Ob/Gyn Sonography
AN ILLUSTRATED REVIEW
SECOND EDITION

1-2-3 Step
Ultrasound Education & Test Preparation

Step 1
Review text

Step 2
Mock examination

Step 3
Q&A memory skills
flashcard drill

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Continuing Education Activity
Approved for 15 CME Credits

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Ob/Gyn Sonography

An Illustrated Review

2nd Edition

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The First Trimester

Sonographic Protocols

Normal First Trimester

Abnormal First Trimester—Failed Pregnancy

SONOGRAPHIC PROTOCOLS

During the first trimester of pregnancy, the standard sonographic exam is performed to assess the following:

- Presence of gestational sac
- Size of sac
- Location of sac
- Number of sacs
- Presence of a yolk sac
- Presence of an embryo/fetus
- Cardiac activity (using a two-dimensional video clip or M-mode imaging)

Spectral and color Doppler imaging is avoided whenever possible during the first trimester as it is associated with a higher exposure to acoustic energy. In addition, the examination should assess the following structures:

- Uterus
- Cervix
- Adnexa
- Cul-de-sac
The rest of this chapter rehearses the development of a pregnancy during the first trimester, including both normal and abnormal sonographic findings, targeted protocols, and diagnostic criteria.

**NORMAL FIRST TRIMESTER**

The first trimester of a pregnancy begins with the first day of the woman’s last menstrual period (LMP) and ends 10 weeks later. The end of the first trimester marks the point when all organ systems have been differentiated and are in place and the embryo has become a fetus. It is important to note that, although ovulation typically occurs 14 days after the first day of the menstrual period, the first day of the last menstrual period—not the date of conception—determines the beginning of a pregnancy in clinical obstetrics. The term for the gestational age based on this date is *menstrual age*, and it is this age on which ultrasound charts and biometric measurements are based. Embryologic tests, by contrast, are based on *conceptual age*, the age from conception, which lags behind menstrual age by 2 weeks. Gestational age is covered in more detail later in this chapter.

**PREGNANCY DIAGNOSIS**

Three main diagnostic tools are used in the diagnosis of pregnancy: patient history and physical examination (H&P), laboratory evaluation, and sonography.

**Patient History and Physical Examination**

Assessing the patient’s history—particularly the date of the onset of the last menstrual period, along with information about historical frequency of menstrual periods, flow, and duration—is the initial approach. A missed menstrual period accompanied by nausea, vomiting, generalized malaise, and breast tenderness is often considered diagnostic of early pregnancy. However, normal implantation bleeding, which occurs at about the same time as an expected menstrual period, may confuse the clinical presentation.

A physical examination will reveal a **gravid uterus** (the uterus during pregnancy), which will be enlarged on bimanual examination, and **Chadwick’s sign** (a bluish discoloration of the cervix), which will be observed by 8–10 weeks. **Goodell’s sign** (softening of the vaginal portion of the cervix), **Hegar’s sign** (softening of the uterine isthmus), and hyperpigmentation of the **linea alba** (the fibrous structure that runs down the abdominal midline) are other physical signs associated with early pregnancy.

**Laboratory Evaluation**

Laboratory evaluation typically centers on assays for the beta subunit of human chorionic gonadotropin (beta-hCG) in maternal serum, but other hormones that have been used in the early diagnosis of pregnancy include progesterone and early pregnancy factor.

**Progesterone**

In a normal first trimester pregnancy, progesterone levels rise to multiples of those observed during the nonpregnant state and are an indicator of the integrity of an intrauterine gestation. Typical serum levels range from 10 to 44 nanograms per milliliter (ng/ml); laboratory values less than expected raise suspicion for ectopic pregnancy and are also associated with an increased risk of failed intrauterine pregnancy.

**Early Pregnancy Factor**

*Early pregnancy factor* (EPF) is a protein produced by the conceptus within hours after fertilization and is the earliest laboratory evidence of pregnancy. Because EPF is produced prior to implantation, abnormal values may indicate embryo loss prior to implantation, earlier than can be discerned using hCG and/or progesterone assays. EPF is measured using the rosette inhibition test (RIT), which yields either positive or negative results.¹

**Human Chorionic Gonadotropin**

*Human chorionic gonadotropin* is a glycoprotein similar in structure to follicle-stimulating hormone (FSH), luteinizing hormone (LH), and thyrotropin. It is composed of alpha and beta subunits and can be detected in the maternal serum as early as 6–8 days post conception. *Qualitative* serum beta-hCG testing, which yields a simple positive or negative result, has a threshold of about 25 million International Units per milliliter (mIU/ml). *Quantitative* serum evaluation is more sensitive, with a threshold as low as 1 mIU/ml, and provides a numeric value that can be followed serially and correlated with a normally progressing gestation to rule out a failed pregnancy.

Human chorionic gonadotropin is secreted by physiologically active trophoblastic tissue. Because every intact conceptus, intrauterine or ectopic, contains trophoblastic tissue, the presence of the beta subunit of this glycoprotein hormone in maternal blood is strong evidence of pregnancy. A “negative” beta-hCG blood test (that is, one resulting in undetectable levels by radioimmunoassay) essentially excludes the
diagnosis of a live pregnancy anywhere in the body. “Positive” results, which are evident at approximately 23 menstrual days (9 days post conception), confirm the presence of viable trophoblastic tissue somewhere.

Three different reference standards have been used to measure beta-hCG. The system known as the First International Reference Preparation (1st IRP, sometimes referred to as FIRP) was developed first, and later the Second International Standard (2IS) came into use.\(^2\) In samples that have equivalent beta-hCG levels, the numeric result using the 2IS system is approximately double the result using the 1st IRP system. The Third International Standard (3IS) yields levels similar to those of the 1st IRP, and therefore many labs have reverted to using the 1st IRP in reporting results. While exact values can vary slightly from one laboratory to the next, typical values for the three measuring systems have been established (Table 1-1).

A correlation can be made between sonographic identification of the gestational sac in early pregnancy and maternal serum beta-hCG levels. Discriminatory serum levels are defined as those at which an intrauterine pregnancy (IUP) will always be seen if, indeed, it is present within the endometrial cavity. If an intrauterine pregnancy is not identified at these levels, a failed pregnancy, as discussed below, is highly suspected.

**Sonographic Diagnosis of Pregnancy**

Sonographic diagnosis of early pregnancy is the final piece of the diagnostic triad, providing visual information about the uterine contents and adnexa. The role of sonography in diagnosing the presence of early pregnancy is well established and is based on the identification of normal intrauterine gestational structures in a patient with correlative clinical and/or laboratory findings. The specific roles and diagnostic criteria used in evaluation of early pregnancy are discussed throughout the rest of this chapter.

### Table 1-1. Discriminatory levels of serum beta-hCG.

<table>
<thead>
<tr>
<th>US Method</th>
<th>1st IRP or 3IS (mIU/ml)</th>
<th>2IS (mIU/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endovaginal</td>
<td>1000–2000</td>
<td>500–1000</td>
</tr>
<tr>
<td>Transabdominal</td>
<td>3600</td>
<td>1800</td>
</tr>
</tbody>
</table>

### Table 1-2. Early pregnancy time line: menstrual vs. conceptual age.

<table>
<thead>
<tr>
<th>Event</th>
<th>Gestational Age (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Menstrual (Clinical)</td>
</tr>
<tr>
<td>LMP begins</td>
<td>1</td>
</tr>
<tr>
<td>Ovulation</td>
<td>14</td>
</tr>
<tr>
<td>Fertilization</td>
<td>15–16</td>
</tr>
<tr>
<td>Conceptus enters uterine cavity</td>
<td>18–19</td>
</tr>
<tr>
<td>Implantation</td>
<td>21–22</td>
</tr>
<tr>
<td>Gastrulation</td>
<td>29–30</td>
</tr>
<tr>
<td>Neurulation starts</td>
<td>35</td>
</tr>
<tr>
<td>Neurulation ends</td>
<td>42</td>
</tr>
<tr>
<td>Heart septation starts</td>
<td>43</td>
</tr>
</tbody>
</table>

**GESTATIONAL AGE**

As mentioned previously, the term gestational age can refer to either of two methods for dating a pregnancy. An embryologic approach calculates gestational age based on when fertilization occurs and is called conceptual age. In a theoretically perfect 28-day menstrual cycle, fertilization occurs 24–36 hours after ovulation. If ovulation transpires on day 14, as is assumed in this perfect menstrual cycle, then fertilization of the ovum happens 15–16 days after the beginning of the last menstrual period.

In clinical obstetrics, however, the exact date of ovulation is usually unknown, so gestational age is calculated based on the last menstrual period, a clinically observable event, and is called menstrual age. When calculated from the first day of the last menstrual period (LMP), gestational age is expressed as menstrual weeks; when calculated from the moment of conception, conceptual weeks. Conceptual age is roughly 2 weeks (14 days) less than menstrual age.

