DEFINITION
Menstruation is the bleeding and shedding of the endometrial lining that occurs at approximately monthly intervals from menarche to menopause.

- **Menarche**: the onset of menses usually occurring between 11-14 years
- **Menopause**: termination of regular menses usually occurring at 45-55 years
- **Premature menopause**: termination of regular menses prior to 40 years

HORMONAL REGULATION
The endometrium responds to estrogen and progesterone levels in the blood. These levels are determined by a feedback mechanism between the ovaries and the hypothalamus/pituitary complex. When serum estradiol levels fall below a given concentration, the hypothalamus elaborates releasing hormone (GnRH) which in turn signals the pituitary gland to secrete the pituitary gonadotropins: follicle stimulating hormone (FSH) and luteinizing hormone (LH).

- **Follicle stimulating hormone**: stimulates growth and development of ovarian follicles. As follicles grow, increasing estradiol levels within the follicles help them respond to LH with eventual ovulation. The follicles also produce estrogen which stimulates endometrial growth.

- **Luteinizing hormone**: stimulates maturation and ovulation of the Graafian follicle and subsequent development of the corpus luteum. Stimulates progesterone production which peaks after ovulation. When implantation of a conceptus occurs in the endometrium, hCG production signals the corpus luteum to continue secreting progesterone to prevent shedding of the endometrial lining. When implantation does not occur, decreasing progesterone levels permit sloughing of the uterine lining.
**Ovarian Response**

Under the influence of the pituitary hormones, the ovaries go through three phases during a normal cycle:

- **FOLLICULAR (DAYS 1 - 14)**
  Varying number (usually 5 - 8) follicles may be identified with EV sonography in each ovary. Dominant follicle may identified by about day 8 and measures approximately 10mm. Its size begins to exceed that of other antral follicles. Other sonographic considerations of a dominant follicle:
  - Any follicle measuring > 11mm will most likely ovulate
  - Grows linearly (approx. 2 - 3 mm/day)
  - Maximum diameter varies between 15 - 30mm
  - Line of decreased reflectivity around follicle suggest ovulation will occur within 24 hours
  - Presence of cumulus oophorus suggests ovulation will occur within 36 hours

Sonographic demonstration of follicular growth through the antral stage.  
*Right:* small, preantral follicle (outlined in blue)  
*Center:* larger, smoothly margined, anechoic fluid-filled follicles  
*Left:* antral follicles beneath the ovarian capsule

Cumulus oophorus seen in mature ovarian follicle (Graffian follicle).
**OVULATORY (DAY 14)**
Ovulation occurs within 24 - 36 hours after onset of the LH surge. Sonographic findings that ovulation has occurred may include:
- Sudden decrease in follicular size
- Fluid in cul de sac

Transverse sonogram through the uterus showing a small amount of fluid in cul de sac following ovulation. (arrow)

**LUTEAL (DAYS 15 - 28)**
Involution of the follicle into a corpus luteum (yellow body). This structure produces progesterone which will maintain the secretory endometrium should implantation occur. In the absence of hCG, the corpus luteum regresses after 14 days. Sonography may reveal:
- Replacement of dominant, cystic follicle with echogenic structure representing thrombus
- Small, irregular cystic mass with crenated borders

Corpus luteum (outlined in blue).
*Left:* histological section showing corpus luteum (cl) and primordial follicles (pf) with numerous immature follicles present.
*Right:* endovaginal sonogram demonstrating an involuting corpus luteum.
**Uterine Response**

Menstruation is a catabolic process whereby the endometrial lining is shed if implantation of a conceptus has not occurred. The sonographic changes seen during the menstrual cycle may be correlated with the histology of the various phases. There are three phases:

**MENSTRUAL (DAYS 1 - 5)**

The endometrium become ischemic, degenerates, sloughs off the myometrium and is expelled as menses. The pattern of menstrual bleeding is varied but typically begins with 12 - 24 hours of heavy flow followed by scanty flow for 4 - 7 days.

**SONOGRAPHIC FINDINGS:**
- Thickened, echogenic endometrium prior to start of menses
- Complex appearance at beginning of menses
- Thin, slightly irregular endometrium after shedding of endometrium
- Maximum AP diameter (post menses) 2mm

**PROLIFERATIVE (DAYS 6 - 14)**

The regrowth of the endometrium in response to estrogen released by ovarian follicles. Begins on fourth or fifth day after the beginning of a period. Lasts about 10 days and ends at ovulation.

**SONOGRAPHIC FINDINGS:**
- Hypoechoic area around prominent midline echo, early phase
- “Laminar” appearance of endometrium
- Thickened, isoechoic endometrium, late phase
- Maximum AP diameter 6 - 8mm

**SECRETORY (DAYS 15 - 28)**

begins at ovulation. No gross histologic changes can be observed in the endometrium. Changes occur in the endometrium as a result of glandular and vascular alterations. In the absence of fertilization and implantation, the corpus luteum regresses and estrogen and progesterone levels fall.
SONOGRAPHIC FINDINGS:
- Hyperechoic endometrium with obscured midline
- Loss of “laminar” appearance
- Maximum AP diameter 10 - 12mm

Abnormal Menstrual Patterns
May be categorized as abnormalities of VOLUME or FREQUENCY

HYPERMENORRHEA (MENORHAGIA) excessive volume during cyclic menstrual bleeding

HYPOMENORRHEA an abnormally small amount of menstrual bleeding

POLYMENORRHEA frequent menstrual bleeding occurring at less than 21 days apart

OLIGOMENORRHEA menstrual bleeding occurring more than 35 days apart

MENOMETRORRHAGIA bleeding that is irregular in both frequency and volume

AMENORRHEA the absence of menstrual flow. Two categories:

