Introduction

Obstetric hemorrhage is a significant cause of maternal morbidity and mortality throughout the world. Causes of hemorrhage include uterine atony, retained products of conception, and lacerations to the birth canal. If local measures to control bleeding are unsuccessful, bilateral uterine or hypogastric artery ligation may be attempted. However, because of the extensive collateral circulation in the pelvis, the success rate of this approach may be as low as 42%. Hysterectomy often follows, but there are reports of persistent bleeding after both arterial ligation and hysterectomy. Arterial embolization may be performed as alternative management ***(Wee et al., 2004)***.

Despite advances in medical, surgical and endovascular therapy, which have decreased the maternal mortality rate by 99% during the past century, obstetric hemorrhage continues to be a leading cause of maternal morbidity and mortality. The incidence of obstetric hemorrhage varies depending on the definition used ***(Ganguli et al., 2009)***.

Postpartum hemorrhage (PPH), defined as blood loss exceeding 500 mL after vaginal delivery, and greater than 1000 ml blood loss after Caesarean delivery. This may be early within the first 24 hours, or late between 24 hours and 6 weeks after delivery. It is a common entity that complicates as many as 18% of all deliveries. More severe obstetric hemorrhage, defined as blood loss in excess of 1,000 mL, may occur in 1%–5% of all deliveries. Obstetric hemorrhage continues to be the single most important cause of maternal mortality worldwide, accounting for 25%–30% of all maternal deaths, and it represents the most common maternal morbidity in the developed world ***(Ganguli et al., 2009)***.

When hemorrhage is severe, successful treatment relies on timely recognition and intervention with appropriate maneuvers. These include excluding retained products of conception and suturing lacerations to the birth canal. At the same time, the uterus should be massaged and oxytocic drugs administered. Blood should be taken for hemoglobin and/or hematocrit estimation plus coagulation studies and cross matching. If uterine atony persists despite pharmacological intervention or if excessive bleeding continues in the face of adequate uterine tone, more aggressive methods of hemostasis may be required. Uterine examination should be undertaken and surgical intervention performed if bleeding persists ***(Hayman et al., 2002).***

The definitive treatment for severe postpartum hemorrhage is hysterectomy, but this renders the woman infertile so other surgical procedures may be considered initially. Packing and other forms of uterine tamponade may be used but advanced surgical techniques may be necessary. Ligation of the uterine arteries or hypogastric arteries may be performed; both operations require laparotomies with the associated risks and increased length of hospital stay. Bilateral hypogastric artery ligation has a success rate less than uterine artery ligation. Both these techniques aim to leave the uterus intact and preserve fertility. Bilateral uterine artery ligation is preferred to hypogastric artery ligation because of its overall higher success rate with lower morbidity ***(Wee et al., 2004)***.

Transcatheter arterial embolization has been a recognized method of hemorrhage control since the 1960s ***(Miller et al., 1967)***, and has been used in the control of pelvic hemorrhage due to malignancy, trauma and radiation. More recently, this technique has been used successfully in the control of postpartum hemorrhage, with the first such reported use in 1979 ***(Heaston et al., 1979)***.

Uterine artery embolization (UAE) has several advantages, including easy identification of the bleeding site, preservation of the uterus and fertility, and decreased rebleeding from collaterals with more distal occlusion of the bleeding vessels. UAE has been shown to be associated with high technical success rates and good clinical outcomes for the treatment of primary and secondary PPH. However, optimal patient selection and the appropriate position of UAE in the treatment decision tree for PPH remain to be elucidated ***(Ganguli et al., 2009)***.

Aim of the Work

The aim of this work is to evaluate the clinical effectiveness and safety of uterine artery embolization (UAE) in the treatment of postpartum hemorrhage (PPH) using gel foam pledges as a temporary embolic agent.

Chapter (1): Anatomy of the Uterus

A) Gross anatomy of the uterus:

Definition

The uterus is a hollow, thick-walled, extra peritoneal and flattened pear-shaped muscular organ ***(Klüner and Hamm, 2007).***

Dimensions

In women of reproductive age, the uterus usually is 6–9 cm long and weighs 40–60 gm ***(Klüner and Hamm, 2007).***

Orientation

The longitudinal axis is flexed forward (anteversion) with the corpus and cervix forming a blunt angle (anteflection) ***(Figure 1-1).*** The uterus straightens with increasing bladder filling and the anteversion angle becomes smaller ***(Klüner and Hamm, 2007).***