In this book, unless otherwise specified, all presentations of gestational age are calculated based on the beginning date of the last menstrual period. While the distinction is important in understanding first trimester events, it becomes less so as the gestation passes from the embryonic to the fetal period at about week 10. (Examples of the two systems for key events in early pregnancy appear in Table 1-2.)
FERTILIZATION AND EMBRYOLOGY
The early development of the conceptus/embryo can be summarized as follows, using menstrual ages.

Conceptus Period: Weeks 3–5
Menstrual weeks 3–5 (conceptual weeks 1–3) constitute the conceptus period.

Menstrual Week 3/Days 15–21: Early Development of the Conceptus
• Days 15–16: Fertilization of the oocyte or (when mature) ovum (the female gamete) by the spermatozoon or sperm cell (the male gamete) occurs within 24–36 hours of ovulation on day 14 (Figure 1-1).
• Days 16–18: The zygote (fertilized egg) traverses the fallopian tube (Figure 1-2).

Menstrual Week 4/Days 22–28: Implantation, Bilaminar Embryonic Disc, Amnion, and Chorion
A normal intrauterine pregnancy begins with the implantation of the conceptus in the secretory endometrium in the central portion of the uterine cavity.
• Days 21–22: Implantation of the blastocyst in the uterine wall and formation of the syncytiotrophoblast,
• Day 17: 8-cell stage.
• Day 18: 12- to 16-cell stage, known as the morula.
• Day 18 or 19: The morula enters the uterus and begins transformation into the blastocyst, a hollow ball of cells with a single germ layer.
• Days 18–21: The blastocyst cavity and inner cell mass form; the blastocyst cavity becomes the primary yolk sac; amniotic cavity formation begins.
The placental precursor (Figure 1-3). Vaginal bleeding may occur at this time.

- Days 23–26: Transformation of the inner cell mass into the bilaminar embryonic disc (Figure 1-4), which has two germ layers, the epiblast and the hypoblast.
- Days 27–28: Regression of the primary yolk sac and formation of a secondary yolk sac and the surrounding chorionic cavity. The amniotic sac enlarges on the side of the embryo opposite the yolk sac. The adjacent amnion and secondary yolk sac (Figure 1-5) are sometimes visible sonographically within the chorionic cavity. This finding is called the double bleb sign. At the beginning of the fourth week, the gestational sac is about 1 mm in diameter.

**Menstrual Week 5/Days 29–30: Gastrulation**

- **Trilaminar disc**: Formation of the trilaminar disc, comprising the three primary germ layers: ectoderm, endoderm, and mesoderm.
- **Notochord**: Formation of the primitive node and streak and the rod-shaped group of cells that defines the body’s primary supporting axis (the notochord). The notochord forms within the embryonic plate between the endoderm and ectoderm.
- **Early embryo**: The notochord induces development of the structure of the early embryo and later develops into the nucleus pulposus of the discs of the spinal column.

**Menstrual Weeks 5–6/Days 31–42: Neurulation and Vasculogenesis**

- Days 31–42: **Neural tube and neural plate**: Formation of the neural plate, neural tube, and somites (blocks of mesoderm located on either side of the neural tube), which develop into the central nervous system.
  - Day 35: Neural tube formation (neurulation) begins (Figure 1-6A) and the first somites appear.
  - Day 40: The rostral (head) end of the neural tube closes.
  - Day 42: The caudal (sacral) end of the neural tube closes and neurulation ends (Figure 1-6B).
- Days 35–42: Formation of primitive blood cells (hematogenesis), blood vessels (angiogenesis), fetal heart, and placental vasculogenesis.
Embryonic Period: Weeks 6–10
During menstrual weeks 6–10 (conceptual weeks 4–8)—the embryonic period—nearly all permanent internal and external structures are formed (a few of the morphologic developments listed below occur after 10 weeks).

Cardiovascular System
- Week 6: Unidirectional blood flow begins.
- Week 8: Formation of the heart is complete.
- Week 10: Formation of the peripheral vascular system is complete.
- For more on the fetal cardiovascular system, see Chapter 7.

Gastrointestinal System
- Week 6: Formation of the primitive gut is complete.
- Week 8: The rectum separates from the urogenital sinus.
- Weeks 8–12: The midgut herniates into the umbilical cord and then returns to the abdomen.
- Week 10: The anal membrane perforates.
- For more on the fetal gastrointestinal system, see Chapter 9.

Urogenital System
- Week 8: The primitive kidneys (metanephroi) begin to form and descend into the abdomen.
- Week 11: Kidneys are in the adult position; external genitalia are visually similar in males and females.
- Week 14: Differentiation of external male and female genitalia is complete.
- For more on the fetal urogenital system, see Chapter 10.

Musculoskeletal System
- Weeks 5.5–6: Formation of limb buds is complete.
- Weeks 7.5–8: Digital rays develop; arms are bent at the elbow.
- Week 8: The clavicle begins to ossify.
- Week 9: The mandible, palate, vertebral bodies, and neural arches begin to ossify.
- Week 11: The long bones begin to ossify.
- For more on the fetal musculoskeletal system, see Chapter 8.

Sonographic Signs—Early Intrauterine Pregnancy
The identification of a gestational sac (GS) within the endometrial cavity is the first sonographic evidence that a normal intrauterine pregnancy is present. A gestational sac is always seen in a normal intrauterine pregnancy when the following discriminatory levels are achieved:
- Serum beta-hCG ≥ 800–1000 mIU/ml (endovaginal) using 2IS.
- Serum beta-hCG ≥ 1800 mIU/ml (transabdominal) using 2IS.
- Certain last menstrual period ≥ 5 weeks.
- Decidual thickening: The earliest sonographic sign of pregnancy is focal thickening of the echogenic decidua at the site of implantation. This finding is quite subtle, and the predictive value of the finding has not been established.

GESTATIONAL SAC
The fluid-filled gestational sac is first visible at about 4.5–5 menstrual weeks, and it is the first definitive sonographic sign of pregnancy (Figure 1-7A).
Endovaginal scanning can reliably visualize a gestational sac in the uterus by 5 weeks, when the mean sac diameter (MSD) is 2–3 mm, and transabdominal scanning can visualize the gestational sac by 6 weeks, when the mean sac diameter reaches 5 mm. A normal gestational sac appears as a small fluid collection surrounded by an echogenic rim. The central lucency represents fluid in the chorionic cavity, while the surrounding echogenic rim represents developing chorionic trophoblastic tissue and adjacent decidual layers. When the sac is measured, the largest diameter is selected.

**Sonographic Signs—Gestational Sac**

The following are the characteristic sonographic signs of a normal intrauterine gestational sac (Figure 1-7B):

- Round, oval, well defined.
- Echogenic, intact borders.
- Positioned in the fundus or mid uterus.
- Growth $≈ 1$ mm/day.

- Yolk sac present when mean sac diameter is $≥ 13$ mm.
- **Intradecidual sign**: The sonographic presence of a small gestational sac within the decidua at approximately 4–4.5 weeks, with a mean sac diameter of approximately 2.5 mm, is known as the *intradecidual sign*. To distinguish a true intradecidual sign from a decidual (endometrial) cyst, the sonographer must be sure that the gestational sac is directly adjacent to the endometrial canal. Because the intradecidual sign can sometimes mimic a pseudogestational sac of ectopic pregnancy, its value appears somewhat limited.

- **Double bleb sign**: At 5.5 menstrual weeks, the developing amniotic sac measures about 2 mm in diameter and becomes visible adjacent to the yolk sac (Figures 1-8A and B). This double sac appearance is called the *double bleb sign*. At this time the bilaminar embryonic disc lies between the yolk sac and the amnion. The double bleb sign is no longer visible by 7 menstrual weeks.
High-frequency (7–10 MHz) transvaginal sonography is required to consistently visualize yolk sacs in 8 mm gestational sacs. The inability to demonstrate a yolk sac when the mean sac diameter is $\geq 8$ mm or when serum beta-hCG levels have reached discriminatory levels is consistent with a failed pregnancy.

Sonographic Signs—Yolk Sac

The following are the characteristic sonographic signs of a normal yolk sac:

- Spherical in shape, with a sonolucent center and a clearly defined echogenic wall (Figure 1-10)
- May be visualized when the mean sac diameter is $\geq 5$ mm (at 5 menstrual weeks)
- Always visualized when the mean sac diameter is $\geq 8$ mm (at 5.5 menstrual weeks)

**EMBRYO**

In a very early intrauterine pregnancy (<6 weeks), endovaginal sonography may reveal a small “embryonic bud,” measuring 1–2 mm and lying adjacent to the yolk sac, with or without cardiovascular activity (Figure 1-11). Absence of these findings at such an early embryonic moment does not portend pregnancy failure. By 6 weeks, however, an embryo with cardiovascular activity can be reliably demonstrated with endovaginal sonography.

