Applied Anatomy
For
Obstetrics and Gynecology

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Preface

Anatomy is a fascinating subject. But so are Gynecology and Obstetrics. Like everybody else, I started with Anatomy as a graduate student. I wanted to do a career in Anatomy then. But when I started clinical subjects, I knew I wanted to spend a lifetime as a Gynecologist and Obstetrician. But I did not forget my first passion. I also remembered that Anatomy formed the basis of all surgical and many medical subjects. My knowledge of Anatomy made understanding Gynecological and obstetric conditions fun, and application of surgical procedures scientific. In a way, Gynecology and Obstetrics made my understanding of relevant Anatomy deeper and more clinically oriented. I am aware that there are a host of books on clinical Anatomy, some of them quite popular. However they devote much more space to subjects other than Gynecology and Obstetrics. They are also written by Anatomists who do understand clinical implications, but perhaps not in such depth as a Gynecologist and Obstetrician. As a clinician and a medical teacher, I always enjoyed teaching the underlying principles of Anatomy to my students, and I sincerely hope they enjoyed learning those too. I have drawn all the illustrations in this book as I draw them while teaching my students. They probably lack what a professional artist would have put into them. But they serve the purpose of driving the point home, and that is what I want more than anything else. If not, at least it should have enriched their experience of learning. I felt that I had learned all these fine points while treating my patients, and it was obligatory that I put these things down as a gesture to repay for the efforts of all great people whose work was the basis on which I based my learning. After all, it is a give and take. One takes what others before one have contributed to science, and then one gives back something that will perhaps help others learn better. This book is the result of this thought process. I hope it achieves what I want it to - making learning Gynecology and Obstetrics fun and enriching at the same time.

Shashank V. Parulekar
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1. Uterus

The uterus is a thick-walled, fibromuscular organ situated in the pelvis between the urinary bladder and uterovesical space in front and the rectum and recto-uterine pouch behind. It is mobile in the sagittal plane around a transverse axis passing through the cardinal ligaments (see later) such that when its upper part moves forwards, the lower part moves backwards. The uterus is made of two parts: the body of the uterus (corpus) which forms the upper two-thirds and the cervix which forms the lower one-third. The cervix is made of two parts: supravaginal (lies above the attachment of the vagina) and vaginal (portio vaginalis – lies in the vaginal cavity). The junction of the supravaginal cervix and portio vaginalis is firmly fixed to the vagina while the corpus is free to move, the fundus being free from any attachment at its upper end.

One fallopian tube joins the uterus at each of its angle (cornu) superolaterally – one on the right and the other on the left. The top of the corpus is called the fundus, which is the part that lies above the level of the entry of the fallopian tubes into the corpus at the cornua. The size of the uterus is 7.5x5x2.5 cm. The ratio of the corpus to cervix is 1:1 in infant and up to the age of 7 years and after menopause. It is 2:1 in the reproductive age. The fundus is convex upwards. The corpus is pear-shaped. Its lateral margins are convex. The uterine wall is covered by serosa or peritoneum which
is firmly adherent to the middle coat made of smooth muscle and fibrous tissue, except in the anterior lower part. This peritoneum continues laterally to become the broad ligament. Anteriorly it continues into the uterovesical fold, and posteriorly into the peritoneum covering the back of the upper vagina. The uterovesical fold lies flat over the lower part of the anterior surface of the uterus when the urinary bladder is empty. It gets lifted up off the uterus when the bladder fills.

Figure 1.2. Pelvic organs in the sagittal plane.

This surface of the uterus lies extraperitoneally. It becomes quite large during pregnancy (called lower segment), and it is the part used to make an incision in, to deliver the baby by a cesarean operation. The uterovesical fold of peritoneum is easily identified during a cesarean operation as it is loosely attached to the uterus and can be lifted up with forceps easily. It is cut transversely and the bladder is dissected down to expose the lower segment. A transverse incision is made into this part to deliver the baby. When the incision is sutured and the uterovesical fold of peritoneum is sutured, the resultant scar on the uterus lies extraperitoneally. This prevents development of adhesions between the uterus and bowel and/or omentum. It also prevents escape of purulent uterine contents into the general peritoneal cavity if puerperal sepsis develops.
The mucosa of the uterus is called endometrium. It is composed of columnar epithelium containing glands and a stroma. The endometrium is anchored to the underlying myometrium with fibrous strands which lie perpendicular to the myometrium.

During a procedure of removal of the endometrium by curettage, the superficial two-thirds of the endometrium gets removed by the edge of curette, and the end point is indicated by a grating sensation, which is caused by the scraping of the edge of the curette against the ends of the perpendicular fibrous strands which anchor the basal endometrium to the underlying myometrium.

The uterine cavity is somewhat triangular, flattened anteroposteriorly, the anterior and posterior walls being almost in contact. Its base is at the fundus. The length of the uterocervical canal is 6.25 cm. It is increased or decreased in certain conditions.

A knowledge of the length is essential to prevent uterine perforation (during intrauterine procedures like sounding of the uterine cavity, rapid cervical dilatation and endometrial curettage) so as to prevent uterine perforation. It is also essential to decide how much of the cervix needs to be amputated during Fothergill's operation for uterovaginal prolapse.

The cavity of the corpus continues into that of the cervix at a circular opening called as the internal os. The peritoneum on the anterior surface of the uterus ceases to be firmly attached to it at the level of the internal os. Uterine vessels enter the uterus at this level.

This serves as an identification point of the level of entry of the uterine vessels into the uterus during a vaginal or abdominal hysterectomy.

The cervix has two parts – portio vaginalis or vaginal portion and supravaginal part. The cervix is 2.5 cm in length. It is narrower than the corpus and cylindrical. The lower end of the cervical canal is called the external os. It is circular in a nulliparous woman, and a transverse slit in a parous woman who had delivered vaginally. The
slit like appearance is due to small tears at 3 and 9 o'clock positions, which occur during childbirth. The slit divides the portio vaginalis into anterior and posterior lips. The cervical canal is narrow at both the internal and external os.

The upper third of the cervix is called as the isthmus. It is a narrow part, measuring 1.5 mm in width. It is lined by epithelium that responds partially to sex steroids. Thus histological changes with the effect of sex steroids in this area lag behind those in the endometrium. Hence a biopsy should not be obtained from this part during curettage when the aim is to evaluate endometrial response to endogenous sex steroids. The isthmus is the part which offers resistance to dilatation, along with the circular fibers of the internal os.

This part is dilated during rapid dilatation of the cervix for varied indications. Since this part lies in the upper portion of the lower one-third of the uterocervical canal, a cervical dilator should not be passed beyond the internal os. Excessive passage of the dilator into the uterine cavity is associated with the risk of uterine perforation.

The width of the internal os is measured ultrasonographically during pregnancy. If it is more than 2.5 mm, the woman is likely to have an incompetent os.

The long axis of the uterus is angled forwards (90°) over the long axis of the vagina in 85% cases. Such a uterus is said to be anteverted. It is angled backwards (90°) in 15% cases. Such a uterus is said to be retroverted. When the position of the uterus is midway between ante- and retroversion, it is said to be midposed. All of these positions are physiological.
This must be kept in mind in view of the fact that a large number of ventral suspensions were performed in the past to correct a retroversion, which was believed to cause backache, infertility, abortions and uterine prolapse. When surgery was not possible, the uterus was kept anteverted with the use of a Hodge or Smith pessary. Both operative and pessary correction of a mobile retroversion of the uterus have fallen into disrepute. A knowledge of ante- and retroversion of the uterus is essential for safe passage of instruments into the uterine cavity during intrauterine procedures. This angle gets obliterated as the first step in the development of uterine prolapse, such that the uterus and the vagina come to lie in the same longitudinal axis.

The long axis of the uterus and cervix make an obtuse angle ($170^\circ$) with each other. When the angle is directed anteriorly, it is called anteflexion, and when it is directed posteriorly, it is called retroflexion. Usually an anteflexed uterus is anteverted and a retroflexed uterus is retroverted.
The angle of uterine flexion has to be removed while performing intrauterine procedures like sounding, dilatation and curettage because the instruments are straight and would go through the wall of the corpus if the angle is maintained. Making firm traction on the cervix held on its anterior lip with a vulsellum straightens the uterocervical canal and prevents perforation of the corpus by the rigid and straight instruments.

Figure 1.5. Uterine perforation during dilatation and curettage. A. perforation of the posterior wall with anteflexion of the uterus; B. perforation of the anterior wall with retroflexion of the uterus.
Sometimes the uterocervical canal does not get straightened adequately by making traction on the cervix and trying to force a dilator starts to avulse the anterior lip of the cervix by the instrument holding it. In such cases simultaneous traction on both the anterior and posterior lips of the cervix straightens the canal and dilatation can be done satisfactorily and safely.

Figure 1.6. Traction on both lips of the cervix: A. traction (red arrow) on the anterior lip of the cervix; B. traction (red arrows) on both lips of the cervix. Blue arrows indicate passage of intrauterine instrument.

In a few cases, the ante- or retroflexion is acute, so that the uterus looks like 'C' in sagittal plane. In such cases the corpus and cervix are both directed anteriorly when the uterus is anteflexed and both are directed posteriorly when the uterus is retroflexed.
The uterus tends to get perforated in posterior wall of the corpus when there is acute anteflexion and in the anterior wall when there is extreme retroflexion. Extreme traction needs to be made on the cervix in a downward direction to straighten the uterocervical canal while performing intrauterine procedures to avoid such perforations. Even then the passage of the long instruments is not easy. A special maneuver is required to go beyond the internal os. When the tip of the instrument reaches the internal os, it meets resistance to further passage. In case of acute anteflexion, the handle of the instrument needs to be depressed until its long axis comes to lie in the long axis of the corpus. Then the instrument can be passed into the corpus safely. In case of acute retroflexion, the handle of the instrument needs to be elevated until its long axis comes to lie in the long axis of the corpus. Then the instrument can be passed into the corpus safely.
Figure 1.8. Method of negotiating the internal os in a cochleate uterus: A. Cochleate uterus without traction on the cervix; B. Traction on the anterior lip of the cervix (green arrow) does not straighten the uterocervical canal sufficiently and passage of the intrauterine instrument (pink) gets obstructed; C. moving the stem of the instrument backward (violet arrow) until it comes to lie in the axis of the upper uterus permits safe passage into the upper uterine cavity (blue arrow) without perforating the uterus.

The round and ovarian ligaments are antero- and posteroinferior, respectively, to each cornu.

The smooth muscle layer of the uterine wall is called the myometrium. It contains smooth muscle, loose connective tissue, blood vessels, lymphatic vessels and nerves. It is thin near the fallopian tubal orifices and thick in the corpus and fundus. The body of the uterus has four muscular layers.

1. The subendometrial layer: longitudinal and some oblique smooth muscle fibers. It forms a circular coat where the lumen of the fallopian tube passes through the myometrium.
2. The vascular layer: external to the subendometrial layer. It has a large number of blood vessels and longitudinal muscle.
4. Subserosal layer: thin, longitudinal muscle layer adjacent to the serosa.

The oblique or criss-cross fibers of the myometrium constrict the blood vessels passing to the placental site after childbirth, and control postpartum bleeding from the placental site.
A failure of the myometrium to contract and retract after delivery of the placenta and membranes results in atonic postpartum hemorrhage because these blood vessels remain open. In such cases myometrial contraction is achieved by administration of uterotonic agents like oxytocin, prostaglandin F2alpha, methyl ergometrine, or misoprostol, aided by bimanual compression and elevation of the uterus.

The muscle fibers of the outer two layers continue into the fallopian tubes, some pass into the round, utero-ovarian ligaments and uterosacral ligaments.

Cesarean operation was done in the early days by making a vertical incision in the uterine corpus in the midline. This upper segment operation has a number of disadvantages. The abdominal wall incision has to be a vertical one, and it has to extend to above the umbilicus. The uterine wall is quite thick in the upper segment and suturing the incision is more difficult in the upper segment than in the lower segment. The muscle fibers of the corpus are circular, vertical and oblique. The latter two get cut across by the incision and they heal by fibrous tissue uniting smooth muscle fibers. Healing is also impaired by contractions of the muscle pulling the edges apart. Such a union is weaker than that in lower segment incision, where the fibers are of fibrous tissue, which are circular and are separated rather than cut across by the incision. They heal by fibrous tissue joining fibrous tissue and the union is stronger. The placenta is usually in the upper segment, and hence occurrence of placental venous sinuses being under the incision is high. Presence of venous sinuses in the sutured muscle impairs healing, making the scar weaker. The upper segment muscle cells contract and relax after the operation. Thus the suture line is constantly stressed by forces trying to pull the edges apart, unlike in the lower segment which is mainly fibrous and is at rest. This contributes to the poorer healing of the upper segment scar. The suture line is
entirely intraperitoneal and pus from the uterine cavity can escape into the peritoneal cavity should puerperal sepsis develop, with serious consequences. The scar being exposed to the peritoneal cavity, there is a high risk of development of adhesions between the scar and bowel and/or omentum. Upper segment scar tends to rupture in future pregnancies in 4% cases as compared to 0.4% with a lower segment operation. Its rupture also tends to be before the patient goes in labor, while the lower segment rupture occurs during labor. Rupture of an upper segment scar is often catastrophic, as the torn myometrium bleeds heavily, especially if the placenta is implanted under the scar. Lower segment ruptures are silent, painless, and not accompanied by any bleeding (dehiscence of a fibrous avascular scar). Hence upper segment cesarean operation is rarely done in modern obstetrics.

The cervical wall has 90% dense fibrous connective tissue and 10% of smooth muscle. The fibrous tissue is arranged in inner longitudinal bundles, mainly in the anterior and posterior walls. It is surrounded by circular fibers.

