of the thigh, and it does not seem as though it was ever generally accepted.

At about the same time Goebell[64] devised a procedure whereby the pyramidalis muscles were freed at their upper ends, passed down behind the symphysis and then sutured together below the urethra. In those cases where they were long enough they were crossed above the urethra. He reports the cure of one case of a child who became incontinent after an operation for meningocele. The pyramidalis muscles vary in size in different people and in some they will be found to be too short for this purpose. .

In 1911 Taussig[15] and Squier[16] independently reported successes with the utilisation of medial parts of the levator ani muscles that were sutured together in the plane between the urethra and vagina, forming a kind of muscular sling. The idea originated with Squier when he had to restore continence in a man whose bladder sphincter had been accidently cut at a previous operation.

Frangenheim[17] of Cologne left a strip of fascia from the rectus sheath attached to the pyramidalis

muscles and brought them down around the bladder neck after the method of Goebell.

In 1917, Stoeckel[18] used the combined pyramidalis muscle-and-rectus fascia strip together with plication of the vaginal side of the bladder neck. The upper end of the rectus fascia strip was split for a short distance and the two ends brought down on each side of the sphincter area, to be sutured below it.

The principle involved in this operation, namely the utilisation of the tension caused in the abdominal wall on coughing, sneezing etc. to pull upwards on a band attached to the abdominal wall and thus shutting off the bladder, is the same as that of the operation of the author of this work, described later in detail.

Miller,[19] in 1932, described an operation based on the aforementioned Goebell-Frangenheim-Stoeckel procedure. He continued the median abdominal incision straight down in the midline over the symphysis and half-way around the urethral meatus on one of its sides.

He then dissects the urethra free from below upwards for some distance and unites the two split limbs of the fascial strip below the urethra.

In 1933, Price[20] described the cure of urinary incontinence in a patient with congenital absence of the sacrum and coccyx, and absence of nerve supply to the bladder sphincter. He used a retropubically placed fascia lata sling under the urethra and sutured the two ends to the rectus muscles.

From about 1940 there has been a fresh upsurge of enthusiasm in work on stress incontinence—an interest which has continued up to the present time.

This period can be described as the third phase of stress incontinence investigation and treatment. The more important work during this phase is briefly surveyed.

Aldridge,[21] in 1942 devised an operation in which he embodied the principles of the Goebell-Frangenheim-Stoeckel procedure. Through a lower abdominal

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transverse incision he took fascia strips from the rectus sheath on both sides with the median ends remaining attached and formed a sling by uniting the ends under the bladder neck which point is reached by bringing the strips down through the space of Retzius.

the strips down through the space of Retzius.

In 1937, Kennedy[22] published his operation for stress incontinence which had the following main features; An incision along the midline of the anterior wall of the vagina from a point 1 cm. below the meatus to a point on the cervix below the bladder fold. The urethra is dissected free from the vaginal wall and is also freed from the pubic rami. The bladder is freed from the cervix and some distance up the anterior surface of the uterus, and the vaginal wall is freed from the bladder laterally as far as the medial edges of the pubic rami. The whole length of the urethra as well as the exposed part of the bladder is then plicated with transverse mattress sutures before the vaginal flaps are again approximated with redundant widths removed. He reinforces the vaginal wall with three sutures of silver wire which are taken out on the twelfth post-operative day.

Studdiford,[23] in 1944, described a modification of the Aldridge operation in that he brings down shorter rectus fascia strips which cannot overlap beneath the

bladder neck but are simply approximated with mattress sutures.

Millen[24] and Read of London in 1948 reported an operation that they had devised in 1945 for cases of severe stress incontinence and which they had performed on 200 patients. It consists of a sling made of two parallel strips of lower abdominal aponeurosis with their ipse-lateral ends remaining attached and passed through from the abdominal side under the bladder neck. This has the effect of closing off the bladder when intra-abdominal pressure puts tension on the abdominal wall.

In 1948, Marshall[25] of Liverpool published a method of developing a musculo-fascial sling from the sheaths of the recti— which sling consisted of strips that were passed from the abdominal route under the urethra by means of a specially made curved forceps. He later modified this procedure by using only a single rectus fascial strip which was split at the free end and the two limbs of the strip thus formed were then passed through under the urethra as in the previous

operation, brought out through the recti muscles and sutured on to these.

The next operation that was reported to have given good results in many cases was that of Shaw[26] of St. Bartholomew's Hospital, London. In 1949 he described a very interesting operation that he invented in which he used a spindle-shaped piece of fascia lata taken from the lateral epicondylar region of a femur. The strip is 6 ins. long, 1½ ins. wide in the middle, and tapering to ½ in, wide at the ends. From a point ½ cm. above and behind the external meatus an incision is made in the mid-line to a point well above the vesical neck which, together with the whole length of the urethra is appropriately exposed by dissecting away the vaginal flaps to the sides. At its widest part the fascial strip is then sutured transversely to the front of the urethra and bladder neck in such a way that all the post-urethral tissues can now be supported by it. The upper edge of the strip is best sutured to the anterior aspect of the cervix itself immediately below the exposed bladder fold. The retro-pubic space is then opened on both sides of the urethra through the

pubococcygeus muscle and the posterior surface of the pubic bone palpated with the finger. At the appropriate level on both sides a ½ in. diameter hole is drilled through the pubic bone which has been exposed through a vertical incision through the skin of the labia majora and underlying soft tissues and periosteum. An assistant, with a finger behind the bone can determine when the inner surface of the bone has been traversed. A thin, curved forceps is now passed through these holes in turn and the narrow ends of the fascial strip brought out through them and sutured to the tendinous tissues around the holes. The vaginal flaps are then properly closed over the piece of fascia. Thus one has a fascial sling in the shape of a hammock holding the vesical neck and urethra upward and forward. Antibiotics and sulphathiazole powder are used in the incisions to prevent the incidence of osteomyelitis. The ingenuity of the operation is admired by this writer and in all respects it appears to be an extremely neat procedure. It is small wonder that Shaw reports a good cure of stress incontinence in 35 consecutive cases.

In 1949, Marshall,[27] Marchetti[28] and Krantz[29] described an operation in which, through the suprapubic route they elevated the urethra and bladder neck by suturing them respectively to the periosteum of the os pubis and to the rectus muscle.

They performed this operation on 50 patients of whom 38 had definite stress incontinence. Of these, 12 had weak urinary control for a variety of reasons. Another 25 had previously, among them a total of forty gynaecological operations without relief of their stress incontinence. On these cases they report 82% of good results with their procedure.

Ball,[30] in 1952, reported success with an operation that consists of plication of the urethra and bladder neck from the vaginal approach followed by suprapubic entry into the space of Retzius through a low Pfannenstiel incision. Here the urethra is freed from its ligamentous attachments to the pubic bone and it as well as the anterior aspect of the vesical neck are then elevated with sutures that pass

through the recti muscles.

In 1952 and 1957 Jeffcoate[31] published some very important work on stress incontinence in which he showed the importance of the urethrovesical angle in urinary control backed by very clear urethrocystographic findings.

In 1952 an elaborate description was given by Frost[32] of a form of urethral and vesical plication for stress incontinence. It is, however, essentially the Kennedy procedure apart from the fact that Frost uses a series of deep transverse mattress sutures to unite the vaginal flaps followed by a final row of interrupted sutures to approximate the edges proper of the vaginal wall.

Ingelman-Sundberg,[33] in 1950 described his method of using strips off the medial edges of the pubococcygeus muscles which he sutures together under the urethra after the anterior vaginal wall had been opened in the usual way. He leaves a catheter in

the bladder and a tampon in the vagina for 24 hours. The patient is usually discharged on the 16th post-operative day with instructions to take exercises in contracting the pubococcygeus muscles for strengthening the pelvic floor.

Bierer,[34] in 1961, described a completely different form of surgical treatment of stress incontinence. In this he uses a 7 cms. long metal instrument called a colporrhaphear and consisting of a fitted half cylinder accommodating a half piston with the cylinder part in the urethra and bladder with its concave side facing down towards the vagina. The piston part is placed in the vagina with its convexity upward pushing the floor of the urethra and part of the bladder floor into the cylinder's concavity, the vaginal mucosa having first been freed from the urethra and bladder for the required length. With interrupted sutures the edges of the bladder and urethral coverings are then united under the whole length of the piston, invaginating them. Bierer reports that "nearly 100 cases responded well" to

this operation but he does not state for how long the cure lasted.

This same principle is used in the Kennedy repair and is possible as successful in mild cases. For permanent cure, however, one would suggest that a sling as later described be added.

It is notable how few authors described any post-operative treatment, of for that matter even refer to it. And yet even small things that are done or neglected during the post-operative period can mean either the success or failure of the operation. This will be referred to in more detail later in the chapter on the sling operation.

Shute,[35] in 1961 reports that he, in cases with uterine pathology where hysterectomy is required, would do a full vaginal repair first and thoroughly re-establish the vesico- urethral angle. Then he would do a total abdominal hysterectomy, lifting the vaginal vault as high as possible by means of the round ligaments and suturing the other ligaments well

into the vaginal cuffs also. He states that he had done two separate series of about 500 cases each. In the one series he did the repair simultaneously with vaginal hysterectomy and achieved 90.6% cure of stress incontinence cases. The series with vaginal repair and total abdominal hysterectomy yielded a cure rate of 98.3% in stress incontinence.

Cope;[36] reported in 1961 that he is against indwelling catheters and packing of the vagina and states that the patients suffer severe pain. He also states that prolonged bed rest is still generally accepted. This writer cannot agree with this and will refer to it in the description of his operation and the post-operative treatment.

Madser[37] and Urich in 1961, report "good results" with the Marshall-Marchetti operation in cases that suffer from stress incontinence without cystocele or a weak pelvic floor being present. They stress the need for applying the correct operation for the type of abnormality to be treated.

Louw,[38] in 1963 describes all the essential problems associated with prolapse in detail and emphasises the fact that the vesico-urethral expansion with funnelling is the main local factor in stress incontinence. He stress the fact that the vesical neck and urethra should be completely identified and mobilised so that the vesico-urethral angle can be properly reconstituted and the relevant muscular elements around this area approximated. His statement that stress incontinence is merely a symptom of abnormalities and that "prolapse is a herniation of the urethra, bladder, uterus, pouch of Douglas and/or rectum— or any one of those organs singly or in combination— into, or together with the vagina", more or less expresses the whole problem in one line.

EMBRYOLOGY.

A short survey is given of the embryological development of the urogenital organs of the human female with the accent on the development of the bladder. To bring this into line, a brief description is given of the early growth of the fertilised ovum. The sketches and diagrammatic representations given in this chapter have been composed from micro-anatomical slides kindly loaned by Prof. Earl T. Engle of the department of gynaecological pathology, Columbia University Medical School, New York, and from descriptions by authors as quoted.

The first description that one finds of the growth of the fertilised ovum in vitro is that by Rock and Menkin[39] of Harvard University in 1944. These workers observed the two-cell stage appearing, in two ova that had been contacted by spermatozoa, in 40.5 and 45 hours respectively. The three-cell stage was reached 46 hours after such exposure. This was the most advanced stage of in vitro life

that could be watched at that time.

At about the same period, however, Hertig and Rock[40] studying seven normal human ova ranging in development age from 7.5 to 16.5 days showed that the blastocyst had implanted itself on the posterior wall of the uterus by about the late 6th or early 7th day of its development. There are no accurate data as to the exact point of time of implantation since the youngest specimen so found is of course already implanted. Uteri containing even younger fertilised ova will have to be obtained in order to find the precise date of implantation.

At the site of growth in the endometrium trophoblast already proliferates and at this early stage consists of solid cysto- and syncytiotrophoblast. Vacuoles appear in the latter by the 8th day, enlarging into lacunae into which maternal blood enters at about the 11th day. On the 12th to the 13th day chorionic villi begin to form and grow towards the periphery of the syncytiotrophoblastic framework of

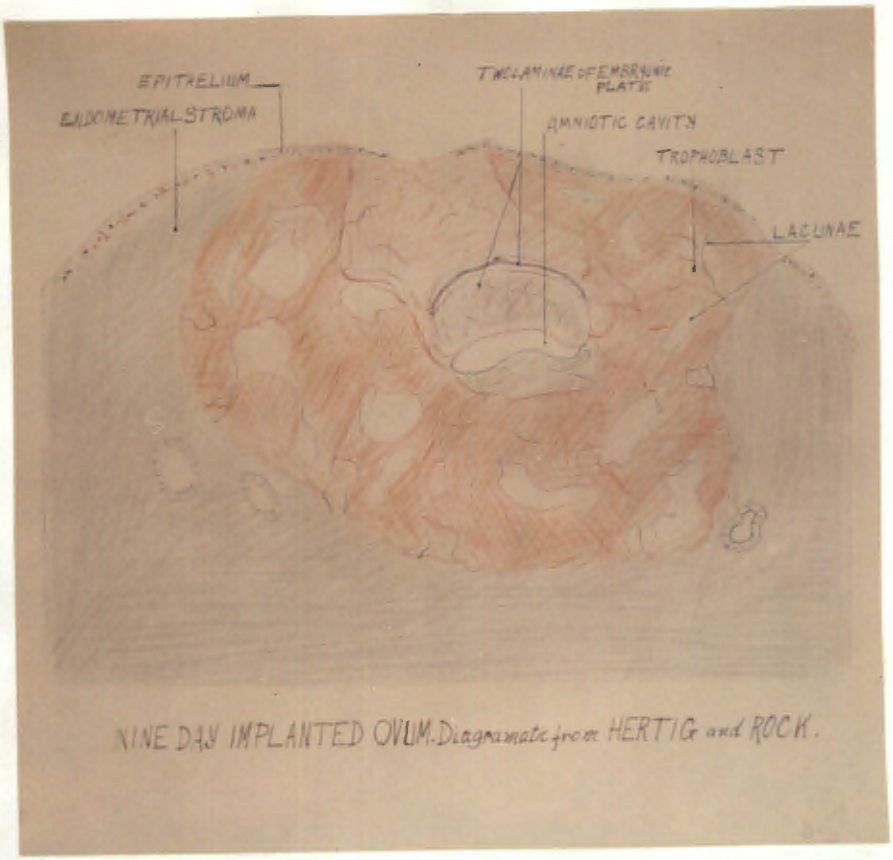


Fig. 1. Nine-day implanted ovum.
Sketch from microphotograph
by Hertig & Rock.

the ovum. Eventually the chorionic villi displace the syncytiotrophoblast, the remnants of which are noted in the placental site as giant cells.Fig ..1.

A series of five ova were found of developmental ages of 11 to 14 days, all of whom were abnormal in that they showed marked hypoplasia of the trophoblast and very shallow implantation. These pathological ova were all found to be implanted on the anterior wall of the uterus.

Davis and Harding[41] of Sheffield University also reported in 1944 the structure of a previllous ovum of 9 days age, and which also constituted the earliest stage of a fully implanted human ovum studied at that time. Their observations established that whereas the ectodermal and entodermal layers of the germ disc are derived from the formative cell mass of the ovum, the amnion and exocoelomic membrane (or primary yolk-sac) are mesoblastic in origin. They compared the status of this ovum with that of other ova and concluded that the definitive yolk sac in the human being

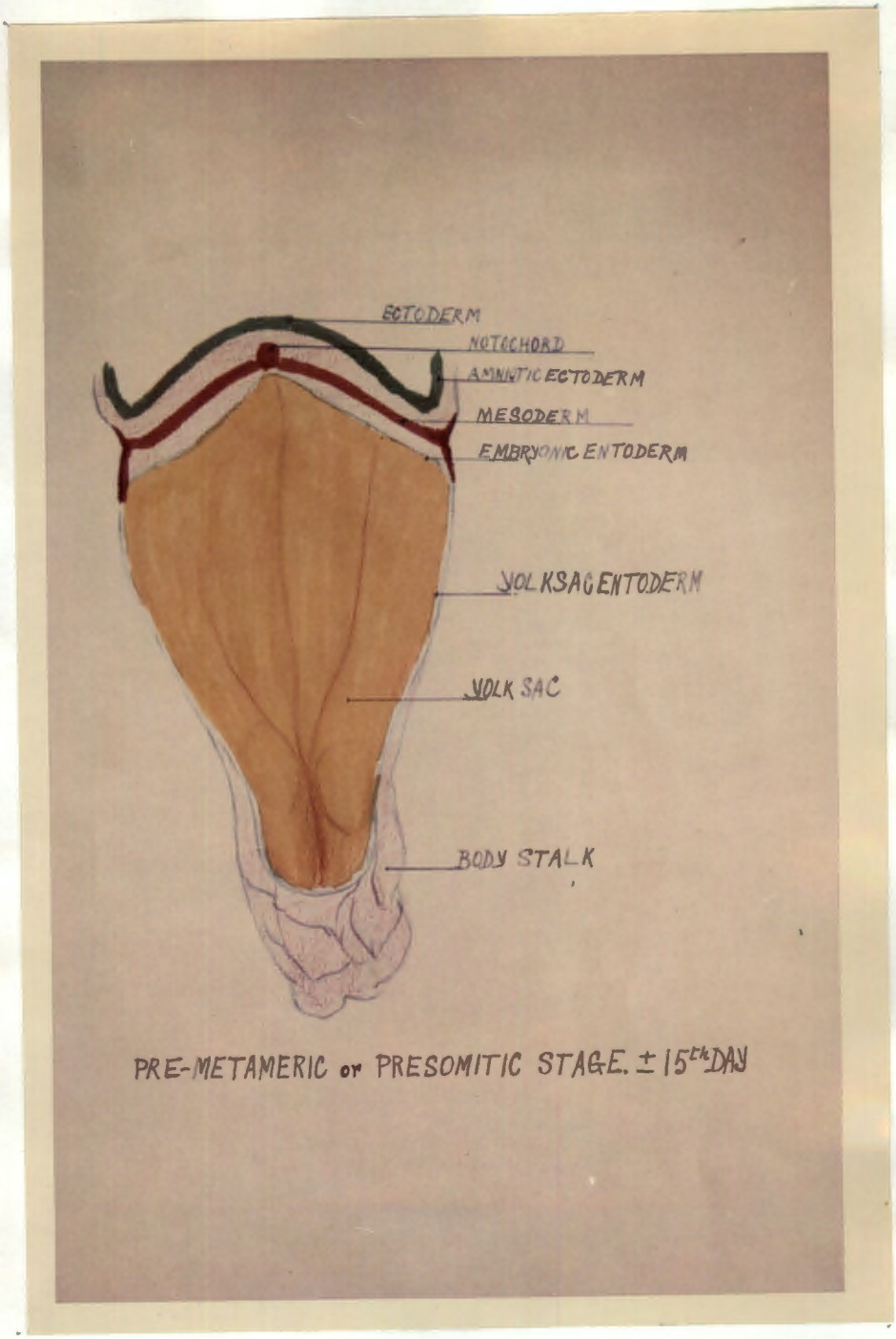


Fig. 2. Sketch of fifteen-day embryo.

develops at about the 12th and 13th day after fertilisation of the ovum.

The aforementioned disc-like structure of the early embryo consists of three layers: the ectoderm, the entoderm, and the mesoderm between the other two. These three together represent the pre-somite embryo (Gr. Soma = body), or pre-vertebrate stage of development. The structure is represented as an oval translucent shield about 1 m.m. in length. This shield or plate lies on the surface of the yolk sac.[42,43].

The excretory and reproductive organs develop from the embryonic mesoderm which lies as a strand of tissue between the other two layers. Through the middle of the mesoderm, running lengthwise is the notochord, (Gr. Notos = Back + Chorde = string), a fibro-cellular rod-like structure constituting the primitive embryonic spinal cord. Fig. ...2..