Sonographic Signs—Cardiac Activity

Embryonic cardiac activity may be visualized when the crown-rump length (CRL) is approximately 2–4 mm and will be observed in normal embryos 5 mm or more in length. In normal pregnancies the embryo will be visualized when mean sac diameter is 5–12 mm, and
cardiac activity when mean sac diameter is 13–18 mm. High-frequency (7–10 MHz) endovaginal sonography probes, appropriate focusing, and low-persistence settings are needed to image the embryo and heartbeat adequately (Figures 1-12A and B). Some investigators have correlated reduced cardiovascular activity in an embryo with unfavorable pregnancy outcomes. At 5–6 weeks, 100–115 beats per minute (bpm) is a normal range for embryonic cardiovascular activity. By about 9 weeks, mean heart rate increases to ≥140 bpm, where it remains for the duration of pregnancy. There is evidence to suggest a correlation between reduced embryonic cardiovascular activity and poor pregnancy outcomes. Table 1-3 summarizes the association between a reduced cardiac rate and pregnancy loss.

Documentation of embryonic cardiac activity during the first trimester ultrasound examination is best accomplished using M-mode rather than either color Doppler imaging or pulsed Doppler spectral display. Both Doppler modalities are associated with higher levels of acoustic output and, in compliance with ALARA exposure standards, should not be used routinely in obstetric imaging when M-mode capabilities are available. M-mode interrogation through the embryonic heart yields a two-axis tracing that permits calculation of heart rate by placing measurement cursors at similar points in two separate cardiac cycles. On-board software algorithms calculate heart rate.

**Sonographic Signs—Gestational Viability**

The primary value of endovaginal sonography in the first trimester of pregnancy is its great sensitivity and reliability in detecting early signs of gestational viability (Table 1-4). The close correlation between the appearance of specific sonographic signs and the normal progression of pregnancy allows early detection of abnormalities that portend a poor outcome.

<table>
<thead>
<tr>
<th>Heart Rate (bpm)</th>
<th>Pregnancy Loss Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;80</td>
<td>100%</td>
</tr>
<tr>
<td>80–90</td>
<td>64%</td>
</tr>
<tr>
<td>90–99</td>
<td>32%</td>
</tr>
<tr>
<td>&gt;100</td>
<td>11%</td>
</tr>
</tbody>
</table>
omphalocele, a pathologic protrusion of part of the large intestine—and, in many instances, other intra-abdominal structures—through the anterior abdominal wall. (See Chapter 9 for more on abdominal anatomy and pathology.)

Prominent Rhombencephalon

The embryonic brain is a collection of cystic cavi- ties surrounded by thin mantles of neural tissue. The rhombencephalon, which in the fetus comprises the hindbrain structures, can appear prominent, a normal finding during the first and second trimesters. However, if seen after the second trimester, this sonographic finding suggests a Dandy-Walker malformation—cystic dilatation of the fourth ventricle, hypoplasia or complete absence of the vermis, an enlarged posterior fossa, and hydrocephalus (Figure 1-14).

Underpinning the reliability of the sonographic findings is the reliability of the dating of the pregnancy. As significant embryonic events are unfolding on a daily basis, uncertainty about the date of the last menstrual period introduces uncertainty into the sonographic findings. Normal variations in the first 14 days of the menstrual cycle that delay fertilization will render even firm dates for the last menstrual period somewhat unreliable. As always in clinical practice, correlation with physical findings and laboratory values, particularly quantitative serum beta-hCG titers, is essential for a proper diagnosis (see Table 1-1).

Sonographic Signs—Embryonic Anatomy

Embryonic development is rapid in the first trimester of pregnancy. By 10 weeks, all major organ systems have appeared and are in place; by 12 weeks, the embryo has transitioned into a fully formed fetus.

Identifying anatomic structural anomalies is not usually possible in the first trimester. However, there are three normal embryonic anatomic findings that, if detected in later trimesters, raise the specter of a major fetal anomaly: midgut herniation, a prominent rhombencephalon, and abnormal nuchal translucency.

Midgut Herniation

In an embryo, the primitive gastrointestinal tract resides in the base of the umbilical cord, as much of the abdominal cavity is filled with liver (Figure 1-13). This normal physiologic herniation of the bowel occurs at about 8 menstrual weeks (6 conceptual weeks) and is reduced into the abdominal cavity by menstrual week 12 (conceptual week 10). The sonographic appearance of midgut herniation when observed later than menstrual week 14 is consistent with an

Table 1-4. Measures of pregnancy viability using endovaginal sonography.

<table>
<thead>
<tr>
<th>Viability Measure</th>
<th>Age (Menstrual Weeks)</th>
<th>Mean Sac Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational sac may be identified</td>
<td>4.5</td>
<td>2</td>
</tr>
<tr>
<td>Gestational sac always identified</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Yolk sac identified</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Embryo detection</td>
<td>5–6</td>
<td>5–12</td>
</tr>
<tr>
<td>Cardiac activity identified</td>
<td>6–6.5</td>
<td>13–18</td>
</tr>
</tbody>
</table>

Figure 1-13. Embryonic midgut herniation: normal herniation of intra-abdominal contents into the base of the umbilical cord (arrow) at 10 weeks’ gestation.
33. All of the following are clinical signs associated with gestational trophoblastic disease EXCEPT:
   A. Beta-hCG levels less than expected for dates
   B. Beta-hCG levels greater than expected for dates
   C. First trimester vaginal bleeding
   D. Hyperemesis gravidarum

34. Which of the following ovarian pathologies is associated with hydatidiform mole?
   A. Corpus luteum cysts
   B. Follicular cysts
   C. Paraovarian cysts
   D. Theca-lutein cysts

35. What term refers to the pathologic entity in which an intrauterine gestation is composed completely of multisized hydropic villi?
   A. Hydatidiform mole
   B. Cornual pregnancy
   C. Anembryonic pregnancy
   D. Hydropic degeneration of placenta

36. A rare form of gestational trophoblastic disease in which molar tissue invades the myometrium or adjacent anatomic structures is called:
   A. Chorioadenoma destruens
   B. Uterine choriocarcinoma
   C. Placenta accreta
   D. Placenta percreta

37. A patient presents with a serum beta-hCG titer at discriminatory levels. She complains of lower-quadrant pain and vaginal spotting. Sonographic examination of the adnexa produces the results shown in this image. The most likely diagnosis is:

   A. Complete abortion
   B. Invasive mole
   C. Ectopic pregnancy
   D. Hydatidiform mole

38. A patient presents at a firm 8 weeks post LMP. Her beta-hCG titers are consistent with 5.5 weeks. She complains of mild vaginal bleeding and lower midline pain. Endovaginal sonography yields this image. The most likely diagnosis is:

   A. Interstitial ectopic pregnancy
   B. Missed abortion
   C. Pelvic inflammatory disease
   D. Hydrocolpos

39. Five days following an episode of brisk vaginal bleeding accompanied by clots and tissue, this patient returns to her practitioner with complaints of continued bleeding, pain, and a mild fever. Her beta-hCG levels are low positive. Sonographic examination of the uterus yields this image. This patient probably has a(n):

   A. Ectopic pregnancy
   B. Incomplete abortion
40. The sonographic findings in these images are most consistent with:

A. Complete hydatidiform mole
B. Partial hydatidiform mole
C. Chorioadenoma destruens
D. Placental abruption

41. The arrow in this image of a 10-week fetus is pointing to:

A. Gastrochisis
B. Normal embryonic midgut herniation
C. Omphalocele
D. Umbilical vein thrombosis

42. A patient presents with a positive pregnancy test, vaginal bleeding, and mid-pelvic pain. A coronal section through the uterus is presented in this image. The most likely diagnosis is:

A. Missed abortion
B. Normal intrauterine pregnancy
C. Interstitial ectopic pregnancy
D. Gestational trophoblastic disease

43. A patient presents with a history of a hydatidiform mole evacuated 3 months prior. Routine serum surveillance demonstrates a sudden increase in beta-hCG levels. This image raises the suspicion of:

A. Stein-Leventhal syndrome
B. Retained molar tissue
C. Recurrent trophoblastic disease
D. Abdominal abscess

C. Persistent trophoblastic neoplasia
D. Choriocarcinoma

44. The sonographic findings in these images are most consistent with:

A. Complete hydatidiform mole
B. Partial hydatidiform mole
C. Chorioadenoma destruens
D. Placental abruption

45. The arrow in this image of a 10-week fetus is pointing to:

A. Gastrochisis
B. Normal embryonic midgut herniation
C. Omphalocele
D. Umbilical vein thrombosis

A. Stein-Leventhal syndrome
B. Retained molar tissue
C. Recurrent trophoblastic disease
D. Abdominal abscess

ANSWERS

See Appendix A on page 477 for answers.
The thoracic cavity, commonly called the chest, encompasses the heart, lungs, great vessels, and mediastinal structures. It is bordered anterolaterally by the rib cage and sternum and posteriorly by the spine. Its inferior boundary is formed by the diaphragm, a thick bilateral muscular structure that separates it from the abdominal cavity. Sonographic examination of all these component anatomic structures is an integral part of a routine obstetric ultrasound examination beginning with the second trimester.

