INTRODUCTION

Endometriosis is a chronic gynecologic disorder that is characterized by the growth of endometrial tissue outside the uterine cavity, primarily as implants in the pelvic peritoneum and ovaries ***(Bulun, 2009).***

This ectopic endometrium responds to hormonal stimulation with various degrees of cyclic hemorrhage, resulting in symptoms and imaging features that suggest the diagnosis of the condition ***(Gougoutas et al., 2000).***

Deeply infiltrating endometriosis, which is manifested as invasive tissue that infiltrates adjacent structures at a depth of more than 5 mm from the peritoneal surface, is associated with fibrosis and muscular hyperplasia. Ovarian lesions are characterized by cysts with hemorrhagic content ***(Bulun, 2009).***

Endometriosis affects approximately 10% of women of reproductive age. It is found in 20%–50% of women with infertility and nearly 90% of women with chronic pelvic pain. Women who have a first-degree relative with the disease reportedly have a risk for endometriosis that is 10 times that of women without such a relation. There is also a strong concordance in monozygotic twins ***(Bedaiwy et al., 2006).***

The pathogenesis of endometriosis is complex and has not yet been fully elucidated. Several pathogenic processes have been hypothesized, including implantation of endometrial glands and stroma on the peritoneum from retrograde menstruation, hematogenous and lymphatic dissemination, celomic metaplasia, stem cell migration from bone marrow, epigenetic factors, and polygenic-multifactorial inheritance Chronic inflammatory insults caused by the augmented number of activated macrophages and peritoneal cytokines may lead to pain and infertility. Pain arises through several mechanisms, such as an increased density of peritoneal nerve fibers in patients with deeply infiltrating endometriosis ***(Anaf et al., 2002).***

Secondary dysmenorrhea, deep dyspareunia, sacral backache with menses, perimenstrual diarrhea, cramping and dyschezia, dysuria, and hematuria are the most common and relevant clinical manifestations. Endometriosis-related pain may not correlate with the disease stage but may be associated with the lesion infiltration depth ***(Chapron et al., 2002).***

A definitive diagnosis of endometriosis is based on histologic confirmation of surgically resected lesions containing endometrial glands and stroma with various amounts of inflammation and fibrosis. A presumptive diagnosis of deeply infiltrating endometriosis may be developed on the basis of imaging with transvaginal ultrasonography (US), transrectal US, rectal endoscopic US, or magnetic resonance (MR)

imaging, all of which have been used for this purpose. Physical examination is often inadequate because of the multiplicity of lesions, most of which are inaccessible to digital pelvic examination. For many years, laparotomy and laparoscopy were the only means of access to pelvic endometriotic lesions ***(Chapron et al., 2002).***

MR imaging provides comprehensive depiction of deeply infiltrating endometriotic lesions in pelvic and subperitoneal areas that are not easily accessible laparoscopically. It is considered an excellent method for identifying the old hemorrhagic content that characterizes endometriomas and for mapping multiple deeply infiltrating endometrial implants, given its large field of view, multiplanar capabilities, and outstanding contrast resolution ***(Bazot et al., 2009).***

AIM OF THE STUDY

The aim of the study is to describe the role of pelvic MR imaging in the investigation of endometriosis, define optimal protocols for evaluating endometriosis using the different MRI techniques and recognize the imaging features that are indicative of endometriosis.

Chapter (I)

ANATOMICAL BACKGROUND

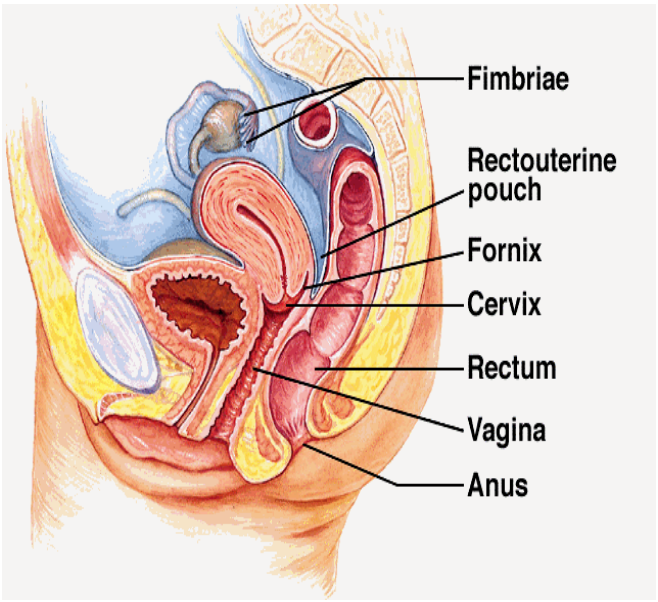

Figure (1.1): Anatomy of female reproductive system ***(Gray, 2001).***

The Uterus

The uterus is an extraperitoneal pear-shaped muscular organ lying between the bladder and rectum. It has a fundus, a body and a cervix. It lies on the posterosuperior surface of the bladder with its cervix projecting into the anterior wall of the upper vagina. The cavity of the uterus is triangular in coronal section, but its anterior and posterior walls are apposed, giving it a slit-like appearance in the sagittal plane. The uterine tubes open into the cornua of the uterus superolaterally. The uterus leads to the vagina via the cervical canal. Just above the cervical canal the uterine cavity narrows to an isthmus. The

internal os is at the upper end of the cervical canal and the external os at its lower end ***(Ryan et al., 2007).***

