Anatomy

Embryogenesis and normal development:

The paramesonephric or mullerian ducts, which are formed in the mesonephrons by invagination of the coelomic epithelium, are responsible for the genesis of the uterus and the upper 2/3 of the vagina.

Uterine epithelium is formed from the urogential sinus. The uterine walls are formed by the splanchnic mesenchyme. The cervix may be of paramesonephric origin ***(Skandalakis et al., 2004).***

Topography:

The adult uterus is a hollow, pear-shaped muscular organ located in the lesser pelvis between the urinary bladder and rectum. It consists of an expanded body or corpus and a smaller cervix**.** ***The fundus*** is that portion of the corpus located cephalad to a plane passing through the points of entrance of the uterine tubes. ***The cornua*** are the two lateral regions associated with the intramural portion of the uterine tubes. The upper part of the cervix is called ***the isthmus*** or lower uterine segment. ***The internal os*** corresponds to a slight constriction on the cervix that represents a narrowing of the uterine cavity internally. There is no definitive anatomic landmark for the internal os, whereas ***the external os*** has an obvious landmark-the opening of the vagina **(Fig. 1 & 2)** ***(McCarthy, 1992)***.

Uterine Ligaments:

The supravaginal cervix is suspended from the lateral pelvic side wall by the cardinal ligaments (for Mackenrodt), which pass from the cervix to the side wall and merge with the connective tissue surrounding the internal iliac vessels. The ureters pass through the middle of these ligaments. Interestingly, the ligaments may be pulled down in uterine prolapse and leads to kinking and obstruction of the ureters.

Anteriorly, the supravaginal cervix is suspended from the posterior aspects of the pubic bone by the pubocervical ligament. This ligament also surrounds the internal urethral sphincter.

Posteriorly, the cervix is connected to the sacrum at (S2-4) by the uterosacral ligaments, one on either side of the rectum. These are common sites of tumor spread from the cervix. All of these ligaments unit to form a continuous sheet of connective tissue across the pelvic floor. **(Fig. 2 & 3)** ***(Tempany and Fielding, 1996*****)**

Blood supply of the uterus: **(Fig. 4)**

- **Arteries:** the main supply to the uterus is through the uterine branch of the *internal iliac artery* on each side; a branch supplies the cervix and the main vessel supplies the body and fallopian tubes
- **Veins**: the uterine veins drain following the route of the artery to the internal iliac vein. (***Gray, 2001)***

Fallopian Tubes

These tubes bear the name of **Gabriele Falloppio** (also spelled Falloppia), a 16th -century (c. 1523-62) Italian physician and surgeon who was expert in anatomy, physiology and pharmacology ***(Diamond, 2008).***

Embryology

Between the fifth and sixth week after oocyte fertilization, a longitudinal groove called Müller's groove arises from the coelomic epithelium on each side lateral to the mesonephric duct .The edges of this groove fuse to form a canal called the Müllerian or paramesonephric duct. The Fallopian tubes develop from the cranial parts of the paramesonephric ducts, with their cranial ends remaining open connecting the duct with the coelomic (peritoneal) cavity and the caudal end communicating with the uterine cornua. Congenital anomalies of the tube include aplasia, in which the tube fails to form; hypoplasia, in which the tube is long, narrow, and tortuous; accessory ostia, and congenital diverticulae ***(Diamond ,2008).***

Anatomy of Fallopian tubes

The fallopian tubes extend laterally from the medial end of the upper lateral margin of the uterus to the ipsilateral ovary. During the adult reproductive years, the fallopian tubes are approximately 9-11 cm long and 1-4 mm wide in luminal diameter **.**

They are composed of four segments (from the medial aspect to the lateral aspect): the intramural (uterine and interstitial) portion, the isthmus, the ampulla, and the infundibulum at the fimbriated end **(Fig. 5).** ***(Anderson et al, 2002)***.

The intramural portion lies within the myometrium and is approximately 1 cm long. The isthmus forms the narrow midsection of the fallopian tube, is adjacent to the uterine wall, and is 2-3 cm long. More laterally, the tube dilates to form the ampulla, which constitutes more than half the length of the fallopian tube. At the ovarian end of the fallopian tube, the infundibulum opens into the peritoneal cavity. The infundibulum is composed of approximately 25 irregular fingerlike extensions, or fimbriae, which overhang the ovary .