**LUNG DEVELOPMENT AND ANATOMY**

**EMBRYONIC AND ALVEOLAR PERIODS**

There are two periods of critical importance when monitoring for abnormalities during pulmonary development:

- The *embryonic period*, from 3 to 6 conceptual weeks (5 to 7 menstrual weeks), when the presence and integrity of normal anatomic structures in the chest is established
- The *alveolar period*, beginning at 36 conceptual (38 menstrual) weeks, which determines the maturity and proper functionality of the lungs at birth
Genetic or toxic insults that adversely affect the proper unfolding of pulmonary embryonic and developmental events will yield hallmark anatomic abnormalities. Abnormalities originating during the embryonic period result in the absence or malformation of fundamental anatomic structures, such as the trachea, bronchial tree, and alveolar bed. Abnormalities arising from later developmental defects, during the alveolar period, produce pathologic transformation of normally present pulmonary tissue, resulting in undeveloped hypoplastic lungs, cystic malformations, pleural effusion, and/or other physiologic deficiencies that deliver a neonate with acute, and often lethal, respiratory distress syndrome (RDS).

Pulmonary development begins around the end of the 5th menstrual week, when a single lung bud appears at the distal end of each primordial bronchus (embryonic period). There are four additional stages of lung development:

- **Pseudoglandular or embryonic phase**, conceptual weeks 7–17 (menstrual weeks 9–19): During this phase the air-conducting bronchi and terminal bronchioles form (Figure 7-1A). This includes the embryonic period described above.
- **Canalicular phase**, conceptual weeks 17–27 (menstrual weeks 19–29): During this phase lung tissue becomes vascularized and the lumina of the bronchioles and the alveolar ducts enlarge (Figure 7-1B).
- **Terminal sac or saccular phase**, conceptual weeks 28–36 (menstrual weeks 30–38): This phase is characterized by the appearance of primordial alveoli and a capillary bed that is sufficiently formed to permit respiratory function adequate for survival outside the uterus (Figure 7-1C).
- **Alveolar phase**, conceptual week 36 (menstrual week 38) to 2 years: During this phase the number of terminal bronchioles and alveoli increases (Figure 7-1D). The exact time of its onset overlaps with the terminal sac phase; the time of its exact onset varies among experts.

An important biochemical component of the final two stages of lung development is **pulmonary surfactant**, which is crucial for reducing surface tension in the alveoli and allowing efficient gas exchange.

![Figure 7-1. Pulmonary embryology. A Pseudoglandular phase, 7–17 conceptual (9–19 menstrual) weeks. B Canalicular phase, 17–27 conceptual (19–29 menstrual) weeks. C Terminal sac or saccular phase, 28–36 conceptual (30–38 menstrual) weeks. D Alveolar phase, beginning at 36 conceptual (38 menstrual) weeks and ending at 2 years. (Sources vary on exactly when phases begin.)](Image)
a lipoprotein produced by the alveolar cells of the lungs. Its primary physiologic function is to increase the compliance of the fetal lung—its ability to expand to accommodate an air volume that will permit adequate oxygen perfusion postnatally. Pulmonary surfactant also regulates the size and expansion of the alveolar bed and serves to normalize surface tension in the alveolar spaces, keeping the tiny air sacs open and available for gaseous exchange. Surfactant levels can be measured on amniotic fluid as an indicator of fetal lung maturity (see “Amniotic Fluid” below).

During the entire fetal period, four conditions are required for adequate lung development. If any of these factors is absent or significantly compromised, the lungs will not develop into the functional respiratory organs that are required to support life outside the uterus. The four conditions are:

- Adequate thoracic space
- Normal fetal breathing movements
- Fluid production in the lungs
- Adequate amniotic fluid volume

**AMNIOTIC FLUID**

While all four of the factors mentioned above are requisite for normal lung development, amniotic fluid plays a uniquely important role. Adequate pulmonary function at birth depends on an adequate and mature surfactant system in utero, comprising lipoproteins suspended in amniotic fluid. While in the third trimester these biochemical markers can be assessed with laboratory analysis of amniocentesis specimens, in earlier stages of pregnancy sonographic assessment of fluid volume provides valuable diagnostic and prognostic information.

Before 15–20 menstrual weeks, amniotic fluid is derived primarily from the maternal perfusion activity of the chorioamnion. However, in the mid to late second trimester and in the third trimester, it is produced primarily by fetal urine. Amniotic fluid serves several functions:

- It cushions the fetus against injury.
- It allows for free movement of the fetus.
- It is essential for fetal lung development.
- It provides a source of fetal nutrition.
- It aids in maintaining fetal temperature.

**Estimating Amniotic Fluid Volume**

Normally the volume of amniotic fluid surrounding the fetus gradually increases through early pregnancy until it reaches a maximum of approximately 800 ml at about 33 menstrual weeks, decreasing gradually thereafter. The increase in amniotic fluid volume during the second trimester reflects the increased urine output of the fetus. The decrease in the later part of pregnancy reflects increased fetal swallowing and decreased fetal urine output.

Many different methods have been described to estimate the amount of amniotic fluid present within the uterus. The primary methods are subjective visual assessment on sonography, the maximum vertical pocket method, and the four-quadrant amniotic fluid index (Table 7-1).

**Subjective Assessment**

The oldest and still one of the most accurate methods of assessing amniotic fluid volume is a subjective visual assessment of the amount of fluid present while scanning the pregnancy in real time. Early in the second trimester, the volume occupied by the fetus is about equal to the volume of amniotic fluid. The fetus does not appear confined within the uterus and is seen to move freely within the surrounding fluid. Throughout the second and third trimesters, the volume of the fetus increases relative to the volume of fluid, and in late pregnancy the amount of fluid appears small in comparison with the fetus. The disadvantage of the subjective assessment method is that it is not a metric, making it unreliable for follow-up examination.

**Maximum Vertical Pocket Estimate**

The maximum vertical pocket (MVP) method, sometimes called the single deepest pocket (SDP) method, is obtained by measuring the anteroposterior (AP) dimension (depth) of the largest pocket of amniotic fluid that is void of both fetal parts and umbilical cord. This metric is valid throughout the third trimester. A pocket measuring 2–8 cm is considered normal.

**Four-Quadrant Amniotic Fluid Index**

With the four-quadrant amniotic fluid index (AFI), measurements are taken in each of four uterine quadrants, and the greatest vertical (anteroposterior) measurements are summed. Except at the extreme
Polyhydramnios (Figure 7-2) is commonly defined as an AFI of 20 cm or greater. It is commonly caused by conditions that result in increased urinary or respiratory fluid production or conditions that result in decreased fetal swallowing. Common causes of polyhydramnios include:

- Idiopathic causes, which may be related to:
  - Fetal swallowing abnormalities
  - Fetal renal insufficiency
  - Gastrointestinal tract absorption abnormalities
- Fetal anomalies:
  - Fetal neural tube defects
  - Fetal gastrointestinal obstructive anomalies
  - Fetal hydrops
  - Trisomy 18 (Edwards syndrome)
  - Cystic hygromas
- Placental abnormalities
- Intrauterine infection
- Maternal diabetes mellitus
- Twin-to-twin transfusion syndrome

percentiles, a progressive increase in the AFI is noted until approximately 28 menstrual weeks (Table 7-1). After that, the AFI slowly decreases.

- After 30 menstrual weeks, the normal AFI generally falls between 10 and 20 cm at the 50th percentile (AFI varies at higher and lower percentiles).
- An AFI ≤ 5 cm is consistent with oligohydramnios.
- An AFI ≥ 20 cm is consistent with polyhydramnios.\(^1,^2\)

### Table 7-1. Amniotic fluid index (AFI) values in normal pregnancy.

<table>
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<tr>
<th>Menstrual Week</th>
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• Phosphatidylglycerol (PG) appears at about the time of lung maturity (35 menstrual weeks). If phosphatidylglycerol is identified in amniotic fluid, it is unlikely that the fetus will develop respiratory distress after delivery.

• Surfactant-protein A (SP-A) measures the level of a protein synthesized primarily in the alveoli of the lung and excreted into amniotic fluid. Diminished levels are associated with neonatal respiratory distress.

HEART DEVELOPMENT AND ANATOMY

EMBRYOLOGY

The cardiovascular system begins its nonstop supporting role in the life of a human organism when the primitive circulatory system, powered by a single-chambered tube, begins to beat at 22 days after conception. By the beginning of the 6th menstrual week, the bulbous, hollow cardiovascular channel has already established vascular communication with the maternal circulation in the chorion and with the main embryonic circulation via the cardinal veins and intersegmental arteries (Figure 7-5).