The medial part of the mesodermal layer becomes

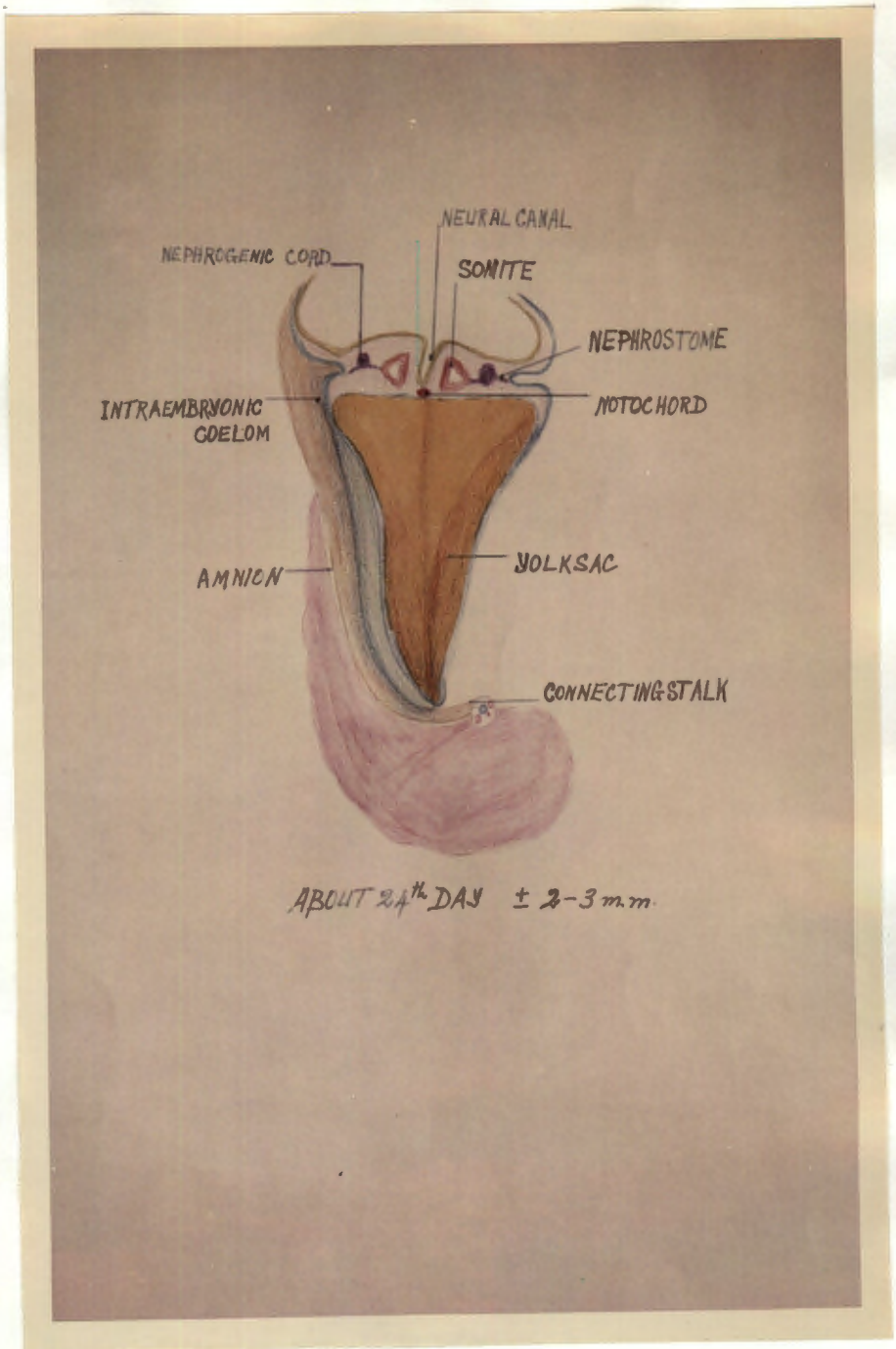


Fig. 3. Twenty-four-day embryo.

thicker along its whole length and at about the end of the third week of embryonic development it begins to divide bilaterally on each side of the mid-line, and close to it, into paired swellings of tissue. This is the begining of the somitic stage. Laterally the mesoderm remains flat and later splits itself into two layers to form the embryonic coelome. The parts of the mesoderm between the segmented somites and the flat lateral areas on each side develop their own cord-like structures— the two nephrogenic cords or tubules. Fig...3.....

The study of the genito-urinary system in embryonic life consists essentially of a consideration of the development of these nephrogenic cords and their two successors and this description is limited chiefly to the growth of these three entities.

A succession of three renal systems have occurred in the higher vertebrates during the course of evolution. The third of these is our present functional system namely the kidneys or metanephros. The

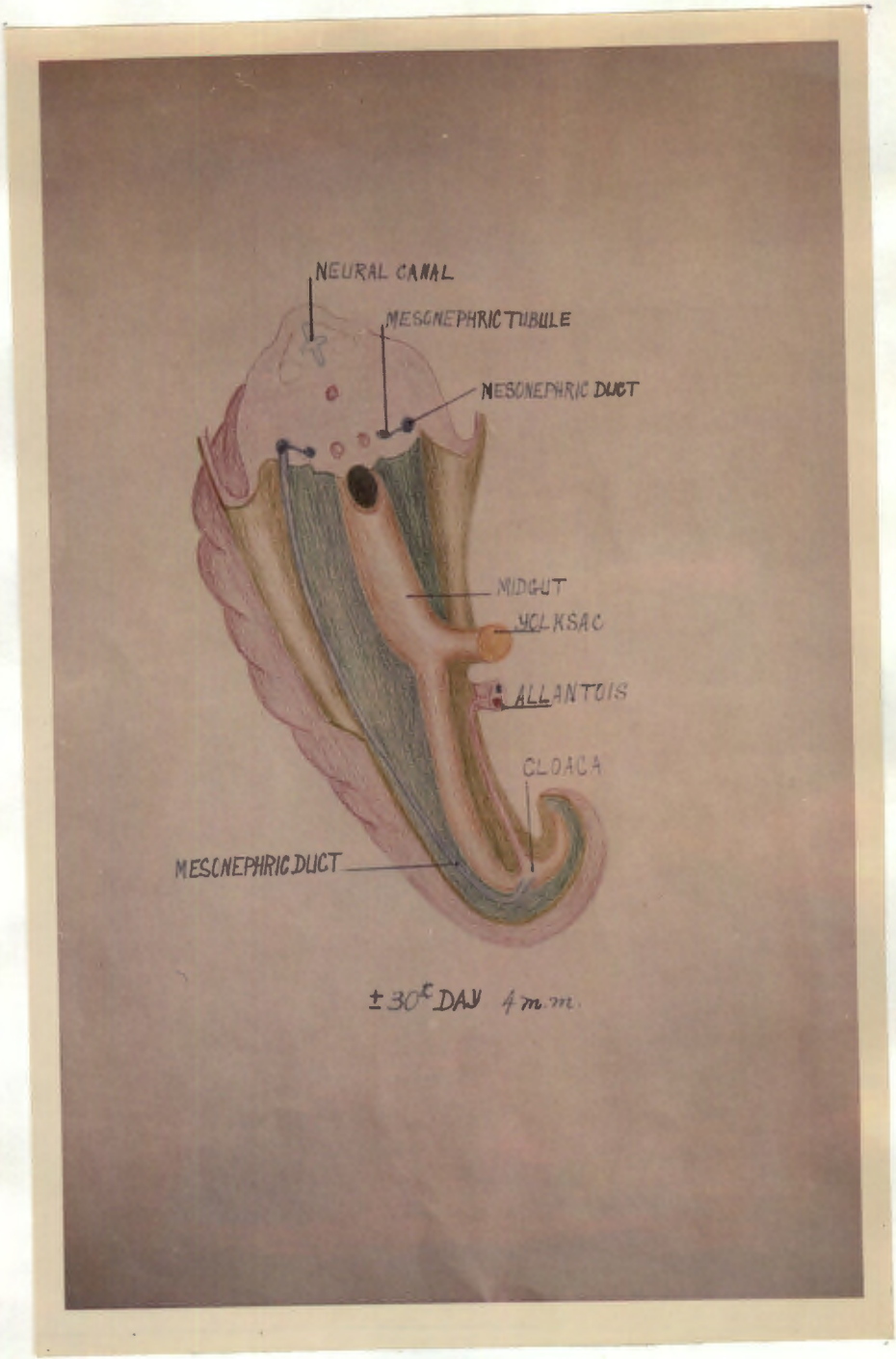


Fig. 4. Thirty-day embryo.

antecedent ones were the pronephros and mesonephros or Wolffian body. These three constitute the serial parts of the same linear system of organs. The three bodies or cords are made up of nephric tubules that open into the common secretory duct namely the pronephric or Wolffian duct.

The pronephros or earliest tubular formation from the nephrogenic cord begins at a point corresponding to the 5th cervical segment and ends at its cephalic end into the coelome. This happens in man and all the higher vertebrates.

At the cephalic end the pronephric buds and tubules atrophy and later also disappear in the thoracic region. Lower down, however, the tubules develop a more complex structure and grow down through the dorsal and lumbar regions, until they reach the sacral region.[44,45].

There are in all seven pairs of pronephric buds and tubules of which six pairs have disappeared by the

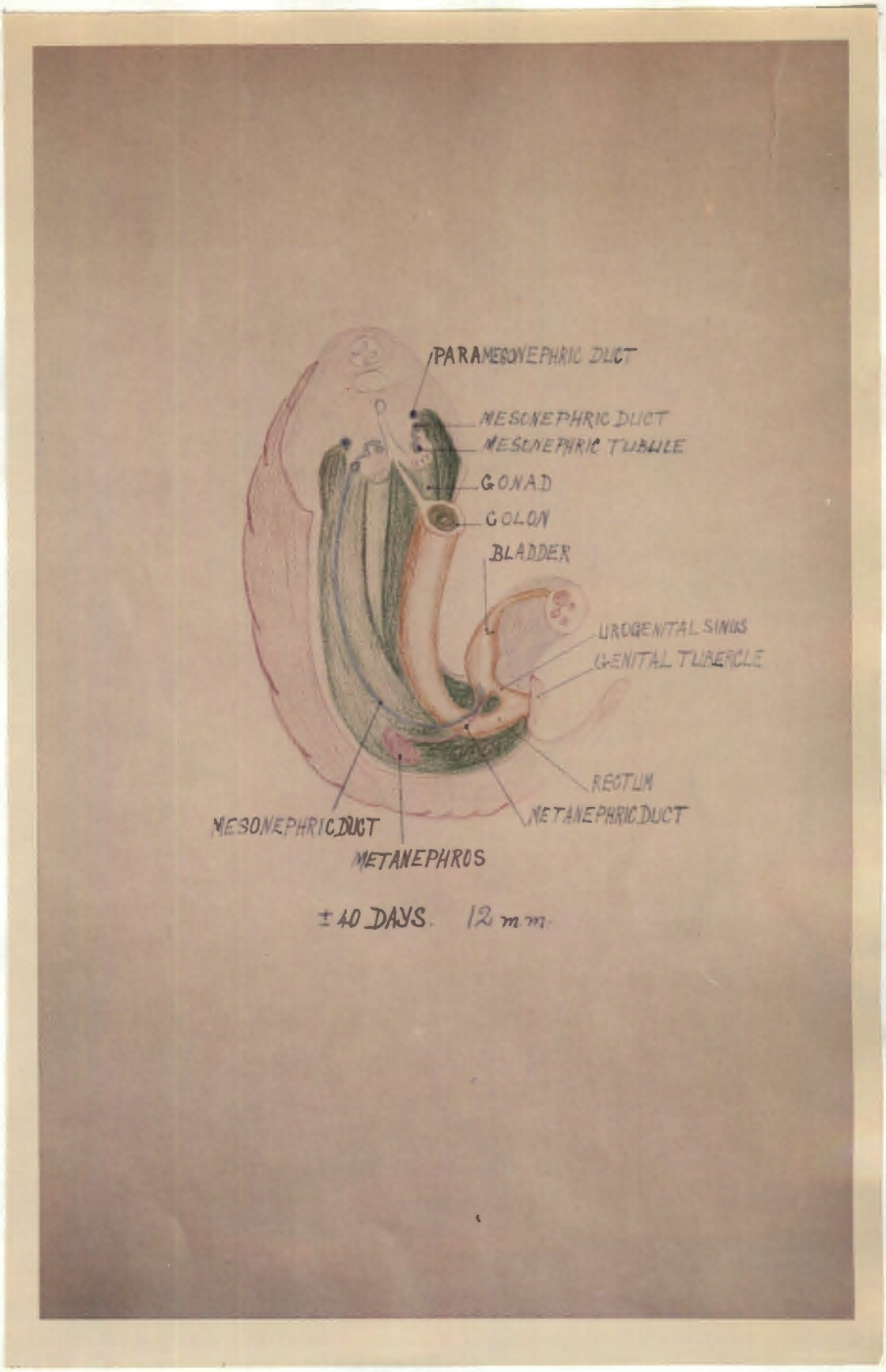


Fig. 5. Forty-day embryo.

4th week of the embryo's life. The remaining pair enter the cloaca on its ventral aspect also by the 4th week as the mesonephric ducts. Fig. .4.. and Fig. .5.. The pronephros has no evident physiological function in mammals according to Waddington,[46] but it plays an important part as the forerunner of the mesonephros which replaces it. Gersh,[47] in some experimental studies on some mammals has shown that the mesonephros does exrete urine and he suggests that such excretion may also take place in the human embryo.

The mesonephros, or Wolffian body, succeeding the pronephros, begins to form when the embryo is about 3 m.m. long and in the four weeks embryo (now about 5 m.m in length) consists of a paired tubular structure that lies against the dorsal surface of the body cavity and extends from the 6th cervical to the 3rd lumbar segment in such a way that its cephalic end overlaps the caudal end of the pronephros and it lies within the nephrogenic cord. It consists mainly of some seventy to eighty tubules and glomeruli. These

tubules and glomeruli continuously atrophy from their cephalic end while they proliferate at the same rate at their caudal end. Each mesonephros grows caudally in direction until it reaches the primary excretory or pronephric duct, fuses with it, becomes canalised, and thus establishes direct communication with the cloaca and is now named the mesonephric duct.[48,49] This takes place at about the 4 m.m. to 5 m.m. length stage. As the urogenital sinus separates from the cloaca at about 6 weeks (12- 14 m.m. stage) the mesonephric duct now opens into this sinus. It begins to degenerate, however, along its caudal aspect, the openings into the urogenital sinus closing at about the 55 m.m. stage. This atrophy continues through the remainder of embryonic life and the ducts have disappeared by the time of full term.

The cephalic end of the mesonephros by about the end of the sixth week begins to form on its ventral aspect, an elongated mass which becomes the gonad. It starts as a thickening of the mesothe-

lial layers over the front of the mesonephros. At about the 17 m.m stage the paramesonephric or Müllerian ducts become discernable.[50] In the human female it is from these ducts that the uterus the uterine tubes and the larger part of the vagina develop. These ducts, at about the 10 m.m. stage, begin as groove-like invaginations of the coelomic epithelium on the lateral side of the mesonephros and lateral to the cephalic end of the mesonephric duct. Fig..5... The invagination becomes the abdominal opening of the Fallopian tube. The Müllerian duct in its growth in a caudal direction turns medially, and penetrates under the basement membranes of the mesonephric duct and thus becomes closely associated with it. Gruenwald[51] has shown that interruption of the mesonephric duct will not permit growth of the paramesonephric duct beyond the point of interruption. At the caudal end of the mesonephros the paramesonephric ducts turn medially, enter the genital cord and proceed together to the posterior wall of the urogenital sinus. It may here be mentioned what the genital cord is. This structure is the middle

portion of a continuous transverse septum of mesodermal tissue that is continuous with the side walls of the pelvis.[52] It plays a role in the division of the cloaca into its ventral and dorsal parts and actually consists of two urogenital ridges that fuse in the mid-line.

In the tenth week of embryonic life the section of the paramesonephric ducts that lie in the urogenital cord, fuse together, loses the partitioning septum to form the utero-vaginal canal, and ends in the urogenital sinus. In this way at about the 12th week the genital canal has been formed and brought down between the bladder and the rectum to the urogenital sinus against the dorsal wall of which it forms a slight prominence called the Müllerian tubercle. The single fused tube now forming the uterovaginal canal later forms the epithelial linings of the uterus and upper part of the vagina. It may be mentioned here that only the epithelium and glands of the endometrium and cervix are provided by the epithelium of the paramesonephric ducts while the mesenchymatous tissue of the

genital cord forms the parametrium, myometrium and the endometrial stroma. The round ligaments appear in foetal life as the homologue of the gubernaculum in the male and consist of a mesenchyme tissue between the urogenital folds and the anterior abdominal wall.

There seems to be some controversy as to how much epithelial lining the vagina receives from the urogenital sinus. Koff[53] states that the Müllerian tubercle disappears at the 50 m.m. stage on account of two solid outgrowths of the dorsal wall of the urogenital sinus, and calls them sinovaginal bulbs. They push inwards and replace the epithelial lining of the lower part of the fused paramesonephric ducts—now the vagina, which thus seems to be of composite origin. This vaginal invagination caused by the inward growth of the sinus and covered on the outside by sinus epithelium and on the inside by vaginal epithelium constitutes the hymen which later breaks down centrally to form the hymeneal orifice.[54]

The metanephros or permanent kidney has a double

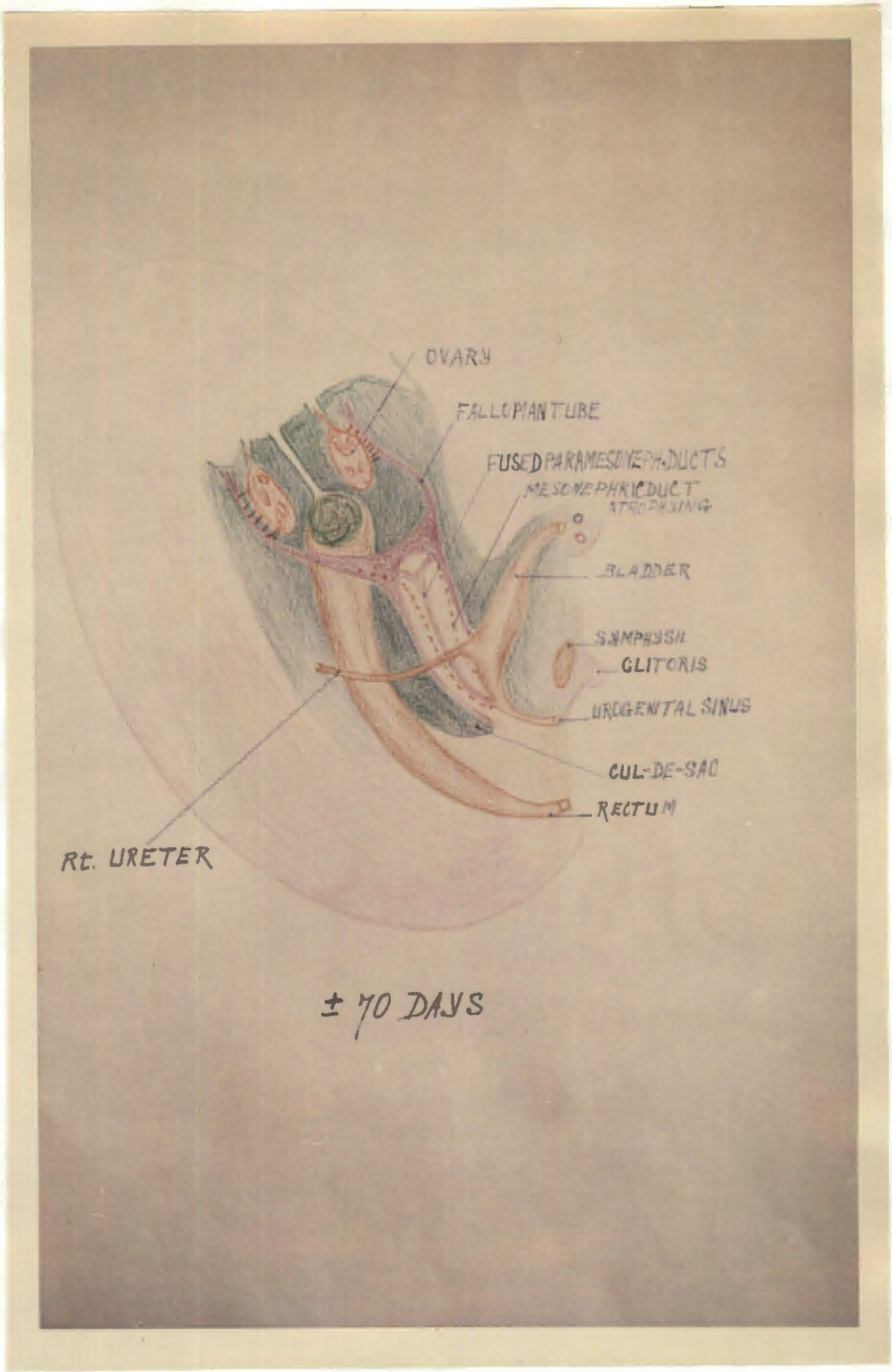


Fig. 6. Seventy-day embryo.

origin. The first is the ureteric diverticulum, an outgrowth from the dorso-medial aspect of the mesonephric duct near the point where it enters the cloaca at about the 5 m.m. stage of embryonic development. This rod-like outgrowth develops first in a dorsal and then in a cephalic direction. Fig 5.&.6 As it passes upwards a group of mesodermal cells collect around its end forming the second part of the kidney in the form of what is called the metanephrogenic cap. The stem of the diverticulum becomes the ureter or receiving part, while the cap-half will form the secretory part of the renal system. The upper part of the ureter turns first into four branches of tubules which later develop into the renal pelvis and calyces. From out of the metanephrogenic cap downwards grow, in turn, the blind secretory tubules. It follows therefore that the two sets of blind tubules must establish communication with one another and failure of this to be accomplished completely, constitutes a cause of congenital cystic kidneys[55,56,57].

The cloaca is the common cavity— recipient of

the hindgut and allantois and reveals the nature of its development somewhat distinctly first at about the fourth week of embryonic growth. It arises very early from entodermal tissue as a widening in the gut with the urogenital sinus on its anterior aspect and more caudally from the exit of the body stalk it has its ectodermal part in the form of an elongated dimple through which the urogenital canal and rectal opening will pass. At about 6 weeks a depression begins to form across the cloaca from side to side and by nine weeks the separation between rectum and urogenital canals is complete.[58,59].

The urinary bladder develops from the ventral part of the cloaca after the rectum has been separated from the dorsal aspect of it. The ventral half of the cloaca forms a viscus that consists of three sections: the more cephalic vesical part containing the area into which the mesonephric ducts open and with which the allantois is continuous, and which contains the trigone; a narrower section which forms the pelvic portion; and thirdly

the phallic and lowest section which is separated from the exterior by the urogenital membrane. The upper or narrow cord-like part of the bladder shrinks away as the urachus and occasionally does not atrophy in its entire length, forming the urachus cysts that anyone who does abdominal surgery has encountered.[60,61,62,63,103,104].

The urethra in the female is derived in its entirety from that part of the ventral portion of the cloaca that is called the vesico-urethral section. It is the homologue of the proximal part of the prostatic urethra that lies above the ejaculatory ducts in the male.

ANATOMY.