Throughout its extrauterine course, the tube lies in a peritoneal fold along the superior margin of the broad ligament, the mesosalpinx ***(Kim et al, 2009).***

Physiology

The tubes act as ducts for sperm, oocyte, and fertilized ovum transport, in addition to being the normal site of fertilization. These functions depend mainly on three factors: tubal motility, tubal cilia, and tubal fluid .

Tubal Motility

Peristaltic contraction of the smooth muscle fibres in the tubal wall allows the gametes (the sperm and egg) to be brought together, thus allow fertilization and subsequent transport of the fertilized ovum from the normal site of fertilization in the ampulla to the normal site of implantation in the uterus. This movement is primarily regulated by three intrinsic systems: the estrogen-progesterone hormonal effect the adrenergic-nonadrenergic system, and prostaglandins .

Estrogen acting at receptors stimulates tubal motility, whereas progesterone, which activates b receptors, inhibits tubal motility. As progesterone level rises 4-6 days after ovulation, relaxation of the tubal musculature take place and allows passage of the ovum into the uterus by the action of the tubal cilia .

Tubal Cilia

There are fewer ciliated cells in the isthmus than in the ampullary portion of the tube, whereas they are most prominent in the fimbriated infundibulum **.**

Ciliary activity is responsible for the pickup of ova by, the fimbrial ostium and movement through the ampulla, as well as the distribution of the tubal fluid which supports gamete maturation and fertilization and facilitates gamete and embryo transport. The importance of ciliary activity is affirmed by the tubal dysfunction seen in associations with the deciliation of salpingitis **.**

Tubal Fluid

Tubal fluid is rich in mucoproteins, electrolytes, and enzymes. This fluid is abundant in midcycle when gametes or embryos are present and may play an important role during fertilization and early cleavage**.** ***(Diamond, 2008).***