The drumstick-shaped truncus arteriosus, sitting cranial to the bilobed bulbus cordis, partitions into the great arteries—the aorta and the pulmonary trunk—by the end of the 7th menstrual week (Figure 7-6). Ridges of tissue arise along the walls of the bulbus cordis and, over several days, spiral into the aorticopulmonary septum, which partitions the aorta and pulmonary trunk. Interference with this embryonic partitioning mechanism will result in a congenital conotruncal cardiovascular anomaly, as described on pages 176–180.

Partitioning of the primordial heart begins around the middle of the 6th and is complete by the end of the 7th menstrual week (Figure 7-7). The membranous septum primum grows from the roof of the single atrial chamber toward the centrally located endocardial cushions (plugs of cardiac mesenchymal tissue). The septum secundum also grows adjacent to the septum primum and together they form the embryonic atrial septum. This septum partitions the right and left atria, leaving a gap that will ultimately become the foramen ovale.

In the single lower chamber, the primordial interventricular septum arising from the apex grows upward to separate right and left ventricles, leaving an interventricular foramen that permits cross-circulation until the end of the 9th menstrual week.

In the central portion of the primordial heart, endocardial cushions grow outward and upward, fusing with the septum primum descending from above and with the interventricular septum arising from below to form the complex, valve-containing atrioventricular partitions.

Embryologic development of the fetal heart can be summarized as follows:

• Cardiovascular tube formation, menstrual weeks 4.1–4.6: A linear tube forms and begins beating as soon as it is formed.
• **Outflow tract** separation, menstrual weeks 7–10: The single outflow tract, or truncus arteriosus, begins to develop into the aorta and pulmonary artery.

• **Ventricular septation**, menstrual weeks 7.4–8.6: The two ventricular chambers are formed by the growth of the interventricular septum. Embryologic development of the heart is complete by approximately 9 menstrual weeks.

### FETAL HEART ANATOMY AND CARDIOVASCULAR CIRCULATION

By 11 menstrual weeks’ gestation, the primitive embryonic heart has evolved into a four-chambered pump that receives blood through a venous inflow system, ejects blood via an arterial outflow system, and regulates flow within its chambers with a series of valves and temporary communication channels that seal off after birth.

As in postnatal cardiac circulation, blood enters both sides of the heart by way of large venous structures that empty into the atria. On the right side, the *superior and inferior venae cavae* empty into the *right atrium*. Blood is pumped past the *tricuspid valve* into the *right ventricle* during diastole and out into the lungs across the *pulmonic valve* via the *pulmonary arteries* during systole. After circuiting through the pulmonary microvasculature, blood returns to the *left atrium* via the *pulmonary vein*. Crossing the *mitral valve* during systole, blood fills the *left ventricle* and...
is pumped across the *aortic valve* into the systemic circulation during systole.

Fetal cardiovascular circulation (Figure 7-8), however, begins at the placenta. As the gaseous physiologic exchange performed in prenatal lungs is carried out by the placenta, fetal cardiovascular circulation shunts a large volume of blood away from the nonfunctioning lungs and directly into the systemic circulation. Oxygenated blood from the fetal side of placental circulation travels through the single *umbilical vein*, which pierces the fetal abdominal wall, courses upward to the undersurface of the liver, and is directed through and around the liver via the *ductus venosus* and *portal sinus*. The portal sinus directs blood into the

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**Figure 7-8.** Schematic overview of fetoplacental circulation. Reprinted with permission from Moore KL, Persaud TVN, Torchia MG: The *Developing Human: Clinically Oriented Embryology*, 9th edition. Philadelphia, Elsevier Saunders, 2013, p 334. (Re-rendered for this publication.)

**Oxygen saturation of blood**

- **High oxygen content**
- **Medium oxygen content**
- **Poor oxygen content**

---
different times during early gestation, give rise to the fetal aortic arch and all of its branches and to pulmonary arterial vasculature. The pulmonary veins develop as an outgrowth of the dorsal atrial wall.

**HEART**

The fetal heart can be most clearly imaged if the fetus is in a supine position within the uterus. If the fetus is lying on its side, the heart can still be imaged fairly well through the ribs. If the fetus is lying in the spine-up position, however, imaging cardiac structures is much more difficult. To define the cardiac position and situs, the sonographer must determine the position of the fetus in the uterus (i.e., the fetal lie; see Chapter 12, pages 330–331) and must establish fetal laterality.
independent of the position of fetal internal organs. A complete cardiac evaluation includes examining the fetal heart in its entirety—its chambers, valves, and connections to the great vessels.

Three main cardiac segments are assessed during the course of a routine sonographic examination of the fetal heart:

- The *visceroatrial situs*, which is important in localization and lateralization of the atrium
- The *ventricular loop*, which is important in diagnosing the relation of the ventricles to each atrium
- The *truncus arteriosus*, which is important for determining the relation between the great arteries and the ventricles

The four valves of the heart that can be routinely visualized sonographically are the following:

- *Tricuspid valve*: located between the right atrium and the right ventricle
- *Pulmonic valve*: located between the right ventricle and the pulmonary artery
- *Mitral (bicuspid) valve*: located between the left atrium and the left ventricle
- *Aortic valve*: located between the left ventricle and the aorta

**Four-Chamber View**

The *four-chamber view* (Figure 7-14A) is the single most important view of the fetal heart and should be obtained during the course of every routine sonographic examination of a fetus. A large proportion of cardiovascular anatomic abnormalities can be detected on this single image. While additional views are often necessary to evaluate and diagnose a particular abnormality completely, variations seen in the four-chamber view can direct the examiner to the additional echocardiographic information that should be obtained.

The four cardiac chambers can be identified by their unique sonographic characteristics:

- The *right atrium* may be identified when scanning in different anatomic planes and noting the hepatic veins, inferior vena cava, and superior vena cava draining into that structure. The flap of the foramen ovale is noted opening from the right atrium into the left atrium.
- The *left atrium* is posterior in location in comparison to the right atrium, with the foramen ovale opening into this chamber. The position of the spine is noted, with the left atrium lying close to the vertebral column.
- The *right ventricle* is retrosternal in location, with the tricuspid valve lower in position within the right ventricle than the mitral valve is within the left ventricle. There is also a large echogenic structure lying within the apex of the right ventricle, the *muscular moderator band*. The right ventricle lies retrosternal in location.
- The *left ventricle* can be identified by the presence of papillary muscles within the chamber. Echogenic foci may be identified within the left ventricle. These are thought to be attachments of the papillary muscles and are not abnormal. The mitral valve is in a higher location within the left ventricle than the tricuspid is within the right ventricle. The apex of the heart and the interventricular septum are just cephalad to the
hernia can be differentiated from an intrathoracic mass by failure to visualize the diaphragm on the affected side. Typically in patients who have pulmonary sequestration or cystic adenomatoid malformation, the diaphragm will be visible below the lesion.

**Sonographic Signs**

The following are the characteristic sonographic signs of diaphragmatic hernia:
- Cardiomedial shift to the nonherniated side of the chest (Figure 7-23A)
- Stomach/bowel loops at the same level as the heart (Figures 7-23B and C)
- Hepatic veins and liver in the thorax (Figure 7-23D)
- Absent bowel loops in the abdomen
- Polyhydramnios

**Associated Abnormalities**

The following abnormalities are characteristically associated with diaphragmatic hernia:
- Pulmonary hypoplasia
- Pulmonary sequestration
- Trisomies 13, 18, and 21
- Turner syndrome
- Neural tube defects
- Congenital cardiac anomalies

Sonographically, the most notable intrathoracic abnormality in congenital diaphragmatic hernia is displacement of the fetal heart toward the right chest wall. Typically, the cardiac apex will be angled to the left. More careful examination usually suggests either bowel or stomach in the left hemithorax. A diaphragmatic hernia can be differentiated from an intrathoracic mass by failure to visualize the diaphragm on the affected side. Typically in patients who have pulmonary sequestration or cystic adenomatoid malformation, the diaphragm will be visible below the lesion.

**Figure 7-23.** Hallmark sonographic findings in diaphragmatic hernia, transverse sections through the thorax.

A Cardiomedial shift (arrow). B Bowel loops (arrow) at the same level of the heart (H). C Stomach (arrow) in the thorax; H = heart, L = liver. D Color Doppler image of an hepatic vein (arrow) in the thorax; H = heart.
smaller when compared with total lung volume as the pregnancy progresses.

Three categories of cystic adenomatoid malformation of the lung exist and are based on the size of the cysts present in the lung:

- **Type I**: macrocystic, consisting of large cysts of variable sizes, usually 2–10 cm; this is the most common type, accounting for 70% of cases (Figure 7-24A).
- **Type II**: multiple small cysts (<1.2 cm); this is a less common type, accounting for 15%–20% of cases (Figure 7-24B).
- **Type III**: microcystic (<0.5 cm) or noncystic lesions producing a mediastinal shift; this type accounts for less than 10% of cases (Figure 7-24C).

