

Specialty Curricula Table of Contents

Obstetrics/Gynecology

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Rationale: Accurate assessment and performance of obstetrical sonograms require sonographers to assemble a comprehensive knowledge of the development and sonographic appearance of the fetal and extra-fetal anatomy throughout the gestational period. An understanding of the fertilization process, clinical indications for obstetrical sonograms, and sonographic characteristics of normal and abnormal gravid uterine anatomy specific to each trimester is essential for the performance of high quality examinations.

SECTION I: First Trimester

1. Define terminology related to obstetrics
2. Explain fertilization process
3. Distinguish between layers of decidualized endometrium
4. Identify normal anatomic features of developing embryo
5. Describe first trimester measurement techniques for determination of gestational age
6. Discuss normal findings of adnexa in first trimester
7. Correlate clinical presentation with sonographic findings
8. Differentiate the normal and abnormal appearances of a first trimester pregnancy
9. Discuss first trimester complications
10. Describe sonographic findings associated with ectopic pregnancy
11. Describe the types and sonographic appearances of abortion
12. List the clinical and sonographic findings associated with gestational trophoblastic neoplasia

I. Clinical Assessment of Obstetrical Patient

- A. Terminology
 1. Gravidity
 2. Parity
 3. Abortion
 4. Fundal height
 5. Gestational age (GA)
 6. Menstrual age (MA)
 7. Embryologic age
- B. Laboratory Tests for Pregnancy Determination
 1. Qualitative
 2. Quantitative
 - a. Rising pattern
- C. Gestational Age Calculation
 1. Obstetric wheel
 2. Nagele's rule
- D. Indications for Sonographic Evaluation
 1. Numerous indications

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2. Often trimester specific
3. Controversy surrounding scanning without clinical indication
4. Pros and cons of routine scanning

II. Normal First Trimester

A. Fertilization

1. Zygote - fertilized egg
2. Cleavage
3. Morula
4. Blastocyst
5. Development of germ layers

B. Decidualization

1. Three layers
 - a. Decidua capsularis
 - b. Decidua parietalis
 - c. Decidua basalis
2. Chorionic villi
 - a. Chorion frondosum

C. Gestational Sac

1. Implantation location
2. Sonographic appearance
 - a. Echogenic ring surrounding fluid-filled space
 - b. Double decidual sac sign
 - c. Correlation with β hCG values
 - d. Mean sac diameter (MSD)
 - 1) An average measurement of three dimensions of gestational sac

D. Embryonic/Fetal Membranes

1. Chorion
2. Amnion
3. Vitelline stalk
4. Allantois

E. Yolk Sac

1. Primary or primitive yolk sac
2. Secondary yolk sac
 - a. First structure to be visualized within gestational sac
 - b. Location
3. Functions
 - a. Hemopoiesis
 - b. Development of sex glands
 - c. Formation of digestive tract

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- d. Transfer of nutrients
- 4. Sonographic technique
 - a. Endovaginal
 - 1) Optimal for earliest visualization
 - b. Transabdominal
 - c. Measurements

- F. Embryonic Period
 - 1. Organogenesis
 - 2. Embryonic trilaminar disc
 - 3. Limb buds
 - 4. Spine
 - 5. Head and trunk differentiation
 - 6. Cranial structures
 - a. Rhomboencephalon - primitive hindbrain seen as anechoic cystic structure in posterior aspect of head
 - b. Cerebral hemispheres - differentiated at week 9
 - 7. Physiologic umbilical herniation
 - 8. Sonographic appearance
 - a. Mean sac size consideration
 - b. Cardiac motion
 - c. Crown rump length (CRL)
 - d. Nuchal translucency

III. Uterine Assessment

- A. Congenital Development Anomalies

- B. Leiomyoma(s)

IV. Extrauterine Assessment

- A. Ovaries
 - 1. Corpus Luteum cyst
 - a. Most common ovarian mass seen in first trimester
 - b. Function
 - c. Resolution

- B. Posterior cul-de-sac
 - 1. Evaluation for fluid

V. First Trimester Complications

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- A. Subchorionic Hemorrhage
 - 1. Spontaneous bleed/hematoma between chorion and endometrium
 - 2. Consequences and pregnancy outcome