Figures (1, 2 , 3&4): Quoted from ***(Tortora, 1999)***

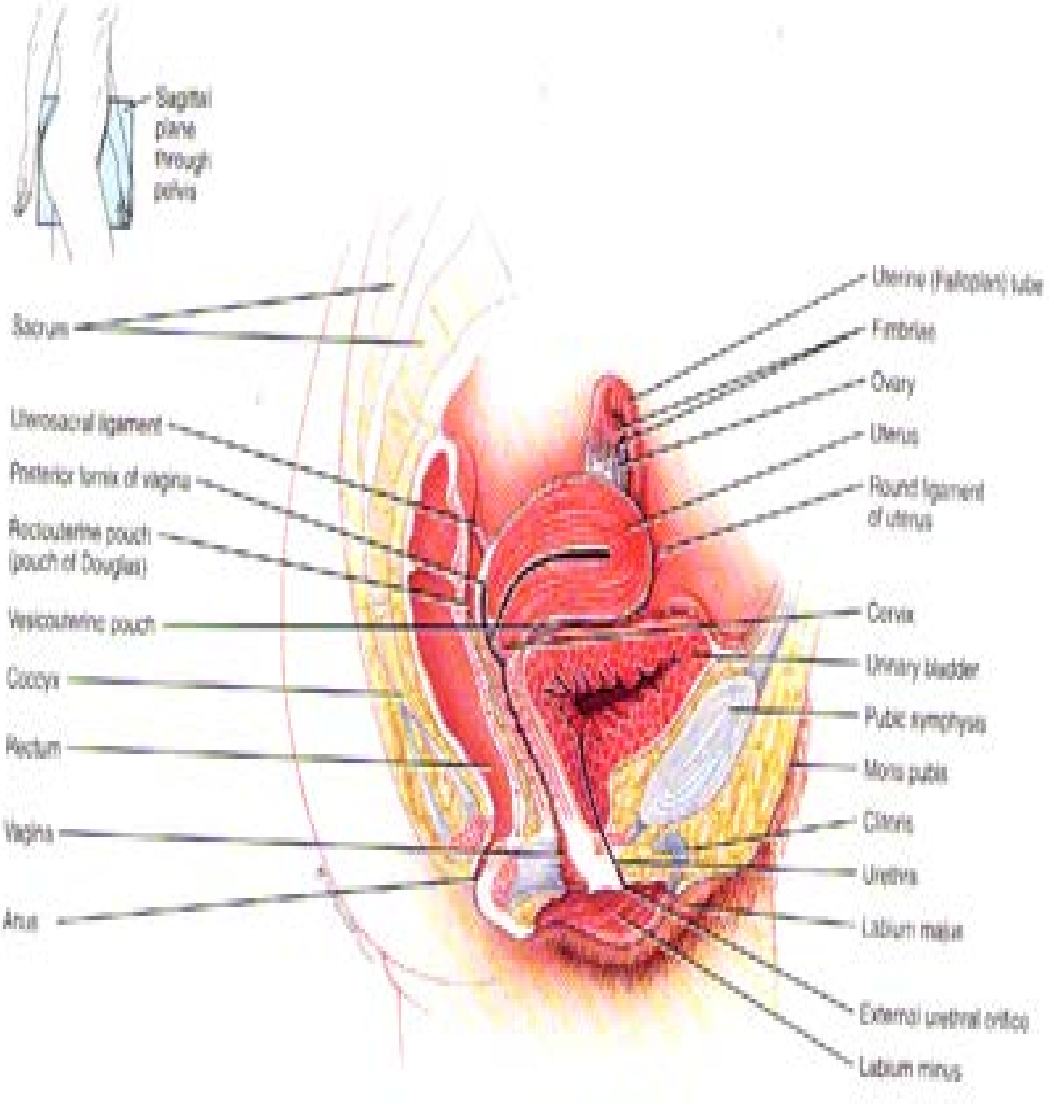

Figure (1): Diagram of sagittal section showing female reproductive organs.