**Associated Abnormalities**

The following abnormalities are characteristically associated with cystic adenomatoid malformation of the lung:

- Pulmonary sequestration
- Renal agenesis

**Sonographic Signs**

The following are the characteristic sonographic signs of cystic adenomatoid malformation of the lung:

- **Type I**: nonvascular cystic masses in the fetal lung (Figure 7-25A)
- **Type II**: homogeneously echogenic lobe(s) (Figure 7-25B)
- **Type III**: mediastinal shift with lateral displacement of the heart (Figure 7-25C)
Tracheal Atresia

Tracheal atresia is a rare pulmonary anomaly in which the trachea fails to form or is obliterated by external compression of the airway structures. It is a uniformly lethal condition. The level of tracheal obstruction is typically at the larynx.

Associated Abnormalities

The following abnormalities are characteristically associated with tracheal atresia:

- Renal anomalies
- Central nervous system malformations
- Tracheoesophageal atresia

Sonographic Signs

The following are the characteristic sonographic signs of tracheal atresia:

- Bilateral diffusely echogenic lungs
- Fluid-filled trachea (Figure 7-26)
- Enlarged lungs adjacent to a relatively small, compressed heart
- Reduced cardiothoracic circumference ratio
- Polyhydramnios

Figure 7-25. Hallmark sonographic findings in cystic adenomatoid malformation of the lung (CAML). A Type I: nonvascular cystic lesions in the lung (arrows). B Type II: homogeneously echogenic lung lobe. L = lung, Li = liver. C Type III: mediastinal shift with heart (H) displaced to the right by cystic mass (CM) in the left hemithorax.

Figure 7-26. Coronal section through the fetal chest in a fetus with tracheal atresia demonstrating a fluid-filled trachea (arrow) coursing between the pulmonary vasculature (arrowheads).
Cardiovascular abnormalities are among the most common congenital defects. The incidence of congenital heart disease is estimated to be approximately 1 in 100 live births.7, 8, 9, 10 Like the range of central nervous system anomalies assessed in sonographic studies, the spectrum of cardiovascular defects subject to ultrasound examination spans a breadth that is beyond the scope of a sonography review text. However, major abnormalities that are incompatible with postnatal life or that portend significant clinical sequelae are identifiable during the course of a routine obstetric sonogram.

Chest Masses

Unilateral fetal chest masses are summarized in Table 7-3. Mediastinal masses—including teratomas, enteric cysts, and thymic masses—are rare, but because they dramatically distort the normal sonographic appearance of the fetal chest they are easily detected. However, pathologic differentiation is impossible with prenatal ultrasound.

Associated Abnormalities

The following abnormalities are characteristically associated with fetal chest masses:
- Pulmonary hypoplasia
- Congenital heart disease
- Tracheal atresia

Sonographic Signs

The following are the characteristic sonographic signs of fetal chest masses:
- Presence of a sonographically complex mass in the thoracic cavity (Figure 7-27)
- Displaced mediastinal structures
- Pleural effusions

Table 7-3. Sonographic appearance of chest masses.

<table>
<thead>
<tr>
<th>Appearance</th>
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</table>
| Cystic                | CAML type I  
 Bronchogenic cyst  
 Congenital diaphragmatic hernia  
 Enteric cyst  
 Mediastinal meningocele  
 Esophageal duplication cyst |
| Cystic and solid      | CAML type II  
 Enteric cyst  
 Teratoma (pericardial)  
 Congenital diaphragmatic hernia  
 Mixed CAML type II and sequestration  
 Pulmonary sequestration  
 Thoracic neuroblastoma |
| Solid                 | CAML type III  
 Pulmonary sequestration  
 Congenital diaphragmatic hernia |

Figure 7-27. Sonographic findings in a fetus with a chest mass. Transverse section demonstrates a complex mass (arrows) in the thoracic cavity with a laterally displaced heart (H).

Heart and Great Vessel Abnormalities

Cardiovascular abnormalities are among the most common congenital defects. The incidence of congenital heart disease is estimated to be approximately 1 in 100 live births.7, 8, 9, 10 Like the range of central nervous system anomalies assessed in sonographic studies, the spectrum of cardiovascular defects subject to ultrasound examination spans a breadth that is beyond the scope of a sonography review text. However, major abnormalities that are incompatible with postnatal life or that portend significant clinical sequelae are identifiable during the course of a routine obstetric sonogram.

Anomalous conditions that can be detected during a routine sonographic survey of the fetal anatomy are presented here. If cardiac abnormalities are detected on an initial obstetric examination, or if there is strong suspicion on the basis of clinical data that there is a cardiovascular problem, a complete fetal echocardiographic study should be performed as a separate procedure by those with expertise in the field.

As a means of review for sonographic practitioners, the universe of cardiac anomalies is distilled into categories consistent with how the condition may appear during the course of a routine obstetric ultrasound examination (Table 7-4): septal defects, conotruncal anomalies,
and pulmonary stenosis. If it persists throughout gestation, hydrops fetalis becomes a serious concern.

**Sonographic Signs**
The following are the characteristic sonographic signs seen with atrial flutter:
- Real-time demonstration of subjectively rapid atrial contractions with normal to increased ventricular contraction rate.
- M-mode demonstration of an atrial contraction rate > 300 bpm

**Premature Ventricular Contractions**
Premature ventricular contractions (PVCs) (Figure 7-46) are ectopic ventricular contractions usually punctuated by compensatory pauses as the heart’s electrical system “reboots.” PVCs can be associated with concomitant cardiac pathology such as myocarditis, cardiac tumors, long QT syndrome, electrolyte imbalances, and complete atrioventricular block. Most isolated sonographically identified PVCs resolve spontaneously prior to birth or within 6 weeks after birth.

**Sonographic Signs**
The characteristic sonographic sign seen with premature ventricular contractions is a real-time demonstration of early contraction of the ventricle without a preceding atrial contraction.

**Premature Atrial Contractions**
Premature atrial contractions (PACs) (Figure 7-47) are ectopic atrial contractions also punctuated by
compensatory pauses. They are rarely associated with other congenital cardiac anomalies and are usually self-limiting, do not compromise cardiac function, and resolve spontaneously either in utero or shortly after birth.

**Sonographic Signs**
The characteristic sonographic sign seen with premature atrial contractions is early atrial contraction before passive ventricular filling.

**Atrioventricular Block**
Atrioventricular block (AV block) is a bradyarrhythmia caused by abnormalities in cardiac conduction. This condition is characterized by an atrial contractile rhythm independent of ventricular contractile rhythm. While dissociated atrial and ventricular contractions can be an isolated and serendipitous observation during routine sonographic examination, persistent congenital complete AV block (CAVB) is also associated with concomitant cardiac anomalies, accompanied by the risk of developing hydrops fetalis, in 35%–53% of cases.20

**Sonographic Signs**
The following are the characteristic sonographic signs seen with atrioventricular block:

- Real-time demonstration of atrial contraction rhythm independent of ventricular contraction rhythm (Figure 7-48)
- M-mode demonstration of a ventricular contraction rate < 70 bpm

---

**CHAPTER 7 REVIEW QUESTIONS**

1. All of the following cardiac segments are assessed during the course of a routine sonographic examination of the fetal heart EXCEPT:
   A. Visceroatrial situs
   B. Ventricular loop
   C. Truncus arteriosus
   D. Abdominal visceral situs

2. Which of the following would be an indication for fetal echocardiography?
   A. Dextrocardia
   B. Two-vessel umbilical cord
   C. Increased diameter of nuchal lucency
   D. All of the above

3. Approximately what percentage of fetal blood flows across the foramen ovale into the left atrium?
   A. 20%
   B. 30%
   C. 40%
   D. 60%

4. All of the following fetal cardiac anomalies can be detected on a four-chamber view EXCEPT:
   A. Transposition of the great vessels
   B. Single ventricle
17. An anomalous condition characterized by an accessory fragment of lung that has no connection to the tracheobronchial tree and that maintains its own, separate arterial circulation is:
   A. Cystic adenomatoid malformation
   B. Diaphragmatic hernia
   C. Pulmonary sequestration
   D. Diaphragmatic eventration

18. Fetal pleural effusion is also called:
   A. Hydrothorax
   B. Pyothorax
   C. Hydrops fetalis
   D. Pulmonary hypoplasia

19. In this image the structure identified as #1 is the:

   A. Right ventricle
   B. Left ventricle
   C. Right atrium
   D. Left atrium

20. In the image accompanying question 19 the structure identified as #2 is the:
   A. Right ventricle
   B. Left ventricle
   C. Right atrium
   D. Left atrium

21. In the image accompanying question 19 the structure identified as #3 is the:
   A. Pulmonary artery
   B. Pulmonary vein
   C. Inferior vena cava
   D. Aortic root

22. In the image accompanying question 19 the structure identified as #4 is the:
   A. Right atrium
   B. Left atrium
   C. Pulmonary artery
   D. Superior vena cava

23. The anomaly demonstrated in this image is:

   A. Aortic coarctation
   B. Transposition of great vessels
   C. Patent ductus arteriosus
   D. Pulmonary stenosis

24. The arrow in this image points to:
   A. Pulmonary sequestration
   B. Pericardial tumor
   C. Cystic adenomatoid malformation of the lung
   D. Pleural effusion
25. The anomaly demonstrated in this image is:

A. Mitral atresia  
B. Pulmonary stenosis  
C. Patent foramen ovale  
D. Patent ductus arteriosus

A. Diaphragmatic hernia  
B. Pulmonary sequestration  
C. Cystic adenomatoid malformation of the lung  
D. Cystic fibrosis

26. This image demonstrates:

A. Normal lung/liver echogenicity  
B. Pulmonary sequestration  
C. Cystic adenomatoid malformation of the lung  
D. Cystic fibrosis

27. This image demonstrates:

A. Diaphragmatic hernia  
B. Duodenal atresia  
C. Ectopia cordis  
D. Cystic adenomatoid malformation

28. This image best demonstrates:

A. Diaphragmatic hernia  
B. Duodenal atresia  
C. Ectopia cordis  
D. Cystic adenomatoid malformation

ANSWERS
See Appendix A on page 480 for answers.