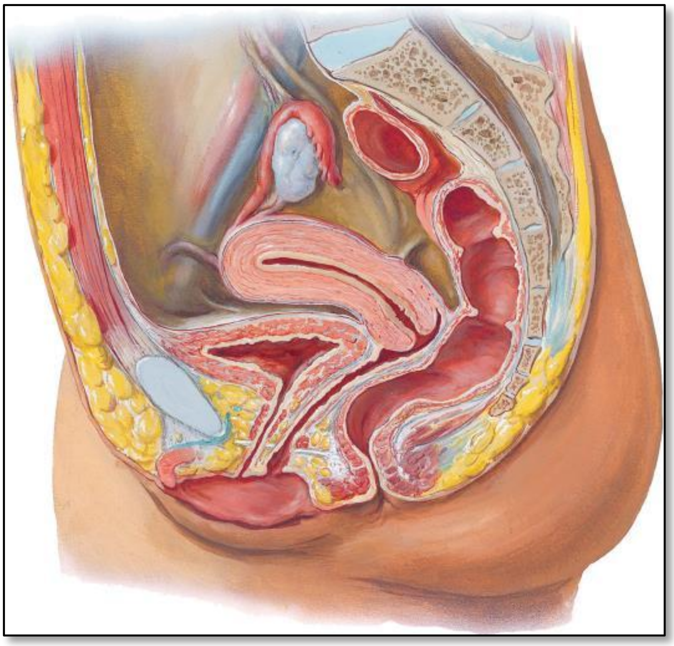

Figure (1-1): Sagittal section through the female pelvis. Note the anteversion and anteflection angles ***(Quoted from Netter, 2014).***

Parts

The uterus is composed of three distinct anatomic regions; namely the corpus, the isthmus (or lower uterine segment), and the cervix (Figure 1-2) ***(Klüner and Hamm, 2007).***

Layers

The uterine wall is composed of three main layers, from its lumen outwards these are the endometrium (mucosa), myometrium (smooth muscle layer) and perimetrium (serosa) or adventitia depending on region. The myometrium is far the largest component ***(Salem and Wilson, 2005).***

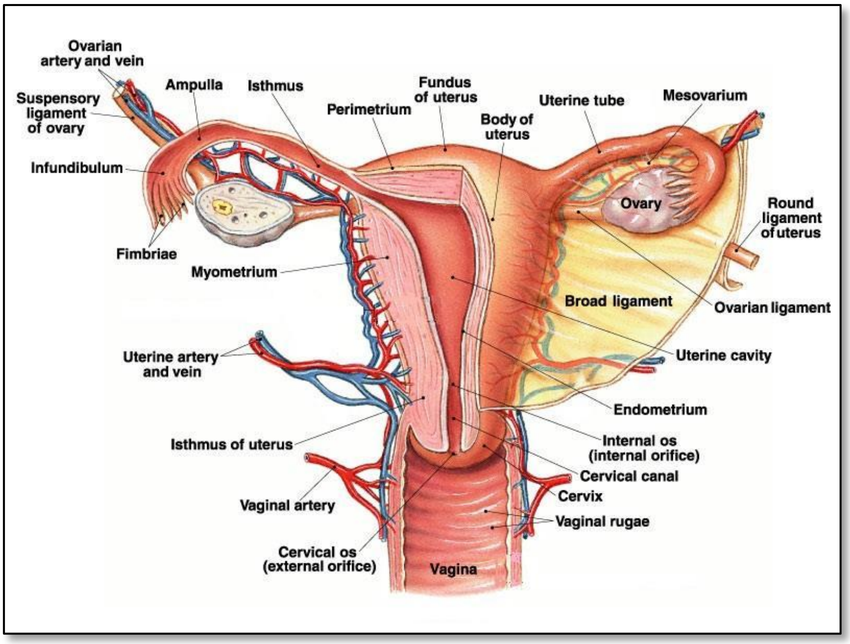

Figure (1-2): Diagrammatic representation of the uterus showing its parts, layers and blood supply ***(Quoted from Ryan et al., 2004).***

Nerves of the uterus:

The autonomic supply comes from the ovarian and hypogastric plexuses. Sympathetic preganglionic fibers proceed from the twelfth thoracic and first lumbar spinal segments while parasympathetic preganglionic axons issue in the second to fourth sacral spinal roots ***(Traurig et al., 1991).***

Pain from the cervix is considered to be carried by the pelvic splanchnic nerves, or run with sympathetic nerves as does pain from the body of the uterus. The cord segments concerned are from tenth thoracic to first lumbar ***(Bannister et al., 1995).***

Arterial supply of the uterus

The arteries of the uterus are the uterine, from the internal iliac artery, and the ovarian, from the abdominal aorta ***(Figure 1-3)***. They are remarkable for their tortuous course in the substance of the organ, and for their frequent anastomoses. The uterine arteries pass medially from the pelvic sidewalls and run to the lateral borders of the cervix. Here, each divides into a descending vaginal branch and a larger uterine branch that ascends along the lateral margin of the uterus supplying it by curving branches known as arcuate artery. The terminal portion of the main trunks continues along the fallopian tubes each ending in small ovarian branches. The termination of the ovarian artery meets that of the uterine artery ***(David and Nayna, 2001)***.