In this chapter anatomical structures are described only in relationship to their importance in urinary control and prolapse of the pelvic organs.

The Urethra.

The female urethra in the live subject is found to be of 4.4 cms. average length in nulliparae and 4.7 cms. in parous women. Tables I and II. The length was established by measuring the urethra in forty parous women and in forty nulliparae. This was done by passing a metrically marked urethroscope to a point just beyond the vesical sphincter. A gloved finger is then passed up in the vagina with the plantar surface tightly against the posterior surface of the urethra. This is done in order to straighten out any transverse folds or distortions that the urethra may contain as the result of previous obstetrical trauma. In nulliparae the procedure of passing a finger up against the urethra

has proved not to be necessary. It has been found that a rubber catheter does not necessarily give the correct length of the urethra. With the end of the urethroscope still in the bladder the obturator of the instrument is withdrawn and the light inserted. Under direct vision the urethroscope is then withdrawn until the sphincter begins to close over its tip. The correct length of the urethra is now read on the sleeve of the instrument against the edge of the external meatus.

The diameter of the urethra in its centre is an average of 7 m.m., measured in forty multiparae and 6 m.m. for twenty nulliparae. The method used was to place a ballooned catheter in the urethra with the centre of the balloon half way up the previously measured length of the urethra. A measured amount of water from a syringe is then instilled slowly into the balloon until slight discomfort is felt by the subject. The water is then withdrawn again and the catheter removed. The balloon is now distended with the same amount of water as when it was in the urethra and its external diameter measured.

The capacity of the urethra was measured in the same series of cases in the following manner: a suitable cystoscope with two stopcocks is introduced into the urethra and the sphincter brought into view. Normal saline at about 98° F is then run into the urethra to balloon it out until the sphincter can be seen just to begin to open. The subject has been told neither to strain nor to hold her urine. At the time that the sphincter is beginning to open the saline is allowed to escape from the second stopcock and it is measured. This amount plus the volume of the length of cystoscope inside the urethra gives the capacity of the urethra, viz. 5.6 mls. for nulliparae and 6.2 mls. for multiparae.

The diameter of the meatus[69,71] was measured in the same number of patients. This was done with a tapering glass rod that had been suitably marked for diameter reading. The rod is inserted into the urethra as far as it would comfortably go and the diameter read against the edge of the meatus. The average diameter of the meatus of the urethra is

4.2 m.m. in nulliparae and 4.72 m.m. in parous women. Tables I and II.

The urethra[82] begins at the edge of the internal sphincteric orifice of the bladder and passes downwards and forwards with a slight curve whose concavity faces anteriorly to the posterior surface of the symphysis pubis. The outer end is a small slit, the external meatus, that lies with its long axis antero-posteriorly at a point 2.5 cms. to 3 cms. inferior to the glans clitoridis. The meatal orifice is guarded in some cases by two or three mucous membrane tags which act like valves. In those cases where these "valves" are absent the edge of the meatus is slightly raised and puckered. A few millimeters' distance from the margin of the meatus there can be seen from two to four pin-point orifices, remnants of the minor vestibular glands or homologues of Littré's glands in the male urethra. The major vestibular glands are the Bartholin glands which are homologues of Cowper's glands in the male.[66,67,70,78]

Around the distal third of the female urethra there are two more groups of tubules,[68] the first

being the para-urethral ducts which consist of simple secretory ducts that intertwine with connective tissue and open into the urethral canal.

The second group of glands and ducts are situated more dorsally and may become related to the vaginal wall. They form what is called Skene's ducts and also open into the distal third of the urethra although occasionally one or two ducts may open externally near the meatus. Skene's ducts are the homologues of that part of the male prostate which develops on the cephalic side or pars phallica of the urogenital sinus in the embryo. These ducts and sinuses leading into the urethra are of primary importance as they can harbour the infection in urethritis and cystitis.[65]

Structure of the urethra: There are three coats, muscular, erectile, and mucous. The muscular coat is a continuation of the bladder musculature. It consists mainly of circular fibres extending throughout the length of the urethra. Where the urethra pierces the urogenital diaphragm, it is surrounded

between the two fascial layers of this diaphragm by the membranous sphincter urethrae as in the male.

The erectile tissue consists of a spongy layer made of venous plexuses and smooth muscle fibres. it lies immediately deep to the mucous membrane.

The mucous lining consists of stratified squamous epithelium that changes into the transitional type when it approaches the bladder sphincter.

At rest the mucous membrane lies in a few longitudinal folds in the urethra as can be readily seen by direct vision through the urethroscope. The median dorsal fold is the most prominent one and is known as the urethral crest.[72,75,77].

The bladder.

The urinary bladder is situated in the anterosuperior part of the pelvic cavity. When empty it can be described as being squeezed into the shape of a triangular pyramid by the structures surrounding

it. Its base rests mainly against the anterior surface of the vagina with the urethra leaving the base near its anterior margin. The anterior surface lies forwards against the symphysis pubis and is separated from it by the space of Retzius which contains connective tissue and fat. When the uterus is in its normal position it lies with its body forwards to rest on the posterior surface of the bladder and is separated from it, as far as the body only is concerned, by a peritoneal fold which forms the utero-vesical excavation. Below this fold it is in close relationship through a thin layer of areolar tissue first with the upper part of the cervix and as it turns to its base it is separated from the anterior wall of the vagina by similar areolar tissue.[76,83].

The vertex of the bladder forms the beginning of the urachus that leads up to the umbilicus.

The capacity of the bladder, with comfort, varies in different individuals from 130 ml. to

450 ml. In cases of cystitis the capacity may be much smaller. On the other hand, in cases of total distension of the bladder through neglect in the post-operative patient the capacity may readily rise to 1200 ml. and overflow incontinence.

The empty bladder is a pelvic organ but in the full state it rises and becomes an abdominal organ. Fig. ...14...

The structure of the bladder:

From within outwards it consists of four layers: first a layer of transitional epithelium, then a submucous coat of areolar tissue that unites together the epithelial and muscular coats. The next is the muscular coat which in turn consists of three layers of unstriped muscle fibres: The internal longitudinal layer consists of thin tissue with a recticular arrangement of which the main fibres are longitudinally directed; The middle, circular layer has its fibres either obliquely or transversely arranged in relation to the outer or inner layers. The external longitudinal layer is called the musculi pubovesicales because it arises from the posterior surface of the os pubis, enters the antero-inferior surface of the bladder, and then passes up its front and over the vertex down to the front of the vagina. The muscular structure as a whole in the bladder is known as the detrusor muscle. This, however, excludes that part of the bladder known as the trigone and which will be described later.

The outermost coat of the bladder consists of a serous layer that covers only the superior surface and

upper parts of the sides of the bladder. This coat is derived from the peritoneum and in front it is reflected on to the abdominal wall and at the sides on to the walls of the pelvis.[73,74,84].

Interior of the bladder.

The mucous membrane lining of the bladder is normally pale yellowish in colour, and smooth in the distended bladder as seen through the cystoscope. In the empty bladder the lining is bundled up in numerous folds to be accommodated in the more confined space. This can best be seen through an endoscope with the bladder empty and the patient in the knee-elbow position.

Of great importance in the inner surface of the bladder is the triangular area, called the trigone, lying with its base on the line between the two ureteric orifices. In the contracted bladder these outlets into the bladder are about 2.5 cms. apart and in the fully distended one the distance between them is 4.5 cms. in the average subject. Through the cystoscope the line between these orifices

can be seen as a slightly raised ridge, called Mercier's Bar. The apex of the trigone is the posterior segment of the internal meatus of the urethra. Here again, during straining by the subject one can observe two raised lines running from the apex to each of the ureteric orifices. Both Ullery[79] and Kennedy[80,81] refer to the action of the muscle of micturition which passes from its origin at the symphysis pubis, along and over the anterior aspect of the urethra, down to the posterior part of its proximal end where some fibres unite with the fibres of the posterior segment of the sphincter. On straining this muscle then pulls the said segment of the sphincter downward, distorting it, and thus opening the bladder for micturition. One has frequently observed this action with care and then passed the cystoscope into the bladder to watch the trigone during straining. It was clear that Bell's muscles definitely tighten during straining while they relax at rest and that there is a slight change in the shape of the ureteric orifices. The subject is then, with the bladder now empty, asked to

take the knee-elbow position. A urethroscope is passed into the bladder, the obturator removed and the light inserted. The orifices are now watched and the intervals noted between the influxes of urine from the ureters. It will then be noticed that if the subject is told to strain immediately before an influx is due, that influx will not occur during straining and while straining is maintained there is a change in the configuration of the orifices and a raising of Bell's muscles.

From this one can conclude that the terminal fibres of the muscle of micturition form a loop arrangement around the ureteric orifices, thus shutting them off and preventing reflux of urine up the ureters during the raised intravesical tension while there is straining. The same phenomenon can be watched during coughing on the part of the patient. In the literature examined one has not found confirmation of these observations.

In some cases with stress incontinence it can be observed that the long axis of the oval shape of the sphincter as seen through the urethroscope is excessive

and that it does not return to a circular form when straining is terminated. In these cases the sphincteric holding pressure as measured with the manometer is likewise lower than in cases where the sphincter can close circularly at rest. This will be referred to again in the chapter on cysto-manometry and volumetry.

The Anatomical supports of the urogenital organs. Dissected in cadaver of a multipara of 42 years.

Examining these structures in the pelvis from the cephalic side in a caudal direction one encounters first the peritoneum. Except for the part this covering plays in the cul-de-sac of Douglas it has no real support to offer in the prevention of descensus of organs, as they lie mainly extra-peritoneally. Curtis, Anson and Ashley,[85] however, state that the peritoneum does supply real support. It is surely a strong membrane as one can see at operation but its containing role applies probably more to the abdominal organs.

The most important layers of tissue that keep the pelvic organs from prolapsing are the endopelvic

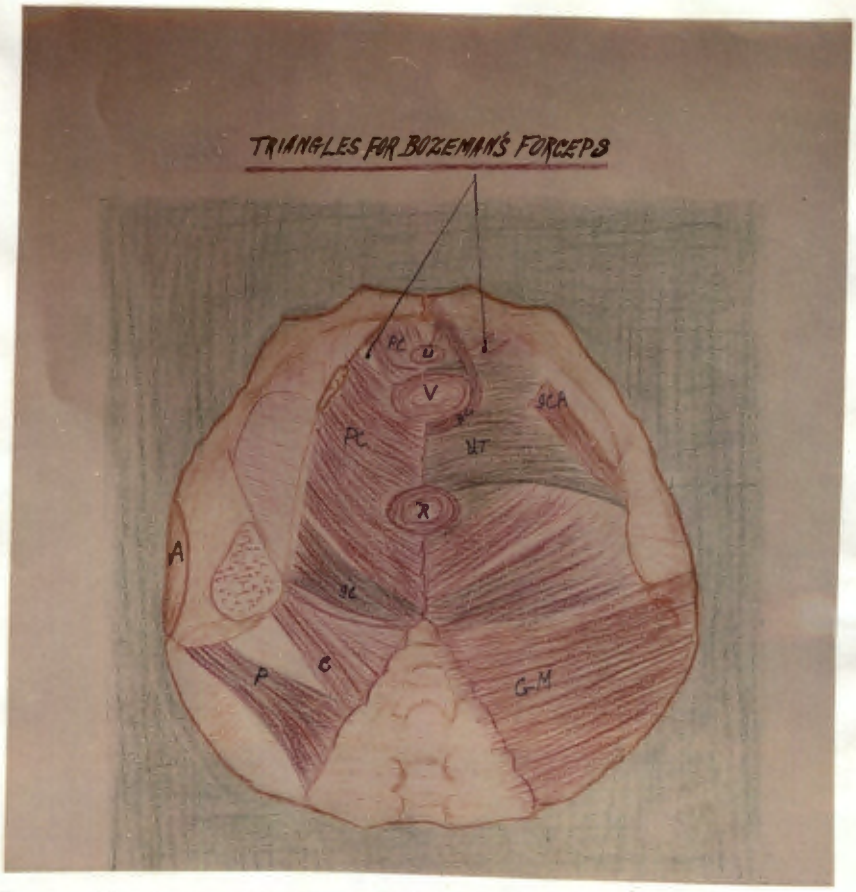


Fig. 7. Sketch of dissection to demonstrate sling-like arrangement of perineal muscles and median raphe.

PC : Pubococcygeus.
U : Urethra.
V : Vagina.
R : Rectum
IC : Ileococcygeus.
C : Coccygeus.
P : Pyriformis.
BC : Bulbocavernosus.
ICA : Ileocavernosus.
UT : Urogenital Trigone
GM : Gluteus Maximus
A : Acetabulum.

Transversus superficialis and Transversus profundus not shown.

fascia;[86] the group of muscles that constitute a series of slings across the pelvic outlet, called the pubococcygeus, iliococcygeus, and ischiococcygeus and over the anterior part of the pelvic outlet the urogenital diaphragm, also known as the triangular ligament. There are also the auxiliary muscles viz. the deep and superficial transverse perineal muscles and the ischiocavernosus and bulbocavernosus muscles. Except for the ischiocavernosi all these pairs of muscles meet in a median raphe (Gr. raphe = to sew together) that runs from the pubic angle to the coccyx to form continuous slings that traverse from side to side the whole width of the pelvic floor. This raphe is interrupted in turn by the urethra, vagina and rectum. Fig. .7. ..

In the long-preserved cadaver one finds that fascial and muscular fibres that intertwine are extremely difficult to separate and identify individually. On fresh specimens this can be done more readily.

<u>The endopelvic fascia</u>[91] (also known as the superior diaphragmatic fascia of the pelvis).

In front this fascia arises from the inner surface of the superior pubic ramus and the inner margins of the pubic arch.[89,90] As it turns laterally from the inferior pubic ramus it becomes the fascia obturatoria, covering the obturator muscles and further inferiorly covering the medial margin of the gluteus maximus. At a distance half-way down the descending pubic ramus this fascia forms a canal that encloses the pudendal nerve and vessels[88](Alcock's canal). These structures may be deemed to be vunerable when the openings are made for the fascial slings in the operation later described. They are, however, lying too low against the ramus for that— being at least 3 cms. below the apex of the pubic angle. In regard to the attachment of the endopelvic fascia to the superior ramus, it passes downwards forming more laterally the obturator canal and medially it covers the pubococcygeus while from the arcus tendineus in an infero-posterior direction it covers the iliococcygeus and coccygeus muscles. As this fascia partly encircles the viscera that pierce it,

it forms a tubular coating for each viscus in turn in an upward direction but it is attached to them by a layer of thin areolar tissue. In the case of each organ, however, the fascia plays a role in the ligamentous supports.

In the case of the rectum a thin somewhat loose fascial covering, the fascia rectalis, surrounds this viscus and tapers off upwards to disappear at the commencement of the sigmoid colon.

The fascia vesicalis or the part of the endo-pelvic fascia in relation to the bladder covers the posterior and inferior surfaces of the urinary bladder and thins off on the superior surface. From the border between the lateral and superior surfaces of the bladder the fascia passes upwards and laterally along the wall of the lesser pelvis, enclosing the iliac vessels and joins the subserous areolar tissue of the greater pelvis as it passes backwards. Still further back this fascia contains the ovarian vessels and forms the fibres of the ovarian ligaments.

Anteriorly, below the bladder it forms the margins

of the opening in the pelvic diaphragm for the vagina and forms between the bladder and the vagina on each side the ligamentum vesicovaginalis or so-called "pillars" of the bladder. At the base of the bladder the vesical fascia passes upwards and outwards encircling the ureters.

Those parts of the endopelvic fascia that pass upward and outward from the lateral surfaces of the bladder to the wall of the lesser pelvis, form the main suspensory supports of the bladder. The urachus or middle umbilical ligament is merely a vestige and does not seem to contribute to the suspension of the bladder.

Around the vagina the fascial covering is thin and areolar but where it surrounds the cervix it becomes a dense sheath. It tapers off and disappears over the body and fundus of the uterus. On the sides of the cervix and uterus the sheath is thickest and merges with the Cardinal ligaments— the main suspensory ligaments of the uterus— and with the utero-sacral ligaments, broad ligaments and round ligaments. The vascular and nervous

supplies of the uterus, cervix and vagina are contained in the suspensory ligaments thus formed.
The broad ligament is a quadrilateral structure, which with its opposite number, and the uterus between the two, divides the pelvis into an anterior compartment containing the bladder, and a posterior one containing the rectum. Its upper free border is the longest of the four and its medial seventy-five percent is taken up by the Fallopian tube—this part of the broad ligament being called the mesosalpinx. The other three sides are fixed to the uterus, and wall and floor of the pelvis.
The short free part of the broad ligament beyond the fimbriated end of the uterine tube, and which forms the suspensory ligament of the ovary is called the infundibulopelvic ligament. Between the two layers of the broad ligament near its upper border, runs the last of the uterine suspensory ligamental elements, called the round ligament. It is mainly a continuation of uterine muscular fibres starting in front of and slightly below the origin of the uterine tubes. The round ligament passes

through the abdominal inguinal ring and along the inguinal canal to disappear into the labium majus. It is the embryonic homologue of the testicular gubernaculum in the male. The round ligament has a point of surgical interest in that one frequently finds cases where, in abdominal hysterectomy, the operator, in an effort to maintain a high vaginal vault, has made the round ligaments too short and therefore too tight in their incorporation in the vaginal cuff. This leads to intractable pain in the round ligaments and labia. It can only be cured by re-opening the abdomen and lengthening the round ligaments appropriately.[87]

The Pelvic Diaphragm.

When the endopelvic fascia has been carefully removed, one finds a firm muscular layer of tissue that radiates outwards on each side from the median raphe, to form the pelvic diaphragm which is the main containing or closing layer covering the pelvic outlet.[94,98,101,102]

Although this diaphragm consists of similar pairs

of muscles that act in unison and lies in the same somewhat irregular concave plane (with the concavity to the cephalic side), it nevertheless consists of distinct elements. Fig. 7.

The first is the pubococcygeus which arises anteriorly low on the body of the pubic bone just lateral to the mid-line. Allowing for shrinkage in the preserved cadaver the width of its pubic origin is 2.3 cms. in a multiparous woman of 42 years. the muscle also has an arcus tendineus origin of a width of 3.5 cms. Its fibres converge to the median raphe where they merge with their opposite numbers and encircle the three piercing visci with whose tissues they also mingle and intertwine. The most lateral fibres of the pubococcygeus as its name implies, reach as far back as the coccyx into the sides of whose last two segments they are inserted while some fibres are also inserted medially into the fibrous anococcygeal raphe. The average thickness of the pubococcygeus and its fellow diaphragmatic muscles in about their middle is, in the cadaver, 3.5 m.m.

The iliococcygeus arises also from the arcus tendineus commencing with its anterior margin where the pubococcygeus ended, and leaving the posterior margin of its origin on the medial side of the spina ischiadica. Its fibres also converge somewhat to be inserted into the ano-coccygeal raphe and lateral surface of the coccyx.

The coccygeus in contradistinction to the last named two muscles starts as a narrow muscle at its origin on the ischial spine and fans out into a wider form as it approaches the mid-line to be inserted into the side of the coccyx and lower two vertebrae of the sacrum. Fig. .7.

In the lower mammals the pubococcygeus and iliococcygeus are inserted only into vertebrae of the tail and not into the median raphe in the perineum. This is for the purpose of wagging the tail by means of the iliococcygeus which is inserted more laterally to the insertion of the pubococcygeus which flexes the tail only forward between the hindlegs. With the disappearance of the swinging caudal extremity in mankind and the higher apes these pelvic diaphragmatic

muscles can be utilised better for strengthening of the pelvic floor as the subject adopts a more erect posture.

The next muscular layer in the pelvic floor superficial to the pelvic diaphragm is that consisting of the pairs of Deep Transverse perineal muscles, the membranous sphincter of the urethra, the ischiocavernosus, bulbocavernosus and superficial transverse perineal in that order from within outwards.

The Transversus perinaei profundus arises on the inner edge of the inferior ramus and passes medially, behind the vagina and just superficial to the pubococcygeus, to meet its opposite number in a raphe that also merges with the vaginal wall. It lies between the two laminae of the urogenital diaphragm.

Higher up along the inferior ramus of the os pubis and about 2 cms. from the apex of the pubic arch there arises a little flat muscle from both sides of the pubic border— the sphincter urethrae membranaceae. It passes ventrally to the urethra to merge with the one from the opposite side. Some fibres encircle the urethra and merge with the front wall of the vagina.

The ischiocavernosus muscle pair is each limited to its own side and arises from the inner surface of the ischial tuberosity. It passes upwards against the pubic ramus and is inserted into the side and inferior surface of the crus clitoridis.Fig. .7.

The bulbocavernosus, also known as the sphincter vaginae, consists of a pair of muscles that arise from the perineal raphe between the vaginal orifice and external rectal sphincter. Their fibres also merge with those of the superficial and deep transverse perinaei and pass upwards on each side, encircling the vagina to be inserted into the corpus cavernosus clitoridis. Some fibres pass further upwards and over the clitoris.