- B. Ectopic Pregnancy
 - 1. Definition
 - 2. Risk factors
 - a. Endometriosis
 - b. Pelvic inflammatory disease (PID)
 - c. Congenital abnormalities of fallopian tubes or uterus
 - d. Tubal scarring
 - e. Use of intrauterine contraceptive device (IUD)
 - f. Artificial reproductive techniques
 - g. Previous history of ectopic pregnancy
 - 3. Clinical Presentation
 - a. Positive β HCG
 - b. Clinical triad
 - 1) Vaginal bleeding
 - 2) Adnexal mass
 - 3) Pelvic pain
 - c. Symptoms outside clinical triad
 - 1) Adnexal tenderness
 - 2) Cervical tenderness
 - 3) Shock
 - a) Hypotension
 - b) Hemoperitoneum
 - c) Life-threatening
 - 4. Potential sites for ectopic pregnancy
 - a. Fallopian tube
 - b. Ovarian
 - c. Interstitial/cornual
 - d. Cervical
 - e. Abdominal
 - 5. Sonographic Assessment
 - a. Endometrium
 - 1) Absence of gestational sac
 - 2) Thickened prominent endometrium
 - a) Decidual reaction
 - b) Pseudogestational sac
 - b. Extrauterine/adnexal
 - 1) Adnexal mass separate from ovary
 - 2) Gestational ring in adnexa
 - 3) Cardiac motion within gestational ring
 - 4) Fluid posterior cul-de-sac
 - 5) Fluid in Morrison's pouch
 - 6. Treatment

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- a. Surgical
 - b. Pharmacologic
- C. Heterotopic Pregnancy
- 1. Definition
 - a. Simultaneous intrauterine pregnancy and ectopic pregnancy
 - 2. Risk with assisted reproductive technology
- D. Anembryonic Gestation
- 1. Definition
 - a. Presence of gestational sac without presence of embryo
 - b. Blighted ovum
 - 2. Clinical associations
 - a. β hGC values
 - b. Brownish vaginal discharge
 - c. Lack of emesis
 - d. Small uterine size
 - 3. Gestational sac considerations
 - a. Shape of sac
 - b. Size of sac
 - c. Yolk sac
- E. Spontaneous Abortion
- 1. Threatened abortion
 - a. Definition
 - 1) Clinical symptoms with normal sonographic findings
 - b. Clinical presentation
 - 1) Cramping
 - 2) Vaginal spotting
 - c. Sonographic appearance
 - 2. Inevitable abortion
 - a. Definition
 - 1) Ruptured fetal membranes or open cervical os
 - b. Clinical presentation
 - 1) Vaginal bleeding
 - 2) Cramping
 - 3) β HCG correlation
 - c. Sonographic appearance
 - 1) Position of sac in lower uterine segment
 - 3. Incomplete abortion
 - a. Definition
 - 1) Partial retained products of conception without viable fetus
 - b. Clinical presentation
 - 1) Vaginal bleeding
 - 2) Cramping
 - 3) β HCG correlation

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- c. Sonographic appearance
 - 4. Missed abortion
 - a. Definition
 - 1) Fetal demise
 - b. Clinical Presentation
 - 1) Variable
 - c. Sonographic appearance
 - 5. Complete abortion
 - a. Definition
 - 1) Expulsion of all products of conception
 - b. Clinical presentation
 - 1) Vaginal bleeding
 - 2) Cramping
 - 3) β HCG correlation
 - c. Sonographic appearance
 - 6. Recurrent spontaneous abortion
 - a. Previously referred to as habitual abortion
 - b. Definition
 - 1) Two consecutive or three total spontaneous abortions
- F. Embryonic Oligohydramnios
- 1. Definition
 - a. Gestational sac is small in comparison to crown-rump length
 - 2. Sonographic appearance
- G. Gestational Trophoblastic Neoplasia (GTN)
- 1. Classifications
 - a. Hydatitiform mole
 - 1) Most common form
 - 2) Types
 - a) Complete
 - b) Partial
 - b. Choriocarcinoma
 - 1) Malignant invasive form
 - 2. Clinical assessment
 - a. Excessively elevated β hCG
 - b. Hyperemesis
 - c. Large uterine size
 - 3. Sonographic appearance
 - a. Complete mole
 - 1) Enlarged uterus with vesicular appearance
 - b. Partial mole
 - 1) Large placenta
 - 2) Gestational sac with or without fetus
 - c. Choriocarcinoma
 - 1) Uterine enlargement