If the circular fibers get torn due to childbirth trauma, the longitudinal fibers do not remain longitudinal. Their upper ends are fixed, while lower ends curl up, so that the cervical canal gets everted at the lower end, exposing endocervical epithelium. This condition is called ectropion. Its treatment is repair by reconstruction of the portio vaginalis by an operation called trachelorrhaphy. Tear of the circular fibers at the level of the internal os or preponderance of smooth muscle over fibrous tissue in the cervix can result in cervical incompetence. Such patients tend to have recurrent second trimester spontaneous abortions or early preterm deliveries characterized by painless dilatation and effacement of the cervix. The treatment is to strengthen the internal os area by a circular suture around it in the second trimester of pregnancy by an operation called cervical cerclage.
Cervical smooth muscle is mainly at the periphery. It connects to the myometrium at upper end and the muscle of the vaginal wall at the lower end.

The peripheral layer of smooth muscle and the fascia lying over it can be dissected off the fibrous part of the cervix both anteriorly and posteriorly. Clamps can then be applied to the cardinal and uterosacral ligaments during a hysterectomy in a technique called as intrafascial hysterectomy, which is done for nonmalignant conditions. Since the urinary bladder and the ureters lie outside the cuff, they are protected from inadvertent injury. The cuff is closed over the sutured vaginal vault and also fixed to it by passing the sutures through the vault. This gives additional support to the vault and helps prevent posthysterectomy vault prolapse.

The cervix contains elastic tissue. It is essential for stretching of the cervix without tearing during childbirth. It also helps the cervix to get dilated without tearing during rapid cervical dilatation surgically.

It explains why the cervix has to be dilated with graduated dilators serially. The dilators are of increasing sizes like 3/6, 4/7, 5/8 etc, the numerator indicating the size of the dilator at the tip and the denominator the size at the widest dilating portion of the dilator. After a dilator of size 3/6 is passed into the cervix and withdrawn, the cervix does not remain dilated to 6 mm, but recoils, so that a dilator of size 7/10 cannot be passed, but one of size 4/7 has to be passed. This produces gradual dilatation without tearing of tissues. The cervix goes back to original size after the procedure due to elastic tissue recoil.

The uterine mucosa is called as the endometrium. It has a columnar epithelium with glands and stroma. The superficial portion of this layer undergoes cyclic change with the menstrual cycle. Spasm of hormonally sensitive spiral arterioles that lie within the endometrium causes shedding of this layer after each cycle, but a
The deeper basal layer of the endometrium remains to regenerate a new lining. Separate arteries supply the basal endometrium, explaining its preservation at the time of menses.

The cervical canal (endocervix) is lined by columnar epithelium with mucous secreting glands which are directed upwards and outwards. The epithelium is thrown into a series of V-shaped folds which give it the appearance of the leaves of a palm. Hence these folds are called as plicae palmatae. The mucus secretion is hormone dependent, being abundant, watery and alkaline just before and during ovulation under the effect of endogenous estrogen and scanty, thick and tenacious after ovulation under the effect of endogenous progesterone. The former is permeable to sperm, while the latter is not. This is the natural mechanism of promoting conception. Sperm escape from seminal plasma after ejaculation and while some of them travel up the cervical canal into the uterine cavity, others enter the cervical glands and remain there as reservoir, to come out and ascend into the uterine cavity periodically, so that fertilization can still take place if ovulation takes place long after sexual intercourse.

Cervical glands are lost with cervical amputation as in Fothergill's operation. This can result in infertility due to cervical factor. This can be managed by intrauterine insemination.

The surface epithelium of portio vaginalis is non-keratinizing stratified squamous, containing glycogen within the cells.

The glycogen gets depleted with cervical intraepithelial neoplasia, so that the epithelium does not stain mahogany brown with application of Schiller's or Gram's iodine, like normal epithelium does. This is the principle underlying Schiller's test used to decide the site of biopsy in a suspected case of cervical intraepithelial neoplasia. The biopsy is obtained from an unstained area.

The portio vaginalis is covered by columnar epithelium like the endocervical canal at the time of birth. It gets replaced by a non-keratinizing stratified squamous epithelium by a process of
squamous metaplasia. The area in which this occurs is called the transformation zone. This process is most active at birth, puberty and during pregnancy. As it progresses, the transformation zone moves towards the external os and is found up the endocervical canal after menopause. Presence of an oncogenic agent like human papilloma virus at the cervix during this process confers it a malignant potential so that invasive cancer may develop in it after a few years.

The cervical cancer develops in the transformation zone, and that is the site to obtain a biopsy from, not the old four quadrants.

Blood supply

The uterus is supplied by the uterine artery, which is a branch of the anterior division of the internal iliac artery. The uterine artery passes in the base of the broad ligament above the ureter at an angle of $90^\circ$ to reach the uterus at the level of the internal os. Then it branches at the uterocervical junction into an ascending branch which runs along the side of the uterus and anastomoses with the ovarian artery under the fallopian tube in the broad ligament, and a descending branch which supplies the cervix and anastomoses with vaginal artery to form the azygos arteries which descend on front and the back of the vagina.

Figure 1.9. Blood supply of the uterus: coronal plane view.
The cervical stump bleeds furiously if the cervix is cut across. Hence the descending cervical arteries are ligated at the level of the proposed site of cervical amputation in Fothergill's operation, by passing a suture through the lateral aspect of the cervix and tying it on the outer surface on each side.

Bleeding during surgical removal of uterine leiomyomas (myomectomy) can be prevented or reduced by injecting diluted vasopressin around the uterine vessels at the uterocervical junction and also under the cornu around the anastomosis of the uterine and ovarian vessels. This is useful during both open and laparoscopic myomectomies.

Branches of the uterine arteries enter the uterine wall, divide further and continue as anterior and posterior arcuate arteries. They anastomose with vessels of the opposite side.

Hence ligation of one uterine artery does not compromise blood supply of the uterus. Ligation of both uterine arteries also does not compromise uterine blood supply, due to anastomoses with ovarian vessels. Uni- or bilateral ligation of the uterine arteries is sometimes
required during a cesarean section, if a uterine artery is traumatized or if there is uncontrollable postpartum hemorrhage.

The terminal branches of uterine arteries (helicine arterioles) in the myometrium are tortuous. They are less prominent in the proliferative phase. They become longer, wider and more tortuous in the secretory phase. They form dense capillary plexuses in the myo- and endometrium.

Any injury to the surface of the corpus bleeds profusely, and is best avoided. Hemostatic sutures tend to cut through the myometrium and the bleeding may get aggravated. Pressure or electrocoagulation may be preferable to hemostatic sutures on the uterine surface.

The uterine veins accompany the uterine arteries and drain into the internal iliac veins. There are two or three uterine veins on each side. There is anastomosis between uterine, vaginal and ovarian venous plexuses.

Injury to uterine veins during surgery can result in serious bleeding. Venous bleeding is at low pressure and a Trendelenberg tilt helps control it by pressure and ligation.

**Lymphatic drainage**

Uterine lymphatics form a plexus in the subperitoneal part of the uterine wall. Cervical and corpus lymphatics drain first into the parametrial nodes, and thence into the obturator, internal iliac, and external iliac nodes. Lymphatics from the fundus may drain into the para-aortic nodes. Secondary drainage occurs into the presacral, common iliac, and paraaortic lymph nodes.

Lymph node dissection is an essential part of radical hysterectomy for cervical and uterine invasive carcinomas. It can be done transperitoneally or extraperitoneally during an open surgery or by
Nerve supply

The inferior hypogastric plexus supplies the uterus. Branches ascending with uterine vessels supply the corpus. They communicate with the ovarian plexus. The nerves to the cervix form the Frankenhaeuser plexus which contains the paracervical ganglia. The Frankenhaeuser plexus is a terminal part of the presacral plexus. Efferent preganglionic sympathetic fibers from the last thoracic and first lumbar spinal segments synapse on their postganglionic neurones in the superior and/or inferior hypogastric plexuses. They cause uterine contraction and vasoconstriction. Preganglionic parasympathetic fibers from the S2-4 spinal segments relay in the paracervical ganglia and the Frankenhaeuser plexus. They cause vasodilatation and uterine inhibition. Visceral afferent fibers from the cervix and corpus pass through the Frankenhaeuser plexus.

Blocking this plexus by a paracervical block using a local anesthetic blocks the pain of rapid cervical dilatation, and most of the pain of endometrial curettage. But it cannot block the pain arising from the fundus, the afferents from where pass along the ovarian vessels. A parenteral analgesic is required to block it, so as to make the procedure of cervical dilatation and endometrial curettage totally painless. Local anesthetic injection for a paracervical block has to be injected to a depth of 2-3 mm under the vaginal mucosa of the lateral vaginal fornix, and not deeper than that, as the latter can cause injury to the uterine vessels and intravascular injection with serious consequences. Labor analgesia with a regional block like an epidural block needs to block T10 to L1 segments. If a cesarean section is required, the level needs to be increased up to T6.

Ligaments

There are six ligaments on each side.

1. Broad ligament: it is a fold of two layers of peritoneum, extending from the lateral aspect of the corpus to the
lateral pelvic wall, a free border above to below the level of the internal os. The anterior layer is continuous with the serosa of the anterior surface of the uterus above the internal os and with the uterovesical fold at the level of the internal os. The posterior layer is continuous with the serosa of the posterior surface of the uterus above and peritoneum on the posterior surface of the cervix and vagina below. The latter forms the anterior wall of the pouch of Douglas. The upper edge of the broad ligament is free. It contains the round ligament in front, fallopian tube in the middle and the utero-ovarian ligament behind. It contains the uterine vessels, ureter, connective tissue, and remains of the parovarium (organ of Rosenmüller) and the Gartner's duct. It does not support the uterus.

2. Round ligament: it is attached to the uterus just below and anterior to the fallopian tube. It passes outward, forward, and slightly upward to enter the inguinal canal through the internal inguinal ring. Then it passes through the inguinal canal and ends in the fibrofatty tissue of the labium majus. It is made of mainly fibrous tissue. Its blood supply is through a branch of the ovarian artery in the broad ligament and a branch of the inferior epigastric artery in the inguinal canal. It is not taut, which shows that it is not a true support of the uterus. Hence it cannot be used to suspend the uterus in case of prolapse, or to suspend the vault of vagina after a hysterectomy to prevent a posthysterectomy vault prolapse.

3. Utero-ovarian ligament: see under 'ovary'.
4. Cardinal ligament (transverse cervical, lateral cervical, or Mackenrodt's ligament): it lies in the base of the broad ligament. It is attached to the pericervical fibrous tissue ring around the supravaginal cervix and vaginal fornix at the medial end and the side wall of the pelvis laterally. It is made of thickened connective tissue. It is supplied by the uterosacral plexus of autonomic nerves. It is an important support of the uterus. It gives lateral stability to the cervix. It also serves as the source of blood supply to the uterus and the vagina. The distal ureter passes within the superior portion of the ligament under the uterine artery.
Care needs to be taken to avoid injury to the ureter while performing a hysterectomy. Once the cardinal-uterosacral ligament complex has been clamped, cut and ligated, it falls away from the uterus and so does the lower ureter. Then the risk of injury to it is considerably reduced.

5. Uterosacral ligament: its anterior end is attached to the pericervical fibrous tissue ring around the supravaginal cervix and vaginal fornix posterolaterally. It passes backwards to be attached to the rectum by its muscular part and the periosteum of the second, third and fourth sacral vertebrae by its fibrous part. Its upper surface is covered by peritoneum of the pelvic floor, while its lower surface is covered by vagina. It forms the lateral border of the pouch of Douglas. It is supplied by the uterosacral plexus of autonomic nerves. The two uterosacral ligaments hold the cervix behind the levator hiatus at the level of the ischial spines in the posterior pelvis, keep the uterus in anteflexed position and keep the vagina suspended over the levatores. It is an important support of the uterus. Smooth muscle accounts for 1/3 content of the ligament, which gives it its strength. Its smooth muscle content is reduced in pelvic organ prolapse due to smooth muscle apoptosis. Though this is clinically important, there is no method of preventing or treating this as yet.

Figure 1.11. Ligaments of the uterus.
6. Pubocervical ligaments: they consist of two firm bands of connective tissue attached to the posterior surface of the pubis medially and the white line laterally in front, and the anterior and lateral supravaginal cervix at the 1-o'clock and 11-o'clock positions behind. They pass on either side of the neck of the bladder. They serve mainly as a vascular conduit and their supporting role is minimal.

**Parametrium:** all the tissue that attaches the uterus to the pelvic wall.

**Paracolpium:** all the tissue that attaches the vagina to the pelvic wall.

**Supports of the uterus**

![Diagram of the uterus with its supports](image)

**Figure 1.12. Supports of the uterus.**

1. Levatores ani muscles: see later.
2. Ligaments: uterosacral and cardinal ligaments.
3. Vagina: the upper end of the vagina is attached to the uterine cervix. The lower end is firmly fixed to the bony outlet of the pelvis. Though the vagina is distensible, its length is fixed. Thus the vagina supports the uterus on its top.
4. Viscera: uterus, bladder and rectum are loosely attached to one another by loose areolar tissue, and support one another like people in a crowded train compartment.
2. Fallopian Tube

The fallopian tubes (uterine tubes) are attached to the cornua of the uterus, one on each side. The mucos of a fallopian tube is continuous with the endometrium. Its uterine opening is at the superolateral angle of the uterine cavity. The tube is made of five parts, from medial to lateral: intramural, isthmus, ampulla, infundibulum and fimbriae.

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<td>Total</td>
<td>11 cm</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.1. Fallopian tube.

The intramural part lies within the myometrium. The isthmus is rounded, muscular and firm. It has uniform diameter and highest wall to lumen ratio among all parts of the fallopian tube.
The isthmus is the part where a tubal ligation procedure is performed because the potential for reversal is best at this site. The reasons for that are that uniformity of lumen ensures that a proper end-to-end anastomosis can be performed and high wall thickness to lumen ratio ensures that sutures hold well. For these reasons, tubal reconstruction for midsegment block causing infertility has the best prognosis when it is in the isthmic area.