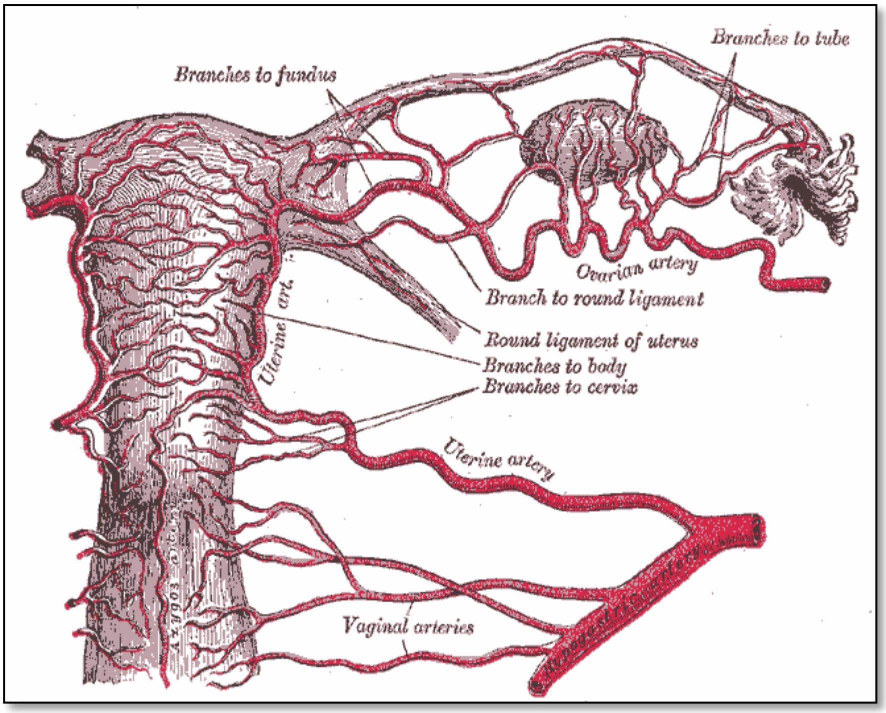

Figure (1-3): The arteries of the internal genital organs of the female, seen from behind ***(Quoted from Williams and Pallerito, 2005).***

Uterine Artery

The uterine artery is the second branch of the anterior division of the internal iliac artery (after the inferior gluteal artery) in 51% of cases. In 6% of cases, the uterine artery is the first branch of the internal iliac artery above the level of the inferior gluteal and superior gluteal arteries. The uterine artery has a characteristic *U* shape, with a descending segment that parallels the lateral pelvic wall, a transverse segment that crosses the distal ureter at the level of the cervix, and an ascending segment that courses along the uterine margin at the medial edge of the broad ligament.

The uterine artery may have a common trunk with the vesical or vaginal artery. The uterine artery has several branches: the cervicovaginal artery, which arises from the transverse segment and which should be spared during embolization, and the intramural (arcuate) arteries, which course through the outer third of the myometrium. The uterine artery may be replaced by small arterial branches or may be absent; it is often replaced by the ipsilateral ovarian artery. The congenital absence of both uterine arteries is encountered in less than 1% of cases. The presence of aberrant uterine vessels that originate in the abdominal aorta also has been reported ***(Pelage et al., 2005).***

Arterial Anastomoses between ovarian and uterine arteries:

There are two different types of arterial anastomoses between the uterine arteries and the ovarian arteries: left-to-right anastomoses (between the left and the right uterine arteries) and utero-ovarian anastomoses (between the uterine artery and the ovarian artery). Left-to-right anastomoses is visible in about 10% of cases, and utero-ovarian anastomoses is identified in 10%-30% of cases. Retrograde filling of the ovarian artery is sometimes observed when contrast material is selectively injected via the ipsilateral uterine artery. The ovary itself is occasionally depicted. The usual diameter of the utero-ovarian anastomoses has been estimated to be less than 500 µm ***(Pelage et al., 2005).***

Venous drainage:

The veins are of large size, and correspond with the arteries. They end in the uterine plexuses. In the impregnated uterus the arteries carry the blood to, and the veins convey it away from, the intervillous space of the placenta ***(Moore, 1998).***