REFERENCES


Ob/Gyn Sonography: An Illustrated Review—Step 1 in Davies’ 1-2-3 Step Ultrasound Education & Test Preparation program—is an efficient and powerful silver-bullet review for the national registry examination in obstetric and gynecologic sonography. It thoroughly covers the ARDMS exam outline, succinctly and systematically explaining and illustrating each exam topic with easy-to-read text, more than 1000 anatomic illustrations and diagnostic scans, 49 tables containing normal fetal measurements and other clinical reference data, bulleted lists of key facts, and self-assessment exercises. Ob/Gyn Sonography: An Illustrated Review is also a practical, manageable, reader-friendly text and reference for students, cross-training sonographers, practicing sonographers, and interpreting physicians that has been peer-reviewed by 19 nationally known experts. A complete CME application and quiz at the end of the book make it possible to earn 15 hours of SDMS-approved continuing medical education credit anywhere, anytime, at your convenience.

Highly recommended companion steps in Davies’ 1-2-3 Step Ultrasound Education & Test Preparation program for Ob/Gyn Sonography

STEP 2—Mock Exams:

Book version—Ob/Gyn Sonography Review, by Kathy Gill, MS, RT, RDMS, FSDMS, Misty Sliman, RT, RDMS, and Peter W. Callen, MD. This registry-like mock exam delivers more than 500 questions, answers, clear explanations, and references to hone your test-taking skills and assess your strengths and weaknesses. More than 90 image-based cases prepare you to tackle the scans on your examination. SDMS-approved for 12 hours’ CME credit.

Digital version (CD-ROM or downloadable)—Powerful and fun, this interactive wonder simulates the ARDMS exam experience right down to the automatic timer, and delivers content you can trust in Study and Learn Mode or Test Mode. Includes hundreds of continuously variable questions in registry format with answers and clear explanations, along with scores of image-based questions, references, tutorials, and automatic performance analysis. SDMS-approved for 15 hours’ CME credit.

STEP 3—Question & Answer Memory Skills Flashcard Drill:

ScoreCards for Ob/Gyn Sonography, by Traci B. Fox, EdD, RT(R), RDMS, RVT. The spiral-bound ScoreCards flip- and flashcard study system yields maximum gain with minimum pain, and it’s fun. Exercise your ability to think fast and recall key facts wherever you are—at lunch, on weekend outings, or between patients. This Step 3 test-prep product is written and reviewed by well-known experts to work synergistically with Ob/Gyn Sonography: An Illustrated Review (Step 1) and Ob/Gyn Sonography Review (our Step 2 mock exam). ScoreCards contains nearly 500 questions keyed to the registry’s own exam outline, plus answers, explanations, and quick references. More than 140 image-based questions prepare you to tackle scans on the exam. Very effective when combined with the other two products in our 1-2-3 Step program. SDMS-approved for 12 hours’ CME credit.

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</tr>
</thead>
</table>

Total number of questions on the topic you selected.

0 Enter the number of questions you want.

Total number of questions on the topic you selected.

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Total number of questions on the topic you selected.

0 Enter the number of questions you want.

Create My Test  Clear My Selections  Return To Start
This sagittal transvaginal image demonstrates a normal appearing intrauterine gestational sac. The hypoechoic structure indicated by the calipers most likely represents an:

A. Leiomyoma
B. Engorged vessel
C. Cyst
D. Artifact
E. Ovary
This sagittal transvaginal image demonstrates a normal appearing intrauterine gestational sac. The hypoechoic structure indicated by the calipers most likely represents a(n):

A. Leiomyoma

B. Engorged vessel

C. Cyst

D. Artifact

E. Ovary

You chose the correct answer, A: Leiomyoma

References


More Q&A Information

This question belongs to the following ARDMS exam topic:

I-A. Obstetrics / First Trimester (6%-8% of ARDMS exam)
RESULTS FOR CURRENT TEST

Date: 5/12/2014
Time: 4:38:15 PM

Your results appear below in three categories:

(1) Overall results.
(2) Results by exam topic.
(3) Results by individual questions.

This analysis also tells you how many questions (if any) you failed to answer and for which questions you changed your first answer. From this page you can also print your results, review wrong answers in Learn Mode, repeat the same test again, return to the Start Page for another activity, or Quit.

OVERALL RESULTS

Total Questions = 60
Total percentage correct = 30% / 18 of 60
Target time / actual time used = 60 minutes / 3.28 minutes
Number of unanswered questions = 0

SUBJECT AREA RESULTS

I-A. Obstetrics / First Trimester = 0% / 0 of 4 (Unanswered 0)
I-B. Obstetrics / Second & Third Trimesters = 33.33% / 2 of 6 (Unanswered 0)
I-C. Obstetrics / Placenta = 100% / 1 of 1 (Unanswered 0)
I-D. Obstetrics / Assessment of Gestational Age = 50% / 1 of 2 (Unanswered 0)
SUBJECT AREA RESULTS

I-A. Obstetrics / First Trimester = 0% / 0 of 4 (Unanswered 0)
I-B. Obstetrics / Second & Third Trimesters = 33.33% / 2 of 6 (Unanswered 0)
I-C. Obstetrics / Placenta = 100% / 1 of 1 (Unanswered 0)
I-D. Obstetrics / Assessment of Gestational Age = 50% / 1 of 2 (Unanswered 0)
I-E. Obstetrics / Complications = 0% / 0 of 4 (Unanswered 0)
I-F. Obstetrics / Amniotic Fluid = 50% / 1 of 2 (Unanswered 0)
I-G. Obstetrics / Genetic Studies = 0% / 0 of 2 (Unanswered 0)
I-H. Obstetrics / Fetal Demise = 0% / 0 of 1 (Unanswered 0)
I-I. Obstetrics / Fetal Abnormalities = 22.22% / 2 of 9 (Unanswered 0)
I-J. Obstetrics / Coexisting Disorders = 50% / 1 of 2 (Unanswered 0)
II-A. Gynecology / Normal Pelvic Anatomy = 16.67% / 1 of 6 (Unanswered 0)
II-B. Gynecology / Physiology = 20% / 1 of 5 (Unanswered 0)
II-C. Gynecology / Pediatric = 100% / 2 of 2 (Unanswered 0)
II-D. Gynecology / Infertility & Endocrinology = 0% / 0 of 2 (Unanswered 0)
II-E. Gynecology / Postmenopausal = 50% / 2 of 4 (Unanswered 0)
II-F. Gynecology / Pelvic Pathology = 50% / 2 of 4 (Unanswered 0)
II-G. Gynecology / Fluid Dynamics = 0% / 0 of 2 (Unanswered 0)
III. Patient Care, Preparation & Technique = 100% / 2 of 2 (Unanswered 0)

INDIVIDUAL QUESTION RESULTS

For your convenience, the following question numbers correspond to those in the book version of this mock exam. Use the CD and the book together for best results.