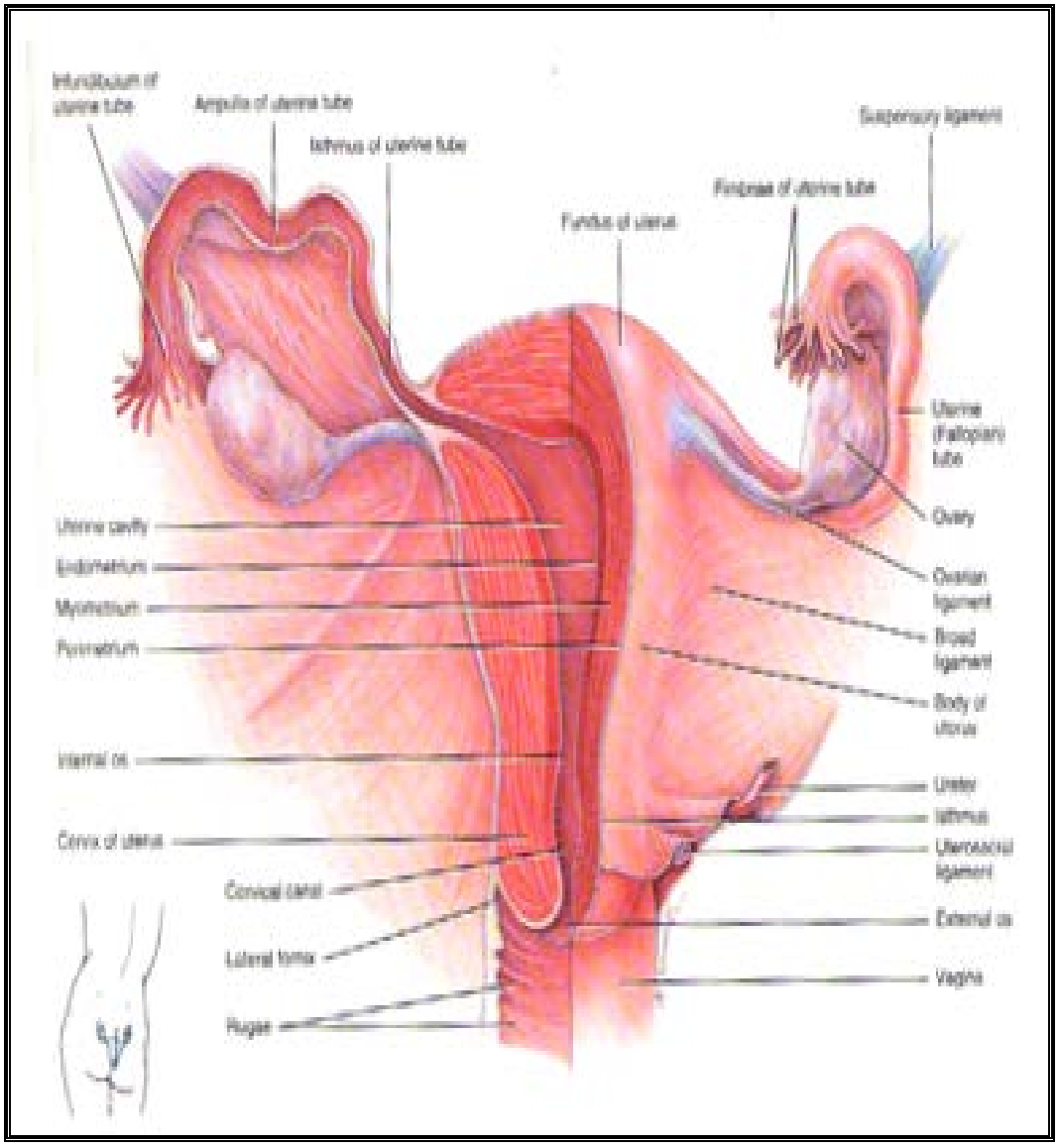

Figure (2): Diagram of posterior view of the uterus and associated structures.

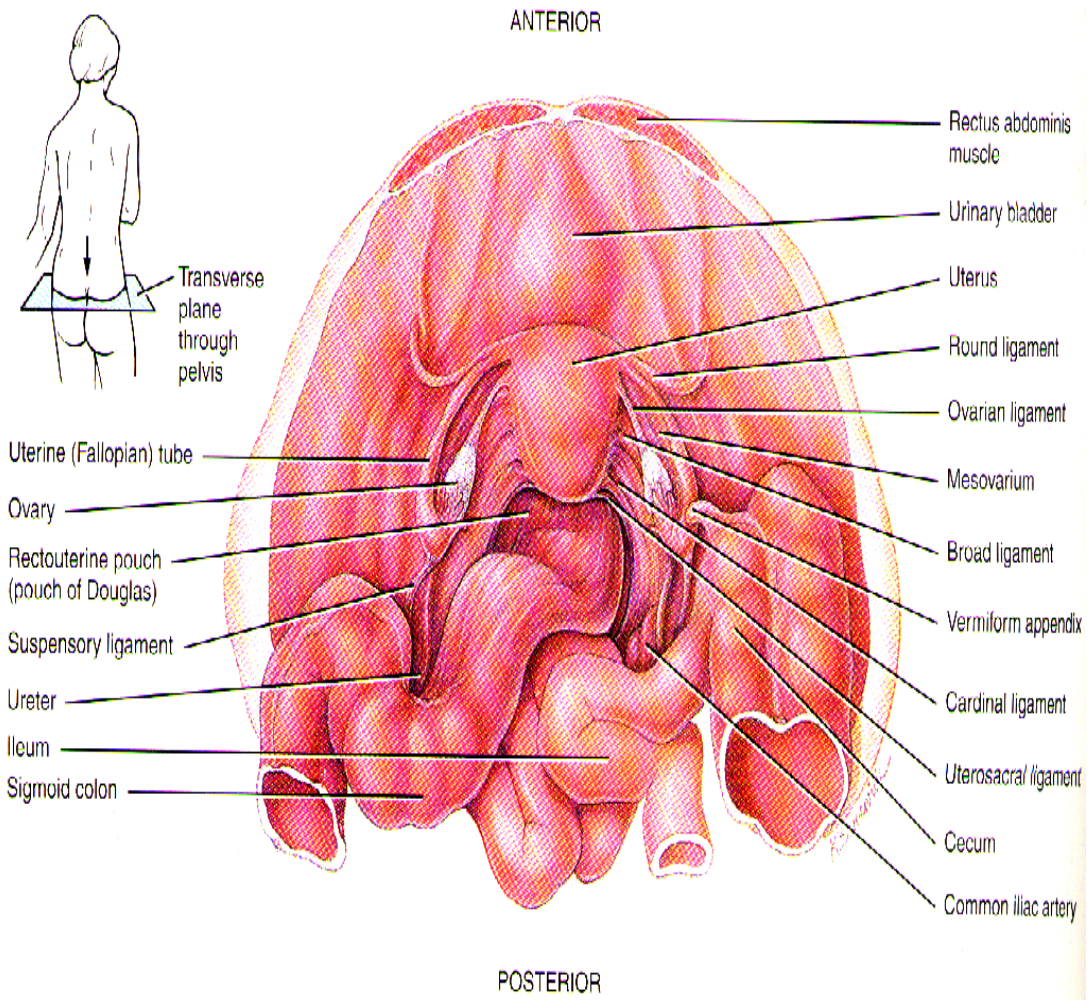

Figure (3): Diagram of superior view of transverse section showing uterus and associated structures.