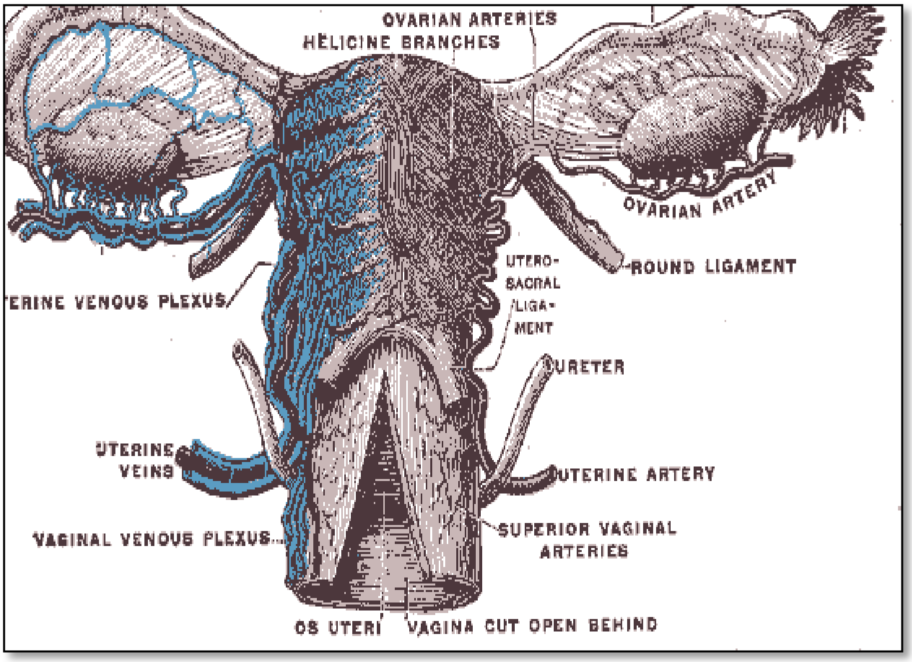

Figure (1-4): Vessles of the uterus and its appendages ***(Quoted from Williams et al., 1995).***

The lymphatics

The lymphatic vessels of the uterus consist of two sets, superficial (subperitoneal) and deep in the uterine wall ***(Williams and Pallerito, 2005).***

The vessels of the upper part of the body and fundus of the uterus pass lateral ward in the broad ligaments, and are continued up with the ovarian vessels to the lateral and pre-aortic glands; a few, however, run to the external iliac glands, and one or two to the superficial inguinal glands ***(Williams et al., 1995).***

Vessels from the lower part of the uterine body pass mostly to the external iliac nodes with those from the cervix ***(Moore, 1998).***

The lymphatic vessels of the uterine tube pass partly with those of the ovary and partly with those of the uterus ***(Williams et al., 1995).***

B) Radiological Anatomy of the Uterus

Ultrasound

- ***Size***

Length: The distance from the fundus to the internal orifice of the uterus on a sagittal view; the mean measurement of a reproductive age patient is 70 mm, while that of a menopausal patient is 50 mm ***(Figure 1-5a).***

Width: The maximum anterior-posterior distance measured in the mid portion of the uterine body also on a sagittal view; the mean measurement of a reproductive age patient is 35 mm, while that of a menopausal patient is 20 mm.

Thickness: The maximum distance measured at the level of the uterine fundus on a transverse view; the mean measurement of a reproductive age patient is 50 mm, while that of a menopausal patient is 25 mm ***(Figure 1-5b) (Mihu and Mihu, 2011).***

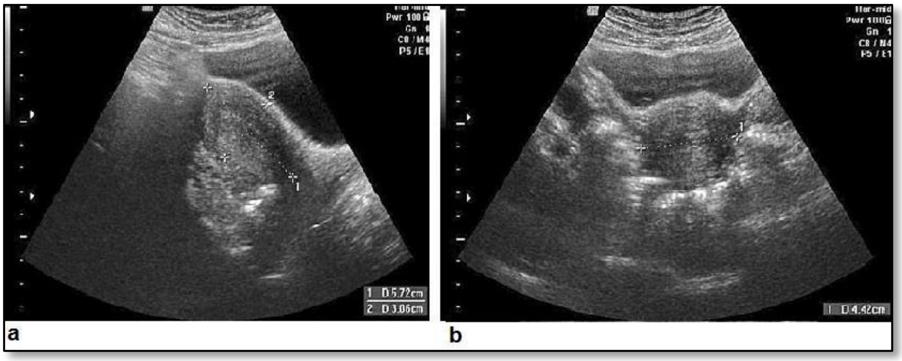

Figure (1-5): Uterine dimensions. Transabdominal US (a) sagittal view: width and length (b) transverse view: thickness in a transverse view ***(Quoted from Mihu and Mihu, 2011).***

- ***Position***

Anteverted-anteflexed,

When the uterine body found in the vesico-uterine space, is the most frequent situation ***(Figure 1-6).***

Retroverted-retroflexed,

When the uterine body is situated in the Douglas pouch.