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- 2) Focal, echogenic myometrial nodules
- d. Ovarian association
 - 1) Theca lutein cysts
- 4. Treatment and follow-up
 - a. Uterine evacuation
 - b. Serial β hCG
 - c. Computed tomography (CT)
 - d. Magnetic resonance

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SECTION II: Fetal Assessment in the normal second and third trimesters

1. Describe the scan planes utilized in fetal sonography
2. Illustrate the various fetal positions
3. Identify normal fetal anatomy
4. Describe anatomical relationship to surrounding structures
5. Describe sonographic appearance of fetal anatomical structures
6. Indicate measurement techniques utilized in fetal gestational age and growth assessment

II. Fetal Assessment in the Normal second and third trimesters

A. Scan Planes

1. Maternal scan planes
 - a. Sagittal
 - b. Transverse (axial)
 - c. Coronal
2. Fetal planes
 - a. Sagittal or longitudinal axis
 - b. Transverse or axial axis
 - c. Coronal axis

B. Fetal Positions

1. Vertex
2. Breech
 - a. Complete
 - b. Incomplete breech
 - c. Frank breech
3. Transverse
4. Oblique

C. Assessment of Fetal Anatomy

1. Cranial
 - a. Identification, sonographic appearance, and anatomical relationship
 - 1) Choroid plexus
 - 2) Lateral ventricles
 - 3) Cavum septum pellucidum and vergae
 - 4) Corpus callosum
 - 5) Interhemispheric fissure or falx
 - 6) Thalami
 - 7) Third ventricle
 - 8) Cerebral peduncles
 - 9) Circle of Willis
 - 10) Posterior fossa
 - a) Cerebellum

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- b) Fourth ventricle
- c) Cisterna magna
- b. Calvarium
 - 1) Frontal bone
 - 2) Parietal bone
 - 3) Occipital bone
- c. Head shape variations
 - 1) Dolichocephaly
 - 2) Brachycephaly
 - 3) Oxencephaly
- d. Measurements of fetal head
 - 1) Biparietal diameter (BPD)
 - a) Fetal axial or thalamic plane
 - b) Level of midline echo complex
 - c) Reliability with increasing gestational age
 - 2) Cephalic index (CI)
 - a) Evaluates head shape for reliability of BPD
 - b) Calculation formula
 - c) Normal values
 - d) Cephalic indices
 - i. Dolichocephaly
 - ii. Brachycephaly
 - 3) Head circumference (HC)
 - a) Measurement obtained at same level as BPD
 - b) Reliability for age determination
 - 4) Lateral ventricle
 - a) Measurement obtained in fetal axial plane
 - b) Measurement criteria
 - 5) Cerebellum
 - a) Shape
 - b) Measurement obtained in fetal axial oblique plane
 - c) Correlation to gestational age
 - 6) Cisterna magna
 - a) Measurement criteria
- 2. Facial anatomy
 - a. Identification, sonographic appearance, and anatomical relationship
 - 1) Sagittal or profile view
 - a) Frontal bone shape
 - b) Nose/nasal bone
 - c) Chin
 - 2) Coronal view
 - a) Upper lip
 - b) Orbits
 - c) Lens
 - d) Nostrils
 - e) Palate