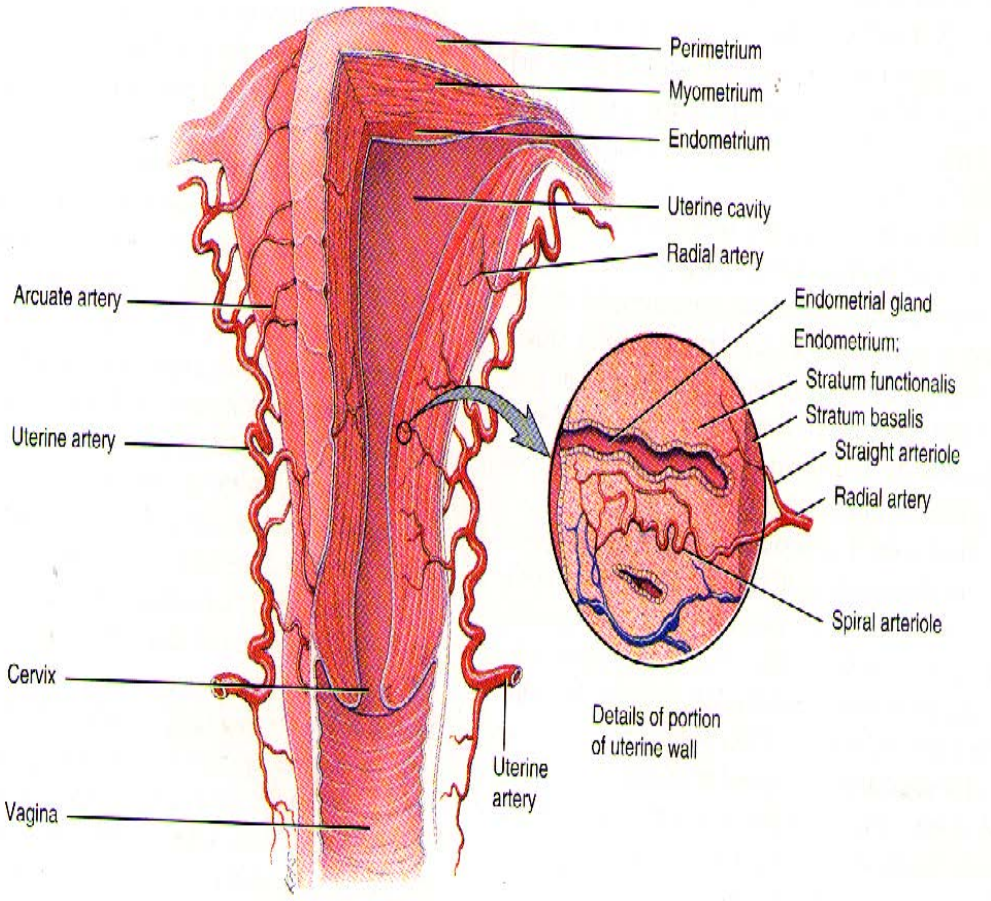

Figure (4): Blood supply of the uterus. Anterior view with left side of the uterus partially sectioned **.**