The ampulla has a thin wall and a folded luminal surface. Fertilization of an ovum takes place in this part. The infundibulum is trumpet-shaped. The fimbriae, which are finger like processes measuring 1 mm in width are attached to the lateral edge of the infundibulum. One of them (ovarian fimbria) is longer and is attached to the ovary. That facilitates pickup of the ovum by the tube, aided by swelling and engorgement of the fimbriae at the time of ovulation. The mucosa of the tube is single-layered, tall, columnar, ciliated epithelium with secretory cells. The ciliated cells predominate laterally and secretory cells medially. Ciliary motion propels the fertilized ovum into the uterine cavity.

Loss of ciliary function of the tube results in infertility due to tubal factor.

The middle layer contains smooth muscle arranged as an inner circular and an outer longitudinal layer. The tubal contractions help propel the sperm and the ovum. The external layer of the tube is a highly vascular serosa.

Tubal block at any part, if bilateral, also results in infertility. Conventional method of management of tubal blocks was tubal reconstruction (tuboplasty) as shown in the following table. It required that the length of tube after the operation be at least 4 cm, the fimbriae be present, the ciliary epithelium be present, and it should be the first attempt at tubal reconstruction. This has been largely superseded by in vitro fertilization and embryo transfer.
<table>
<thead>
<tr>
<th>Tubal segment with block</th>
<th>Operative procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intramural</td>
<td>Tubocornual anastomosis</td>
</tr>
<tr>
<td>Isthmus</td>
<td>Midsegment reconstruction</td>
</tr>
<tr>
<td>Ampulla</td>
<td>Midsegment reconstruction</td>
</tr>
<tr>
<td>Infundibulum</td>
<td>Midsegment reconstruction</td>
</tr>
<tr>
<td>Fimbria</td>
<td>Salpingostomy, fimbrioplasty</td>
</tr>
</tbody>
</table>

The anatomical position of the tube is usually hanging downward and backward, as in 'at ease' position of cadets, and not perpendicular to the long axis of the uterus as of arms stretched outward from the body. The ovary hangs next to the fimbrial end, and the lateral ends of the two tubes lie next to each other behind the uterus. Thus ovum can be picked up by the tube of the same side or opposite side with a 50:50 chance.

The blood supply to the medial two-thirds of the fallopian tube is derived from uterine artery and the lateral third from the ovarian artery, both of which run in the free fold of broad ligament raised by the tube and anastomose with each other. The venous drainage of the medial two-thirds of the fallopian tube is through the uterine plexus into the internal iliac vein, and that of lateral one-third through the pampiniform plexus to the ovarian veins. The right ovarian vein opens into the inferior vena cava and the left one into the left renal vein. The lymphatic drainage is through lymphatics along the ovarian vessels to the para-aortic nodes, the uterine vessels to the internal iliac nodes, and that from medial part along the round ligament into the inguinal nodes.

Nerve supply of the tube is by autonomic fibers along the ovarian and uterine arteries. Preganglionic parasympathetic fibers from the vagus supply the lateral half of the tube and those from pelvic splanchnic nerves supply the medial half of the tube. Preganglionic sympathetic fibers from the intermediolateral column of the T10-L2 spinal segments and postganglionic sympathetic fibers from the superior hypogastric plexus through the superior hypogastric and hypogastric nerves supply the tube. Modified Pacinian corpuscles are present in the ampullary submucosa.
Tubal implantation of a pregnancy is called tubal ectopic pregnancy. Since the thin wall of the tube and its relatively poor vascularity cannot support this pregnancy to term, the tube tends to rupture during the first trimester, This causes intraperitoneal hemorrhage, which can prove fatal unless treated in time. The rupture occurs earlier when the lumen is narrow (isthmus, intramural part) and later when the lumen is large (ampulla and infundibulum).
3. Vulva

The vulva includes the mons pubis, labia majora, labia minora, clitoris, vestibule, vestibular bulb and the greater vestibular glands.

Figure 3.1. Vulva.

Mons pubis

It is the area of skin and underlying adipose tissue lying over the pubic symphysis and adjacent part of the pubic bone. It is rounded and hair-bearing. It is hairless and relatively flat before puberty. It develops to adult type through adolescence and early adult life.

Labia majora

These are the lateral boundaries of the vulva. They are two prominent longitudinal folds of skin between the mons pubis in front and the perineum behind. External surface of each labium majus is pigmented and covered with hair. Its internal surface is pink, smooth and hairless. It has sebaceous follicles. The labium majus contains loose connective tissue, fat and some smooth muscle. The superficial fatty layer and deep membranous layer
(Colles’ fascia) under the skin are continuous with Camper’s fascia and Scarpa’s fascia of the anterior abdominal wall. The uterine round ligament ends in the fibrofatty tissue under the skin at the anterior part of the labium. The two labia join in front to form the anterior commissure. Their posterior ends merge into neighboring skin. The posterior commissure is the ridge between the posterior ends of the two labia majora.

**Labia minora**

They are two small folds of skin. They do not contain any fat. Each labium minus lies medial to the labium majus of the same side and lateral to the vaginal orifice. It bifurcates anteriorly. The lower layer passes below the clitoris and joins with that of the opposite side forming the frenulum of the clitoris. The upper layer passes above the clitoris and joins with that of the opposite side forming the hood or prepuce of the clitoris. Medial surface of the labium minus has numerous sebaceous follicles. The area joining the posterior ends of the labia minora is called as the fourchette.

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Adhesions of labia minora to each other may occur in a child due to hypoestrogenism and poor local hygiene. It was treated in the past by forceful separation of the labia under anesthesia. However local application of an estrogen cream over a few days results in their separation and surgery is not required.

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**Clitoris**

It is situated in the midline, between the anterior ends of the labia minora. It has a glans, a body and a root. The body has two corpora cavernosa which contain erectile tissue covered by dense fibrous tissue. An incomplete fibrous septum separates the two corpora cavernosa. A suspensory ligament formed from the fibrous tissue attaches the clitoris to the pubic symphysis. A crus extending from the root of the clitoris attaches each corpus cavernosum to the ischiopubic ramus of that side. The glans is a small round structure at the end of the body, containing spongy erectile tissue. Thin bands of erectile tissue connect it to the bulbs of the vestibule. The epithelium of the glans has high cutaneous sensitivity.
**Hymen**

The vaginal orifice is closed in a virgin by a thin fold of mucosa called the hymen. It has a perforation for outflow of menstrual blood. This perforation can be circular, semilunar, annular, fringed, septate or cribriform. The hymen tears during the first coitus. It can also be torn by sports like horse riding. The remains of the ruptured hymen are called as the carunadce hymenales. The hymen tears further during vaginal delivery, leaving behind a few tags called carunculae myrtiformes.

Imperforate hymen is a congenital malformation in which the hymen does not perforate. This is an outflow tract obstruction, which causes collection of menstrual blood behind the hymen, cryptomenorrhea, cyclical lower abdominal pain and sometimes retention of urine due to elevation of the bladder neck by a vagina distended with blood (hematocolpos). Excision of the hymen (hymenectomy) cures this condition.

An intact hymen at the time of marriage is considered important in some cultures. Surgical reconstruction of the hymen (hymenoplasty) may be requested prior to marriage by girls who have torn hymens.

**Vestibule**

It is also called as the fossa naviculares. It is the space between the labia minora on the sides, the clitoris anteriorly and the fourchette posteriorly. It has the openings of urethra and vagina in the midline (from before backwards). An opening of the duct of the greater vestibular gland (Bartholin’s gland) is present posterolaterally, at 5 and 7 o'clock positions. Ducts of numerous mucous, lesser vestibular glands are also found in the vestibule.

**Vestibular bulb**

It lies on each side of the vestibule, uniting with bulb of the opposite side anterior to the vestibule. Two slender bands of erectile tissue join the anterior ends to the clitoris. It contains erectile tissue. It is an elongated mass of erectile tissue, 3 cm long, which flanks the vaginal orifice and unites anterior to it with the bulb of the
opposite side, by a narrow commissura bulborum (pars intermedia). Its posterior ends is expanded, is in contact with the greater vestibular gland and is covered posteriorly by bulbospongiosus.

**Bartholin’s glands**

There is one gland on each side of the vaginal orifice, superficial to the superficial perineal pouch. It is 1 cm in diameter, oval or round, reddish-yellow in color. It contains columnar secretory cells which secrete a clear or whitish mucus. The gland is in contact with the vestibular bulb in front of it. The ducts of the glands are 2 cm long. They open into the vestibule in the groove between the hymen and the labium minus at 5 and 7 o’clock positions.

The duct of the Bartholin's gland may get obstructed due to trauma or infection. Then the secretions of the gland collect in the duct and distend it to produce a cyst called Bartholin's cyst. It is a swelling in the posterior part of the labium majus, stretching the posterior part of the labium minus of the same side over it. It forms an abscess if the contents get infected. The treatment of both Bartholin's cyst and Bartholin's abscess is marsupialization, where a window is made on its medial mucosal aspect to drain the contents and keep draining them subsequently. Thus the function of the glands is preserved, while it is not with the older treatment of surgical excision of the cyst. Just incision and drainage of the abscess is not adequate as the opening closes and the abscess recurs.

**Blood supply**

Arterial supply to the vulva on each side is by the superficial and deep external pudendal branches of the femoral artery superiorly and the internal pudendal artery inferiorly. Its venous drainage is through external pudendal veins which drain into the long saphenous vein. Clitoral venous drainage is through deep dorsal veins draining into the internal pudendal vein, and superficial dorsal veins into the external pudendal and long saphenous veins.

**Lymphatic drainage**
Lymphatic drainage of the vulva is through three or four collecting trunks formed from a meshwork of lymphatics of the vulva, which drain into the superficial inguinal nodes lying on the cribriform fascia over the femoral vessels. They drain into the deep inguinal nodes lying medial to the femoral vein. These nodes drain into the pelvic nodes through the femoral canal. Cloquet’s node lies in the femoral canal. Clitoral lymphatics drain directly to the deep inguinal nodes and the internal iliac nodes. Lymphatics from the lower part of the labia majora and the perineum drain into the rectal lymphatic plexus.

Cloquet’s node is considered as a sentinel node. If there are no lymphatic metastases of vulvar carcinoma into this node, deeper nodes are considered to be free of metastases. In that case lymph node dissection may not be done along with radical vulvectomy.

Nerve supply

Figure 3.2. Nerve supply of the vulva.

The pudendal nerve (S2-4) supplies most of the vulva through its inferior rectal and perineal branches and the dorsal nerve of the clitoris. The posterior two-third part of the labium majus is supplied by the pudendal nerve through the posterior labial branches of the perineal nerve (S3), the anterior one-third part by the ilioinguinal nerve (L1), and the lateral aspect by the perineal branch of the posterior cutaneous nerve of the thigh (S2).
Absolute alcohol is injected into the subcutaneous tissue of the vulva for controlling pruritus vulvae in patients with recurrent or chronic dermatitis, in whom local therapy has proved unsuccessful.

Mering procedure is done for controlling vulvar pruritus and dysesthia resistant to medical treatment. The branches of the ilioinguinal and genitofemoral nerve in the adjacent tissue are severed with a finger passed through an incision made through the outer aspect of the labium majus, extending from the clitoris to slightly beyond the fourchette. It is extended further posteriorly to the level of the anus if the disease extends up to there. The depth of the incision is up to the fascia of the urogenital diaphragm.
4. Vagina

The vagina is a tubular structure continuous with the uterine cervix at the upper end and opening to outside in the vestibule. The lower end is partially closed by the hymen. Its upper part near its attachment to the cervix is called the fornix. For convenience of description, the fornix is divided into anterior, posterior, right lateral and left lateral parts. The anatomical position of the vagina is upwards and backwards from the vestibule, making an angle of 60–70° with the horizontal. The vaginal axis is directed posteriorly just above the center of the fourth sacral vertebra, which is also the area of the origin of the uterosacral ligaments. The length of the posterior vaginal wall is 11 cm, and that of the anterior wall is 9 cm. Its anterior and posterior walls are in contact with each other. The anterior vaginal wall is related to the urinary bladder in its upper 2/3 and the urethra in its lower 1/3. The posterior vaginal wall is related to the pouch of Douglas in its upper 1/3, rectum in the middle 1/3 and the perineal body in the lower 1/3. The uterosacral ligaments are attached to the posterolateral aspect of the fornix. The cardinal ligaments are attached to its lateral aspect at the same level. The levatores ani support the middle of its lateral walls through fascial attachment. The lower part of the lateral walls are related to the bulbospongiosus muscle. The ureters pass close to the lateral fornices, above the surface of the uterosacral ligaments. The vagina has fibrous tissue and smooth muscle. The muscular layer has an outer longitudinal and an inner circular layer. The former is continuous with the superficial muscle fibers of the uterus. The vagina is capable of stretching greatly, as during childbirth. Its mucosa is stratified, squamous nonkeratinized epithelium. The epithelium has many rugae, which are found in larger number in the posterior wall and near the orifice. They increase during puberty and pregnancy, and decrease after the menopause.

The distal 1/3 of the vagina is almost vertical in the standing position. In the upper 2/3 part it angles 120° dorsally due to its attachment to the levator plate. The vagina will not move caudally through the genital hiatus in this position. If the connective tissue supports
fail, the genital hiatus will not remain closed and that predisposes to pelvic organ prolapse.

Remnants of the of Gartner's duct may be found near the lateral fornices or lateral parts of the vagina.

A Gartner's duct cyst may form. It will be symptomatic when large. Its treatment is excision or marsupialization. Care must be taken to avoid ureteric injury during its excision. Sometimes the ureter opens in it, and then a ureteric fistula forms if excision or marsupialization is done.