Peritoneum covers the fundus, body, cervix and upper part of the vagina posteriorly. From here it is reflected on to the anterior surface of the rectum, forming the pouch of Douglas. Anteriorly, the peritoneum is reflected from the upper part of the body to the superior surface of the bladder. On either side of the uterus the peritoneum is reflected to the lateral pelvic walls covering the fallopian tubes. The fold of peritoneum so formed is called the broad ligament **(fig. 1.2)** ***(Ryan et al., 2007).***

Ligaments of the Uterus

The ligaments of the uterus are eight in number: one anterior; one posterior, two lateral or broad; two uterosacral, and two round ligaments.

The anterior ligament consists of the vesicouterine fold of peritoneum, which is reflected on to the bladder from the front of the uterus, at the junction of the cervix and body ***(Gray, 2001).***

The posterior ligament consists of the rectovaginal fold of peritoneum, which is reflected from the back of the posterior fornix of the vagina on to the front of the rectum. It forms the bottom of a deep pouch called the recto-uterine excavation, which is bounded in front by the posterior wall of the uterus, the supra-vaginal cervix, and the posterior fornix of

the vagina; behind, by the rectum; and laterally by two crescentic folds of peritoneum which pass backward from the cervix uteri on either side of the rectum to the posterior wall of the pelvis. These folds are named the sacrogenital or recto-uterine folds. They contain a considerable amount of fibrous tissue and non-striped muscular fibers which are attached to the front of the sacrum and constitute the uterosacral ligaments ***(Cunningham et al., 2005).***

The two lateral or broad ligaments pass from the sides of the uterus to the lateral walls of the pelvis. Together with the uterus they form a septum across the female pelvis, dividing that cavity into two portions. Between the two layers of each broad ligament are contained: (1) the uterine tube superiorly; (2) the round ligament of the uterus; (3) the ovary and its ligament; (4) connective tissue; (5) unstriped muscular fibers; and (6) blood vessels and nerves. The portion of the broad ligament which stretches from the uterine tube to the level of the ovary is known by the name of the mesosalpinx. Between the fimbriated extremity of the tube and the lower attachment of the broad ligament is a concave rounded margin, called the infundibulopelvic ligament ***(Cunningham et al., 2005).***

The round ligaments (ligamentum teres uteri) are two flattened bands between 10 and 12 cm. in length, situated between the layers of the broad ligament in front of and below the uterine tubes. Commencing on either side at the lateral angle of the uterus, this ligament is directed forward, upward,

and lateral over the external iliac vessels. It then passes through the abdominal inguinal ring and along the inguinal canal to the labium majus, in which it becomes lost ***(Gray, 2001).***

In addition to the ligaments just described, there is a band named the ligamentum transversalis colli (Mackenrodt) on either side of the cervix uteri. It is attached to the side of the cervix uteri and to the vault and lateral fornix of the vagina, and is continuous externally with the fibrous tissue which surrounds the pelvic blood vessels ***(Gray, 2001).***