Primary: patient has never had a period
Secondary: patient had periods but they stopped

Dysfunctional Uterine Bleeding
Vaginal bleeding NOT related to estrus or endometrial pathology. Causes may be functional or organic and include: endocrine disorders, endometrial disorders, many others.
There are many causes for infertility. Approximately 40% are due to female factors, 40% to male factors, 5-10% are related to both partners, and 5-10% remain unexplained. Female factors include:

- ANOVULATION AND ABNORMAL OVULATION
- TUBAL AND TRANSPORT FACTORS
- ENDOMETRIOSIS
- UTERINE FACTORS
- POLYCYSTIC OVARY DISEASE
- OTHERS

Management options of infertility include: artificial insemination, ovulation induction alone or in conjunction with other techniques. These other techniques may include:

- **In Vitro Fertilization (IVF):** a variety of techniques exist for the *in vitro* assistance of fertilization including oocyte retrieval/harvesting and deposition of gametes or zygotes into the uterus.
- **Gamete Intrafallopian Tube Transfer (GIFT):** sperm and ova are placed into fallopian tube via EV guided cannulization.
- **Zygote Intrafallopian** tube transfer (ZIFT): embryo (or zygote) is placed into fallopian tube via EV guided cannulization.

**OVULATION INDUCTION**

Several pharmacologic agents can be used to induce superovulation and increase the chances of fertilization.

- **Clomid** (clomiphene citrate, CC) increases FSH secretion which stimulates more primary follicles. hCG is given to induce final follicular and oocyte maturation.

- **Pergonal** (human menstrual gonadotropin, hMG) contains equal parts of FSH and LH. Since more complications are encountered with this agent it is used only in selected patients.

Since these agents stimulate follicular growth and development, multiple cystic follicles may be seen bilaterally with ultrasound.
SONOGRAPHY

Sonography is used in *in vitro* fertilization programs to:

- **Establish** normal uterine anatomy and expected physiologic changes during the menstrual cycle
- **Monitor** the development of the growing follicles
- **Confirm** ovarian response to various drugs (Clomid, Pergonal) to induce ovulation
- **Identify** hyperstimulated ovaries

OVULATION MONITORING

Endovaginal sonography (EVS) is the method of choice for monitoring follicular development. Follicles are typically aspirated for IVF when they measure 18 - 24mm.

**IVF Sonographic Protocol**

- Baseline transabdominal sonogram
- Preliminary EV evaluation of follicles
- Daily EV to monitor dominant follicle

COMPLICATIONS

OVARIAN HYPERSTIMULATION SYNDROME (OHS)

A condition resulting from the excessive stimulation of the ovaries, OHS most commonly occurs in women taking infertility drugs. Mild cases usually resolve spontaneously following the next menstrual cycle. More severe cases are associated with a high mortality rate (50%) and require hospitalization for correction of fluid and electrolyte imbalances.

**Sonographic appearance:**

- Large simple cysts
- Bilateral
- Resemble theca lutein cysts

MULTIPLE GESTATIONS

Incidence of multiple gestations is increasing with more prevalent and more successful infertility treatment. Multiple gestations can complicate pregnancy by impacting maternal health and well-being, fetal outcome (including prematurity) and associated costs that are often incurred.
**Contraception**

**INTRAUTERINE CONTRACEPTIVE DEVICES (IUD’s)**

IUD's are infrequently used as a method of contraception in contemporary practice. Many women, however, retain these devices that may have been implanted years in the past. For this reason, a sonographer should be familiar with the most common types of IUD's.

- COPPER 7
- COPPER T
- SAFETY COIL
- LIPPE’S LOOP
- PROGESTASERT
- PARAGARD

**ORAL CONTRACEPTIVE PILLS (OCPs)**

Oral contraceptive pills are synthetic agents similar to natural female sex hormones that prevent contraception by inhibiting ovulation. The most common regimen in the United States is a combined one in which pills containing both estrogen and progestin are taken every day for 20 - 21 days.
SONOGRAPHIC CONSIDERATIONS:
Oral contraceptives may alter the normal sonographic appearance of the uterus and ovaries.

Dominant follicle
Most patients on OCP’s will not develop a dominant follicle and ovulate. However EV imaging may reveal follicles in these patients but they are smaller measuring 5 - 19mm.

Dysfunctional Uterine Bleeding
The endometrial appearance may assist in evaluating therapeutic dosage in patients on OCPs to treat DUB.
- Normal endometrium = single hypoechoic line
- Thick, secretory endometrium = inadequate progesterone
- Very thin endometrium = inadequate progesterone and estrogen
Quick Quiz 1

Time: 5 minutes

1. The ligament that helps suspend the uterus in the pelvis and arises from its lateral aspect and attaches to the pelvic sidewall is the:
   a. round ligament
   b. broad ligament
   c. sacrouterine ligament
   d. suspensory ligament

2. How is the piriformis muscle anatomically related to the levator ani muscles?
   a. inferior, lateral
   b. anterior, lateral
   c. posterior, lateral
   d. posterior, medial
   e. anterior, medial

3. A Müllerian anomaly in which there are two separate and distinct uterine bodies is:
   a. uterus bicornuis
   b. uterus unicornuis
   c. uterus didelphys
   d. uterus pedunculus

4. The widest portion of the uterus is found at the:
   a. fundus
   b. isthmus
   c. mid corpus
   d. cervix

5. When the uterine body and fundus are tilted posteriorly but the cervix maintains normal position, the uterus is correctly described as:
   a. antverted
   b. anteflexed
   c. retroverted
   d. retroflexed
   e. retroverted, retroflexed

6. What is the maximum normal antero-posterior sonographic thickness of the endometrium during the proliferative phase?
   a. 1mm
   b. 4mm
   c. 7mm
   d. 12mm