Pubovesicocervical fascia covers the vagina and connects it to the urinary bladder and the urethra. It also connects to the pericervical fascial ring to which the uterosacral-cardinal ligament complex is attached. This fascia is attached to the white line on the levator ani fascia laterally. Detachment of the fascia from the pericervical ring and the uterosacral-cardinal ligament complex due to childbirth trauma causes development of central transverse defect type of cystocele (prolapse of bladder wall into the vagina). Detachment of the fascia from the white line causes a lateral type of cystocele. The lateral defects can be uni- or bilateral. These defects can exist simultaneously. Site specific repair of cystocele (anterior colporrhaphy) is required to correct the defects.

A defect in fascial support of the upper 1/3 of the posterior vagina causes development of a hernia of the pouch of Douglas (enterocele). It can be repaired vaginally (as in a hernia repair) or abdominally by Moschcowitz's culdoplasty (occlusion of the pouch of Douglas by a series of purse-string sutures from the bottom to the top of the pouch) or Halban's operation, in which approximation of the anterior wall (front of the recum) and posterior wall (back of vagina) of the pouch of Douglas with a series of sutures is done. A defect in the fascia under the middle 1/3 of the posterior vagina causes a prolapse of the rectum into the vagina.
(rectocele). If it is due to detachment from the uterosacral ligaments, it causes a central transverse defect. If it is due to detachment from the fascia over the levator ani, it causes a lateral type of defect. Site specific repair (posterior colporrhaphy) corrects the defects. If the fascia has got detached from the perineal body, it needs to be resutured to it.

If previous colporrhaphy has failed, or if the vaginal prolapse is due to attenuation of fascia due to postmenopausal atrophy, a biological mesh or a synthetic mesh is interposed between the vagina and the urinary bladder or rectum in case of cystocele and rectocele respectively.

If the vault of the vagina is not supported from the uterosacral-cardinal ligaments after hysterectomy, a posthysterectomy vault prolapse may develop. It is managed by the abdominal approach using suspension from the sacrum (sacrocolpopexy) or the vaginal route (suspension from the sacrospinous ligament or uterosacral ligament.

The peritoneum of the floor of the pouch of Douglas and the vaginal epithelium of the posterior fornix lie next to each other without any fat in between. This permits an easy access to the pelvic peritoneal cavity through the posterior fornix for the following indications.

1. Colpopuncture: to collect fluid from the pouch of Douglas: if it is blood that does not clot, it is ruptured ectopic pregnancy; if it is pus, it is pelvic abscess or pelvic peritonitis.

**Blood supply**

The vagina is supplied by the azygos arteries of the vagina, which arise from the internal iliac arteries. They descend on the anterior
and posterior aspects of the vagina. Some blood supply may come from the uterine, internal pudendal and middle rectal branches of the internal iliac artery. Vaginal venous plexus drains into the vaginal veins, one on either side. They drain into the internal iliac veins.

Upper lymphatic vessels of the vagina pass along the uterine artery to the internal and external iliac nodes. Middle vessels of the vagina pass along the vaginal artery to the internal iliac nodes. Lower vessels of the vagina drain into the superficial inguinal nodes.

**Nerve supply**

The pudendal nerve (S2-4) supplies the lower vagina. The pelvic splanchnic nerves (S2, S3 and sometimes S4) supply the upper vagina.
5. Pelvic Floor

The pelvic floor is made of the pelvic diaphragm, the urogenital diaphragm and the ligamentous supports of the uterus. Levatores ani and ischiococcygeus muscles form the pelvic diaphragm.

Figure 5.1. Internal view of the pelvic floor.

Figure 5.2. Top view of the pelvic floor.
Levator ani

It is a broad muscle which forms a large part of the pelvic floor. It is made of four parts: pubococcygeus, iliococcygeus, puborectalis and ischiococcygeus.

**Pubococcygeus**: it originates from the back of the body of the pubis. It passes backward lateral to the urethra and its sphincter (without being attached to it), the middle third of the vagina (to which it is attached by pelvic fascia), rectum (sending some fibers to be attached to the perineal body and the anorectal junction) and forms a tendinous structure as a part of the levator raphe. Some of its fibers join the longitudinal rectal muscle and fascia in the conjoint longitudinal coat of the anal canal.

**Iliococcygeus**: it originates from the inner surface of the ischial spine and the tendinous arch up to the obturator canal. Most of its fibers join those from the muscle of the opposite side forming a raphae which is continuous with the anococygeal ligament. This raphae is a strong attachment of the pelvic floor posteriorly. The most posterior fibers of the muscle are attached to the tip of the sacrum and coccyx.

**Puborectalis**: it arises from the inner surface of the ischiopubic rami close to the perineal membrane. It passes lateral to the iliococcygeus and pubococcygeus and decussates posterior to the rectum at the junction of the anus and rectum. Its border partially blends with external anal sphincter.

**Ischiococcygeus**: it is the most posterosuperior part of levator ani. It is triangular, with its base attached to the lateral margins of the coccyx and the fifth sacral vertebra, and its apex attached to the pelvic surface and tip of the ischial spine. It is usually musculotendinous, but may be totally tendinous too. It lies over the pelvic aspect of the sacrospinous ligament and is sometimes fused with it.

The upper and lower surfaces of levatores ani are sheathed with pelvic fascia, which is continuous with fascia on pelvic organs. The gap between the two levatores ani is called the levator hiatus, through which pass the urethra, vagina and anus from before backwards. The two levatores together form a basin which is the
pelvic floor. Outer surface of the muscle forms the medial wall of the ischiorectal fossa.

Blood supply of the muscle is through the inferior gluteal, inferior vesical and pudendal arteries. The nerve supply to levator ani is mainly from the S3-4, partly from S2 and sometimes from the pudendal nerve.

The pudendal nerve is important in sensory and motor supply of the pelvic floor and perineum. It is vulnerable to injury by stretch and pressure during labor while it passes between the piriformis and coccygeus muscles posterior to the ischial spine. Neuropathy of the pudendal nerve contributes significantly to the development of pelvic organ prolapse.

Pubococygeus and puborectalis muscles contract to occlude the levator hiatus. This occludes the vagina and prevents pelvic organ prolapse. It pulls the anorectal junction forwards by sling action, and maintains fecal continence. The muscles have to relax to let the anorectal canal straighten, so that feces can pass through. Puborectalis helps maintain urinary continence too, by compressing the bladder neck from the sides. The resistance offered by the sloping pelvic floor during labor makes the fetal head rotate internally as it descends.

With the use of an epidural block for labor analgesia, levatores ani relax, the resistance of the pelvic floor is lost, and internal rotation of the fetal head may not take place. Thus the need for rotation forceps increases.

Breaks in the levator muscles and their atrophy are seen on magnetic resonance imaging in parous women with pelvic organ prolapse. Thus myopathy of the levator muscles is a significant causative factor in the development of pelvic organ prolapse.

The pubococygeus and iliococygeus muscles may weaken due to myopathies or neuropathies. As a result the levator plate sags and the genital hiatus remains open, which makes the proximal vagina vertical (the
original being horizontal) and predisposes central pelvic organ prolapse.

It was believed that the levator hiatus enlarged during childbirth due to separation of the levatores ani from each other, and the support to the vagina was lost due to tearing of the fascia connecting the levator to the vagina on that side. This was believed to lead to pelvic organ prolapse. As a method of repairing it, the levatores were approximated in the midline anterior to the rectum, and the sutures were also passed through adjacent vaginal walls. However this lead to retention of urine and did not help reduce the prolapse. This practice is not recommended any more.

**Delancey's Division Of Vaginal Support**

<table>
<thead>
<tr>
<th>Level</th>
<th>Support</th>
<th>Result of damage to the support</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Suspension by the ligaments of the paracolpium at the level of the ischial spines.</td>
<td>Uterovaginal prolapse, posthysterectomy vaginal prolapse, and enterocele.</td>
</tr>
<tr>
<td>II</td>
<td>Midvaginal level attachment of fascial septa to white line and arcus tendineus fasciae rectovaginalis.</td>
<td>Paravaginal and pararectal defects.</td>
</tr>
<tr>
<td>III</td>
<td>Fusion to the proximal perineum posteriorly and the urogenital diaphragm anteriorly.</td>
<td>Perineal body deficits and urinary incontinence.</td>
</tr>
</tbody>
</table>

**Perineum**

It is a roughly diamond-shaped region that lies between the pubic symphysis and its arcuate ligament in front, the coccyx behind, the ischiopubic rami and the ischial tuberosities anterolaterally and sacrotuberous ligaments posterolaterally. It lies superficial to the inferior surface of the pelvic diaphragm. Its outer surface is lined by
skin. A line joining the ischial tuberosities (the inter-ischial line) divides it into the urogenital triangle in front and the anal triangle behind. The former faces downwards and forwards, whereas the latter faces downwards and backwards at an angle of about 120° from the plane of the former. The urogenital triangle is divided into superficial and deep perineal pouches by a strong perineal membrane.

The anal triangle lies between the ischial tuberosities on each side and the coccyx. It is lined by superficial and deep fascia. It contains the anal canal and its sphincters, levator ani, the ischiorectal fossa and its contents.

Figure 5.3. Perineum.

**Superficial perineal fascia**: it is attached laterally to the margins of the ischiopubic rami up to the ischial tuberosities and posteriorly to the posterior limit of the perineal membrane and the fascia over the superficial transverse perineal muscles. It continues into the Scarpa’s fascia of the lower abdominal wall anteriorly.

**Deep perineal fascia**: it lies over the superficial muscles of the perineum. It is attached to the ischiopubic rami, posterior margin of the perineal membrane and perineal body, the suspensory ligament of the clitoris, the fasciae of external oblique and the rectus sheath.

**Subcutaneous perineal pouch**: it lies between the superficial and deep perineal fascia. It contains loose connective tissue.
Blood or fluid collected here after trauma expands this space considerably, and can pass to labia majora and abdominal wall, but not to the anal triangle or thighs due to firm attachments of the fascia there.

**Superficial perineal pouch**: it lies between the perineal membrane and the deep perineal fascia. It contains the superficial perineal muscles, the clitoris, corpora cavernosa and corpus spongiosum, and branches of the pudendal vessels and nerves. The urethra and vagina pass through it. It is an enclosed space and blood or fluid collected in it does not spread beyond it.

**Perineal body**: it is made of fibromuscular tissue located between the urogenital and anal triangles, ventral to the external anal sphincter. It is attached to the middle part of the external anal sphincter, the conjoint longitudinal coat of the anal canal, rectovaginal septum, puborectalis, superficial and deep transverse perineal muscles, bulbospongiosus, perineal membrane, the superficial perineal fascia, perineal skin, the posterior commissure of the labia majora and the introitus of the vagina.

Childbirth trauma may cause tears of the perineum, which leave a gaping introitus if not repaired. A third degree perineal tear involves the anal mucosa and anal sphincter too, which can lead to fecal incontinence if not repaired. A perineal tear can be avoided by using the modified Ritgen's maneuver to deliver the fetal head, and when required, making an episiotomy (a surgical incision in the perineum).

Sometimes the perineal skin remains intact while the underlying structures get torn, leaving behind a deficient perineum called the dashboard perineum. The surgical correction of this condition involves cutting the skin open, repairing the torn structures and resuturing the skin.
**Superficial transverse perineal muscles:** they are attached to the medial and anterior aspects of the ischial tuberosities laterally and the perineal body medially.

**Bulbospongiosus:** it is attached to the perineal body and perineal membrane posteriorly and the corpora cavernosa clitoridis anteriorly. A few fibers cross over the dorsum of the body of the clitoris to meet the muscle from the other side. These fibers help in the erection of the clitoris by compressing its deep dorsal vein. The muscle covers the superficial parts of the vestibular bulbs and Bartholin's gland and runs anteriorly on either side of the vagina.

**Ischiocavernosus:** it covers the crus of the clitoris. It is attached to the medial aspect of the ischial tuberosity posteriorly and the ischial ramus on both sides of the crus of the clitoris.

The perineum is supplied by the pudendal vessels and nerve which enter the perineum around the posterior aspect of the ischial spine and pass on the lateral wall of the ischiorectal fossa in the pudendal canal. The cavernous artery, a branch of the pudendal artery, supplies the corpora cavernosa of the clitoris. The dorsal artery supplies the glans and prepuce of the clitoris. The perineal artery, a branch of the internal pudendal artery, supplies the transverse perinei, the perineal body and the labia through its branch called the posterior labial artery.

A pudendal block is a local anesthetic block in which the pudendal nerve is blocked to give anesthesia for procedures on the perineum, like an episiotomy. Care must be taken to avoid injury to pudendal vessels while giving this block.
6. Pelvic Connective Tissue and Spaces

Pelvic fascia

It is divided into the parietal and the visceral parts. The former covers the pelvic muscles (obturator fascia, the fascia over piriformis, the fascia over levator ani and presacral fascia). The latter covers the pelvic organs, their blood vessels and nerves.

Obturator fascia: it covers the pelvic surface of obturator internus muscle. It is attached to the posterior part of the arcuate line of the ilium behind and the line of origin of obturator internus and the back of the pubis in front. It is continuous with the iliac fascia. It passes below the obturator vessels and nerve, lining the obturator canal. The tendinous arch of levator ani is attached to it. It merges with the fasciae of the muscles of the deep perineal space anteriorly. It forms a part of the lateral wall of the ischiorectal fossa in the perineum posteriorly. It is continuous with the pelvic periosteum and the fascia over piriformis.

Fascia over piriformis: it fuses with the periosteum on the front of the sacrum at the margins of the anterior sacral foramina. It covers the anterior primary rami of the sacral nerves which emerge from these foramina. The internal iliac vessels lie in front of it.