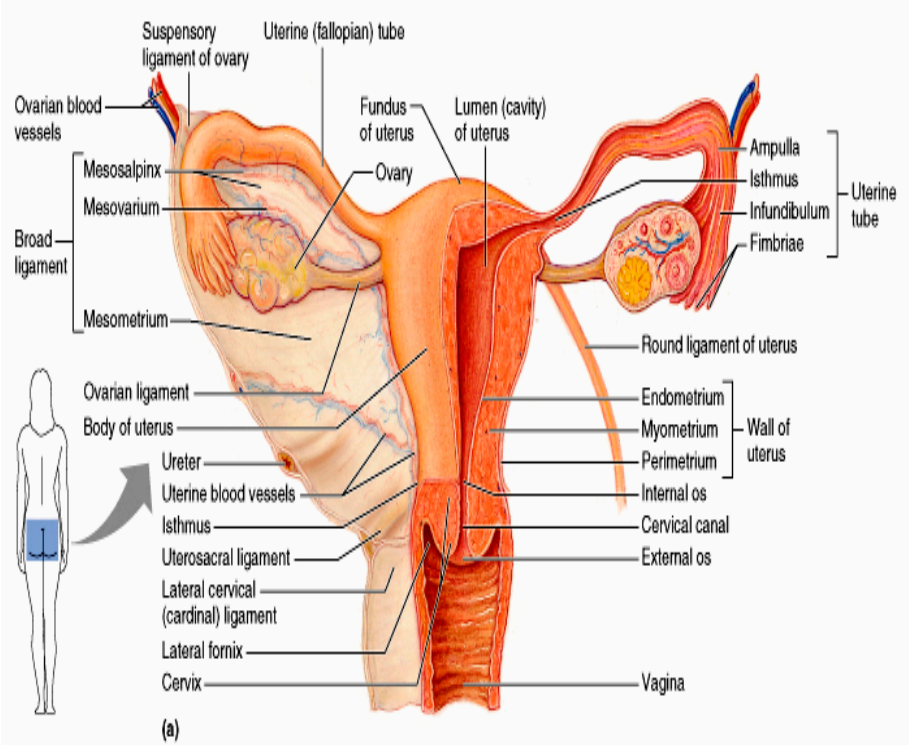

Figure (1.2): The uterus & the uterine ligaments ***(Gray, 2001).***

Layers of the Uterus

I. Perimetrium

The serosal layer is formed by the peritoneum that covers the uterus. It is firmly adherent except at sites just above the bladder and at the lateral margins, where the peritoneum is deflected to form the broad ligaments ***(Cunningham et al., 2005)***.

II. Myometrium

The myometrium makes up the major portion of the uterus. It is composed of bundles of smooth muscle united by connective tissue in which there are many elastic fibers. The number of muscle fibers of the uterus progressively diminishes caudally such that, in the cervix, muscle comprises only 10 percent of the tissue mass. In the inner wall of the body of the uterus, there is relatively more muscle than in the outer layers; and in the anterior and posterior walls, there is more muscle than in the lateral walls ***(Cunningham et al., 2005).***

III. Endometrium

This mucosal layer lines the uterine cavity. It is a thin, pink, velvet-like membrane that on close examination is found to be perforated by a large number of minute ostia of the uterine glands. The endometrium normally varies greatly in thickness, and measures from 0.5 mm to as much as 5 mm. It is composed of surface epithelium, glands, and interglandular

mesenchymal tissue in which there are numerous blood vessels ***(Cunningham et al., 2005).***

The epithelium of the endometrial surface is made up of a single layer of closely packed, high columnar, ciliated cells. The tubular *uterine glands* are invaginations of the epithelium. The glands extend through the entire thickness of the endometrium to the myometrium, which is occasionally penetrated for a short distance ***(Kim et al., 2009).***

Histologically, the inner glands resemble the epithelium of the surface and are lined by a single layer of columnar, partially ciliated epithelium that rests on a thin basement membrane. The glands secrete a thin, alkaline fluid. The connective tissue of the endometrium, between the surface epithelium and the myometrium, is a mesenchymal stroma **(Fig. 3)** ***(Cunningham et al., 2005).***

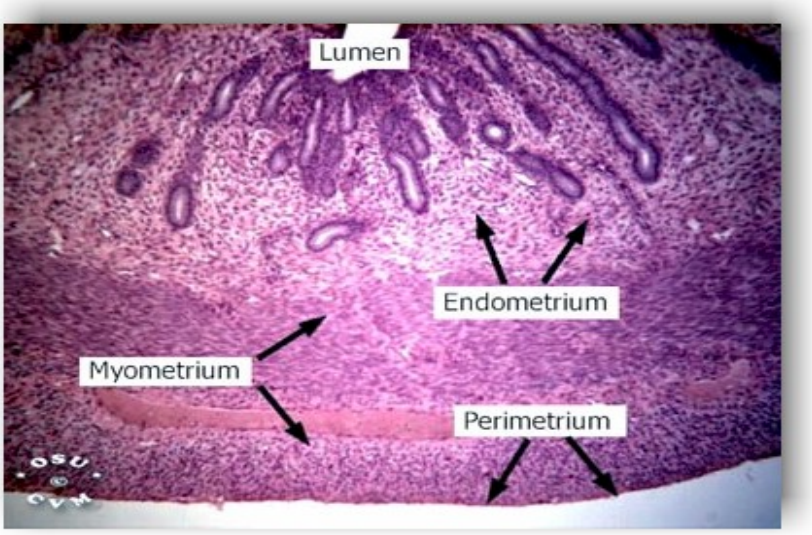

Figure (1.3): Layers of the uterus ***(Cunningham et al., 2005).***

The 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 ***(Anderson et al., 2002).***

They are composed of four segments (from the medial aspect to the lateral aspect):

- The intramural (uterine and interstitial) portion.
- The isthmus.
- The ampulla.
- The infundibulum at the fimbriated end ***(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.