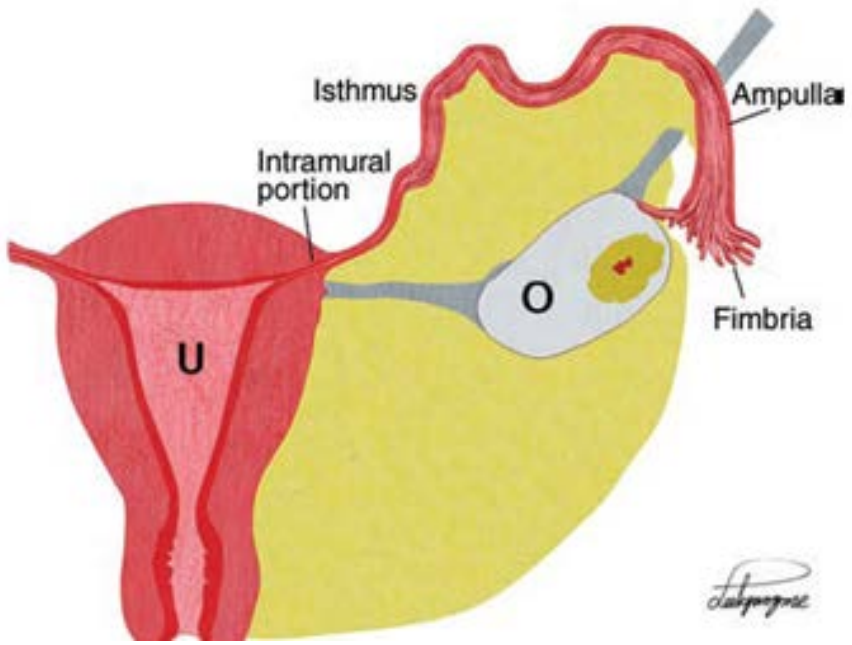

Figure (5): Diagram shows the anatomy of a normal fallopian tube. There are four segments, from the medial aspect to the lateral aspect: the intramural portion, the isthmus, the ampulla, and the infundibulum at the fimbriated end. U = uterus, O = ovary ***(Kim et al., 2009).***

Pathology of fallobian tubes obstruction

Histology of Fallopian tubes:

The fallopian tube is composed of a mucosal lining, a muscular layer, and an outer serosa. The wall of the fallopian tube is complex, consisting of longitudinal folds and mucosal rugae, both of which increase in size and number from the medial aspect to the lateral aspect ***(Brown and Ascher, 2006)***.

The structural complexity of the mucosa increases substantially as the lumen enlarges from the uterine end to the ovarian end. The intramural portions contain about five or six blunt plicae, or folds. In the isthmus, the plicae, of which there are a dozen or more, increase in height to more nearly fill the larger lumen. In the ampulla and infundibulum, the plicae are frond like and delicate, and they may have secondary and tertiary branches**.**The mucosal surface contains ciliated cells that help the ovum to pass into the uterus **.**

Hydrosalpinx:

Hydrosalpinx occurs when a distally blocked fallopian tube fills with fluid. The blocked tube may be substantially distended, with a characteristic sausage like shape. Serous fluid, hemorrhage, or pus may accumulate within the tube. A fallopian tube that is filled and distended with blood is referred to as hematosalpinx, and a tube filled with pus is referred to as pyosalpinx ***(Kim et al., 2009)***.

Pathogenesis:

Normally, when the cilia of the inner lining (endosalpinx) of the fallopian tube beat towards the uterus, meanwhile the tubal fluid is discharged from the fimbriated end into the peritoneal cavity, where it is cleared. Occlusion of the fimbriated end of the tube may lead to tubal dilatation, usually in the ampulla and infundibulum .

Serous fluid, blood, or pus may accumulate, depending on the cause of the hydrosalpinx. The dilated tubal wall generally appears whitish, thin, and translucent, with occasional fibrous adhesions on the surface .

An inflammatory process may selectively damage the tubal folds, resulting in uneven scarring and disappearance of the plicae .

**** Hydrosalpinx as an Isolated Finding***

Hydrosalpinx may occur as an isolated adnexal lesion or as one component of a complex adnexal lesion that has caused distal tubal occlusion .

The most common cause of distal tubal occlusion and hydrosalpinx is pelvic inflammatory disease. Other causes include endometriosis, peritubal adhesions from a previous operation, tubal cancer, and tubal pregnancy .

Rare causes of tubal occlusion include granulomatous salpingitis due to tuberculosis, intraluminal endometriosis, parasitic infection, and congenital atresia of the fallopian tubes ***(Kim et al., 2009)***.

**** Hydrosalpinx as a Component of a Complex Adnexal Lesion***

<u>Pelvic Inflammatory Disease:</u>

Pelvic inflammatory disease is one of the most common causes of tubal and peritubal damage. Pelvic inflammatory disease occurs when an ascending bacterial infection causes inflammation of the upper female genital tract, including the endometrium, fallopian tubes, and ovaries .