The Transverse perinaei superficialis is a flat membranous muscle that arises from the antero-medial margin of the ischial tuberosity. It passes medially and merges with the tendinous perineal raphe between the rectum and vagina.[95,96,97,99]

<u>The Urogenital diaphragm</u>;[92,93,100] (urogenital or triangular ligament) is, as its name implies, a fascial membrane that covers the triangle formed by the two

ischial tuberosities and the apex of the pubic angle. It consists of two layers of strong fibrous plates harbouring between them the sphincter urethrae membranaceae muscle and as was mentioned earlier, the transversus perinaei profundus. The more superficial of the two laminae is the denser and stronger—known as the inferior fascia of the urogential diaphragm. Posteriorly it merges with the central tendinous perineal point and with the anal fascia and connects with the deep layer of the superficial fascia (Colles) behind the transversus perinaei superficialis. At the sides it is attached to the medial borders of the pubic rami and ischial tuberosities and at the apex its upper edge forms the transverse ligament of the pelvis just below the arcuate pubic ligament. Between the two ligaments the dorsal vein of the clitoris enters the pelvis. About 3 cms. below the symphysis pubis the urogenital diaphragm is pierced by the urethra, and immediately below this by the vagina.

This writer has to state here that in the dissection of the perineum the urogenital trigone does

not, as stated in the various text books, consist of a definite triangle of fascia only. From its base it continues posteriorly in a narrowing fashion to send fibres looping around the external rectal sphincter. Fig. .7.

INVESTIGATION OF SOME ASPECTS OF CONTINENCE AND MICTURITION IN THE FEMALE.

This investigation has been carried out under the following headings:

1. Urethroscopy and Cystoscopy.
2. Vesical volumetry and manometry.
3. Radiography.

Continence for the purpose of this work, is defined as the voluntary and involuntary control of urine while stored in its reservoir, the bladder, into which it has been excreted from the kidneys.

Micturition will mean the voluntary release of urine through the urethra.

Incontinence will refer to loss of urine through the urethra in various forms which will be described in detail.

The muscular entities involved in the mechanism of continence and micturition are five in number:-

1. The muscle layers that constitute the bulk of the wall of the bladder as described in the section on anatomy and called the detrusor vesicae. It has the characteristic of expanding at such a rate when filling that the intravesical pressure remains constant. Fig. ...9... It must be stated, however, that that part of the bladder wall known as the trigone does not take part in this expansion. It will be recalled that in the chapter on embryology it was stated that the trigone develops from a distinct part of the cloaca— the half which becomes the bladder.

2. The internal sphincter of the urethra, although not discernable as a distinct sphincter, to the naked eye, consists of bundles of circular fibres at the urethro-vesical junction, fibres that merge and intertwine with the musculature of the bladder wall

itself. Watched through the urethroscope with the subject straining and restraining, this particular area seems to play an important part in continence of the bladder. It follows therefore that its disorganisation through trauma or its isolation from central nervous control through injury or disease, or congenital defects, will readily contribute to incontinence of the bladder.

3. The external sphincter of the urethra consists of voluntary muscle from the pubococcygeus that surrounds its middle third, and from the sphincter urethrae membranaceae just superficial to the pubococcygeus.

4. The muscle of micturition according to Kennedy,[81,106] originates on the posterior surface of the pubic bone, enters the ventral aspect of the urethra and then passes over it on both sides to be inserted in the posterior segment of the internal sphincter.

5. The pair of pubococcygei which aid in the

contraction around the urethra and lift the bladder neck.[108,105,107]

Urethroscopy and Cystoscopy

In order to investigate the action of the sphincter mechanism of the bladder under direct vision the following procedure is carried out:

The patient is asked to void and she is then catheterised with a soft catheter and the amount of residual urine recorded.

Should the urethral meatus not be wide enough to take a suitable scope easily and painlessly, then it is first dilated. This can be done painlessly after a few minims of local anaesthetic material has been injected through a very fine needle that has been inserted once only in the mid-line immediately above the meatus and directed to each side to a depth of 1 cm. If manometric tests be required also, then these have to be done on a subsequent visit as the local anaesthesia may affect the strength of the sphincters.

The other investigations may be carried out forthwith.

It is wise to view the interior of the urethra by means of water distension first, as in the event of there being lesions in the urethra these may be affected or distorted if the scope is pushed through the urethra as a first step.

It is useful to have both a urethroscope and cystoscope available as features that may not be so clear with the one can often readily be seen through the other. The knee-elbow position with air in the bladder and vagina can likewise be helpful in some cases.

When the urethroscope is used, the obturator is left in until the scope is gently passed into the bladder which is empty. The obturator is then withdrawn and the light inserted. The scope is now, under direct vision, withdrawn to a point where the sphincter can be seen to close over the end of the instrument. The length of the urethra can now be read on the side of the scope. (All scopes have been metrically calibrated for taking direct

readings). The size, contour and action of the sphincteric orifice may now be studied under straining, resting and restraining on the part of the patient.

Due to trauma or old inflammatory conditions the edges of the orifice may be irregular. It is noted whether the closure is concentric and complete. The withholding closure is very fast indeed and should it be sluggish, then the sphincter is weak.

These signs can be properly demonstrated only by direct observation or by high-speed cinematographic pictures. In the subject with normal bladder control the sphincter under observation will not open on coughing even if the bladder is full. When there is stress incontinence, however, the degree of weakness of the sphincter can be determined by allowing measured amounts of normal saline to flow into the bladder and then to let the patient cough while the sphincter is observed at intervals through the scope to note at what volume of fluid in the bladder the sphincter begins to open on coughing. In order to avoid the repeated removal and insertion alternately

of catheter and urethroscope, the observer with the required experience may use a cystoscope and fill the bladder through this instrument while it is periodically withdrawn into the urethra for viewing the sphincter. Intravesical pressure readings can be taken at the same time by connecting one inlet into the cystoscope to a manometer, while the inlet with the saline supply is shut off. It will be noticed that the ease with which a cough can open the sphincter in a case of stress incontinence is in direct proportion to the amount of liquid in the bladder and to the intracystic pressure.

In nulliparae with stress incontinence it will be seen that invariably the contour, and the marginal edge of the sphincter are regular. This can best be seen with the patient straining to void. In multiparae with stress incontinence it will be noticed that in the majority of cases the edges of the sphincter are irregular and distorted and that the symmetrical oval shape of its opening on straining has been changed.

These facts would confirm the view that trauma is a major factor in the aetiology of stress incontinence in parous women whereas in nulliparae the cause would be either in the central nervous system or it would be an intrinsic weakness of the musculature of the sphincter mechanism that permits the leakage under intra-abdominal stress.

With the end of the cystoscope in the bladder which contains 200 - 250 mls. saline an examination is made of the inner surface of the bladder and the following conditions recognised if present:

1. Normal appearance of inner surface of the bladder wall.
2. Cystitis and trigonitis.
3. Neoplastic change.
4. Diverticulum.

1. The normal appearance of the mucous membrane of the bladder is a pale straw colour,

but the trigone is pink due to vascularity.[110]

2. In acute cystitis the patient complains of painful micturition and frequency. There may also be severe terminal tenesmus due to the tender opposite surfaces of the bladder making contact when the urine no longer keeps them apart. The infection is usually introduced through the urethra. Sometimes it is brought down by the urine from the kidneys. More rarely it occurs through trauma or surgical accidents. Many organisms are found in the urine in cystitis and a mixed infection is common— the organisms found most commonly are Bacillus coli communis staphylococci, streptococci, B.proteus, B. pyocyaneus, gonococci and B. typhosus.[109,113] In the series in this work only the first five of these organisms were found. Unless there is pyelitis or pyelonephrosis there is usually no pyrexia with cystitis.

The cystoscope will reveal a markedly reddened and swollen mucous membrane. Small

patches of ulceration may be noted. The trigone, normally more vascular than the rest of the inner bladder surface, will appear more intensely red. Should there be chronic interstitial cystitis, also called Hunner's ulcer, this will be characterised by small superficial ulcers on the mucosa that may bleed as the bladder is distended with liquid. The ulcers always occur in the vertex of the bladder. They have a white scar in the centre, surrounded by a brick-red area. They may last for many years, and patients may be classified as neurotics. There is marked inflammatory reaction in the muscularis of the bladder causing severe urgency and frequency with suprapubic pain.[111,112,114] The history may be somewhat confusing and the patient may think that she has stress incontinence.

3. Neoplastic change in the bladder wall has to be looked for carefully. Should a swelling be noted it can be considered to be oedema if it flattens out and merges with the surrounding

tissues. A new growth, however, will present a more distinct and discrete edge. Should a tumour be pedunculated it is probably benign. Cardiovascular changes can sometimes be recognised in the bladder as small submucous haemorrhages, analogous to what one might see in the retina.

The importance of a thorough urethro-cystoscopic examination before extensive gynaecological procedures on the bladder and vagina are carried out can hardly be over-emphasised. The following case report will illustrate this:-

Case 238/J/57 A White, 63 years old para II consulted her doctors about mild stress incontinence and "some pressure over the bladder". Her medical advisers performed what they called a vaginal repair. The incontinence did not change but the pressure feeling became a pain with urgency and frequency. She was seen four months after her operation and when a pedunculated polyp of 1 cm. diameter was removed from the upper half of the urethra she became symptom-free.

This brings the subject to lesions of the urethra— examination of which is naturally carried out before the cystoscopy is done.

Everett[115] states that except for caruncles, true new growths of the urethra occur rarely, and he goes on to say that 20 specimens diagnosed clinically as urethral polypi on histological examination proved to be caruncles.

A caruncle occurs on the mucous membrane of the posterior segment of the meatus as a small, brilliant red, soft mass of tissue from a few m.m.s to about 1 cm. in diameter. It is polypoidal in shape and usually very tender. Microscopically it consists of connective tissue that shows marked telangiectasia and is regarded as a capillary angioma with round cell infiltration and a covering of squamous epithelium.[116]

Walther and Willoughby[117] report that in 35 cases with proliferative lesions of the urethra 4 were papillomas while the remainder were caruncles and carcinomata. In an analysis of 100 cases of urethral caruncle Walther[118] found 5 specimens of unsuspected carcinoma and 2 of precancerous lesions in 47 of the cases in which microscopic examination was carried out. This

goes to show how imperative it is to have an histological examination done.

Ratner and Strasberg[119] report a case of leiomyoma of the female urethra in a woman of 38 years. It occurred as a pedunculated firm growth, the size of an almond, attached to the roof of the urethra.

In regard to carcinoma of the urethra, Clayton[120] reports 109 cases, mostly in post-menopausal women. The average age was 53 years. These new growths occurred in two forms; as malignant ulceration in the urethral floor, and as peri-urethral induration.

4. A diverticulum must also be watched for during urethroscopic examination. It occurs as a bulge or sac in the floor of the urethra. Menville and Mitchell[121] studied 80 cases of which 11 were personal ones. The average age in the 80 cases was 38.8 years, the oldest being 69 and the youngest 20. The eleven personal cases were drawn from a relatively equal number

of White and Negro patients and the incidence ratio was 8 Negro to 3 White women with diverticula. The condition arises from congenital weakness of the musculature in the urethral floor, from trauma, or from infection in the para-urethral glands. The condition is of some importance in incontinence studies as these patients came up with symptoms of dysuria, partial incontinence and frequency with dribbling. A fluctuating mass presents in the anterior vaginal wall. Pressure on this mass may release cloudy urine or pus from the urethra.

Downer and Virgilio[122] found their series of cases mostly in multiparous women, and ascribe their occurrence therefore chiefly to obstetrical trauma.

Furniss[123] reports 4 cases in which the diverticula were paired, one on each side of the median line on the same level in the urethra.

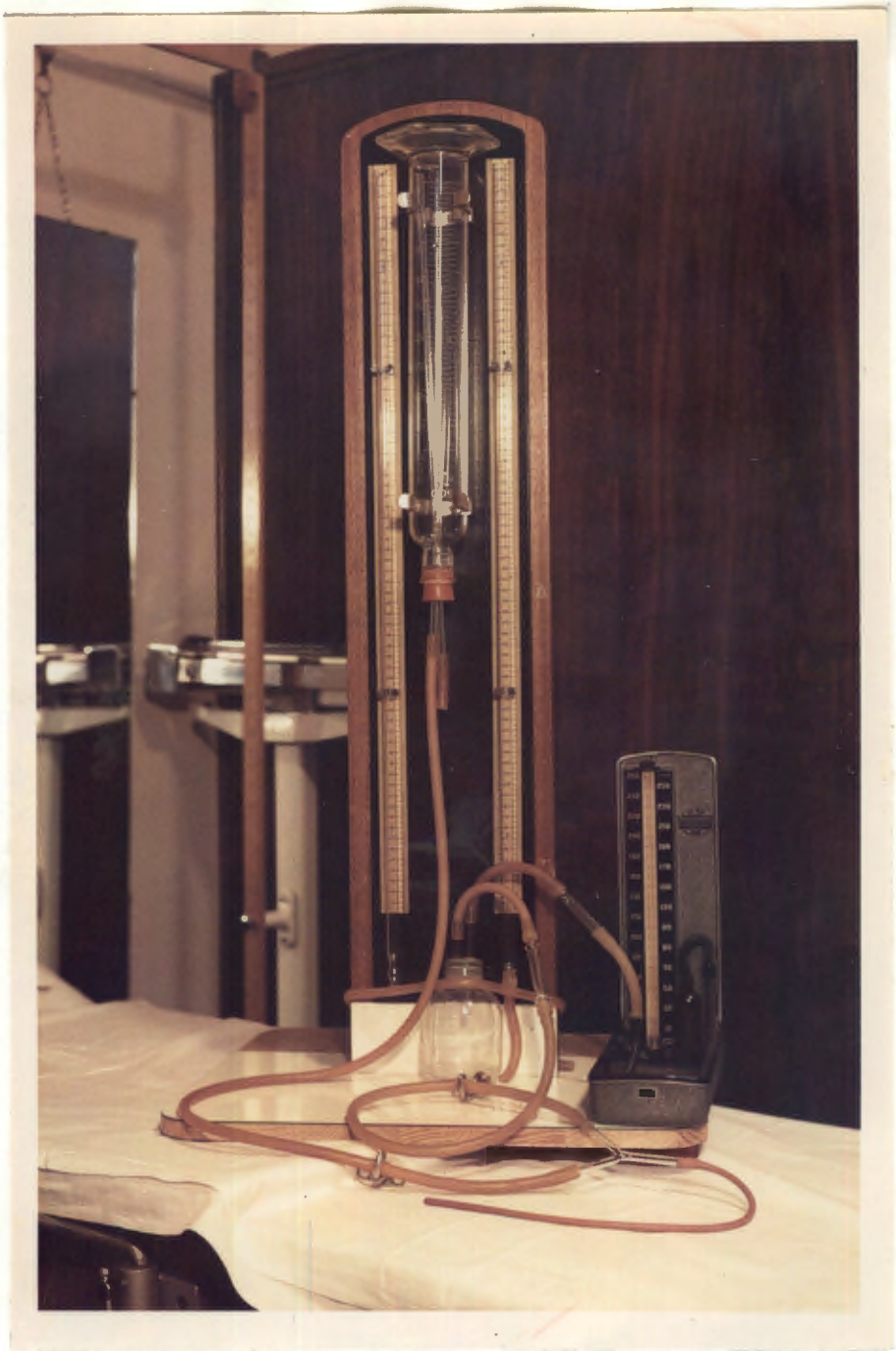


Fig.8. Cysto-urethro-manometer for taking volumetric and manometric measurements of the female bladder.

VESICAL MANOMETRY AND VOLUMETRY.

The Cysto-urethro-manometer.

In order to study the variations of pressure and volume in the bladder and urethra the writer has designed and constructed the apparatus shown in Fig. .8.. and called it a cysto-urethro-manometer. It consists of a wooden stand holding clipped to it a 500 ml. glass container marked in millilitres and suitably stoppered as shown. The flexible tubing running from this reservoir to the one arm of a glass Y-tube and also from the other arm to a glass water trap, and thence to the connection of a standard mercury manometer, consists of firm nylon and has an outer diameter of 1 cm. and lumen calibre of 3 m.m. The water trap is for the purpose of preventing water from acidentally getting through to the manometer. The stem of the Y-tube leads to a regular size 16 Jacques catheter, or a double-barrelled one which is useful should one wish to withdraw fluid from the bladder during the tests.

On each side of the glass container is a manometer tube 80 cms. long with 0.6 cm lumen calibre, clipped to a metre scale. Should one thus wish to take a direct water pressure reading of the intravesical pressure, then the tube leading to the water trap (and mercury manometer) is simply disconnected from the water trap and connected to the lower end of one of the tubes against the metre scale.

The reason for a second 80 cms, glass tube is that should one wish to compare variations in intravesical pressure simultaneously with variations of strength of sphincteric and urethral contractions in terms of cms. of water, then one connects that arm of the Y-tube that leads to the mercury manometer, directly to one of the glass tubes on the stand, while the other catheter with its balloon in the urethra or sphincter is connected via tubing of suitable length directly to the other 80 cms. glass tube. Variations of pressure in the bladder and of force in the urethra or sphincter can therefore be read simultaneously in terms of cms. of water at varying

Case 35/M/55 Nullip. See Fig.14 for
27 yrs. Normal Bladder. Cystogram of this case.

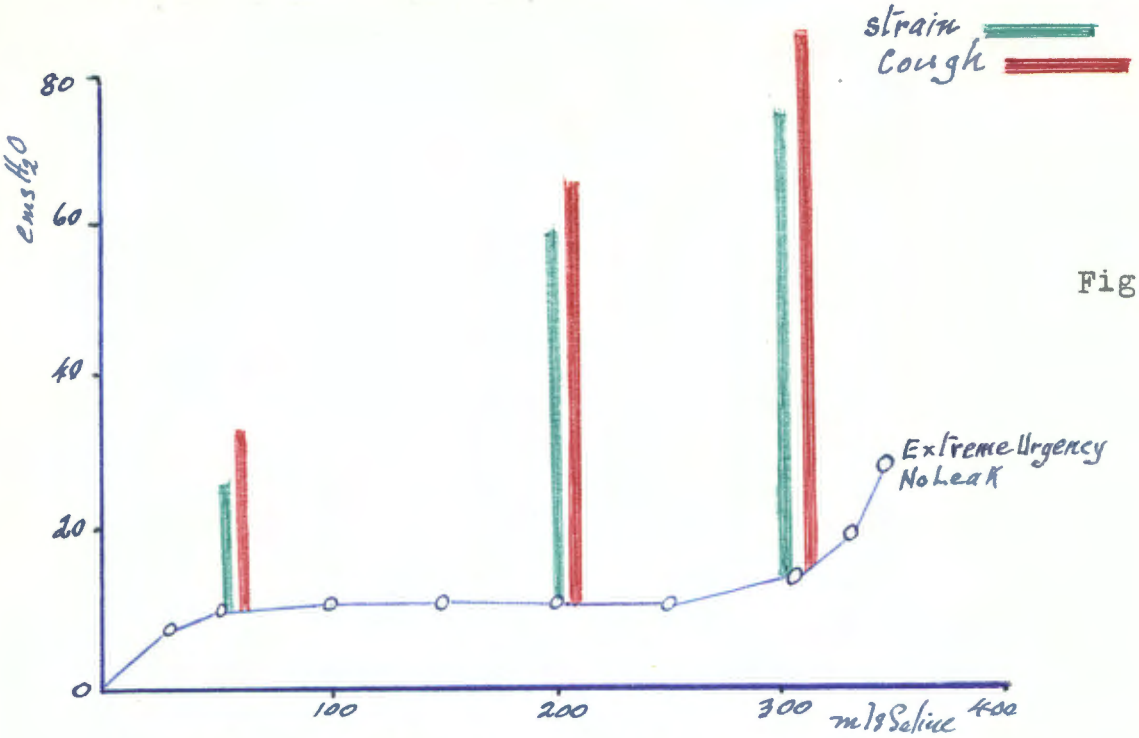


Fig.9

Case 31/M/55 Para.4 See Fig.20 & 21 for Cysto-
51 yrs. grams. Severe stress incont.

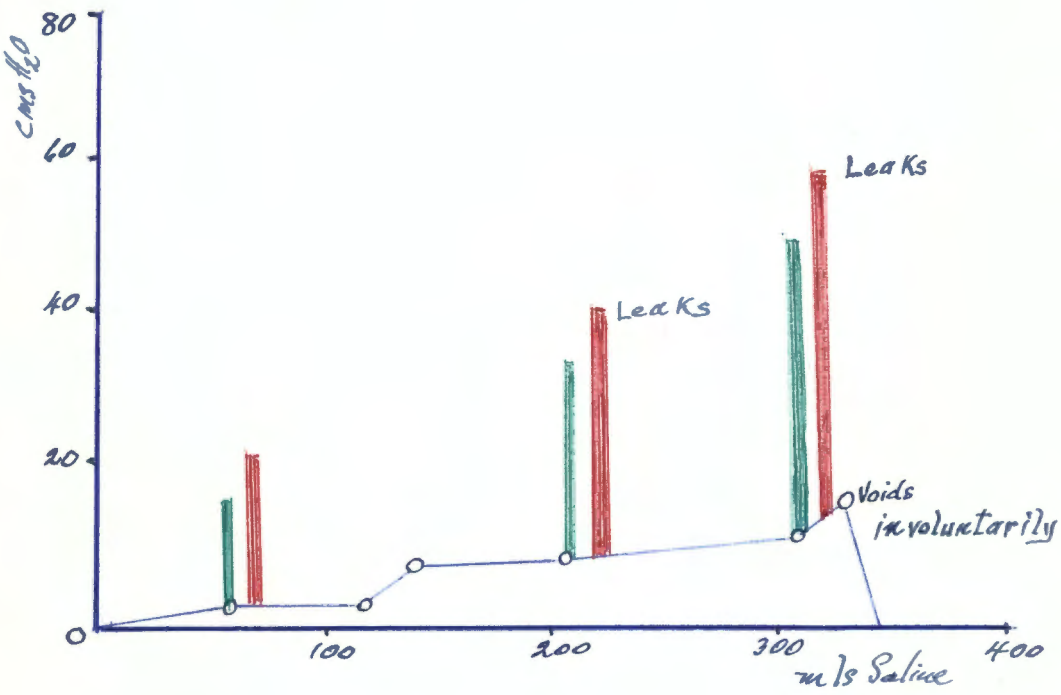


Fig.10

capacities of the bladder that can be changed at will and during different forms of exertion as sitting, standing, coughing etc. In Figs. ..9.&.10. graphic representations are given of readings taken on the water manometer in (a) a case with normal bladder control and (b) in a woman with established stress incontinence and residual urine of 115 mls.