Fascia over levator ani: it covers both upper and lower surfaces of the levator ani muscle. It blends below with the obturator fascia and the fascia over the urethral and the external anal sphincters. It blends above with the obturator fascia, the fascia over piriformis, the anterior sacrococcygeal ligament and the visceral pelvic fascia. This fascia is condensed into a thick, white band on the superomedial aspect of the upper fascia, extending between the lower part of the pubic symphysis and the superior margin of the ischial spine. It is called the white line of the parietal pelvic fascia. During a paravaginal repair, the white line can be felt as a string-like structure between the ischial spines and the pubic arch. The pubovesicocervical fascia is attached to it. Bilateral attachment of
this fascia results in giving a good support to the urinary bladder. A fascial thickening which runs posteriorly from the white line is called the arcus tendineus fasciae rectovaginalis. The distal rectovaginal septum is attached to it. That line supports the rectum.

Disruption of this attachment causes a lateral rectocele.

Presacral fascia: it extends laterally to the origin of the fascia over piriformis and the fascia over levator ani, inferiorly between the white line of the parietal pelvic fascia on both sides and to the anorectal junction to fuse with the posterior aspect of the mesorectal fascia and the iliococcyeal raphae. It extends superiorly up to the origin of the superior hypogastric plexus and then blends with the retroperitoneal tissues. The presacral veins lie posterior to it, the inferior hypogastric plexuses lies on its surface.

Visceral pelvic fascia: it covers all pelvic organs and their neurovascular bundles. It blends with the parietal fascia. It is relatively ill-defined, loose and highly elastic, so that it can permit high degree of physiologic distention of the bowel, urinary bladder, and the uterus without affecting the adjacent organs.

It also permits easy dissection between the organs during surgery.

Rectovaginal fascia (Denonvilliers' fascia): it is trapezoid in shape, the broad end located proximally. It is made of fibroelastic connective tissue and smooth muscle. It is attached to the uterosacral ligaments and the pericervical ring proximally, perineal body distally, the white line (arcus tendineus fascia pelvis) and the arcus tendineus fasciae rectovaginalis laterally, the vagina above and the rectum below. It supports and suspends the posterior vagina, stabilizes the rectum, and guides the descending bowel peristalsis into the anus.

Pericervical ring: it is a collar of connective tissue around the supravaginal cervix. It is between the base of the bladder and the anterior cervix. It is made of fibroelastic connective tissue. The pubocervical ligaments are attached to it at the 11 o'clock and 1 o'clock positions, the cardinal ligaments at the 3 o'clock and 9 o'clock positions, the uterosacral ligaments at the 5 o'clock and 7
o'clock positions and the proximal rectovaginal septum centrally. It stabilizes the cervix.

Detachment of the structures attached to it leads to various types of pelvic organ prolapse.

Pelvic Spaces

1. **Prevesical space (cave of Retzius):** it is bounded by the back of the pubes and pubic symphysis in the front, the urinary bladder and the urethra behind, the attachment of the bladder to the cardinal ligament and that of the pubocervical fascia to the white line dorsolaterally, and the abdominal wall above. It contains the dorsal clitoral vessels (at its lower border), obturator nerve and vessels (where they enter the obturator canal), a branch of the external iliac artery to the obturator canal and a venous plexus and the nerves of the lower urinary tract (lateral to the bladder neck). The transversalis fascia has to be penetrated to enter this space between the recti abdominally.

2. **Vesicovaginal and vesicocervical space:** it is bounded by the lower urinary tract in front, the lower genital tract behind, the plane at the junction of the proximal 1/3 and distal 2/3 of the urethra below and the pelvic side walls laterally.

3. **Rectovaginal space:** it is bounded by the back of the vagina in front, the rectum behind, the apex of the perineal body below, the pouch of Douglas above and the attachment of the rectovaginal septum to the parietal endopelvic fascia laterally.

4. **Pararectal spaces:** each space has the rectum and the rectal pillars (fibers of the uterosacral-cardinal ligament complex connecting the vagina to the lateral walls of the rectum) medially and the lateral pelvic wall laterally. The sacrospinous ligament is accessed surgically in this space.

5. **Retrorectal space:** it is bounded by the rectum in front, the sacrum behind, and pararectal spaces laterally. They separate the midline rectovaginal space in this region from the lateral pararectal spaces.

6. **Presacral space:** it is bounded by the bifurcation of the aorta, internal iliac arteries laterally, the sacrum behind and
posterior parietal pelvic peritoneum in front. It contains the middle sacral artery and vein, lateral sacral vessels and presacral (superior hypogastric) nerve plexus.

Injury to the vessels during surgery can cause serious hemorrhage, especially if the torn vessels retract through sacral foramina. The autonomic nerves may be injured during pelvic lymphadenectomy affecting orgasmic function.

7. **Pelvic retroperitoneal space**: it contains the internal iliac artery and its branches, corresponding veins and lymphatics, pelvic nerves, pelvic part of the ureter and lymph nodes.
7. Ovary

It is the female gonad. There is one ovary on each side, lying in the ovarian fossa on the lateral pelvic wall. It is shaped like an almond. It measures 4x2x3 cm in an adult, while it is 1.3x0.6x 0.4 cm in the neonate, 1/3 the adult size prior to menarche and double the adult size during a pregnancy. It is dull white in color. Its surface is smooth prior to the beginning of ovulation. Ovulations make the surface scarred. It is suspended by the mesovarium, which is a double fold of peritoneum raised from the upper part of the posterior leaf of the broad ligament.

Parietal peritoneum lines the lateral wall of the ovarian fossa, in the angle between the external and internal iliac vessels, with the ureter, obturator vessels and nerve behind it. The utero-ovarian ligament connects the medial pole of the ovary to the uterus. The ovarian fimbria of the fallopian tube and the lateral end of the fallopian tube lie above its superior extremity. The posterior border is free, while the anterior border is attached to the mesovarium which is attached to the posterior leaf of the broad ligament. The ileocecal junction, cecum and appendix lie superolateral to the right ovary. The sigmoid colon lies superolateral to the left ovary.

Ligaments

1. Infundibulopelvic ligament: it is a peritoneal fold attached to the upper part of the lateral surface of the ovary. It contains ovarian vessels and nerves. Its outer end is attached to the parietal peritoneum posterosuperior to the cecum and appendix on the right side. On the left side it is attached lateral to the level of junction of descending and sigmoid colon. Each ligament passes over the external iliac vessels, genitofemoral nerve and ureter and then ends in the peritoneum over the psoas major muscle of that side.

2. Utero-ovarian ligament: it lies in the posterior leaf of the broad ligament of that side. It is attached to the lateral angle of the uterus posterosuperior to the fallopian tube at the cornu medially and the ovary laterally. It is made of
fibrous tissue and smooth muscle. It does not support the uterus or the ovary.

It can be used to cover the tied pedicle of the fallopian tube after partial salpingectomy for a tubal ectopic pregnancy. This is done by suturing the round ligament to the uteroovarian ligament over the pedicle. It prevents development of adhesions of bowel or omentum to the ischemic tissues of the pedicle.

In case of prolapse of the ovary into the pouch of Douglas causing collision dyspareunia, the uteroovarian ligament is plicated with a suture, which is then passed through the adjacent part of the uterus to suspend the ovary (Ohlhausen's operation).

**Blood supply**

The ovaries are supplied by the ovarian arteries, which arise from the abdominal aorta below the level of the renal arteries. Each ovarian artery passes retroperitoneally, crosses the external iliac artery and vein at the pelvic brim and enters the pelvis. It turns medially in the infundibulopelvic ligament, gives a branch to the ovary in the mesovarium and continues in the broad ligament to give a branch to the fallopian tube and then anastomose with the uterine artery of that side.

Venous drainage of the ovary is through a pampiniform plexus in the mesovarium and utero-ovarian ligament. The plexus gives rise to two veins, which later unite to form a single ovarian vein, which accompanies the ovarian artery to end in the inferior vena cava on the right side and the left renal vein on the left side.

**Lymphatic drainage**

It is through lymphatics which pass along the ovarian veins to para-aortic nodes near the origin of the renal arteries. Some lymphatics drain into the pelvic nodes and thence into the lower para-aortic nodes, and rarely along the round ligament to the inguinal nodes.

**Nerve supply**
It is through the autonomic plexuses containing preganglionic parasympathetic fibers from the sacral outflow, postganglionic sympathetic fibers, visceral afferent fibers, and preganglionic sympathetic efferent fibers from T10-T11 segments. The upper part of the plexus is derived from the renal and aortic plexuses, the lower part from the superior and inferior hypogastric plexuses.

**Histology**

The ovarian surface is covered by a single layer of cuboidal epithelium, which is continuous with the mesovarium. There is a tough collagenous coat called the tunica albuginea beneath it. Underneath it is the ovarian cortex surrounding the medulla. The cortex contains the ovarian follicles at various stages of development, corpora lutea and albicans (hyalinized white-colored structures) from past ovulations. The number of primordial follicles in the ovary is about 1 million at birth, 40000 at puberty, and then it falls progressively up to menopause to become zero. These are surrounded by a dense stroma containing a mesh of thin collagen fibers and fusiform fibroblast-like cells containing lipids in whorls. The medulla contains a large number of spiral arteries and veins in a loose connective tissue stroma. A small number of hilus cells like Leydig cells are seen too.
8. Pelvis

Pelvis is a skeletal ring formed by two innominate bones and the sacrum. The part of the pelvis of obstetric importance is below an oblique plane bounded by the top of the pubic symphysis in front, the sacral promontory behind and the arcuate line of the ilium, the iliopectineal line and pecten pubis on each side. The superior pelvic aperture or the pelvic inlet is variable in contour, being rounded or oval. The anteroposterior diameter of the pelvic inlet (anatomical conjugate) passes through the midpoint of the sacral promontory and the top of pubic symphysis. This is not the anteroposterior diameter available for the passage of the fetus. The diameter passing through the midpoint of the sacral promontory and that point on the back of the pubic symphysis which lies nearest to the sacral promontory is known as the obstetric conjugate. It is shorter than the anatomical conjugate and is the diameter available for the passage of the fetus. The transverse diameter of the pelvic inlet is the maximum transverse diameter that can be found between similar points on opposite sides of the pelvic brim. Available transverse diameter passes through the midpoint of the anteroposterior diameter of the inlet. The transverse diameter and the available transverse diameter coincide in all the pelvic types except in an android pelvis, in which the transverse diameter lies posterior to the available transverse diameter. There are two oblique diameters of the inlet, right and left. Each oblique diameter passes through one iliopectineal eminence and opposite sacroiliac joint. Whether the sacral promontory and the transverse diameter are very close or not determines whether the posterior segment is flattened anteroposteriorly or elongated. The part of the anteroposterior diameter behind the transverse diameter is known as the posterior sagittal diameter and the part in front is known as the anterior sagittal diameter. The capacity of the posterior inlet is largely determined by the size of the sacrosciatic notch, due to its effect on the iliac bone and consequently on the length of the posterior iliac segment of the inlet. If it is large, the capacity is large and if it is small, the capacity is small. The pelvic cavity is bounded by the pubic symphysis and the pubes below and in front, the sacrum and the coccyx behind and on each side by the pelvic aspect of the fused ilium and ischium. It is short and curved, the posterior wall being
Figure 8.1. Pelvic inlet.

Figure 8.2. Pelvic outlet.

Figure 8.3. Pelvis: lateral view.
considerably longer than the anterior wall. The anteroposterior diameter of the plane of maximum pelvic dimensions passes through the disc between the 2nd and 3rd sacral vertebrae behind and the midpoint of the back of the pubic symphysis in front. Its transverse diameter is the widest transverse distance between the bony side walls of the cavity. The oblique diameter passes through the center of one acetabulum and the lowest point of the opposite sacroiliac joint. The anteroposterior diameter of the plane of the least pelvic dimensions passes between the midpoint of the 4th sacral vertebra behind and the lowest point of the pubic symphysis in front. Its transverse diameter passes through the ischial spines. The anatomical outlet of the pelvis is much less smooth than the inlet. It is indented behind by the coccyx and sacrum and on each side by the ischial tuberosities. It is rhomboidal or diamond shaped, bounded by the inferior pubic ligament, the ischiopubic rami, the ischial tuberosities, the sacrotuberous ligaments and the coccyx. The anterior, ischiopubic part of the opening has a plane which inclines downwards and backwards to a transverse line joining the lower limits of the ischial tuberosities. The posterior half of the aperture corresponds roughly to the sacrotuberous ligaments and slopes downwards and forwards to the same transverse line. The anteroposterior diameter of the anatomical outlet lies between the midpoint of the lower rim of the symphysis and the apex of the coccyx, despite the mobility of the latter. However many obstetricians consider the tip of the sacrum as the posterior limit of the anteroposterior diameter of the outlet if the sacrococcygeal joint has not fused. The transverse diameter lies between the lower borders of the ischial tuberosities. The oblique diameter lies between the midpoint of the sacrotuberous ligament on one side and the junction of the ischial and pubic rami on the opposite side. The diagonal conjugate diameter lies between the midpoint of the sacral promontory and the lowest point of the pubic symphysis. The diagonal conjugate is longer than the anatomical conjugate by 0.1 to 3.1 cm. The diagonal conjugate is longer if the height of the pubic symphysis is more or if the pubis is less inclined. Obstetric outlet is the space bounded by the plane of least pelvic dimensions above and the anatomical outlet below. Rotation of the presenting part takes place in this space. The plane of the pelvic inlet makes an angle of 50° to 60° with the horizontal, while the anteroposterior diameter of the outlet makes an angle of 15° with the horizontal.
The axis of the inlet passes through the center of and at right angles to the plane of the inlet. It is directed downward and backward and when extended it passes through the umbilicus above and the middle of the coccyx below. The axis of the outlet passes through the sacral promontory. The axis of the pelvic cavity is J-shaped, following the curvature of the cavity. Depending on the shape of the pelvic cavity, four types of pelvis have been described. The following table shows comparative features of the various pelvic types.