Question ID OGR207 = WRONG I-H. Obstetrics / Fetal Demise (0%–3% of ARDMS exam)
Question ID OGR316 = WRONG II-A. Gynecology / Normal Pelvic Anatomy (10%–15% of ARDMS exam)
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Current Credentials

Date of Birth

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Traci B. Fox, EdD, RT(R), RDMS, RVT
Jefferson College of Health Professions
Thomas Jefferson University
How to Use ScoreCards  V

1 OBSTETRICS  1

First Trimester  1
Gestational sac, yolk sac, embryo, ovaries, cul-de-sac, pregnancy failure, ectopic pregnancy

Second and Third Trimesters  79
Cranium, spine, heart, thorax, abdomen, extremities, fetal position

Placenta  169
Development, position, anatomy, membranes, umbilical cord, abruption, previa, masses and lesions, maturity and grading, Doppler flow studies, physiology, adherence (accreta, increta, percreta)

Assessment of Gestational Age  241
Gestational sac, embryonic size/crown-rump length, biparietal diameter, femur length, abdominal circumference, head circumference, transcerebellar measurements, binocular measurements, cephalic indices

Complications  281
Intrauterine growth restriction, multiple gestations, maternal illness, antepartum complications, fetal therapy, postpartum complications

Amniotic Fluid  355
Assessment, polyhydramnios, oligohydramnios, fetal pulmonic maturity studies

Genetic Studies  371
Maternal serum testing, amniotic fluid testing, chorionic villus sampling, dominant/recessive risk occurrence

Fetal Demise  391

Fetal Abnormalities  397
Cranial, facial, neck, neural tube, abdominal wall, thoracic, genitourinary, gastrointestinal, skeletal, cardiac, syndromes

Coexisting Disorders  621
Leiomyomas, cystic disorders, trophoblastic disease, solid/mixed masses, myometrial contraction
2 GYNECOLOGY  651

Normal Pelvic Anatomy  651
Uterus, ovaries, fallopian tubes, supporting structures, cul-de-sacs, vasculature, Doppler flow studies, gynecology-related studies

Physiology  721
Menstrual cycle, pregnancy tests, human chorionic gonadotropin, fertilization

Pediatric  755
Precocious puberty, hematometra/hematocolpos, sexual ambiguity

Infertility and Endocrinology  777
Contraception, causes, medications and treatment, ovulation induction (follicular monitoring), assisted reproductive technology (GIFT, IVF, ZIFT)

Postmenopausal  801
Anatomy, physiology, therapy, pathology

Pelvic Pathology  825
Congenital uterine malformation, uterine masses, ovarian masses, endometriosis, polycystic ovarian disease, inflammatory disease, Doppler flow studies, gynecology-related studies

Extrapelvic Pathology  899
Ascites, liver metastasis, hydronephrosis

3 PATIENT CARE, SCANNING TECHNIQUE, AND PHYSICAL PRINCIPLES  915
Review charts, communication, supine hypotensive syndrome, bioeffects, infectious disease control, scanning techniques, physical principles, artifacts

Application for CME Credits  991

ScoreCards Cross-Referenced to the ARDMS Exam Content Outline  1030
As part of our 1-2-3 Step Ultrasound Education and Test Preparation program, ScoreCards for Ob/Gyn Sonography systematically prepares you to pass the Ob/Gyn Sonography exam for the Registered Diagnostic Medical Sonographer (RDMS)® credential. It also helps you to master the facts, problem-solving skills, and habits of mind that form the foundation of success not only on your registry exams but also in your career as an ultrasound professional. And it’s fun.

These 495 ScoreCards cover core concepts and principles topic by topic—facts you must master to pass the Ob/Gyn exam. At the bottom of every question page is a “footer key,” indicating the study topic’s place within the exam coverage—from first to second/third trimester protocols, fetal anomalies to pregnancy complications, pediatric gynecology to postmenopausal pathologies—so you always know where you are and how you are doing. And at the end of the book you’ll find a handy list of all these ScoreCards cross-referenced to the task-oriented ARDMS Ob/Gyn exam topics.*

*We use the last best ARDMS content outline for test preparation, updated to ensure complete coverage. The latest exam outlines from ARDMS provide a generalized categorical overview together with very specific clinical tasks, but they can miss key intermediate topics you must know to pass your exam—hence our hybrid approach to study outlines. Here you get it both ways: The table of contents reflects the key topics you need to know to pass the exam; at the end of the book, “ScoreCards Cross-Referenced to the ARDMS Exam Content Outline” lists the questions under the ARDMS exam outline categories that were current as of press time.
ARDMS Advanced Item Type (AIT) Questions

All questions specifically designed to prep you for the ARDMS “Advanced Item Type” (AIT) questions are identified. This is a new class of ARDMS exam question that tests practical sonographic skills by simulating hands-on clinical experience. (See “AIT Preparation Questions” at www.ARDMS.org.)

The ARDMS Ob/Gyn exam uses an Advanced Item Type called “Hotspot” questions. These items require examinees to indicate the answer to a question by using the cursor to point at or mark directly on an image. In ScoreCards, similar questions are identified in the question page footers as “AIT—Hotspot” questions. These flashcards ask you to indicate the label on an image that corresponds to the correct answer.

“AIT—PACSIm” items are similarly marked. These highly interactive case-based Picture Archive and Communication Simulation (PACSIm) questions simulate a reading station and require examinees to read a patient’s clinical history, evaluate existing image(s), and complete a diagnostic ultrasound report by selecting from the options presented. Currently these items are specifically designed for reading physicians taking the Physician in Vascular Interpretation (PVI) exam; however, other specialties such as Ob/Gyn lend themselves to this type of question, so as a bonus feature we have identified such questions in the ScoreCards footers as well.

Finally, “AIT-SIC” (Semi-Interactive Console) items are questions that require the examinee to use a semi-interactive console to correct a problem with the image presented. These are limited to the
Sonography Principles and Instrumentation (SPI) examination. They do not appear in the Ob/Gyn specialty exam and are therefore not included among these Ob/Gyn ScoreCards.

**Tips for Maximizing Your Learning**

Here are some tips for maximizing the value of the *ScoreCards* system:

**Take it with you.** The *ScoreCards* study system is designed to be portable. Use it on breaks or between patients. You can review a dozen question/answer items in five minutes.

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**Triangulate on your target.** By itself, the *ScoreCards* study system is a powerful, convenient, and fun way of learning and testing yourself. It is especially effective when used with *Ob/Gyn Sonography: An Illustrated Review* (Step 1: review text) and *Ob/Gyn Sonography Review* (Step 2: mock examination). Just as each ScoreCard tells you which study topic it covers, it also indicates exactly where you can find further information about the subject, often in the Step 1 review text. So do the Davies mock examinations. This integrated, systematic strategy triangulates on your target—exam and career success!
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**Shuffle it!** After using the flipcard format for a while, consider removing the spiral binding and mixing up the cards to vary the order in which they challenge you.

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What is the earliest sonographic sign of a pregnancy?

a. double bleb sign
b. double sac sign
c. yolk sac
d. decidual thickening
D. Decidual thickening.

Thickening of the endometrium is an early sign of pregnancy. Thickening does not always confirm an intrauterine pregnancy (IUP), as the uterine lining will increase in size in the presence of an ectopic pregnancy as well. Follow-up ultrasound and serial beta-hCG values must be obtained to confirm an IUP.
A normal gestational sac grows at the rate of:

a. 0.5 mm per day
b. 1.1 mm per day
c. 1.5 mm per day
d. 2.1 mm per day
B. 1.1 mm per day.

The normal gestational sac has a growth rate of approximately 1.1 mm per day. Inadequate gestational sac growth may be a predictor of pregnancy failure.
What is the term for the sonographic appearance of a small fluid-filled sac contained within the decidua at approximately 4.0–4.5 menstrual weeks?

a. double bleb sign  
b. double sac sign  
c. intradecidual sign  
d. pseudogestational sac sign
C. Intradecidual sign.

The intradecidual sign represents the very early gestational sac. This sign is seen prior to the appearance of the secondary yolk sac.
When can you first identify a gestational sac using endovaginal sonography?

a. 4–5 menstrual weeks  
b. 2–3 menstrual weeks  
c. 5–6 menstrual weeks  
d. 6–7 menstrual weeks
A. 4–5 menstrual weeks.

The gestational sac can be seen as early as 4–5 menstrual weeks, but an intrauterine pregnancy (IUP) cannot be confirmed until the secondary yolk sac is seen, typically at about 5–6 menstrual weeks.

What term describes the echogenic ring formed by the decidua parietalis and decidua capsularis?

a. double bleb sign
b. intradecidual sign
c. double decidual sac sign
d. pseudogestational sac sign
C. Double decidual sac sign.

The *decidua parietalis* (also called the *decidua vera*) and the *decidua capsularis* can be visualized together at 5.5–6.0 menstrual weeks and indicate the presence of a pregnancy. Their appearance together is known as the *double decidual sac sign* or *double decidual ring sign*.
The sophisticated ScoreCards™ flip- and flashcard study system yields maximum gain with minimum pain, and it’s fun. Exercise your ability to think fast and recall key facts wherever you are—at lunch, on weekend outings, or between patients. Written and reviewed by well-known experts, these handy ScoreCards deliver nearly 500 questions keyed to the registry’s own exam outline, plus answers, explanations, more than 140 images, and handy references. Step 3 in Davies’ CME-approved 1-2-3 Step Ultrasound Education and Test Preparation program, ScoreCards for Ob/Gyn Sonography is very effective in combination with Ob/Gyn Sonography: An Illustrated Review (Step 1—review text), Ob/Gyn Sonography Review, and Ultrasound Physics Review (Step 2—mock exams).