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- b. Measurements
 - 1) Outer to outer orbital diameter (OOD)
 - 2) Inner orbital diameter (IOD)
 - 3) Correlation to gestational age
 - 4) Qualitative assessment
- 3. Spine
 - a. Vertebral development
 - 1) Three ossification centers
 - a) Centrum
 - b) Right and left neural processes
 - b. Sonographic assessment
 - 1) Sagittal plane
 - a) Vertebral body
 - b) Lateral ossification center
 - c) Caudal end tapering
 - d) Skin integrity
 - e) Curvature of spine
 - 2) Coronal plane
 - a) Lateral ossification centers
 - 3) Transverse
 - a) Most important view for evaluation of spinal defects
 - b) Angulation of posterior centers
- 4. Thorax
 - a. Identification, sonographic appearance, and anatomical relationship
 - 1) Lung
 - 2) Diaphragm
 - 3) Larynx
 - 4) Thymus
- 5. Heart
 - a. Identification, sonographic appearance, and anatomical relationship
 - 1) Fetal position and situs
 - 2) Cardiac axis
 - 3) Heart/thorax ratio
 - 4) M-Mode to determine fetal heart rate
 - a) Optimal for practice of as low as reasonably achievable (ALARA)
 - 5) Identification of normal four heart chambers
 - a) Left atrium lies closest to fetal spine
 - b) Right ventricular apex may appear thicker due to moderator band
 - c) Four chambers should be nearly equal in size
 - 6) Anatomy demonstrated with 4-chamber view
 - a) Atria
 - b) Foramen ovale/septum primum
 - c) Ventricles
 - d) Atrioventricular valves
 - e) Papillary muscles
 - f) Intercardiac septae

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- 7) Great vessels
 - a) Aorta
 - b) Pulmonary artery
- 8) Anatomy demonstrated in a fetal sagittal view
 - a) Aortic arch and great vessel branching
 - i. Sonographic appearance resembles a candy cane shape
 - b) Ductal arch
 - i. Communication between main pulmonary artery and descending aorta
 - ii. Sonographic appearance resembles a hockey stick shape
- 9) Additional anatomy to be evaluated
 - a) Subcostal view can demonstrate continuity of interventricular septum to aortic root
 - b) Entrance of inferior vena cava and superior vena cava into right atrium
 - c) Entrance of pulmonary veins into left atrium
6. Abdomen/pelvis
 - a. Identification, sonographic appearance, and anatomical relationship
 - 1) Abdominal wall
 - a) Umbilical cord insertion
 - b) Anterior muscles
 - i. Pseudoascites
 - 2) Gastrointestinal
 - a) Liver
 - b) Stomach
 - c) Intestines
 - i. Small intestine
 - ii. Colon
 - iii. Meconium
 - a) Gallbladder
 - 3) Genitourinary system
 - a) Kidneys
 - i. Location
 - ii. Sonographic assessment
 - i) Number of kidneys
 - ii) Size
 - iii) Echogenicity pattern
 - iii. Renal function association to amniotic fluid
 - b) Bladder
 - i. Sonographic assessment
 - i) Fill/empty cycle
 - c) Ureters
 - d) Adrenals
 - i. Sonographic appearance
 - 4) Genitalia
 - a) Documentation of fetal gender

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- i. Genitourinary anomalies
 - ii. Multiple gestation
 - iii. Sex-linked anomaly
 - b. Measurements of abdomen
 - 1) Abdominal circumference
 - a) Transverse axis at level of umbilical vein and portal sinus junction
 - b) Correlation to gestational age and fetal weight
 - 2) Renal length
 - a) Indications for measurement inclusion
 - b) Length measure in fetal sagittal plane
 - c) Circumference
 - d) Renal pelvis
- 7. Skeleton
 - a. Osteogenesis
 - b. Appendicular skeleton
 - 1) Sonographic identification of bones
 - a) Femur
 - b) Humerus
 - c) Radius/Ulna
 - d) Tibia/Fibula
 - e) Hands
 - f) Feet
 - g) Digits
 - c. Pelvis
 - 1) Iliac wings
 - d. Measurements
 - 1) Femur
 - a) Humerus
 - b) Correlation to gestational age
 - 2) Long bone measurements
 - a) Indications for long bones assessment
- 8. Estimation of fetal weight
 - a. Formulas used
 - b. Generated through biometry
 - c. Standard errors
 - d. Gestational age dependant

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SECTION III: Extra-Fetal Assessment of the second and third trimesters

1. Describe techniques utilized for assessment of the cervix
2. Describe developments, functions, and sonographic appearance of the placenta
3. List anomalies associated with the placenta and their sonographic appearances
4. Differentiate anomalies of the umbilical cord and their significance
5. Identify normal and abnormal Doppler waveforms of the umbilical artery
6. Discuss the production, role, and regulation of amniotic fluid
7. Describe technique for obtaining an amniotic fluid index (AFI)