When intra-vesical pressure readings are desired simultaneously with the variations of strength of contraction of the urethra and sphincter, it is of course necessary to have a catheter with a balloon in the urethra and the other one through into the bladder, this latter one of necessity having to be very thin, of the order of size 7 or 8. This intra-vesical catheter, even though so thin, has proved through its irritation of the sphincter to affect the readings of the pressure of the urethra in that the latter is shown to contract down more firmly with the other catheter through the sphincter than when the ballooned catheter occupies the urethra by itself. As such readings then therefore do not give the true strength

of the urethra and sphincter, the two kinds of tests are therefore carried out independently.

The water manometer does have value in any particular patient for keeping a record of progress or deterioration in sphincteric strength and emptying capacity of the bladder, but on account of the varying zero level of the urine in the bladders of different patients, this method cannot be used as a standard for comparison. Even in a particular case it is not known exactly where the level of the urine is in the bladder, but one can record a fixed point in relation to the upper surface of the symphysis pubis or the pubic angle as the level for that patient.

In order to have a uniform standard of measurement that will not be affected by the position of the bladder, for the purpose of these investigations which were begun in 1955, a standard mercury manometer was used throughout for the findings recorded in Tables I to IV.

The Sphincterometer.

The apparatus for testing the strength of the sphincteric contractions was arranged as shown in Fig. 11.. A double-barrelled size 8 Bardex ballooned catheter is taken. The balloon is carefully and completely excised from the catheter. A piece of colostomy tubing, 1 cm. in diameter and 4.5 cms. long is then tied over the end of the catheter in such a way that it includes both of the apertures in the catheter. Either silk or fully shrunk cotton can be used as tying material.

This apparatus has been called a sphincterometer and is for the purpose of measuring the force of contraction of the bladder sphincter in terms of millilitres of mercury.

With the patient's bladder empty the ballooned catheter is inserted in such a way that the sphincter lies over the centre of the balloon. The accuracy of this is achieved by marking off the catheter by laying it against a calibrated urethroscope, with

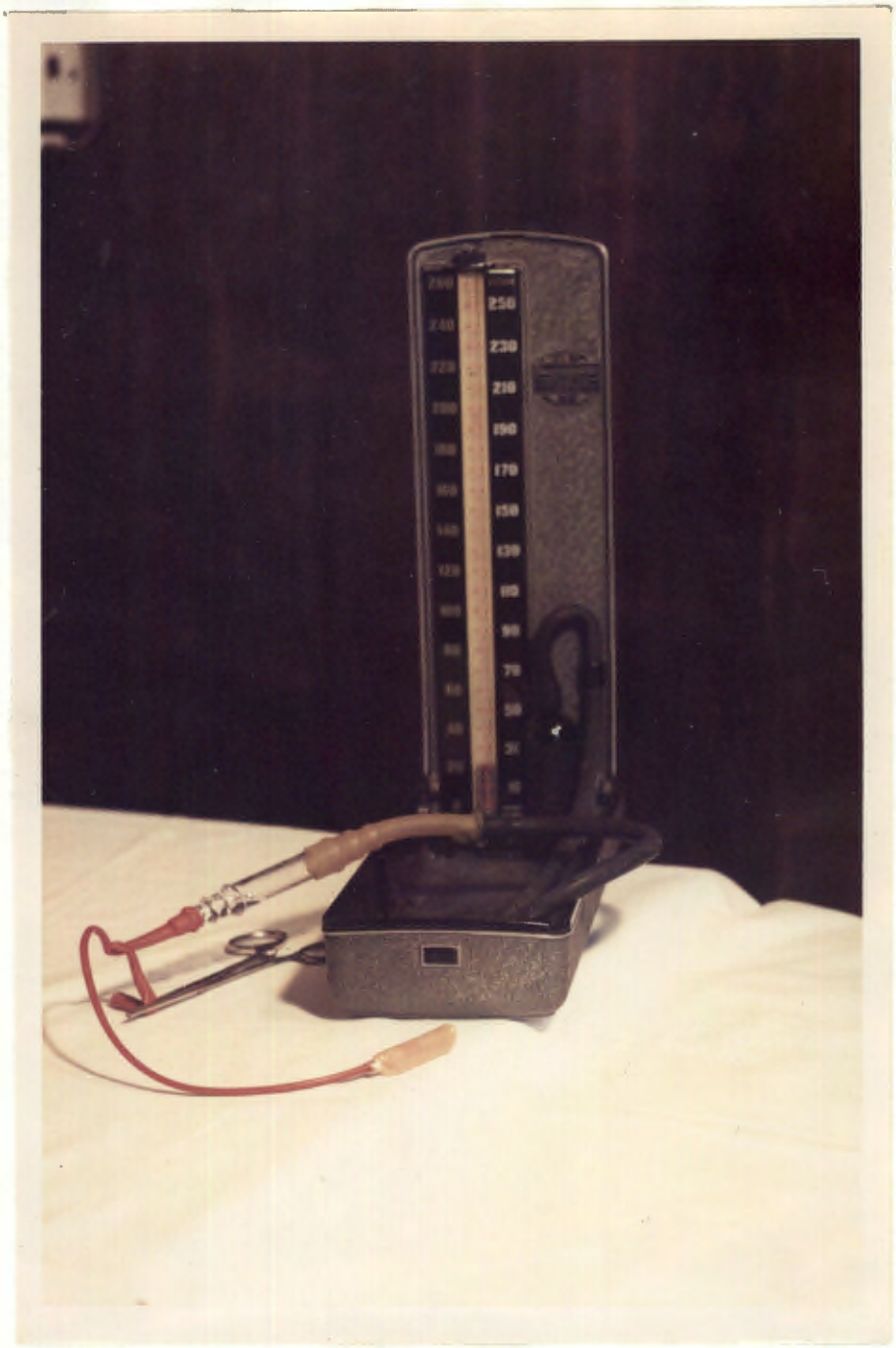


Fig.11. Sphincterometer for measurement of the strength of the sphincter of the female bladder in terms of m.m.^{s} of mercury.

which the exact distance of the sphincter from the meatus had been previously determined for the particular patient to be examined.

With the one barrel connected to the manometer the balloon is filled from a syringe until it is just smoothly distended and the amount of air required as read on the syringe is recorded. Say it is 4 mls. The resistance of the balloon to the air contained will be reflected in the rise of the mercury in the manometer tube. Say it is 20 m.m. The air is now removed from the balloon and the catheter inserted into the urethra until the sphincter would surround the middle of the balloon. The 4 mls. air are now pumped back into the balloon from the syringe, this end clamped off as shown in Fig. 11 and readings noted in the manometer with the patient's bladder:

1. at rest
2. withholding or restraining.

The difference between the original 20 m.m. and the present reading will respectively give the pressure

in m.m. Hg. of the involuntary strength of the sphincter, and its power to contract.

The resting strength in subjects with normal control in an average of 10 cases was 7 m.m.^{s} In 10 cases of established stress incontinence it was 4 m.m.^{s} The withholding readings had an average of 11 m.m.^{s} and 7 m.m.^{s} respectively. In this sphincteric strength test it is important that the bladder be empty as liquid in it would exert pressure on the part of the balloon deep to the sphincter and influence the reading in the manometer.

It must be recorded here that during the cystometric investigations it has been found that where there is residual urine the bladder does not go into its tonic contraction until its contents increase beyond the volume of the residual amount. That is for the residual urine the bladder remains in a kind of flaccid state. This is graphically demonstrated in Fig. 10... where the tonic resistance of the bladder only rose at about 115 mls—

the residual volume.

A by-product of these cystometric investigations was the fact that in cases of frequency due to the bladder having lost its ability to distend to capacity on account of previous chronic cystitis, the subjects reported that after the tests they found that they "could sleep through the night" following on the tests. This suggested the possibility of curing this kind of frequency with graded distension of these bladders. It can now be reported that 17 consequtive cases of this nature have had their normal bladder capacity restored after cystoscopy had excluded the presence of other pathology. It is done by the influx of saline at 98° F until there is discomfort. On subsequent visits at 3-day intervals the volume is increased to discomfort or 20 mls. more whichever occurs first, so that the resistance of the bladder wall may not be over-taxed. Four to six such distensions seem to cure the frequency.

In Tables I - IV on the following pages the effect is shown of parturition on the volume and pressure in the bladder, and on the size of the urethra.

TABLE I.

40 NULLIPARAE

Diameter of Meatus, Length of Urethra, Capacity of Bladder Residual Urine.

Identity	Age yrs.	Diam.of Meatus m.m.	Length of Urethra cms.	First desire to void ml.	Strong urge to void ml.	Residual Urine ml.
620/N/62	26	4	4.5	225	330	5
529/M/62	23	4	4.0	185	295	0
609/J/62	31	5	4.0	210	295	0
542/F/61	32	3	5.1	205	320	3
72/0/55	24	5	4.5	190	300	0
540/F/61	23	4	4.3	210	320	0
211/M/57	30	3	4.0	200	325	4
108/F/56	27	6	5.0	195	310	3
522/0/60	21	4	4.2	205	310	0
493/M/60	26	4	4.1	220	330	0
485/F/60	27	4	4.5	180	305	0
591/M/62	28	6	4.1	190	300	3
384/S/58	24	4	5.0	195	305	0
604/M/62	32	3	5.2	205	315	3
17/N/54	21	4	4.8	205	320	0
582/J/62	40	4	4.2	200	315	4
541/F/61	21	4	4.2	215	300	0
182/D/56	31	6	4.4	210	320	0
427/M/59	40	4	4.5	195	320	0

Cont'd.

TABLE I. (Cont'd.)

40 NULLIPARAE

Identity	Age yrs.	Diam.of Meatus m.m.	Length of Urethra cms.	First desire to void ml.	Strong urge to void ml.	Residual Urine ml.
586/M/62	23	4	4.0	205	315	3
545/F/61	19	5	4.2	200	320	2
222/A/57	17	4	4.2	195	320	0
577/D/61	32	3	4.5	195	305	0
602/M/62	32	4	4.0	210	325	0
607/J/62	24	4	5.0	230	325	2
581/J/62	27	4	4.8	205	325	2
206/F/57	28	5	4.6	210	315	0
594/A/62	33	3	4.8	215	320	2
469/D/59	20	4	4.2	220	325	3
568/S/61	18	3	4.5	200	310	0
228/M/57	24	5	4.2	195	300	0
142/J/56	46	4	4.5	200	300	4
195/J/57	24	5	4.0	210	315	0
596/A/62	27	5	4.5	215	325	0
144/J/56	49	5	4.4	205	320	2
628/J/63	39	4	4.2	195	305	0
612/S/62	24	5	4.8	185	295	2
584/F/62	21	4	4.5	205	320	0
148/J/56	54	5	4.8	205	305	6
630/F/63	75	4	4.6	180	210	3
Average		4.2	4.4	203	310	1.4

TABLE II.

40 PAROUS WOMEN

Diameter of Meatus, Length of Urethra, Capacity of Bladder Residual Urine.

Identity	Age yrs.	Para.	Diam.of Meatus m.m.	Length of Urethra cms.	First desire to void ml.	Strong urge to void ml.	Residual Urine ml.
450/S/59	49	1	5	4.0	195	300	3
238/J/57	63	1	4	4.2	210	330	10
153/A/56	52	2	4	5.0	210	310	4
244/J/57	32	4	4	5.0	190	300	0
496/A/60	35	2	3	4.5	215	320	5
136/J/56	43	2	5	4.2	220	310	5
229/M/57	46	2	6	5.0	200	315	8
101/J/56	45	2	4	5.2	205	330	5
479/F/60	54	3	4	4.8	215	315	5
33/M/55	69	3	4	4.2	190	295	12
85/D/55	44	2	5	5.0	195	310	4
480/F/60	38	5	4	4.6	230	340	4
223/A/57	37	2	5	4.8	220	335	5
4/N/54	47	4	5	4.0	215	325	15
259/A/57	54	2	6	3.8	220	315	10
360/M/58	45	3	5	4.2	185	300	5
366/J/58	38	2	5	5.0	200	305	10
605/M/62	27	2	4	5.0	195	310	5
603/M/62	51	2	6	4.5	210	330	10

Cont'd.

TABLE II. (Cont'd.)

40 PAROUS WOMEN.

Identity	Age yrs.	Para.	Diam.of Meatus m.m.	Length of Urethra cms.	First desire to void ml.	Strong urge to void ml.	Resi-dual Urine ml.
523/0/60	47	3	5	4.6	200	315	0
254/A/57	46	3	5	5.0	210	325	20
452/A/59	50	2	4	4.8	190	310	10
162/S/56	41	3	4	4.5	185	290	0
163/S/56	43	1	6	4.5	240	330	5
444/J/59	27	1	5	5.0	210	310	8
137/M/56	62	3	5	5.2	215	300	15
165/0/56	46	4	4	4.2	200	305	15
576/D/61	33	1	5	4.0	220	295	5
119/M/56	31	1	5	5.2	215	310	0
501/A/60	62	2	3	4.6	220	315	5
334/F/58	63	2	6	4.0	185	300	10
425/D/59	29	3	5	5.0	210	295	10
133/M/56	55	1	5	5.4	215	310	5
31/M/55	51	4	4	4.8	185	295	10
325/N/57	42	2	5	4.4	190	300	0
124/A/56	38	2	5	5.0	195	290	5
574/N/61	35	3	6	6.0	200	310	5
509/J/60	38	2	5	4.8	195	310	10
437/J/59	46	3	4	4.6	210	325	20
531/D/60	44	2	5	5.5	200	350	15
Average			4.7	4.70	204.7	312.5	9.7

TABLE III

Intra-vesical Pressure in m.m. Hg.

40 NULLIPAROUS WOMEN

250 ml. Normal Saline at 98° F in Bladder.

Identity	Age yrs.	Dorsal Position		Sitting		Standing	
		At rest	Straining.	At rest	Straining.	At rest	Straining.
620/N/62	26	11	15	14	19	15	19
529/M/62	23	10	15	14	17	16	20
609/J/62	31	10	13	12	18	16	19
542/F/61	32	11	15	14	18	16	19
72/0/55	24	10	15	13	18	16	18
540/F/61	23	10	14	12	17	15	19
211/M/57	30	11	15	13	20	16	19
108/F/56	27	10	13	14	18	16	18
522/0/60	21	11	15	15	18	17	19
493/M/60	26	10	15	12	17	16	19
485/F/60	27	10	14	12	18	14	17
591/M/62	28	10	13	13	16	14	18
384/S/58	24	10	15	14	17	15	18
604/M/62	32	10	14	14	18	16	18
17/N/54	21	12	15	14	19	15	19
582/J/62	40	10	14	15	17	16	19
541/F/61	21	10	15	12	17	14	17
182/D/56	31	10	14	12	17	14	18
427/M/59	40	10	15	13	17	15	18

Cont'd.

TABLE III. (Cont'd)

40 NULLIPAROUS WOMEN

Identity	Age yrs.	Dorsal position		Sitting		Standing	
		At rest	Straining.	At rest	Straining.	At rest	Straining.
586/M/62	23	10	14	13	17	14	18
545/F/61	19	10	15	14	17	15	20
222/A/57	32	11	15	14	18	16	18
602/M/62	32	10	14	12	17	17	19
607/J/62	24	11	14	14	17	16	19
581/J/62	27	10	13	14	16	17	18
206/F/57	28	10	10	15	20	18	20
594/A/62	33	9	10	12	19	16	19
469/D/59	20	10	10	11	19	17	19
568/S/61	18	11	13	11	18	16	19
228/M/57	24	11	11	11	18	14	18
142/J/56	46	10	15	14	17	15	18
195/J/57	24	11	15	14	18	16	19
596/A/62	27	10	14	13	17	15	18
144/J/56	49	10	15	15	18	17	20
628/J/63	39	11	15	15	17	16	18
612/S/62	24	10	13	14	18	16	18
584/F/62	21	10	15	15	18	17	20
148/J/56	54	11	15	15	19	17	19
630/F/63	75	10	14	14	18	17	19
577/D/61	32	11	15	14	18	16	18
Average		10	13	13	17	15	18

TABLE IV.

Intra-vesical Pressure in m.m. Hg.

40 PAROUS WOMEN

250 ml. Normal Saline at 98° F in Bladder.

Identity	Age yrs.	Para.	Dorsal Position		Sitting		Standing	
			At rest	Straining.	At rest	Straining.	At rest	Straining.
450/S/59	49	1	11	17	14	20	15	20
238/J/57	63	1	10	17	14	18	14	20
153/A/56	52	2	10	16	12	17	15	18
244/J/57	32	4	9	16	12	17	14	17
496/A/60	35	2	10	16	13	18	14	20
136/J/56	43	2	10	15	12	16	14	18
299/M/57	46	2	10	14	13	16	15	16
101/J/56	45	2	11	14	13	15	15	17
479/F/60	54	3	11	15	12	16	15	16
33/M/55	69	3	10	14	13	16	14	16
85/D/55	44	2	11	14	14	17	15	17
480/F/60	38	5	11	15	14	17	15	18
223/A/57	37	2	10	15	14	17	15	18
4/N/54	47	4	10	14	13	17	16	18
259/A/57	54	2	12	16	15	17	16	18
360/M/58	45	3	10	14	12	16	15	18
366/J/58	38	2	11	15	13	17	15	18
605/M/62	27	2	10	14	12	16	15	17
603/M/62	51	2	11	14	13	17	14	17

Cont'd.

TABLE IV. (Cont'd.)

40 PAROUS WOMEN

Identity	Age yrs.	Para.	Dorsal Position		Sitting		Standing	
			At rest	Straining.	At rest	Straining.	At rest	Straining.
523/0/60	47	3	12	15	14	17	15	17
254/A/57	46	3	10	15	12	17	15	18
452/A/59	50	2	10	14	13	17	15	17
162/S/56	41	3	12	14	14	16	15	18
163/S/56	43	1	11	16	13	18	16	20
444/J/59	27	1	10	15	12	17	15	18
137/M/56	62	3	11	15	14	17	15	17
165/0/56	46	4	11	14	14	16	15	17
576/D/61	33	1	12	14	14	16	16	17
119/M/56	31	1	12	15	16	17	18	18
501/A/60	62	2	10	14	15	16	16	17
334/F/58	63	2	11	15	13	16	15	16
425/D/59	29	3	10	14	12	14	13	16
133/M/56	55	1	10	15	13	15	16	16
31/M/55	51	4	11	14	13	15	14	16
325/N/57	42	2	10	14	12	16	16	17
124/A/56	38	2	10	15	12	17	18	18
574/N/61	35	3	10	14	13	17	16	18
509/J/60	38	2	10	15	12	16	16	17
437/J/59	46	3	11	15	14	17	18	17
531/D/60	44	2	11	14	14	16	16	18
Average			10.3	14	13	16	15	17

RADIOLOGICAL FINDINGS IN CASES OF STRESS INCONTINENCE.

To study the nature of stress incontinence by means of cystograms, a number of patients with normal urinary control were studied in comparison with others that had established incontinence. Figs. 14.to.22, inclusive, represent the more important features of this work and call for no special elaboration. The results obtained appear to confirm in a modest way the work done by Muellner,[148] Jeffcoate,[31] and Ingelman-Sundberg,[149] all of whom stress the fact that the bladder base drops, the vesico-urethral angle is straightened and funnelling of the urethra takes place, making it impossible for the sphincter to contract and exercise involuntary control over the bladder outlet.

Fig.14. Case No. 35/M/55. Nullipara, 29 years. At rest. Normal bladder control. Shows high abdominal position of bladder containing 250 ml. diadrast. See Fig.9 for Cystometric graph of this case.

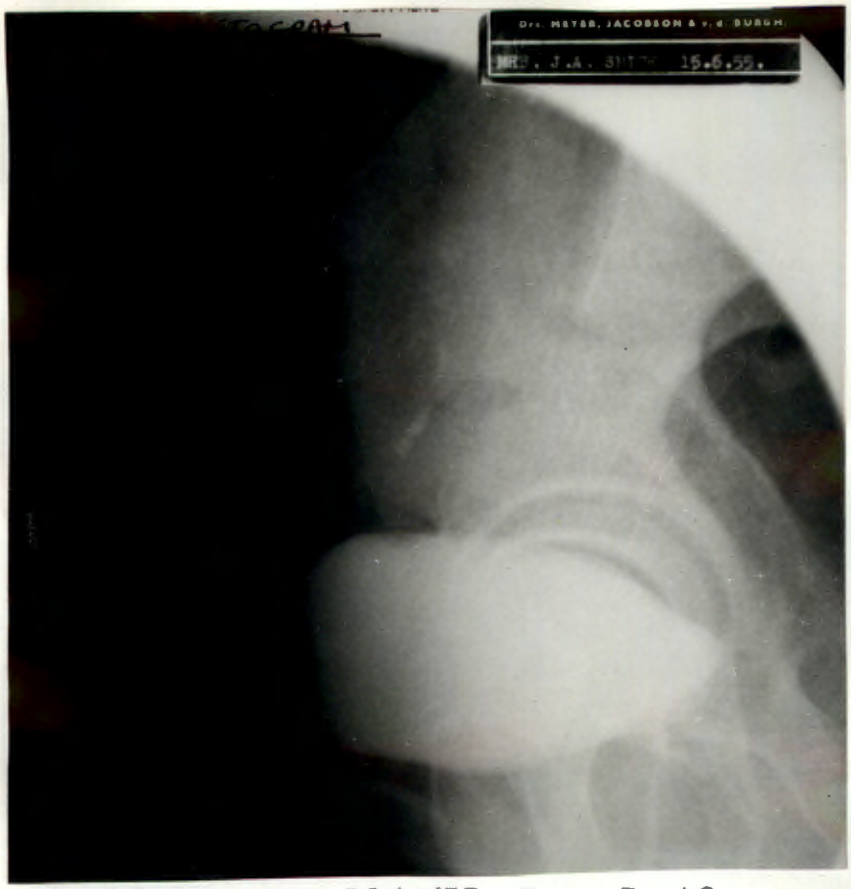


Fig.15 Case No. 32/M/55, Para.3. 42 years. Normal bladder control at rest. Bladder base still high compared with nullipara in Fig.14. 250 ml. diadrast in bladder. Excellent obstetrical history without trauma.