<table>
<thead>
<tr>
<th></th>
<th>Gynecoid</th>
<th>Anthropoid</th>
<th>Android</th>
<th>Platypelloid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brim</td>
<td>Transverse oval</td>
<td>Antero-posterior oval</td>
<td>Triangular</td>
<td>Kidney shaped</td>
</tr>
<tr>
<td>Sacral angle</td>
<td>100°</td>
<td>100°</td>
<td>90°</td>
<td>90°</td>
</tr>
<tr>
<td>Sacral line</td>
<td>Parallel to pubis</td>
<td>Parallel to pubis</td>
<td>Convergent</td>
<td>Divergent</td>
</tr>
<tr>
<td>Sacrum</td>
<td>Not prominent</td>
<td>Not prominent</td>
<td>Flattened, narrow, long.</td>
<td>Broad, short, concave.</td>
</tr>
<tr>
<td>Ischial spines</td>
<td>Not prominent</td>
<td>Not prominent</td>
<td>Prominent, heavy.</td>
<td>Prominent</td>
</tr>
<tr>
<td>Pelvic side walls</td>
<td>Broad, shallow, concave.</td>
<td>Broad, shallow, concave.</td>
<td>Convergent</td>
<td>Divergent</td>
</tr>
<tr>
<td>Pubis</td>
<td>Parallel to sacral line.</td>
<td>Parallel to sacral line.</td>
<td>Heavy, deep.</td>
<td>Shallow</td>
</tr>
<tr>
<td>Subpubic</td>
<td>85°</td>
<td>80°</td>
<td>Narrow</td>
<td>85°</td>
</tr>
</tbody>
</table>
(Note: Sacral angle—angle between the anatomical conjugate and the front of the first sacral vertebra. Sacral line—line joining the midpoint of the sacral promontory and the tip of the sacrum.)

The average values of various diameters of a gynecoid pelvis are shown in the following table.

### Diameters Of A Gynecoid Pelvis

<table>
<thead>
<tr>
<th>Plane</th>
<th>Antero-posterior</th>
<th>Oblique</th>
<th>Transverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet</td>
<td>10.8</td>
<td>12</td>
<td>13.2</td>
</tr>
<tr>
<td>Plane of maximum pelvic dimensions</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Plane of least pelvic dimensions</td>
<td>13.2</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Anatomical outlet</td>
<td>13.2</td>
<td>12</td>
<td>10.8</td>
</tr>
</tbody>
</table>

Assessment of pelvic dimensions is done after 36 weeks of gestation by clinical pelvimetry in nulliparas and women with prior cesarean section or a breech.
presentation when a vaginal delivery is considered. Radiological pelvimetry (plain radiography or computed tomography) is not done much in modern obstetrics.

**Pubic Symphysis**

It is a cartilagenous joint between the medial surfaces of the two pubic bones. The articulating surfaces are covered by a thin layer of hyaline cartilage. There is an interpubic disc made of fibrocartilage connecting the two hyaline cartilages. It has a non-synovial cavity in its posterosuperior part. The anterior pubic ligament covers the front of the joint. It is made of interlacing collagen fibers in continuity with fibers of external oblique aponeuroses and the medial tendons of the recti abdominis. The superior pubic ligament extends between the pubic tubercles and covers the top of the joint. The arcuate pubic ligament covers the lower part of the joint. It is quite thick. The posterior pubic ligament covers the back of the joint. It is much less well developed. The strength of the joint is from the interpubic disc, the superior and arcuate ligaments. Blood supply to the joint is through the obturator, superficial external pudendal and inferior epigastric arteries. Its nerve supply is through iliohypogastric, ilioinguinal and pudendal nerves. A movement through 0.1 and 2 mm is possible in the joint.

During pregnancy the tissues of the pelvic joints imbibe water, the capsules thicken, the vascularity increases and there is an increase in the synovia. Pubic, sacroccocygeal and sacroiliac joints are affected in that order. There is a rather marked mobility of the pelvis at term, caused by an upward gliding movement at the sacroiliac joints. The displacement, which is greatest in dorsal lithotomy position, may cause an increase in the diameters of the outlet by 1.5 to 2 cm.

Symphysiotomy is a division of the pubic symphysis of a gravida in labor with a view to enlarge the pelvic diameters and achieve a vaginal delivery that otherwise would not be possible. It avoids the need for a cesarean section. Care must be taken to avoid complications like injury to the bladder neck and urethra and formation of a urinary fistula. Urinary incontinence not related to
a fistula may develop in some cases. Pelvic instability may develop due to subluxation of the sacroiliac joints. Persistent pain is its commonest sequel and may be complained of several years later.

Diastasis of pubic symphysis is a condition in which there is a separation of the joint in the absence of a pelvic fracture. There is an excessive anterior or lateral movement at the joint, which can cause dysfunction of the joint. Its symptoms may get aggravated during a pregnancy. Its treatment is conservative in the form of analgesics, stabilization of the joint with strapping or a pelvic belt and exercises for strengthening the muscles of the pelvic girdle.

![Image of pelvic ligaments]

**Figure 8.4. Pelvic ligaments.**

**Sacrospinous Ligament**

It is thin and triangular. It is attached to the ischial spine and the lateral margins of the sacrum and coccyx in front of the sacrotuberous ligament. It fuses with the sacrotuberous ligament in its medial portion. It is in contact with the coccygeus muscle in front. Along with the sacrotuberous ligament it opposes upward tilting of the lower part of the sacrum. It is separated from the rectovaginal space by the rectal pillar. The sacral plexus lies close to it, on the surface of the piriformis muscle. The pudendal nerve and vessels pass lateral to the ligament at its attachment to the ischial spine. The nerve to the levator ani is on the inner surface of the midportion of coccygeal muscle.
The sacrospinous ligament can be accessed surgically from the rectovaginal space by perforating the rectal pillar or by dissecting under the peritoneum of an enterocele. It is used to suspend the vault of the vagina in the management of massive eversion of the vagina (sacrospinous colposuspension). The venous plexus of the internal iliac vein and the middle rectal vessels can be injured while developing the space around the ligament and cause severe hemorrhage.

**Pelvic Vessels**

The common iliac artery bifurcates in front of the sacroiliac joint to form the external and internal iliac arteries. The ureter, ovary and fimbrial end of the fallopian tube lie anterior to the internal iliac artery. The external iliac vein, psoas major and the obturator nerve lie lateral to it. The internal iliac vein, lumbosacral trunk and sacroiliac joint lie posterior to it. It is about 4 cm long. It descends to the superior margin of the greater sciatic foramen. It divides there into its anterior and posterior branches. The anterior trunk continues in the direction of the parent vessel, while the posterior trunk passes backwards to the greater sciatic foramen.

![Figure 8.5. Pelvic vessels.](image-url)

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Branches Of The Internal Iliac Artery

<table>
<thead>
<tr>
<th>Division</th>
<th>Branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Associated with the bladder</td>
</tr>
<tr>
<td></td>
<td>1. Superior vesical</td>
</tr>
<tr>
<td></td>
<td>2. Obliterated umbilical (first branch)</td>
</tr>
<tr>
<td></td>
<td>3. Inferior vesical</td>
</tr>
<tr>
<td>Other visceral</td>
<td>1. Middle rectal</td>
</tr>
<tr>
<td></td>
<td>2. Uterine</td>
</tr>
<tr>
<td></td>
<td>3. Vaginal</td>
</tr>
<tr>
<td>Parietal</td>
<td>1. Obturator</td>
</tr>
<tr>
<td></td>
<td>2. Internal pudendal (terminal branch)</td>
</tr>
<tr>
<td></td>
<td>3. Inferior gluteal (terminal branch)</td>
</tr>
<tr>
<td>Posterior</td>
<td>1. Iliolumbar</td>
</tr>
<tr>
<td></td>
<td>2. Lateral sacral</td>
</tr>
<tr>
<td></td>
<td>3. Superior gluteal</td>
</tr>
</tbody>
</table>

The anterior division of the internal iliac artery is ligated surgically for helping control intractable pelvic hemorrhage, as in atonic or traumatic postpartum hemorrhage and operations for cervical carcinoma or extensive endometriosis. Ligation must be done distal to the branching of the posterior division of the internal iliac artery as it has major anastomotic channels with the aorta and the femoral artery. The ligation should be done as close to the branching of the uterine artery as possible so that collaterals from inferior mesenteric artery do not continue to feed the bleeding uterine artery. So the site of ligation should be distal to the branching of the middle rectal artery. Avascular necrosis of the uterus or any other structure usually does not develop after ligation of the anterior division of the internal iliac artery because there are a large number of anastomoses between the branches of the internal iliac artery and branches of other vessels, as shown in the table below. Ligation of the vessel does not cut off the supply to the target organ. It just converts arterial bleeding to low pressure venous type,
so that hemostasis can be achieved by local pressure and ligation of the bleeding blood vessels.

<table>
<thead>
<tr>
<th>Branch of internal iliac artery</th>
<th>Anastomosing vessel</th>
<th>Parent vessel of anastomosing vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uterine</td>
<td>Ovarian</td>
<td>Aorta</td>
</tr>
<tr>
<td>Middle rectal</td>
<td>Superior rectal</td>
<td>Inferior mesenteric</td>
</tr>
<tr>
<td>Obturator and pubic</td>
<td>Inferior epigastric</td>
<td>External iliac</td>
</tr>
<tr>
<td>Obturator</td>
<td>Medial femoral circumflex</td>
<td>Deep femoral</td>
</tr>
<tr>
<td>Inferior gluteal</td>
<td>Medial femoral circumflex</td>
<td>Deep femoral</td>
</tr>
<tr>
<td>Iliolumbar</td>
<td>Lumbar</td>
<td>Aorta</td>
</tr>
<tr>
<td>Iliolumbar</td>
<td>Lateral femoral circumflex</td>
<td>Deep femoral</td>
</tr>
<tr>
<td>Lateral sacral</td>
<td>Median sacral</td>
<td>Aorta</td>
</tr>
<tr>
<td>Superior gluteal</td>
<td>Lateral femoral circumflex</td>
<td>Deep femoral</td>
</tr>
<tr>
<td>Communicating pelvic branches</td>
<td>Obturator</td>
<td>Inferior epigastric</td>
</tr>
</tbody>
</table>

The procedure can still cause complications in a small percentage of cases, such as necrosis of the buttock, perineum and bladder mucosa, paresthesia over gluteal area, spasm and thrombosis of the external iliac artery, atony of the urinary bladder, interstitial cystitis and circulatory disturbances of the inferior extremities.
Lymph nodes draining pelvic structures

Figure 8.6. Lymph nodes draining female genital tract.
9. Abdominal Wall

Skin

Skin of the abdominal wall is like skin elsewhere. There is no extension of pubic hair towards umbilicus, as is found in a man. The Langer's lines run predominantly transversely with a gentle upward concavity.

Because of this the tension on the skin suture line is greater in a vertical scar and the scar tends to be wider than in case of a transverse incision. A transverse incision produces a thin scar that is also hidden under clothes and even a bikini. Hence its cosmetic popularity.

Subcutaneous Tissue

Camper's fascia lies just under the skin. It has mainly fat and less fibrous tissue. Underneath that lies Scarpa's fascia, which has mainly fibrous tissue and less fat. It is thin in the midline and not very apparent under a midline vertical incision. Blood vessels, lymphatics, and nerves lie in the superficial fascia.

Muscles and Aponeuroses

Rectus abdominis: there is one on each side of the midline, attached to the sternum and cartilages of ribs 5-7 above and the anterior surface of the pubic bone below. There are three tendinous interruptions within the muscle that firmly attach it to the rectus abdominis sheath above the umbilicus and usually none below. That makes separation of the muscle from the rectus sheath in Pfannenstiel incision easier.

Pyramidalis: there is one on each side of the midline, attached to the pubic bone below and the linea alba a few centimeters above the pubic symphysis.
Flank muscles: these include the external oblique, internal oblique and transversus abdominis muscles. These muscles are broad and flat, lying lateral to the rectus abdominis on each side. The external oblique is most superficial. It is attached to the lower eight ribs and iliac crest laterally and the rectus sheath medially, its fibers running anteroinferiorly. The internal oblique lies under the external oblique, attached to the anterior two thirds of the iliac crest, the lateral part of the inguinal ligament, and the thoracolumbar fascia laterally and the rectus sheath medially, its fibers running in a direction perpendicular to that of the external oblique. The transversus abdominis is the deepest muscle, attached to the lower 6 costal cartilages, thoracolumbar fascia, anterior 3/4 of the iliac crest, and the lateral part of the inguinal ligament laterally and the rectus sheath medially, its fibers running in a horizontal direction. Its caudal part is fused with the internal oblique, as seen while making a Pfannenstiel incision. A vertical line through the anterosuperior iliac spine separates the muscular and aponeurotic parts of the external oblique in the lower abdomen. The internal oblique and transverse abdominal extend farther toward the midline. The nerves and blood vessels are present between the internal oblique and transverse abdominis.
A tap block given in this plane under ultrasonographic control achieves anesthesia for abdominal wall for postoperative period.

Lateral pull of the muscles on the suture line in the rectus sheath in case of a vertical incision increases the risk of dehiscence of the sheath.

**Rectus sheath**: it is preferable avoiding the term conjoined tendon for this because it can be confused for the conjoined tendon of the inguinal canal. The rectus sheath covers the rectus abdominis in front and behind. The lateral border of the rectus muscle is called the semilunar line. The anterior fascial sheath is made by the fusion of the external oblique and anterior split part of the aponeurosis of internal oblique. The posterior sheath is formed by the fusion of the posterior split part of the internal oblique and transverse abdominis aponeurosis. In the lower half of the sheath below the umbilicus (below arcuate line or linea semicircularis), the anterior rectus sheath is made by the fusion of aponeurosis of all three muscles, while the posterior fascial sheath is absent. The two sheaths join each other in the midline in a vertical ridge called linea alba.