In the acute phase of disease, the fallopian tubes are swollen, edematous and congested. As acute suppurative salpingitis ensues, the tubal lumen fills with pus, and tubal fimbriae may adhere to the ovary. This process results in tubo-ovaritis (salpingo-oophoritis), a condition in which the ovaries and tubes partially adhere to one another but remain largely separate and identifiable on images **(Fig. 6).** If tubo-ovaritis goes undiagnosed or is inadequately treated, it may progress to a tubo-ovarian abscess or a chronic inflammatory mass **.**

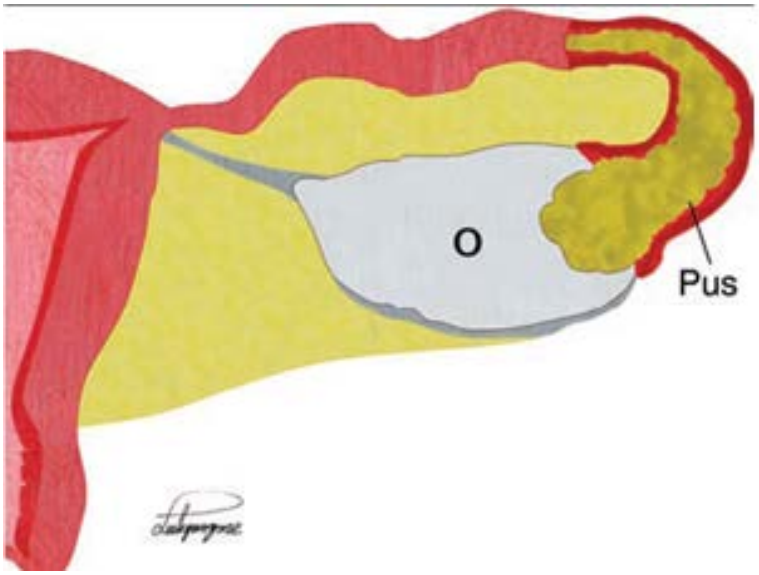

Figure (6): Diagram shows the characteristic appearance of hydrosalpinx associated with early-stage tubo-ovaritis and pyosalpinx. *O* = ovary ***(Quoted from Kim et al., 2009).***

If the fimbriae close before the ovary becomes extensively involved, the inflamed dilated tube forms a pyosalpinx. As the inflammation subsides, the pus undergoes slow proteolysis and the tube is filled with a thin serous fluid; the pyosalpinx thus is transformed into a hydrosalpinx ***(Kim et al., 2009)***.

Salpingitis Isthmica Nodosa:

Salpingitis isthmica nodosa (SIN) is a disease process characterized by nodular thickenings in the intramural (interstitial) and isthmical part of the tubes **.**

It is common around the age of 35 and more common among African Americans. The exact cause of the disease is unknown, but the inflammatory process due to tuberculosis, gonorrhea, or bilharziasis is the most accepted explanation. The condition is bilateral in about 35% of cases; the nodules vary from a few millimeters to 2.5 cm in diameter. These are firm with a smooth surface, giving a beaded appearance. *Microscopically*, these are gland-like spaces scattered throughout the myosalpinx with hyperplasia and hypertophy of muscle fibers. The surrounding stroma is infiltrated with plasma cells or eosinophils. This condition has the sequence of ectopic pregnancy and infertility due to occlusion at the isthmic-ampullary junction ***(Diamond, 2008).***

Endometriosis:

Endometriosis is defined as the presence of endometrial glands in locations outside the uterus. The ectopic endometrium responds to hormonal stimulation with various degrees of cyclic hemorrhage that result in suggestive symptoms and appearances **.**

Types: (endometrial implants, endometriomas, solid endometriosis and visceral endometriosis) **.**

Endometrial Implants

The peritoneal implant represents the presence of endometrial surface epithelium and stroma embedded in serosal tissues in the peritoneal cavity. The ectopic location of endometrium in the peritoneal cavity causes reactive proliferation of the stromal vessels that leads to recurrent hemorrhage **(Fig. 7).** The implant has a varied appearance depending on the age of associated blood products. *Pathologically*, the implants begin as red highly vascular lesions, typically 2-3 mm. Recurrent bleeding and inflammation cause fibrosis and hemosiderin deposition, leading to a raised nodular "powder burn" lesion. **.**

Endometriomas

Endometriomas ("chocolate cysts") of the ovary contain dark gelatinous material surrounded by a fibrous wall of variable thickness. Endometriomas are usually multiple and bilateral. They have characteristically high concentrations of intracystic methemoglobin and other protein or iron products **.**

The blood products are in various stages of degradation from multiple episodes of bleeding. As free water in the cyst is resorbed, the concentration of iron increases along with the viscosity of the cyst contents ***(Gougoutas et al 2000).***

Takahashi et al, (1996) have shown the echogenicity (chronicity) of cyst contents to be directly proportional to the iron concentration.