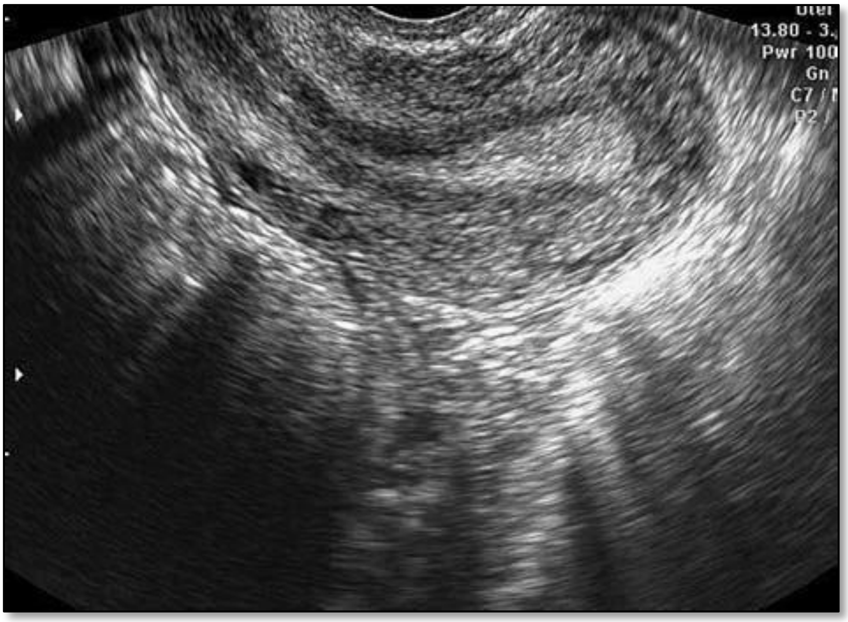

Figure (1-6): Normal position and internal structure of the uterus on endovaginal ultrasonography ***(Quoted from Mihu and Mihu, 2011).***

- ***Internal structure***

The myometrium has a homogeneous structure, with fine, parallel, linear echoes. The hyperechoic area in the middle is the uterine cavity ***(Figure 1-7a).***

The endometrium is evaluated on a sagittal view. The thickness and the echogenicity of the endometrium varies with the different stages of the menstrual cycle ***(Figure 1-7b) (Mihu and Mihu, 2011).***

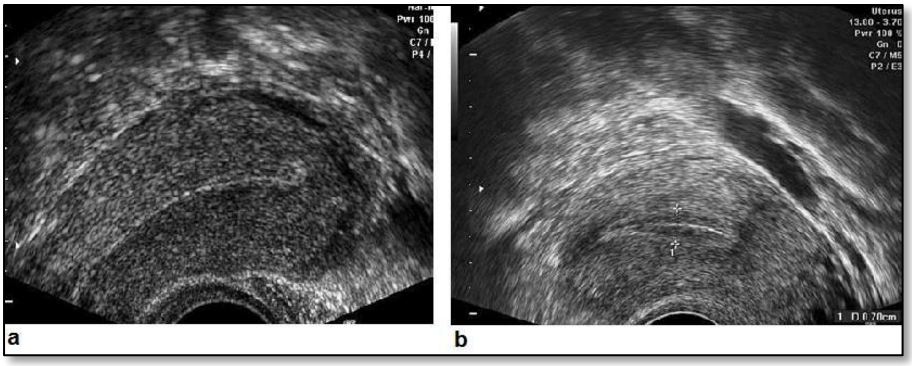

Figure (1-7): Endovaginal ultrasonography. (a) uterine cavity line (arrow), (b) endometrium thickness (double layer) ***(Quoted from Mihu and Mihu, 2011).***

CT

- ***Unenhanced***

On unenhanced CT scans, the layered anatomy of the wall cannot be distinguished ***(Figure 1-8a) (Klüner and Hamm, 2007).***

- ***Contrast-enhanced***

After administration of contrast medium, the myometrium can be distinguished in most cases during the arterial phase as it shows early and strong enhancement while the junctional zone/endometrium is of relatively low density ***(Figure 1-8b) (Klüner and Hamm, 2007).***