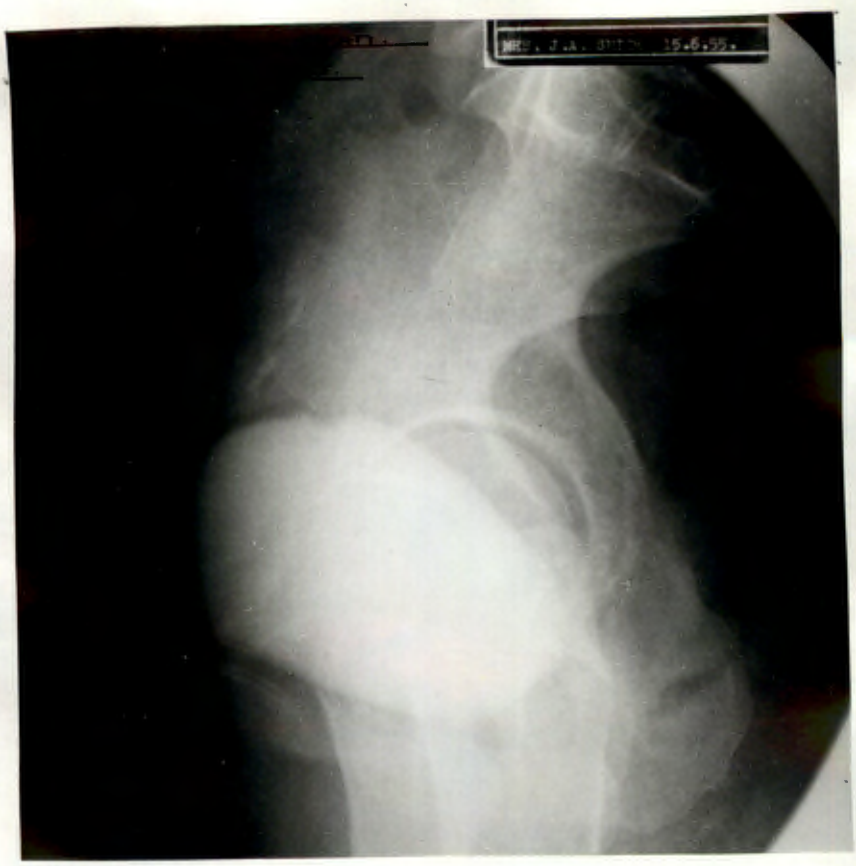


Fig.16. Case No. 32/M/55 Same as in Fig.15. Erect position. Shows lowering of bladder base during straining to void.

Fig.17 Case No. 32/M/55 Same as in Figs.15 & 16. A P, erect. At rest. Shows normal high position of bladder.

Fig.18. Case No. 63/J/55, 28 years. Para. 3. Lateral, erect, at rest, 250 ml. diadrast in bladder. History of severe obstetrical trauma. Severe stress incontinence. Bladder leaks when containing only 200 c.c. on coughing in sitting position. Sphincterometer shows only 3m.m. Hg. withholding pressure.

Fig. 19. Case No. 63/J/55 Same as in Fig. 18. Erect, A P at rest. Shows low position of bladder base compared with multipara with good obstetrical history in Fig. 17.

Fig.20. Case No. 31/M/55. 51 years.Para.4
Obstetrical history of severe trauma.
Severe stress incontinence since age of
40 years. Had two failing vaginal
operations for this condition during the
last 4 years.
A P, erect, at rest with 250 ml. diadrast
in bladder. Shows low position of bladder
base. Asymmetry is due to fibromyomata
uteri.

Fig.21. Case No. 31/M/55 Same as in Fig. 20. A P, erect, 250 ml. diadrast in bladder, taken 5 months after 2-sling operation in 1955. Bladder control is still normal 8 years later.

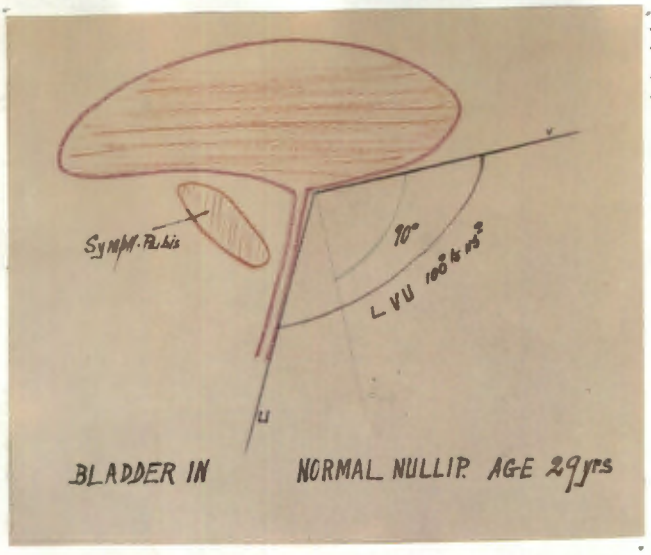
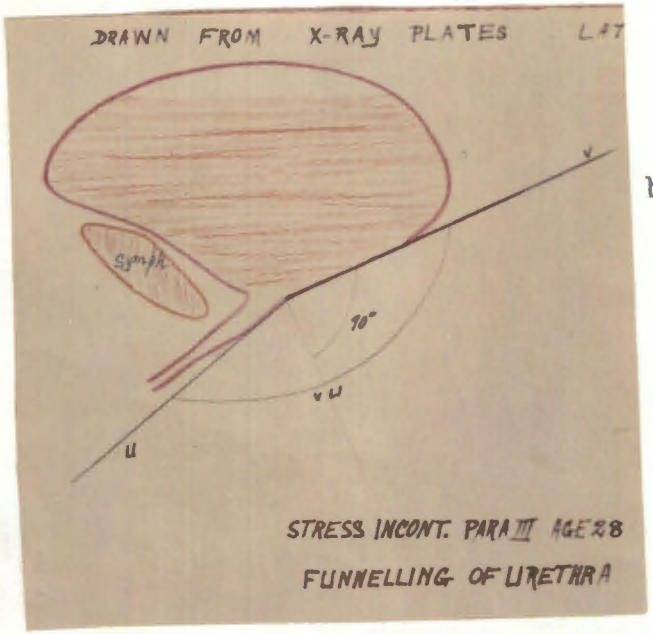


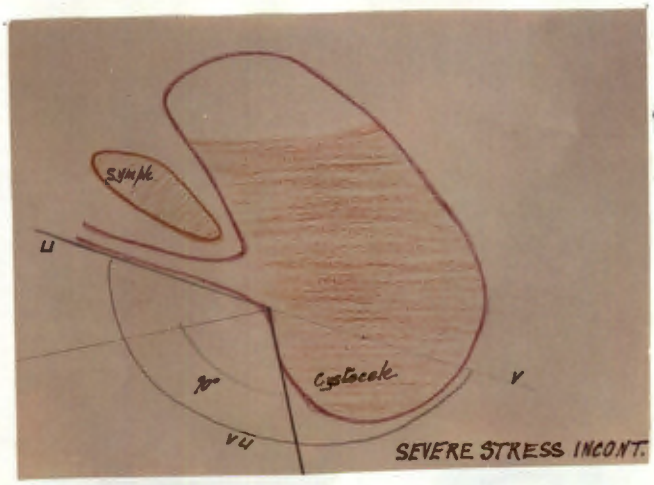
Fig. 22

Legend on next page

a. Case 35/M/55
29 years.
Nullipara.



b. Case 63/J/55
28 years.
Para. 3.



c. Case 31/M/55
51 years.
Para.4.

Legend to Fig. 22.

These are diagrammatic representations of cystograms and fluoroscopic views of three cases that illustrate the descensus of the bladder and urethra, their rotation with the sphincter more or less as axis making the urethra point upwards and finally straightening out of the vesico-urethral angle from its normal 100° to 115° to a straight angle. They may be observed together with the cystograms on the previous pages.

AETIOLOGY OF STRESS INCONTINENCE.

Stress incontinence in the human female is a condition that may occur at any age but typically it is a malady that occurs mainly in obese, old, middle-aged or parous women. It may, however, present itself even in virgins of tender age— due to inherent weakness of the musculature of the sphincter mechanism of the bladder and/or congenital defects in the central nervous system due to mal-development as in spina bifida. To complicate the issue one finds patients with varying degrees of descensus and even with complete prolapse who do not suffer from stress incontinence.[124]

In considering the problem in detail it is convenient to place it under two main headings viz.:-

1. Congenital

2. Acquired.

The congenital variety of stress incontinence

may be due to gross or occult spina bifida and resultant defects in the spinal cord may cause loss of bladder sphincter control.

There may be congenital weakness per se of the intrinsic muscles of the bladder neck with weakness also of the supporting musculature.

Case report: No.592/M/62, A 24 years old white secretary, unmarried, nullipara has had nocturnal enuresis three to four times a week— depending on her fluid intake at night— throughout her conscious life, and from the age of 15 years she began to have moderate stress incontinence "only when my bladder is full!" Investigation for specific infection proved negative. Extensive radiological examination revealed nothing abnormal and neither did tests on the sacral nerves distribution. Vesico-volumetric examination revealed that she had stress incontinence only when standing with 310 ml. or more fluid in the bladder. There was no descensus or cystocele of any degree whatsoever. One could find no explanation for her condition other than congenital weakness of the bladder neck musculature. The enuresis was cured by gradual distension of the bladder over a period of four weeks to a capacity of 400 mls. This had no effect on the stress incontinence and the patient was advised to wait until after issue from her impending marriage when her condition can be re-assessed. Should it then seem necessary she can have the two-sling operation and any subsequent deliveries by means of Caesarean section.

Amongst the acquired causes the commonest is

that brought on by the injuries of childbirth. Here one has to list the following: excessive distension and even laceration of the pubococcygeus muscles and/or all the muscles and fasciae constituting the anterior half of the perineum. The suspensory ligaments that hold the urethra and bladder neck forward in relation to the symphysis may be stretched or lacerated. Continence depends to a great extent upon the firm integrity of the supporting muscles of the bladder neck. When this mechanism breaks down or is weakened by parturition, senility or obesity, then the bladder may show incontinence on exertion.[125]

Incontinence due to tabes dorsalis is now very rare due to the advent of the anti-biotics.

Jeffcoate[126] states that stress incontinence is sometimes brought on by anatomically successful operations for descensus. The rationale of this is perfectly logical as in cases of colporrhaphy where the meaning of this word is strictly and too literally

adhered to, the vagina would be narrowed as a tube and thus pull down the bladder base, bladder neck and urethra, causing stress incontinence. A little diversion into etymology may not be far out of place here. Raphe is the Greek for "to sew" and the vagina is called "colpos" in Greek.[127,128,129] Now some surgeons may do no more than this and therefore bring down the bladder. It is also interesting to note that both the Greeks and Indians in circa 500 B.C. believed that there was only the one viscus deep to the perineal entroitus viz., the "udara" in Sanskrit[130] and "colpos" in Greek that carried the foetus, and not a separate vagina and uterus as is known now. They believed that the milk for the foetus was formed in this single container from where it would be led by tubes to the breasts to which organs the infant would turn for its nourishment after birth. The early Sanskrit "udara", later "utara" also forms the root of "uterus" via Latin. Compare English "udder" and modern Greek "ustera";[131] and "oestrus" cycle.

The following case supports the view that a

narrowed down vagina can cause stress incontinence.

Case report: No.446/J/59, A 19 years old, unmarried white girl, virgo intacta, consulted for stress incontinence "of many years duration" and menstruation twice a month for 5 days. She revealed a uterus bicornis duplex and double vagina. Figs. ..12.... and ..13.. p132-3. The sphincter opened on coughing with only 215 mls. in bladder in dorsal position. She proved to menstruate independently from the two uteri— each having its own cycle. When the septum, which was only 0.5 cm. high, was removed, the stress incontinence was, to one's surprise, completely and permanently cured.

One refers in this respect only to those colporrhaphies that are done too superficially and without the principles embodied in the procedures described by Kennedy,[132] Jeffcoate,[133,134] Louw[135] and Shaw.[136]

Muellner[137] made detailed radiographic and fluoroscopic studies of 85 women, 30 of whom had stress incontinence. He concluded that the mechanism of urinary control consisted of two parts— the internal sphincter and the pubococcygeus muscles. In the anatomical dissections that one has done on these muscles one can only agree with his statement. He

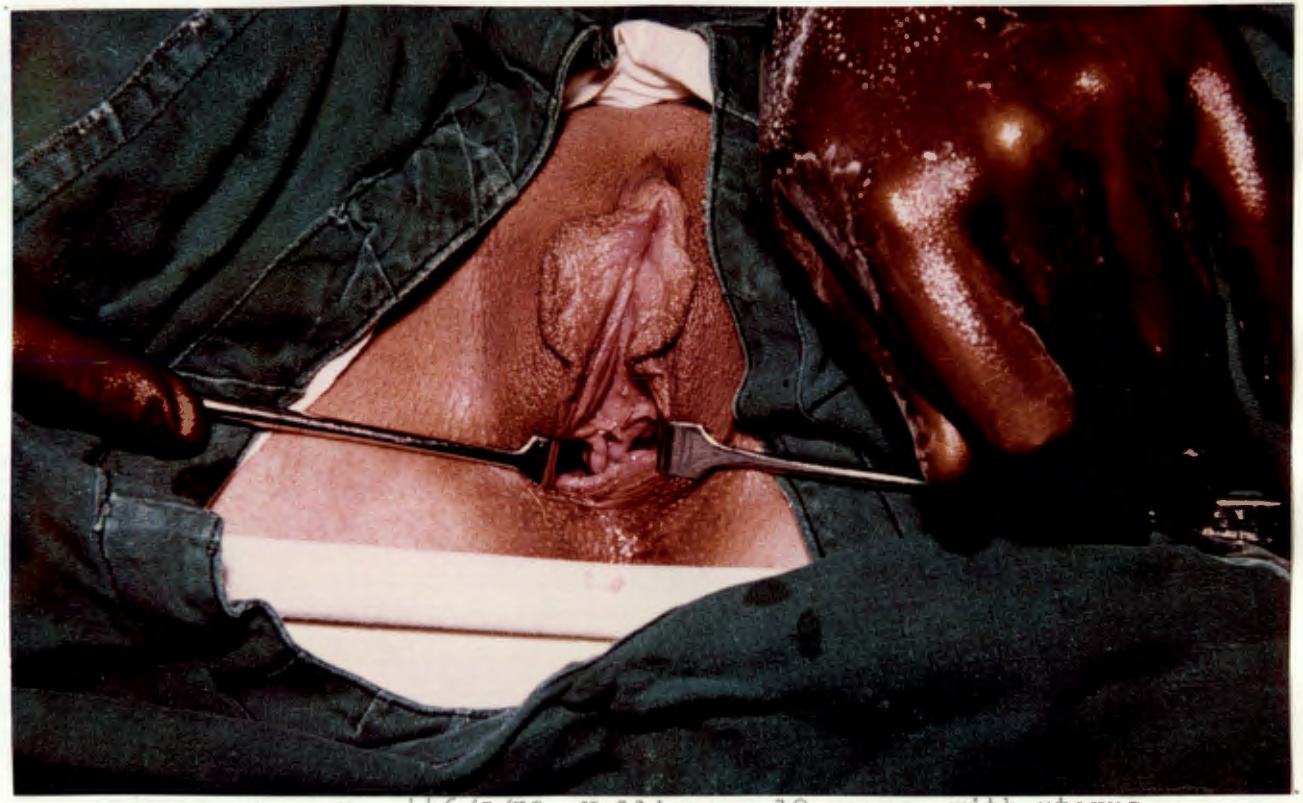


Fig.12. Case No. 446/J/59, Nullipara, 19 years, with uterus bicornis duplex and double vagina. Severe stress incontinence.

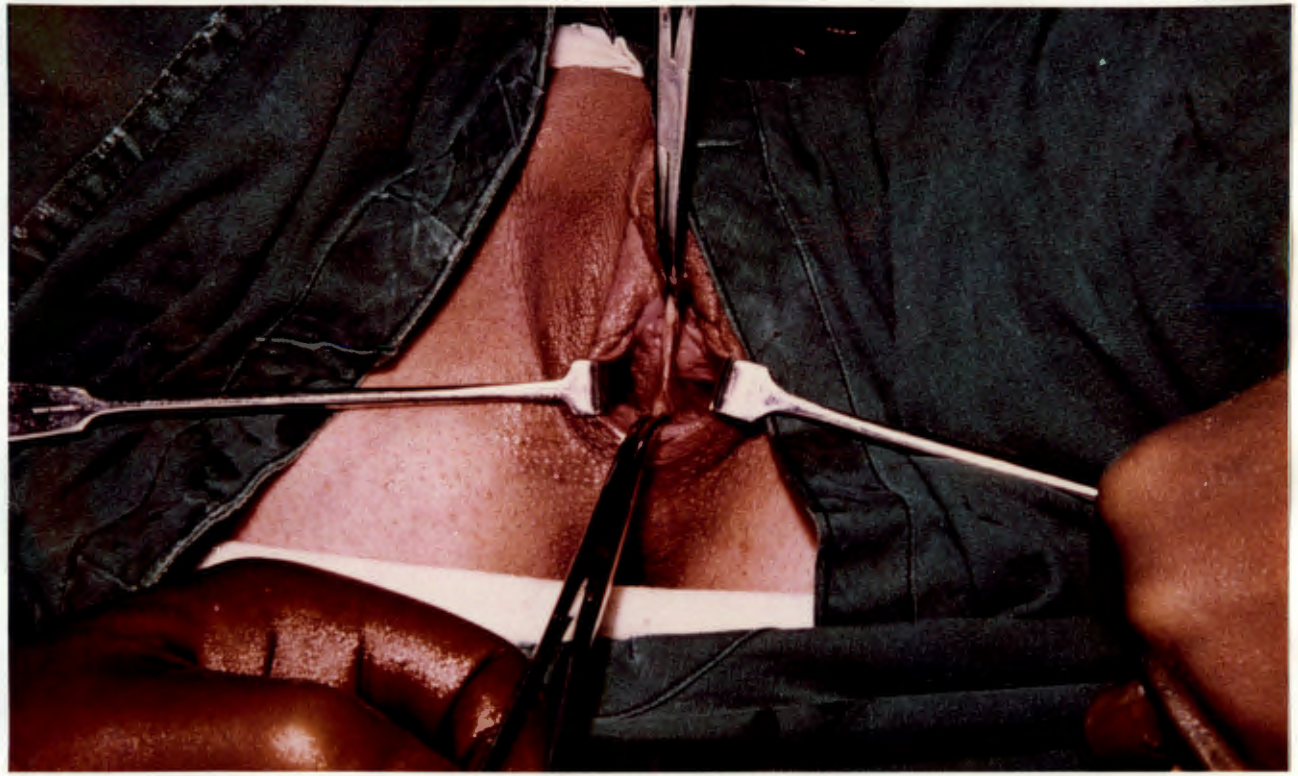


Fig.13. Case No. 446/J/59. Same as in Fig.12. The septum in the vagina being removed.

goes on to say that stress incontinence is due to failure of the pubococcygeus to support the bladder neck. This is a very reasonable conclusion for cases of obstetrical trauma with stretching or laceration of the pubococcygeus as it surrounds the urethra and vagina or even in its median raphe. Fig. ...7... in section on anatomy.

In regard to the aetiology of stress incontinence it is clear from the small number of cases presented here in Table ...V..... and from the experience of the various workers quoted that the chief causal factor of stress incontinence is obstetrical trauma not only to the bladder neck itself but also to the various supporting ligaments and muscles that sustain the posture and level of the urethra and bladder. When these structures lose their integrity, there is dislocation to the positioning of the organs, the bladder base and neck are lowered, the urethro-vesical angle is straightened and the urethra itself falls backward, away from the symphysis. Figs. ..14.. to ..22.. in section on radiography.

DIAGNOSIS OF STRESS INCONTINENCE.

In considering the diagnosis of stress incontinence it is necessary to classify the various kinds of incontinence. These fall into two main groups:

1. Complete Incontinence.
2. Partial Incontinence.

Complete Incontinence.

This one finds in:-

a. Vesico-vaginal fistula.

b. Uretero-vaginal fistula — bilateral.

c. Congenital abnormalities as absence of the vesical sphincter, extrophy of the bladder.

d. Lesions in the central nervous system.