A hematoma can form in the rectus sheath after a laparotomy if hemostasis is not achieved prior to closing the rectus sheath. It can also form after an injury to the inferior epigastric vessels while performing Purandare's cervicopexy. The hematoma can be quite large and can be life threatening if not diagnosed in time, and treated by transfusion of adequate quantities of blood and blood products, and an exploration to evacuate the hematoma and ligate the bleeding vessel.

**The inguinal canal**: it is a 3-6 cm long oblique tunnel slanting obliquely downwards and medially. It is bounded by skin, superficial fascia and the aponeurosis of external oblique in front, muscular fibers of the internal oblique in its front lateral 1/3, the reflected inguinal ligament, the conjoint tendon and the transversalis fascia behind, the transversalis fascia and the inguinal ligament below, and the lacunar ligament at the medial end. The conjoint tendon is formed by the fusion of the lower fibers of internal oblique and the lower part of the aponeurosis of transversus.
abdominis. It has deep and superficial openings (rings). It lies at the lower edge of the musculofascial layer of the abdominal wall. Medial half of the inguinal ligament is curled in on itself to form the floor of the inguinal canal. Through the inguinal canal pass the round ligament, the ilioinguinal nerve and the genital branch of the genitofemoral nerve. The inferior epigastric vessels ascend obliquely behind the conjoint tendon to enter the rectus sheath and run upwards behind the rectus abdominis.

Transversalis fascia: it is a layer of fibrous tissue between the muscular layers, and the preperitoneal fat.

Peritoneum

It it is a single layer of serosa. It is thrown into five vertical folds raised from it by underlying ligaments or vessels, all converging on the umbilicus.

1. Median umbilical fold: it is caused by the urachus. Its lower end blends with the apex of the urinary bladder elevation. This point is higher than the remaining bladder.

   Hence the bladder is more vulnerable to surgical trauma with a midline incision than a lateral incision.

2. Medial umbilical folds: they are on either side of the median fold, raised by the obliterated umbilical arteries which are connected to the internal iliac vessels.

3. Lateral umbilical folds: they are lateral to the medial umbilical folds, caused by the inferior epigastric vessels.
Figure 9.2. Lower anterior abdominal wall, posterior aspect. IIR: internal inguinal ring; FC: femoral canal.

**Blood Supply**

1. Superficial epigastric vessels: they are in the subcutaneous tissue, running from the femoral vessels to the umbilicus.
2. External pudendal artery: it runs from the femoral artery to the mons pubis.
3. Superficial circumflex iliac vessels: they run from the femoral vessels to the flank.
4. Branches of the external iliac arteries: to musculofascial layer.
5. Branches of the inferior epigastric arteries: to musculofascial layer.
6. Branches of the deep circumflex iliac arteries: to musculofascial layer.

**Nerve Supply**

1. Intercostal nerves T7-11 and subcostal nerve (T12): each gives off a lateral cutaneous branch, and then pierces the lateral border of the rectus sheath to provide a lateral branch the rectus muscle, passes through it and gives the anterior cutaneous branches. The dermatome T6 lies at xiphisternum, T10 at the umbilicus and L1 above the pubis.
2. Iliohypogastric nerve (L1): it passes medial to the anterosuperior iliac spine to supply the skin of the suprapubic area.

3. Ilioinguinal nerve (L1): it passes medial to the anterosuperior iliac spine to supply the lower abdominal wall, upper portions of the labia majora and medial aspect of the thigh.

4. Genitofemoral nerve (L1-2): it forms in the psoas major muscle, passes in front of it, crosses obliquely behind the ureter, divides into genital and femoral nerves. The former passes through the inguinal canal and supplies skin of the external genitalia. The latter passes through the femoral sheath and supplies the skin of the upper part of the femoral triangle.

5. Lateral femoral cutaneous nerve (L2 and L3): it passes from the posterolateral border of psoas major and crosses iliacus towards the anterior superior iliac spine. It passes behind or sometimes through the inguinal ligament, about 1–2 cm medial to the anterior superior iliac spine.

The ilioinguinal and iliohypogastric nerves may get trapped in the closure of a transverse incision and cause chronic pain syndromes.

The genitofemoral nerve can be injured while preparing the psoas loop during Shirodkar's abdominal sling surgery for uterine prolapse.

The femoral cutaneous nerves can be injured during surgery by the pressure of a retractor lateral to the psoas major or exaggerated lithotomy position. That would cause anesthesia in the medial thigh and lateral labia.

The lateral femoral cutaneous nerve can be injured while fixing the polyester tape to the lateral end of the inguinal ligament in Khanna's sling for uterine prolapse. That causes paresthesia and pain in lateral aspect of the thigh.
The ureter descends posterior to the parietal peritoneum of the abdomen, on the medial part of psoas major, behind which lie the tips of the transverse processes of the lumbar vertebrae. It crosses in front of the genitofemoral nerve anterior to psoas major. The gonadal vessels cross it obliquely. It passes over the bifurcation of the common iliac artery into the external and internal iliac arteries, just medial to the ovarian vessels and enters the pelvis. It lies in extraperitoneal areolar tissue in the pelvis. It descends on the pelvic side wall, where the internal iliac artery and the beginning of its anterior trunk lie posterior to it, behind which lie the internal iliac vein, lumbosacral nerve and sacroiliac joint. Here it is part of the posterior wall of the ovarian fossa. The fascia of obturator internus lies lateral to it. It passes through a connective tissue sheath which is attached to the peritoneum of the lateral pelvic wall and medial leaf of the broad ligament. It passes obliquely to lie medial to the umbilical, inferior vesical and middle rectal arteries successively. The ureter passes under the uterine artery in its course through the cardinal ligament in the base of the broad ligament, about 1 cm from the anterolateral surface of the cervix. The uterine artery
remains anterosuperior to the ureter for about 2.5 cm. Then it passes to become medial to it and ascends to the uterus. The ureter turns anteriorly a little above the lateral vaginal fornix, 2 cm lateral to the supravaginal part of the uterine cervix. Then it turns to the bladder. As the uterus usually has some dextrorotation, the left ureter may run a longer course to enter the bladder, and may even cross the midline while doing so.

This needs to be kept in mind while operating in that area so as to avoid injury to the left ureter.

The lower 1–2 cm long part of each ureter is surrounded by the sheath of Waldeyer, which is an incomplete collar of smooth muscle. The ureters runs obliquely through the bladder wall for 1.5–2.0 cm and open as the ureteric orifices in the bladder. This part is compressed and closed when the bladder is filled, which prevents vesico-ureteric reflux. The distance between the ureteric orifices is 2.5 cm when the bladder is empty and 5 cm when it is full.

### Blood Supply

It is through the branches from the abdominal aorta, the renal, gonadal, common iliac, internal iliac, vesical and uterine arteries. These branches join one another in the wall of the ureter to form a vessel which runs with the ureter on its lateral surface. This longitudinal anastomosis between these vessels is good.

It permits cutting the ureter during surgery and then performing uretero-ureteral anastomosis to achieve good healing.

The vessels supplying the abdominal part of the ureter enter it from the medial aspect, and those supplying the pelvic part enter it from the lateral aspect.

This needs to be kept in mind while dissecting the ureter so as not to compromise its blood supply.

The branch from the renal artery (which supplies the upper ureter) and the branches from the inferior vesical
artery (which supply the lower part of the ureter and a large part of the trigone of the bladder) are constant and are preserved as far as possible during surgery.

Ureteric veins follow the course of its arteries.

**Lymphatic Drainage**

Lymphatics form plexuses in the submucosal, intramuscular and adventitial parts of the ureter. The collecting vessels drain into lymph nodes as shown in the following table.

<table>
<thead>
<tr>
<th>Part of the ureter</th>
<th>Lymph nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper abdominal ureter</td>
<td>Lateral aortic nodes near the origin of the ovarian artery.</td>
</tr>
<tr>
<td>Lower abdominal ureter</td>
<td>Common iliac nodes</td>
</tr>
<tr>
<td>Pelvic ureter</td>
<td>Common, external or internal iliac nodes.</td>
</tr>
</tbody>
</table>

When the pelvic anatomy is distorted and the ureter is likely to be difficult to identify, a ureteric catheter or a double-J stent may be passed into the ureter preoperatively. Then the ureter can be located by palpation during surgery and can be protected from inadvertent injury. The stent may be removed after the operation immediately or electively at a later date.
11. Urinary Bladder

It is a smooth muscle organ for collection of urine. When empty, it is shaped like a pyramid with three sides. It has a base, neck, apex, and a superior and two inferolateral surfaces. Its base is posteroinferior, triangular in shape. The anterior vaginal wall lies behind it. Its neck lies just above the plane passing through the inferior aperture of the lesser pelvis, 3–4 cm behind the lower part of the pubic symphysis and facing it. On the inside, it forms the internal urethral orifice. The urachus raises the median umbilical fold between the apex and the umbilicus. The anterior surface of the bladder has adipose tissue and the transversalis fascia anterior to it in that order. The pubis and pubovesical ligaments lie next to the inferolateral surfaces. The inferolateral surfaces are not covered by peritoneum. The triangular superior surface is bounded by lines joining the apex and ureteric orifices. This surface is mostly covered by peritoneum, which continues through the uterovesical fold onto the anterior surface of the uterus. The posterior part of this surface is not covered by peritoneum. It is related to the supravaginal cervix. The bladder is in the pelvis when empty in an adult. It becomes palpable abdominally when it fills up, lifting the anterior parietal peritoneum off the lower part of the abdominal wall in front and the front of the supravaginal cervix and lower part of the uterine corpus behind. Up to the age of three years, it is an abdominal organ because the pelvis is small.

The inside of the bladder shows the trigone with the ureteric orifices posterolaterally and the internal urethral meatus anteroinferiorly. The ureteric orifices are connected by a transverse ridge called the interureteric bar. When the bladder is empty, the mucous membrane is thick and thrown into folds. It is smooth and thin when the bladder is distended. The mucosa is always smooth over the trigone. The muscle of the bladder (detrusor) in the area of the bladder neck is in the form of fasciculi of small diameter which extend obliquely or longitudinally into the urethral wall. The bladder neck is supported by the pubovesical ligaments, levator ani and endopelvic fascia.
Ligaments

1. Pubovesical ligaments: they extend from the bladder neck to the inferior aspect of the pubic bones. They are the upward extensions of the pubourethral ligaments.
2. Lateral ligament: it is a 5 to 7 cm long band of dense connective tissue on each side, between the lateral pelvic wall and the bladder base near the termination of the ureter. The middle rectal artery and lymphatics from the lower rectum are contained in it.
3. False ligaments: median umbilical ligament (containing the urachus) between the bladder apex and the umbilicus, and two medial umbilical folds (containing the obliterated umbilical arteries).

Figure 11.1. Ligaments of the urinary bladder.

Blood Supply

It is through the superior and inferior vesical arteries (branches of the anterior division of the internal iliac artery), obturator, inferior gluteal, uterine and vaginal arteries. Venous drainage of the bladder is through a plexus on its inferolateral surfaces that drains into the internal iliac veins.

An injury to this plexus during anerior colporrhaphy or insertion of tension free transobturator tape for urinary stress incontinence can cause significant bleeding. It is managed by giving head-low position to reduce venous pressure and hemostatic sutures and/or
Lymphatic Drainage

Mucosal, intermuscular and serosal plexuses drain into three sets of vessels which drain into the external iliac nodes. Some lymphatics from superior surface may drain into the internal or common iliac nodes too. Lymphatics from the inferolateral surface drain into nodes in the obturator fossa.

Nerve Supply

Sympathetic and parasympathetic afferent and efferent fibers from pelvic plexuses, autonomic nerves and ganglia along the lateral aspects of the rectum, internal genitalia and bladder base supply the bladder. Parasympathetic fibers provide the main motor innervation.

The urinary bladder is kept empty with a Foley's catheter during abdominal and vaginal pelvic operations because that provides space for surgery and prevents trauma to the bladder.

The urinary bladder can be approached abdominally both extra- and transperitoneally.
12. Urethra

It is the tube that connects the urinary bladder to the outside, for emptying of the bladder. It is 4 cm long and 6 mm wide in an adult. Its length is 23 mm at birth, 26 mm in prepubertal girls and 32 mm at 15 years. It extends between the internal and external urethral meatuses, running between the back of the pubic symphysis in front and the anterior wall of the vagina behind. The external urethral meatus is 2.5 cm behind the glans clitoris and directly in front of the vaginal opening. Urethral mucosa is thrown into longitudinal folds, of which the most posterior one is called the urethral crest. A number of small, mucous glands and minute recesses open into the urethra. A number of these glands (Skene’s glands) are found at the lower end of the urethra. They open at the lateral margin of the external urethral meatus through a paraurethral duct on each side.

Supports

Posterior pubourethral ligaments suspend it from the pubis, and by the suspensory ligament of the clitoris in front.

Blood Supply

It is supplied mainly by the vaginal artery, but also through a branch of the inferior vesical artery. Urethral venous plexus drains into the vesical venous plexus, which drains into the internal pudendal veins. There is a venous plexus of erectile tissue around the urethra, continuous with the erectile tissue in the vestibular bulb.

Lymphatic Drainage

Its lymphatics drain into the internal and external iliac lymph nodes.

Nerve Supply

| Parasympathetic preganglionic axons arising from neuronal cell bodies in the intermediolateral column of the S2-4 of the sacral spinal cord. | Smooth muscle of the urethral wall |
Histology

The mucosa is like bladder mucosa in the proximal urethra and non-keratinizing stratified squamous epithelium in the remaining part. It is keratinized at the external urinary meatus. It is supported by a lamina propria containing loose, fibroblastic, well vascularized connective tissue, longitudinal and circular elastic fibers, and a nerve plexus. There is an outer muscle coat containing outer striated muscle and inner smooth muscle fibers. The fibers are longitudinal or oblique. Detrusor fibers replace urethral smooth muscle near the bladder neck. The external sphincter is seen around the middle urethra at the level of the perineal membrane. It is composed of small striated muscle fibers arranged circularly.