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

The Cervix

The upper boundary of the cervix is the internal os, which corresponds to the level at which the peritoneum is reflected upon the bladder. The supravaginal segment is covered by peritoneum on its posterior surface. This segment is attached to the cardinal ligaments anteriorly, and it is separated from the overlying bladder by loose connective tissue. The other segment is the lower vaginal portion of the cervix, also called the portiovaginalis ***(Gray, 2001).***

The mucosa of the cervical canal is composed of a single layer of very high ciliated columnar epithelium that rests on a thin basement membrane, while The stroma of the cervix is composed of dense, fibro-muscular tissue through which vascular, lymphatic and nerve supplies pass to the cervix and form a complex plexus ***(Cunningham et al., 2005).***

Blood Supply of the Uterus, Fallopian Tubes & Cervix

The uterine artery, a branch of the internal iliac, runs medially in the base of the broad ligament to reach the lower lateral wall of the uterus. It ascends tortuously within the broad ligament to supply the uterus and tubes and anastomoses with the ovarian artery **(Fig. 1.4).**

Venous drainage is via a venous plexus in the base of the broad ligament to the internal iliac vein ***(Gray, 2001).***

Lymph drainage

The fundus drains along ovarian vessels to para-aortic nodes. The body drains via the broad ligament to nodes around the external iliac vessels and occasionally via the round ligament to inguinal nodes. The cervix drains to external and internal iliac nodes and posteriorly to sacral nodes ***(Gray, 2001).***

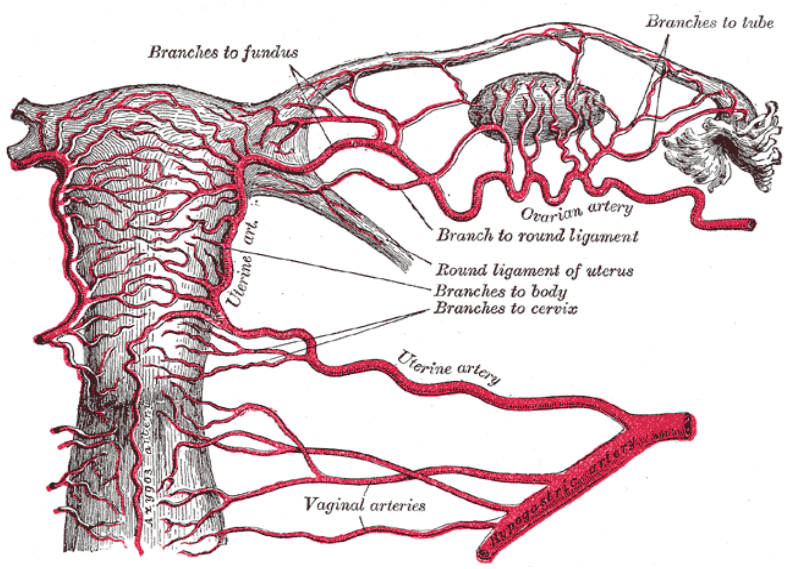

Figure (1.4): Blood supply of the uterus ***(Gray, 2001).***

The Vagina

This musculo-membranous structure extends from the vulva to the uterus and is interposed anteriorly and posteriorly between the urinary bladder and the rectum **(Fig. 1.1).** The upper portion of the vagina arises from the mullerian ducts, and the lower portion is formed from the urogenital sinus. Anteriorly, the vagina is separated from the bladder and urethra by connective tissue, often referred to as the vesicovaginal septum. Posteriorly, between the lower portion of the vagina and the rectum, there are similar tissues that together form the rectovaginal septum. The upper fourth of the vagina is separated from the rectum by the recto-uterine pouch, also called the cul-de-sac of Douglas ***(Gray, 2001).***

Normally, the anterior and posterior vaginal walls lie in contact, with only a slight space intervening between the lateral margins. Vaginal length varies considerably, but commonly, the anterior and posterior vaginal walls are, respectively, 6 to 8cm and 7 to 10 cm in length. The upper end of the vaginal vault is subdivided into anterior, posterior, and two lateral fornices by the uterine cervix ***(Cunningham et al., 2005).***

Blood Supply of the Vagina

- The upper third is supplied by the cervico-vaginal branches of the uterine arteries
- The middle third is supplied by the inferior vesical arteries.
- The lower third by the middle rectal and internal pudendal arteries. The vaginal artery may branch directly from the internal iliac artery.

An extensive venous plexus immediately surrounds the vagina and follows the course of the arteries ***(Kim et al., 2009).***

Lymph drainage

- Lymphatics from the lower third of the vagina, along with those of the vulva, drain primarily into the inguinal lymph nodes.
- Those from the middle third drain into the internal iliac nodes.
- Those from the upper third drain into the iliac nodes ***(Cunningham et al., 2005).***