Partial Incontinence.

This occurs in the following:

a. Overflow or paradoxical incontinence. It is due to over-looked or neglected retention of urine causing paralysis of the musculature of the bladder wall.

b. Urgency incontinence; due to cystitis, or irritative lesions of the urethra or of the trigone.

c. Stress incontinence— due to inability of the sphincter mechanism to prevent the involuntary escape of urine.

d. Unilateral uretero-vaginal fistula which permits incontinence via the vagina while there is also normal voiding.

e. Intermittent dribbling with strangury, occurs in severe forms of acute cystitis and in lithiasis or tumours involving the sphincter or urethra.

f. Lesions of the central nervous system causing intermittent incontinence.

g. Small vesico-vaginal or urethro-vaginal fistulae that cause intermittent leakage of small amounts of urine. These fistulae may be small and escape of urine may take place only on exertion causing a mistaken diagnosis of stress incontinence to be made.

h. A diverticulum of the urethra may likewise cause slight leakage from it on exertion and create confusion with stress incontinence.

From the history given by the patient the diagnosis may seem obvious but as the above list shows there are many pit-falls. Jeffcoate[138] states that his unit every year has to deal with patients who have been operated on for stress incontinence elsewhere while the actual condition was something else.

The obstetrical history especially must be

elicited in complete detail with particular regard to puerperal urinary retention, subinvolution and known trauma.[139] Should there be any history that suggests asthma or previous or present conditions of tuberculosis, signs of these must be looked for thoroughly. Cystoscopic examination, should there be a tuberculous cystitis, will show in the early stages some erythematous patches surrounding small miliary tubercles on the bladder mucosa. In older lesions there may be ulceration. As the primary focus is usually in the early stages in only one of the kidneys, the appearance of the ureteric orifices must be noted. On the affected side the orifice is usually trumpet-shaped or in the shape of a deep, straight excavation.

Diseases of the central nervous system that may have a marked effect on bladder sphincter control are tabes dorsalis, myelitis and disseminated sclerosis. Syringomyelia, amyotrophic lateral sclerosis, and Friedrich's ataxia do not affect bladder control.

The micturition of tabes dorsalis is hesitant and with interruptions.[140]

A reliable way to confirm whether or not a patient has incontinence is to fill her bladder to capacity and to let her cough. Should the condition not be severe, then the leakage will only occur if she is standing when she coughs.

Final confirmation is viewing of the sphincter through the urethroscope while the patient strains or coughs with a measured amount of urine in the bladder. The severity of the incontinence can also be ascertained in this way.

TREATMENT OF STRESS INCONTINENCE.

The majority of parous women probably suffer from some form of stress incontinence under different circumstances when the bladder is full. If it is mild they will not mention it and only to very diplomatic questioning may it be admitted. In the severer form the stress incontinence may be the only symptom that makes them seek advice. These unfortunate patients are often frustrated and distressed. They feel forsaken and lonely as they frequently have to avoid company and feel they are a burden to their family. They may have had one or more unsuccessful operations and are afraid of more failures. It may depend upon the gynaecologist's acumen as a psychologist whether there will be submission to more surgery. And here it may be stated that it is of vital importance to the success of the procedure that the complete confidence of the patient be obtained. The patient's mentality and personality must be summed up as the nature of these will determine how much she is to be told if

she has to undergo a major operation, especially if it be a second or third one. Should she be an enlightened person, the principles of the whole procedure may be explained to her. In any event she is told that she will wake up and have an indwelling catheter in the bladder for continuous drainage for 6 to 7 days. This will prevent her from jerking it out because she thinks a nurse had forgotten it in her bladder. She is told that she need have no fear of pain but that there will only be some discomfort during the first two post-operative days, and if she has no other disability she would be walking around her bed on the first post-operative day. To know this beforehand will strengthen the patient's morale and give her new hope.

In regard to actual treatment of a particular case, this will depend upon a variety of conditions. For example, a multipara of over 40 years' age cannot be treated in the same way as a nullipara of, say, 22 years' age whose stress incontinence had been established as being of neurogenic origin. In

the latter case any nervous tensions may be removed as far as possible, her bladder may be dilated to full capacity should this have been lost and she may first have a few or all of her children should she so wish. If her condition becomes aggravated by childbirth she may then have the suspension operation with bladder neck reconstitution and any further deliveries by Caesarean section.

It may be noted here that Hunter[142] in 1955 advocated the serious consideration of Caesarean section in all cases that have had vaginal plastic operations. He reports a 2.2% death-rate in a series of 83 cases that were allowed to give birth per vaginum, and refers also to the large number of puerperal complications as sepsis, deep pelvic thrombosis and superficial phlebitis that were contracted in the other patients.

Averill[144] reports that he had to do Caesarean sections in 18% of women who have had vaginal repairs and who formerly had normal deliveries.

In the multipara beyond the child-bearing age, on the other hand, the two-sling operation plus a full Fothergill - or Kennedy type of repair to the vagina and bladder neck may be required. Likewise the degree of any prolapse, presence or not of rectocele and/or enterocele, whether or not it may be desirable to do a hysterectomy also— all these influence the decision as to the procedure or sequence of more than one procedure that may be in the best interests of the patient.

Ball[141] states that "The surgery of urinary stress incontinence in women is noted for its high percentage of failures" and goes on to stress the importance of applying a procedure best suited to the particular type of case. Cases with chronic coughs from serious respiratory disease, cases of extensive birth trauma, cases of spina bifida that suffer from stress incontinence cannot all be cured with the same kind of vaginal procedure.

That stress incontinence is no small problem is

reflected in the statement of men of stature in gynaecology. To quote a few:-
Stallworthy[143] states that stress incontinence was the most common complication of operations for prolapse and occurred in 16% of his series of operated cases. Waters[145] says that incidence of failure of cure is in reverse ratio to experience and applied anatomical technique in operations for stress incontinence and prolapse.

Muellner[146] declares: "The ideal operation has not yet been devised".
As late as 1961 Aldridge[147] stated: "It will be difficult to devise a precise surgical procedure for relief of stress incontinence until we have exact knowledge as to how urination is controlled. I am hopeful that the ultimate solution of the problem will be a vaginal plastic operation by which the abnormalities which cause this distressing condition can be corrected".

THE TWO-SLING OPERATION.

The patient is appropriately anaesthetised and prepared on the horizontal operating table for abdomino-perineal procedure. She is placed in such a way that the perineum is at the break of the table and her legs raised by means of foot stirrups until the thighs are elevated to a height of 30 degrees to 35 degrees. With this arrangement the operation can be completed without the lower limbs interfering with either the abdominal or vaginal part of it. In order to prevent pressure on the blood-vessels, of the popliteal fossae, knee-rests are not used.

A curved incision is made on the lower abdomen between two points 3 cms. medial to each anterior-superior iliac spine through a point 3 cms. above the upper edge of the symphysis pubis. This incision is carried through the fatty layer. The external oblique aponeuroses and sheaths of the recti muscles are exposed by blunt dissection to a width of 3cms.

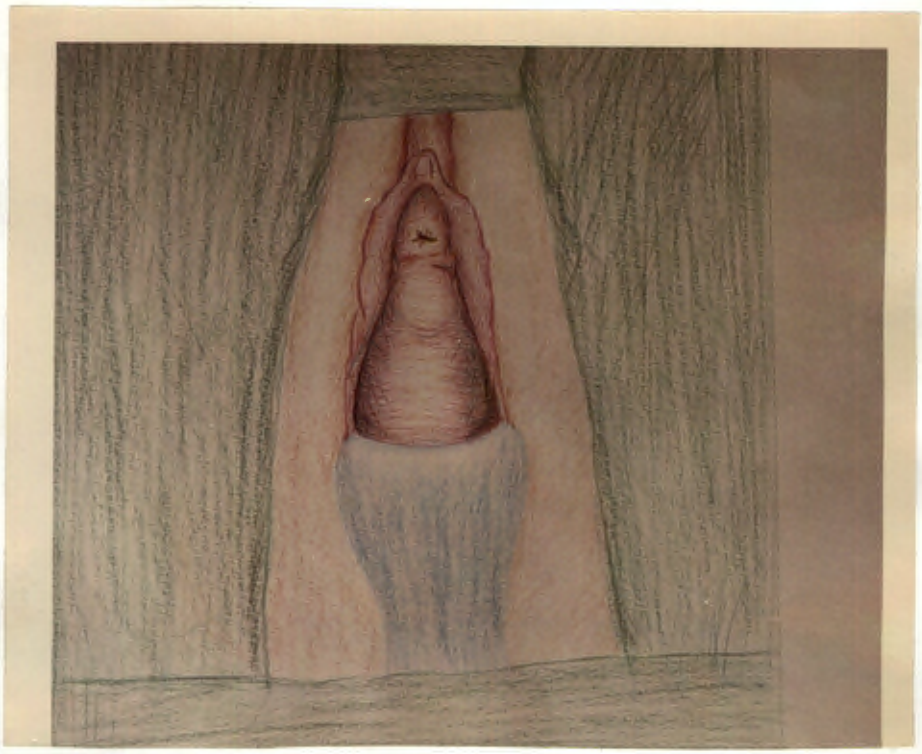


Fig. 23. Sketch of urethrocele and cystocele.

From points 2 cms. lateral to the midline and 2 cms. above the pubic edge two strips of aponeurosis 1.5 cms. wide are now freed with the lateral ends detached and the medial ends remaining attached, see Fig. ..26.. The length of these strips is about 14 cms. in a patient of average size. The two rectangular windows thus formed are immediately closed with interrupted 00 chromic catgut sutures. The two strips of tissue are now covered with warm, moist gauze and left in their respective sides of the abdominal wound which in its turn is closed with gauze packs and towels and the vaginal part of the operation carried out as follows:

A weighted speculum is placed in the vagina and a size 14 Foley-type self-retaining catheter with a 5 ml. bulb placed in the bladder which is emptied and the catheter then shut off and made to rest on the patient's abdomen. During the operation the inflated bulb will enable the surgeon to know at all times where the bladder sphincter is situated. With a suitable retractor the anterior wall of the vagina is now lifted and the cervix, if present, seized with a

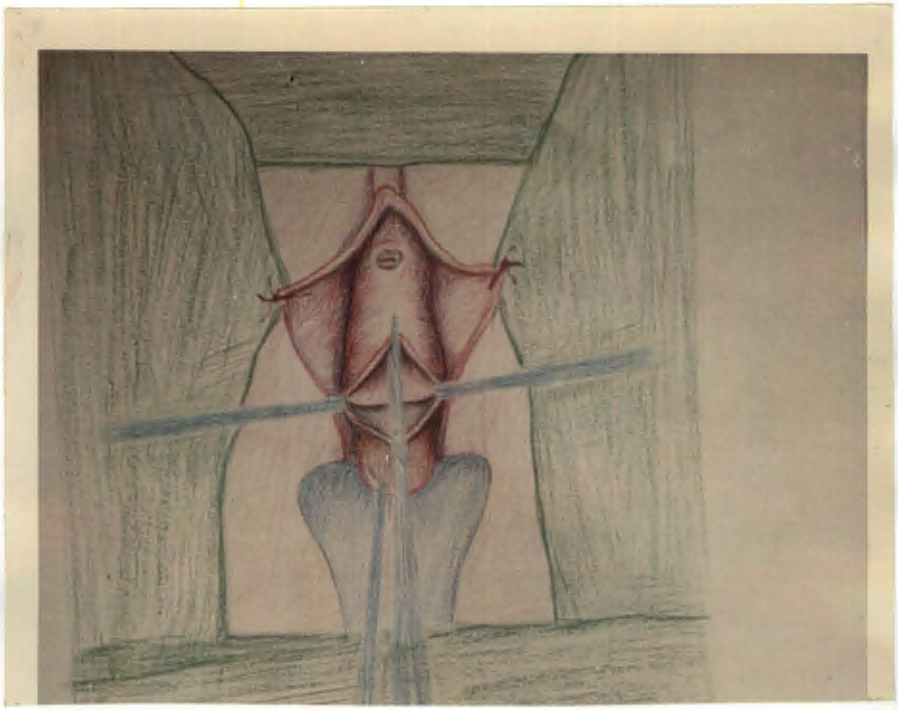


Fig. 24. Bladder is completely freed from anterior vaginal wall and from lower segment of uterus.

tenaculum. If the cervix is not present and a total hysterectomy had been carried out, then the middle of the vaginal vault is likewise seized and a No.1 chromic catgut figure-of-eight suture put across the scar in the vault and not tied but grasped in a Kelly forceps to be used as an anchor and guide.

About 1 cm. below the bladder fold on the cervix an incision 2 cms. in length is made across the mid-line and through only the thickness of the mucosa. In cases that have had previous vaginal operations care has to be exercised as there may be no mucosa in the median area at all but only scar tissue - the mucous membrane and subjacent tissues having retracted to the sides. In such cases the scar tissue may be extremely thin and the bladder exposed to possible damage. With the flat, curved, Mayo scissors, however, a canal in the correct superficial plane is burrowed in stages up to 0.5 cms. below the meatus urethrae. Fig. ..24.. The vaginal flaps should be readily freed from the bladder and urethra by means of the gauzed finger and sharp dissection. The

edges of the flaps are best held in small toothed forceps. Should the vaginal wall not come away with comparative ease and with minimal oozing, then the operator is most likely advancing in too deep a plane.

The urethra is freed from the vaginal wall to an extent at least half-way up its sides for its whole length. The vaginal wall is freed from the bladder laterally until the descending rami of the pubic bone can be felt from behind the vaginal flaps. The bladder is freed from the uterine surface to a height at least as far as a line half-way up its attachment to the uterus. (In cases where the uterus is absent only the vaginal aspect of the bladder is dealt with). At this stage the surgeon returns his attention to the area behind the vaginal flaps and with the gauzed finger he reaches the edges of the descending rami and about 2 cms. from the apex of the pubic arch there will be palpated a weakness in the tissues of the pubococcygeus in the form of a small triangle with the edge of the ramus as base. With a little manoeuv-

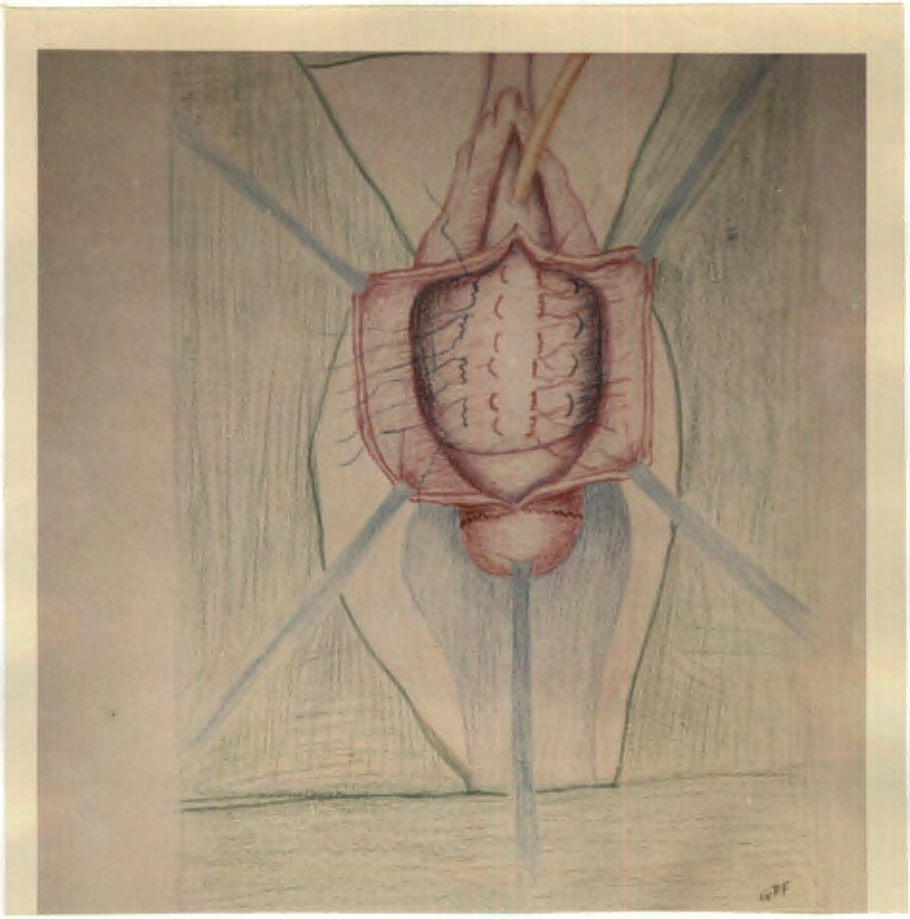


Fig. 25. Two rows of plicating sutures of 00 chromic over bladder. One row of 000 black silk over urethra and bladder neck. Cervix to be amputated. This is a diagrammatic representation. In reality the suture area lies horizontally and is not as visible as shown here.

ring the gloved finger-tip will pass through this and the inner aspect of the bone can be felt.

With the fore-finger of the left hand as a guide to the afore-mentioned opening on the patient's left and with a Bozeman's forceps in the surgeon's right hand the tip of this intrument is pushed gently through into the space of Retzius, hugging the bone as it goes up towards the abdominal wall and then moved over to pierce the wall 0.5 cms. lateral to the attachment of the right aponeurosis strip, the free end of which is grasped in the forceps and is brought down to cross the mid-line above the bladder neck and out to the left into the vagina. Figs. ..26. and .27.. In patients with a very large pelvis the bands may be somewhat short and may then be taken on the ipsi-lateral side and crossed only below the bladder neck. When the first band has been pulled through, the procedure is likewise carried out on the other side. This is the only stage of the operation that can in-volve serious injury to the bladder and in teaching it has been found that here the pupil may wish to

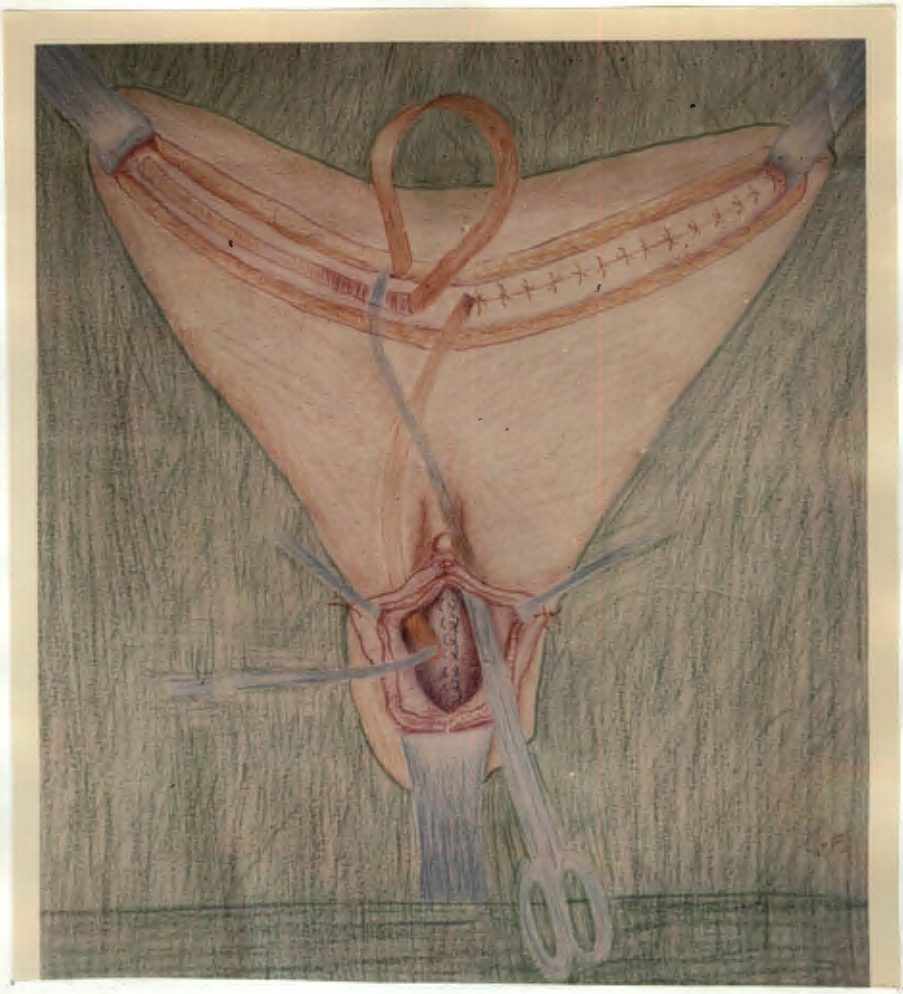


Fig. 26. Aponeurosis strip is fetched on opposite side, brought out, sutured first to bladder neck and then to pubic ramus of ipsilateral side.

"hand over" the operation. With gentleness, however, and care to prevent the forceps from slipping away from the pubic bone and into the abdomen, no damage whatsoever can be done to any neighbouring organ. The free ends of the two bands are now caught in holding sutures which are in turn held in forceps that are put out of the way on the patient's abdomen.

If the cystocele present is small it is now eliminated with a single purse-string suture of OO chromic catgut on an atraumatic needle. Should it, however, be larger, then it is dealt with by a double layer of transverse plicating mattress sutures of the same kind of gut with the bites not wide enough to cause fore-shortening.