The urethra is straight as compared to the urethra in a male. Thus urethral dilatation is relatively easier.

Urethral sphincter

Figure 12.1. Urethral sphincter.

The urethral sphincter has striated and smooth muscle components. The former has an upper circular part which surrounds the urethra between the perineal membrane and bladder neck. It extends laterally at the level of the perineal membrane as two arching bands.
which lie above the perineal membrane. One of them called the compressor urethrae, runs along the pubic arch and gets attached near the inner surface of the ischiopubic ramus. The other is called the urethrovaginal sphincter. It extends caudally and surrounds the lateral margin of the vaginal wall. The smooth muscle part of the sphincter has cells arranged circularly between the striated sphincter and the longitudinal smooth muscle of the urethral wall. The urethral sphincter extends from the perineum through the urogenital hiatus into the pelvic cavity. Nerve supply of the sphincter is from S2-4, through branches from the sacral plexus and the pelvic splanchnic nerves and probably through the perineal branch of the pudendal nerve.
13. Pelvic Organ Prolapse

**Ring Pessary**

Uterine prolapse was treated conservatively in the past using a ring pessary. A ring pessary is a rubber ring, the thickness of which is about 1 cm. It is flexible and can be compressed into an oval shape. It was inserted while compressed into an oval, the plane of the pessary held in the sagittal plane while passing into the vagina between the labia minora. Once inside the vagina, it was rotated through 90° and pushed upwards into the vaginal fornix.

![Figure 13.1. Ring pessary for the management of uterine prolapse.](image)

The ring pessary was supported by the levatores ani edges just outside the vagina. The vaginal fornix was on top of the ring pessary, and the cervix was attached to the vaginal fornix. Thus the levatores supported the pessary, the pessary supported the vaginal fornix and held up the uterus which was attached to the vaginal fornix. Ring pessary is not used much in modern gynecology. It still has some place in the management of uterine prolapse in pregnancy, when surgical treatment is not possible.
Shirodkar's modification of Fothergill's operation

This is a vaginal operation in which a uterine prolapse, along with cystocele, rectocele, and lax perineum is managed conservatively, i.e. without removing the uterus. Cystocele and rectocele are repaired by site specific repair as has been discussed before. The prolapsed uterus is elevated by reducing the effective length of the uterosacral ligaments, so that the cervix gets pulled upward and backward. The fundus of the uterus falls forward and the uterus gets anteverted.

Figure 13.2. Uterosacral advancement. A. Before advancement of the uterosacral ligaments; B. After advancement of the uterosacral ligaments.

Resection and anastomosis of the middle portion of uterosacral ligaments would weaken them. Instead they are detached from their uterine attachments and sutured to the front of the supravaginal cervix. This is called uterosacral advancement. The length of the ligament anterior to the posterolateral aspect of the cervix (where it was originally attached) is the length through which the ligament is shortened. This removes the slack in the ligament and that pulls the cervix backward and upward.

Fothergill's operation

This vaginal operation is done for a uterine prolapse, along with elongation of the supravaginal cervix, cystocele, rectocele, and lax perineum to be managed conservatively, i.e. without removing the uterus. Extra length of the cervix is reduced by amputation of the cervix. Cystocele and rectocele are repaired by site specific repair as has been discussed before. The prolapsed uterus is elevated by reducing the effective length of the cardinal ligaments.
Two sutures are passed – each passing through the anterior half thickness of the cardinal ligament of one side, the front of the supravaginal cervix and then the anterior half thickness of the cardinal ligament of the other side. When these sutures are tied, the medial parts of the cardinal ligaments get bunched by the side and the front of the supravaginal cervix. This reduces the slack in the ligaments and the cervix gets elevated.

**Purandare's cervicopexy**

This is an abdominal operation done for a nulliparous type of uterine prolapse when the existing supports of the uterus are too weak to be strengthened by any vaginal procedure. A polyester tape is fixed to the front of the supravaginal cervix and is then passed through the broad ligaments to the angle of the rectus sheath on each side, where it is made to emerge in the rectus sheath and is fixed to the angle after traction to elevate the uterus such that its top comes to lie flush with the top of the pubic symphysis.

This operation gives a dynamic support to the uterus. When Valsalva's maneuver is done, the abdominal wall muscles contract and pull the uterus up, countering its tendency to descend with the increase in the intraabdominal pressure. But it tends to fail when the abdominal wall muscles become weak due to any reason, or when the rectus sheath degenerates.
Shirodkar's sling operation

This is an abdominal operation done for a nulliparous type of uterine prolapse when the existing supports of the uterus are too weak to be strengthened by any vaginal procedure. A polyester tape is fixed to the back of the supravaginal cervix. Its right end is passed through the broad ligaments to the right lateral pelvic wall, turned backward and then medially to exit in front of the sacral promontory. The left part is passed similarly to the left lateral pelvic wall. But instead of continuing further as on the right side, it is passed through a loop of polyester tape fixed to the left psoas major. Then it is passed medially to exit in front of the sacral promontory. The two halves are driven through the anterior longitudinal ligament and pulled until three fingers can be passed comfortably between the two halves. Then they are sutured to each other. Passage of the left half of the sling through a loop made in the psoas major prevents the two halves of the sling coming close together on straining and compressing and obstructing the sigmoid colon between them. Passing three fingers comfortably between the two halves of the sling ensures that feces can pass through the sigmoid colon without any obstruction.

This operation suspends the uterus from a stable bony point and hence does not fail. But the route of the tape is along a number of important structures on the left side, such as the neurovascular bundle, left ureter, sigmoid colon and mesocolon, which can be injured during the operation.
Figure 13.5. Shirodkar's sling operation.

**Khanna's sling operation**

This is an abdominal operation done for a nulliparous type of uterine prolapse when the existing supports of the uterus are too weak to be strengthened by any vaginal procedure. A polyester tape is fixed to the back of the supravaginal cervix. Its each end is passed through the broad ligament to the anterior superior iliac spine over iliacus muscle of the respective side. The ends are then fixed to the lateral ends of the inguinal ligaments after elevating the uterus such that its top lies at the level of the top of the pubic symphysis.

Figure 13.6. Khanna's sling operation.
This operation suspends the uterus from a stable bony point and hence does not fail.

**Hysterectomy and vault suspension**

If the woman with pelvic organ prolapse is old and does not wish to retain the uterus, a vaginal hysterectomy is done. Since the uterosacral ligaments are cut off their attachments to the supravaginal cervix and vagina, unless the vault is resuspended from them, it can prolapse in future.

The pedicles of the two uterosacral ligaments are tied to each other in the midline after closure of the pelvic peritoneum. Then the center of the vault is sutured to the common pedile, so that the center of the vault gets suspended from it. The cornual pedicles are not used for this suspension because the cornual structures do not give any support to the uterus and hence cannot be used to suspend the vaginal vault. Also, using them would place the ovaries next to the vaginal vault and may cause collision dyspareunia later.

**Uterosacral shelf operation**

![Figure 13.7](image.png)

Figure 13.7. Uterosacral shelf for repair of a massive cystocele. A. The vagina has been dissected off a large cystocele; B. The tips of the uterosacral pedicles have been sutured by the side of the bladder neck; C. The uterosacral ligaments have been approximated in midline.
In case of a massive eversion of the vagina and a large cystocele, if a hysterectomy has been done as a part of the operative treatment, the two large uterosacral ligaments are used to support the cystocele. They are passed anteriorly and fixed to the fascia by the side of the bladder neck. Any gap between them is closed with interrupted sutures. Gap between the side of each ligament and subvaginal fascia on that side is closed with interrupted sutures.

This procedure is a form of site specific anterior colporrhaphy, as the continuity between the pubovesicocervical fascia, pericervical ring and uterosacral ligaments is reestablished, the only difference from the conventional technique being that the uterosacral ligaments are drawn forwards to achieve this. An advantage of this procedure is that the strength of the thick uterosacral ligaments is put to good use and a lot of time is saved that would be required to repair a very large cystocele.
14. Urinary Stress Incontinence

Valsalva's maneuver causes a rise in the intraabdominal pressure which gets transmitted to the urinary bladder and the intravesical pressure rises. Since the proximal urethra lies above the urogenital diaphragm, this rise in pressure is transmitted to the upper urethra and the pressure inside it rises too. Since the intraurethral pressure at rest exceeds the intravesical pressure at rest, there is urinary continence. With Valsalva's maneuver the rise in both intravesical and intraurethral pressures is equal and hence the intraurethral pressure exceeds intravesical pressure. Then there is no incontinence of urine. But if the intraurethral pressure does not rise along with the intravesical pressure, the two equal at some time, and then the intravesical pressure exceeds the intraurethral pressure, and there is incontinence of urine. This stops when the intravesical pressure drops below intraurethral pressure.

Urinary stress incontinence is believed to be due to damage to the neuromuscular function of the pelvic floor, along with injury to the connective tissue supports of the urethra and bladder neck. Loss of urethral resistance may be due to atrophy of mucosa, reduced vascularity, and local scarring. Most of the cases probably have both neuromuscular and urethral structural components.

An older theory to explain urinary stress incontinence was that there was a loss of the posterior urethrovesical angle with stress, which caused incontinence. It was demonstrated with bead chain cystourethrography as well as ultrasonographic studies that it was not actually this straightening of the bladder base and the urethra so that they came to lie in a straight line obliterating the posterior urethrovesical angle, but funneling of the bladder neck and upper urethra, which was the normal process seen during micturition. Operations designed to create the posterior urethrovesical angle, like Kelly's operation of plicating the bladder neck posteriorly, worked not by creating that angle, but by elevating the bladder neck and upper urethra to above the urogenital diaphragm.
With loss of support to the bladder neck and upper urethra, they descend to a level below the urogenital diaphragm with Valsalva's maneuver. Then the rise in the intraabdominal pressure does not get transmitted to the upper urethra like it does to the urinary bladder, and the intravesical pressure exceeds the intraurethral pressure so that urinary incontinence develops. This can be proved by the performance of Bonney's test, in which the patient is asked to cough in presence of a full bladder. When urinary incontinence is demonstrated, the bladder neck is elevated by placing two fingers on either side of the bladder neck and the patient is asked to cough. If the incontinence is controlled by this maneuver, the woman is diagnosed to have urinary stress incontinence. Care needs to be taken to place the fingers by the side of the bladder neck and not over the urethra, which would compress and obstruct the urethra and produce continence.

Figure 14.1. Bonney's test for urinary stress incontinence.

This is the principle underlying a number of surgical procedures prescribed for management of urinary incontinence, as shown below.

1. Kelly's operation: the fascia on either side of the bladder neck is plicated in midline by the vaginal approach. Two more sutures like this are placed, one 1 cm distal to it and the other 1 cm proximal to it.
2. Burch retropubic urethropexy: vagina on either side of the bladder neck is suspended from the Cooper's ligament of the same side by an abdominal approach, using two sutures on each side, one at the level of the bladder neck and the other at the level of the proximal urethra. Burch procedure
is considered the gold standard for surgical management of urinary stress incontinence.

3. Marshall-Marchetti-Krantz procedure: the urethra, bladder neck, and a portion of the bladder dome are sutured to the periosteum and midline fibrocartilage of the pubic symphysis.

4. Laparoscopic retropubic urethropexies.

5. Modified Pereyra procedure: pubourethral endopelvic connective tissue is sutured by a helical suture to the anterior rectus sheath above the pubes.

6. Stamey procedure: a special needle is used to pass retropubically two sutures, one on either side of the midline, in tissue by the bladder neck to the anterior rectus sheath.

7. Suburethral sling procedures.

Loss of urethral support causes a posterior dislocation of the urethra with stress in some cases, so that the urethra and bladder neck swing backwards, away from the back of the urethra. When it swings in this manner, it descends to below the level of the urogenital diaphragm and pressure equalization type of urinary stress incontinence develops. Such dislocation can be demonstrated by a Q-tip test. A Q-tip (swab stick) is passed into the urethra, its tip lying at the upper end of the urethra. The angle of the Q-tip with the vertical is measured. Then the patient is asked to cough and the angle is measured again.

![Diagram](image)

Figure 14.2. Backward dislocation of the urethra with stress. A. At rest; B. With stress.
Normally the urethra is stabilized during stress by a number of mechanisms.

1. Reflex closure of the pelvic floor by contraction of the levatores ani causes an elevation of the proximal urethra and bladder neck, tightening of the connective tissue supports and elevation the perineal body, which supports the urethra from behind.

2. The pubourethral ligaments suspend the mid urethra from the back of the pubic bone, the arcus tendineus fascia pelvis and the perineal membrane. They augment the supportive effect of muscular closure of the pelvic floor by contraction of the levatores ani during stress.

3. The urethrovaginal sphincter and the compressor urethrae (deep transverse perineal muscles) lie along the lateral and ventral aspects of the urethra and compress and close it during stress.

Now tension-free vaginal tape is used to create artificial pubourethral ligaments. A transobturator tape placement is preferred to transvaginal tape placement. In the former, special needles are used to place a narrow strip of polypropylene mesh under the midurethra and draw out its end in the thigh. The tape is without tension and thus does not compress the urethra. It does the function of the pubourethral ligaments. Its results are comparable to those of Burch procedure. Care needs to be taken as complications like infection in the presence of a foreign body and mesh erosion can occur.

In case of urinary stress incontinence due to intrinsic sphincter defect and hypermobility of the bladder neck, periurethral injection procedures are useful. Different bulking agents like autologous fat, Teflon, GAX collagen and silicone microspheres have been used. They restore urethral resistance and reduce motility of the bladder neck.