The whole length of the urethra is now similarly plicated with mattress sutures of OOO black silk. The bites are taken well up on the lateral aspects of the urethra including the longitudinal fibres of the urethral ligaments and the tissues of the insertions

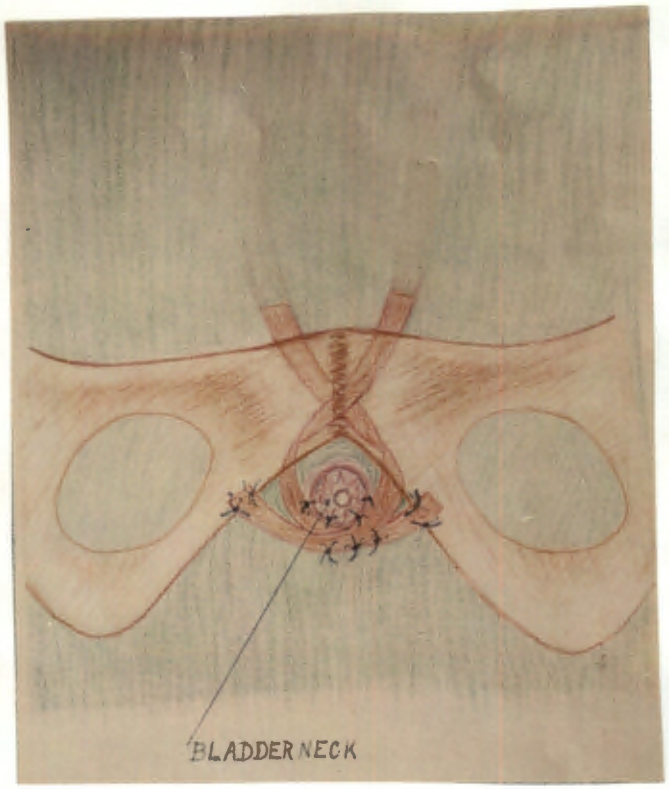


Fig. 27. Diagrammatic sketch showing arrangement of the strips around bladder neck.

of the pubo coccygeus muscle. The uppermost of these sutures is placed with slightly wider bites across the bladder-neck. One has had personal communications that silk sutures may in a matter of months get deposited inside the bladder and in the lumen of the urethra. It is, however, not the experience of the writer in cases of up to eight years standing, and such deposition of sutures in the bladder and urethra is most likely the result of their being placed too deeply so that they include the superficial layers of mucosa in these organs. The catheter with its balloon can be of assistance to prevent this. The two aponeurosis strips are now crossed over one another under the bladder sphincter and enough tension put on them to hold the bladder-neck at its normal height. Here they are sutured together with 000 black silk and they are also sutured to the bladder-neck itself. Figs...27.& 28

The holding sutures are now removed. The ends of the remaining parts of the strips, after suitable trimming for length, are sutured to the periostium

of the pubic rami at the points where the Bozeman's forceps were pushed through. This is also done with OOO black silk.

The excess width of the vaginal flaps are now trimmed to suitable dimensions.

If the uterus is present a No.1 chromic catgut suture is now put through a segment of the uterine tissue on the anterior aspect, immediately below the bladder fold and each end in turn taken from within outwards through the vaginal flaps at the level of the dimple situated at the depth of the descending pubic rami— the needle passing through right against the bone. The ends of this suture are tied when the edges of the vaginal mucosa have been sutured together to its level, working from the meatus backwards. The purpose of this suture is to anchor the uterus forwards and upwards, pushing the bladder even higher up. The vaginal edges are approximated with OO chromic catgut, each interrupted suture including a bite of the posterior surface of the

urethra, bladder, surface of the lower segment of the uterus and finally of the cervix as the case may be. The ligaments around the cervix are sutured in the Fothergill manner and the lower part of the cervix amputated if child-bearing is no longer in the picture. If parturition is still anticipated, then the cervix is left intact and any future babies have to be delivered by Caesarian section before the patient goes into labour. One can to-date cite only two cases in which delivery has been done in this way but four years later in the one case and two years in the other, the bladders are still functioning normally.

The posterior vaginal wall is dealt with according to its needs should a rectocele and even a cul-de-sac hernia be present. An appropriate perineorraphy is done if required.

Gauze packing, soaked in suitable antiseptic and mineral oil is now placed in the vagina for the purpose of keeping the repaired organs elevated, to

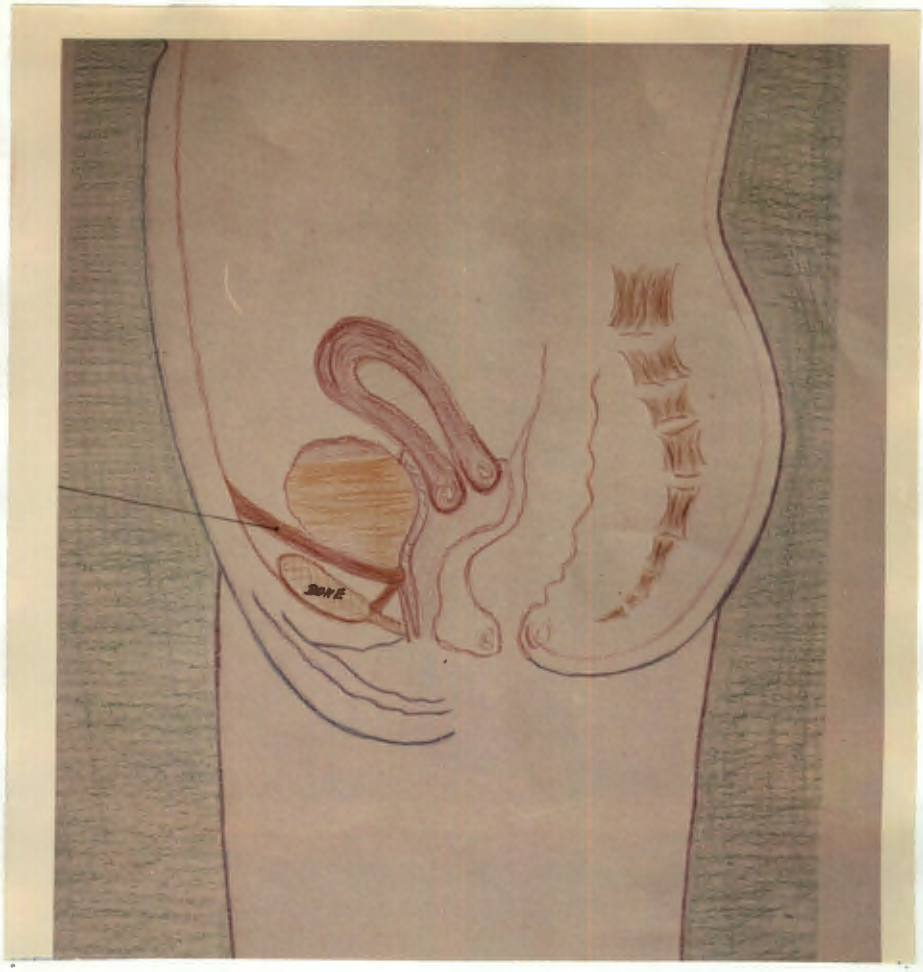


Fig. 28. Diagram showing route of aponeurosis sling in standing position.

control oozing which causes haematomata to form in the layers of repaired tissue— thus preventing proper healing— and finally to keep out infection that may enter the vagina via a wick of blood-clot that will form in this cavity post-operatively. (This gauze is taken out after 24 to 36 hours). The abdominal incision is closed in an appropriate manner after gowns and gloves have been changed. The catheter stays in the bladder, connected to continuous drainage, for seven days so as to keep the bladder empty for this period. This naturally would be a sure way of introducing infection into the bladder. However, this will not happen if the following is carried out by either the surgeon himself or his assigned assistant:

1. The catheter is strapped with adhesive tape straight up in the mid-line over the mons veneris with just enough "slack" to prevent tension on the bladder-neck.

2. The bladder is irrigated daily with a sterile solution of 2% Boric acid in water. Through an Asepto syringe only

50 mls. are run in and sucked back at a time and discarded. This is done three - or four times. Now 20 mls. of a sterile solution of silver proteinate is run into the bladder and the catheter clamped off leaving the solution in for 1 hour. The catheter is then reconnected to continuous drainage.

3. No perineal pads are applied but the perineum, vulva and entroitus are sprayed with a suitable antiseptic and it is assured that the perineal hygiene is properly attended to.

On the first post-operative day the catheter is clamped off and the patient helped to walk 6 or 8 paces and put back to bed. In elderly or infirm patients, this activity is suitably delayed. The exercise is increased each day. On the 7th day the abdominal skin sutures are removed and the catheter is taken out. The patient now voids on demand and the voided urine

as well as the catheterised residual amount recorded. As soon as the residual quantity is less than 60 ml., this procedure may be discontinued and the patient allowed to void naturally only. This stage is reached in 24 to 36 hours later. In a few cases there may be delay for several days before the patient can empty her bladder. This should not cause concern as it is probably due to the bladder being lifted a little too high by the slings. The majority of cases can be discharged home on the 8th post-operative day. They are warned not to lift weights like their small children or grandchildren, and to avoid staircases for several months. Mode of travelling home is important too. A short distance may be done by car— lying on the back seat. Long distances may be undertaken by train or aeroplane after they had convalesced for a few days outside the hospital. They may increase their exertion by degrees at home and provided they are otherwise normal and healthy they may resume a normal life in two months time. This period will however, be influenced by any concurrent infirmity or disease.

TABLE V.

20 2-sling Operations for advanced stress incontinence.

Identity	Age yrs.	Para.	Unsuccessful Number of Previous Ops.	Date of Present Op.	Bladder Control up to 1963
162/S/56	41	3	0	1956	Normal
31/M/55	51	4	2	1955	Normal
101/J/56	45	2	0	1956	Normal
238/J/57	63	1	1	1957	Normal
223/A/57	37	2	0	1957	Normal
259/A/57	54	2	0	1957	Normal
254/A/57	46	3	0	1957	Normal
163/S/56	43	1	0	1956	Normal
249/J/57	36	4	1	1957	Normal
437/J/59	46	3	2	1959	Normal
475/D/59	29	3	0	1959	Normal
244/J/57	32	4	0	1957	Normal
229/M/57	46	2	1	1957	Normal
479/F/60	54	3	0	1960	Normal
532/O/60	47	3	0	1960	Normal
480/F/60	38	5	0	1960	Normal
574/N/61	35	3	0	1962	Normal
570/S/61	76	3	3	1961	Normal
605/M/62	27	2	2	1962	Normal
630/F/63	75	0	1	1963	Normal

CASE REPORTS.

A series of 20 cases, whose stress incontinence was so severe that their normal activities were curtailed to varying degrees, is listed in Table V.

Two patients, 480/F/60 and 475/D/59 have since their operations given birth by means of Caesarean section in 1961 and 1962 respectively. This procedure has had no effect on the restored normal function of their bladders.

Four representative cases are reported in somewhat greater detail.

Case Report No.244/J/57, Married, white, blonde, housewife, age 32 years, born in Shetland Islands. Grav. IV, Para. IV. Blood Gr. 4/O, Rh Positive. Complaint: Urgency of micturition, leakage of urine on coughing and sneezing, and pressure over womb. Duration about 8 years. States she occasionally had slight leakage of urine with stress since age of 25yrs. but the condition became severe after "difficult" birth of first child in 1949, eight years prior to

Fig. 29. Case No. 244/J/57. Photograph taken in 1962 of healed scar of curved incision for obtaining long aponeurosis strips for 2-sling operation for stress incontinence performed in 1957. Vertical scar allegedly made for appendicectomy when patient was 20 years old.

this consultation (in 1957). Had no operative procedure for her incontinence. Locally she presented large cystocele and rectocele with first degree descensus of uterus. Cystoscopic examination revealed nothing abnormal in bladder. Sphincteric strength was 4 m.m. Hg. On standing a cough produced leakage with 210 mls in bladder. She was operated on for stress incontinence in 1957, a full Fothergill procedure being included. Recovery was uneventful and bladder control is still normal six years later. Fig..29. shows the curved horizontal scar of the incision for the aponeurosis strips in this patient. The vertical scar was for an alleged appendicectomy at the age of 19 yrs.

Case Report No. 605/M/62. Married, white, brunette, secretary and housewife, age 27 years. Born in S. Africa. Grav. III, Para. II. Complaint: stress incontinence, complete incontinence of rectum and dyspareunia since birth of second child for three years prior to consultation in May 1962. States that repair of laceration of perineum at last confinement did not hold, and that two subsequent attempts at correction had failed. Examination revealed cystocele protruding into entroitus on coughing. Extensive scarring over unhealed perineal laceration into the rectum with part of anterior wall of rectum bulging out. Rectal sphincter lies like a crescent with one end at 2 o'clock and the other

Fig. 30. Case No. 605/M/62. Obstetrical Trauma. Cystocele, Rectocele, Ruptured rectal sphincter. Age 27 yrs. Para. II.

Fig. 31. Same case as in Fig. 30. Photograph of perineum 6 months after bladder neck suspension and rectal repair. Bladder and rectal control normal 1 year after operation.

at 8 o'clock. Figs. 30 & 31 The patient's bladder is incontinent on coughing when standing with only 230 mls. in bladder. Residual urine: 120 mls. The sphincterometer records only 3 m.m. Hg. for the bladder sphincter. There is no sphincteric action in the rectum at all. Blood report: Gr. 3/B Rh Negative. Hgb. 11.6 gms. Col. index 0.83. Rbcs 4.8 mill. Leucs. 6.4 thousand Polys 56%, Large Monos. 6%, Lymphs. 35% Eos. 3%, Basophils 0%. Red cells microcytic & hypochromic. There is an iron deficiency anaemia. Urine report: moderate numbers of epithelial cells. No rbcs, white cells, casts or crystals seen. Culture: Scanty growth of B.colli. Sensitive to:Mandelamine ++, Chloromycetin ++, Kanamycin +. The patient was first treated for the anaemia and cystitis and was then subjected to the bladder operation elsewhere described. The perineum and rectum were repaired by first removing all the scar tissue and then identifying the various layers of muscle and fascia of the perineum and approximating these with interrupted 00 chromic sutures and likewise denuding the torn rectal edges and repairing the tear with interrupted 000 black silk. The ends of the rectal sphincter were identified and approximated with a single suture and its fascial capsule repaired with figure of eight 000 chromic catgut sutures. This patient, apart from the bladder attention elsewhere

Fig. 32. Case No. 570/S/61. Age 75 yrs. Complete prolapse after 2 vaginal operations for stress incontinence.

Fig.33. Same as case in Fig.32.
Shows stage at which strips can be brought down in Le Fort operation, but with uterus first reposited into pelvis.

described as post-operative procedures, was not ambulated until the 5th post-operative day. No pads were allowed on the perineum which was sprayed with a suitable antiseptic three times a day. She was discharged home on the 9th post-operative day with normal function of bladder and rectum— which condition still obtained ten months later at the present time.

Case Report No. 570/S/61. Married, white, blonde housewife born in S. Africa, 75 years old, Grav. IV. Para. IV. Blood Gr. 2/A, Rh positive.
Complaint: Obstruction of bladder when uterus has slipped out and stress incontinence when it is back in the pelvis. States that 12 yrs. prior to this consultation in 1961 she had a vaginal operation for stress incontinence and "pressure on the bladder". She had relief for some months but the symptoms came back. Six years later she had another operation but was then actually worse as far as the stress incontinence was concerned. She was then told to do "exercises" for relief. Three months before her present visit her womb slipped out completely and her doctors now showed her how to reposit it. This she has to do when she wants to void because there is complete obstruction when the procidentia is present. She is now in distress and feels desperate as the uterus slips out in a few hours time if she is ambulant after a reposition. On

Fig. 34. Same as in Fig. 32.
Condition 2 years after composite operation on bladder with Le Fort for prolapse. Bladder control normal.

examination she was found to present a procidentia with the cervix somewhat ulcerated. Fig. .32. Cystoscopic examination was negative and urine culture sterile. Diagnostic curettage and biopsy of cervix were negative. The cervix was allowed to heal and she was then given the bladder repair and the reposition of the uterus maintained by means of a Le Fort operation. Fig. 33. shows the stage of the operation when the aponeurotic strips may be brought down from the abdomen. Two years later she is free from any descensus and has normal urinary control, and prolapse has not recurred. Fig. 34.

Case report No. 31/M/55. Married, white, blonde housewife, born in Belgium, 51 years old, Grav. IV. Para. IV, all described as long and difficult labours. Consulted in 1955, complaining of stress incontinence that started in 1945. Two years later she had a vaginal operation that brought no relief. After a further two years she had a second vaginal operation. This did not bring improvement either and the incontinence became progressively worse— confining her to her home. Examination revealed marked cystocele and rectocele with much scarring, consistent with that of previous operations. Uterus had fibromyomata but these caused no symptoms. Her bladder was repaired in 1955 and the sphincter area in addition dealt with in the Kennedy manner. Figs. .20. and .21. show the position of the bladder before and 5 months after the operation respectively. The bladder is still functioning normally 8 years later.

SCHEME FOR

INCONTINENCE INVESTIGATION.

No. .....

Date .....

Name .....

Age ..... M.S.W.D. Grav. ..... Para. .....

Address ..... Country of Birth .....

Occupation ..... Race .....

Duration of incontinence ..... Age at onset .....

Any change in natureof it, e.g. remissions, worsening ....

.....

Any history of urgency with inability to void .....

.....

Nocturnal enuresis until what age ..... Any treatment ....

Any injuries ..... Accidents .....

Vesico-vag. fistula .....

Nature and time of any previous operations .....

.....

Neurological:

Mental state ..... Well adjusted ..... Neurotic .....

Any signs of Spina Bifida ..... Paralysis of limbs .....

Any abnormalities in legs ..... in pelvis .....

Local:

Knee jerks ..... Plantar .....

Pin exam. over urethral nerve supply .....

.....

.....

Perineal reflexes ..... Perineal sensitivity .....

History of injury to head or spine .....

Conjugal life normal .....

Obstetrical:

Year	Age of patient	Weight, sex of baby	Nature of labour	Type of delivery	Signs of episiotomy lacerations	Operation
.....						
.....						
.....						
.....						
.....						

Additional information .....

.....

.....

Degree of incontinence :.

Nature of leakage during the following:

Sneezing ..... Sitting down ..... recumbence .....

Coughing ..... Standing up ..... Ascending stairs ...

Laughing ..... Vomiting ..... Bending .....

Descending stairs ..... Shock movement .....

Passing flatus ..... Lifting heavy articles .....

On laughing does leakage tend to continue until bladder feels empty .....

.....

Continuous leakage all the time .....

.....

Nature of urination:

Frequency: 1. Dirurnally every ... hrs. 2. Noct. every ...

Amount every time, day ..... night .....

Stream: Calibre ..... Force ..... Dribbling .....

Normal continuous ..... Intermittent with dribbling...

Dysuria: ..... Degree of severity .....

When during urination .....

Urgency ..... Its nature .....

Urgency incontinence .....

Urgency with inability to void .....

Sense of relief or urgency after urination .....

Terminal dribbling .....

Posture assumed to effect voiding .....

Any pain and its nature in pelvis, abdomen or back with or without urination .....

.....

Physical examination:

Height ..... Weight ..... Blonde .... Brunette .....

.....

.....

.....

.....

.....

Any abdominal or Pelvic Tumours .....

B.P. ..... Rh ..... Group .....

Capacity of bladder when urgency present .....

Residual urine .....

Bacteriological report on urine .....

.....

Chemical report on urine .....

.....

Cystoscopy .....

.....

Urethroscopy . .....

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Cystometry .....

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X-ray findings .....

.....

Any other data .....

.....

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Treatment advised .....

.....

CONCLUSION.

The congenital and neurogenic varieties of stress incontinence cannot be prevented, but the majority can be cured with suitable procedures. Where there is neurosis the removal of tensions may at least bring improvement.

In cases of trauma due to childbirth the degree of obstetrical skill in the full sense of the word can aid to reduce the incidence.

In regard to the post-operative occurrence of stress incontinence the prevention lies in the hands of the surgeon. Choosing the correct operation for the correct diagnosis is mandatory while the post-operative care has to be meticulous. An operation technically well performed can have its effect neutralised even by a bladder neglected to distension once only.

With the present day safety of Caesarean section

women of child-bearing age may have a suitable sling-type of operation and then avoid vaginal delivery in subsequent pregnancies.

There is not a particular operation that will cure all forms of stress incontinence but there is a particular procedure that is the most suitable for each particular form of the malady and the decision about this is as important as the operation itself. In the last analysis the successful treatment of stress incontinence seems to require a certain amount of skill, knowledge, imagination, and also some boldness, but all rooted in the great ethic of responsibility.

The treatment of stress incontinence is one of reconstruction and not of extirpation and is therefore not easy. It may draw on the full pattern of a surgeon's complex mentality. Although it is claimed for the 2-sling operation that it would cure any case of stress incontinence, in mild forms of the condition a lesser procedure may be adequate. When

it is carried out on women who may still have children it is essential that they have any subsequent deliveries by Caesarean section.

SUMMARY.

A short historical survey is given of the approach to the problem of stress incontinence.

The embryonic development of the urogenital organs of the human female is briefly described.

The anatomical relationships of the muscular elements in the perineum and around the bladder neck and urethra as far as they affect the normal position and function of the bladder have been described.

Some volumetric and manometric research on the function of the bladder and its sphincter have been carried out. A method is mentioned for the cure of chronic frequency by means of graded distension of the bladder.

A number of radiological findings are given of the normal bladder and of some bladders that are incontinent under intra-abdominal stress.

A short series of case reports are given.

An operation that has proved to be remarkably successful in the treatment of stress incontinence is presented.

A scheme for the investigation of incontinence in the human female is offered.

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