III. Extra-Fetal Assessment of the second and third trimesters

A. Cervix

1. Role of sonography in assessment of cervix
 - a. Related to risk for premature birth and morbidity
 - b. Evaluation for determination of cervical length, funneling, or beaking
2. Indications for cervical evaluation
 - a. History of premature birth
 - b. History of premature labor
 - c. Multiple gestation
 - d. Premature rupture of membranes
 - e. Uterine anomaly
 - f. Other
3. Sonographic technique
 - a. Patient position
 - b. Application of fundal pressure
 - c. Transabdominal
 - 1) Length may vary with bladder filling decreasing reliability
 - d. Translabial
 - 1) May be referred to as transperineal
 - 2) Used when endovaginal approach is contraindicated
 - 3) Empty bladder
 - 4) Cervix is oriented horizontally on the image
 - e. Endovaginal
 - 1) Considered gold-standard approach
 - 2) Higher frequency transducer
 - 3) Too much pressure on cervix shortens length
 - f. Measurement from external os to internal os
4. Incompetent cervix
 - a. Clinical diagnosis
 - b. Treatment options
 - 1) Bedrest
 - 2) Cerclage

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B. Placenta

1. Development of placenta
 - a. Decidual changes
 - 1) Decidua basalis
 - a) Develops to become maternal surface of placenta
 - 2) Decidua capsularis
 - a) Lies closest to endometrium
 - 3) Decidua vera
 - a) Also known as decidua parietalis
 - b) Endometrial changes in side opposite site of implantation
2. Functional unit
 - a. Chorionic villi
 - b. Chorion frondosum
 - 1) Referred to as chorionic plate
3. Circulation
 - a. Role of uterine spiral arteries
 - b. Intervillous spaces
 - c. Maternal blood returns via network of veins
 - 1) Basilar veins
 - 2) Subchorionic veins
 - 3) Interlobar veins
 - 4) Marginal veins
4. Physiology
 - a. Respiration
 - b. Nutrition
 - c. Excretion
 - d. Protection
 - e. Storage
 - f. Hormone production
 - 1) Human chorionic gonadotropin
 - 2) Estrogen
 - 3) Progesterone
5. Positions
 - a. Anterior
 - b. Posterior
 - c. Lateral - left or right
 - d. Fundal
 - e. Combination
 - f. Relationship to internal os
6. Maturity and grading criteria
 - a. Grading scale of 0-3
 - b. Maturity
 - 1) Causes for premature maturation
 - a) Maternal hypertension
 - b) Maternal cigarette smoking
 - c) Intrauterine growth restriction

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- d) Multiple gestation
- 2) Causes for delayed maturation
 - a) Maternal diabetes
- c. Placental lakes
- 7. Size considerations
 - a. Weight
 - b. Overall size hard to measure
 - c. Anteroposterior dimension
 - d. Associations with large placenta
 - 1) Maternal diabetes
 - 2) Isoimmunization
 - 3) Feto-maternal hemorrhage
 - 4) Intrauterine infection
 - 5) Non-immune hydrops
 - 6) Chromosomal anomaly
 - 7) Uterine anomaly
 - 8) Twin-to-twin transfusion syndrome
 - 9) Congenital neoplasm
 - 10) Other
 - e. Associations with small placenta
 - 1) Intrauterine growth restriction
 - 2) Placental infarction
 - 3) Chromosomal anomaly
 - 4) Intrauterine infection
- 8. Placenta abnormalities
 - a. Placenta previa
 - 1) Placenta completely or partially covering internal os
 - 2) Risk factors
 - a) Multigravida and multiparous women
 - b) Prior cesarean section
 - c) History of therapeutic abortion
 - d) Advanced maternal age
 - e) Closely-spaced pregnancies
 - f) Abnormal fetal position
 - g) Maternal anemia
 - h) History of uterine leiomyomata
 - i) History of uterine infections
 - 3) Classifications of previa
 - a) Complete
 - b) Partial
 - c) Marginal
 - d) Low-lying
 - 4) Clinical symptoms
 - a) Painless vaginal bleeding
 - b) Presents in second and third trimesters
 - 5) Sonographic considerations

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- a) Transabdominal approach
 - i. Over distention of bladder may cause false-positive appearance
 - ii. Partial void technique assists in determining most accurate assessment
 - iii. Limited visualization in third trimester with cephalic presentations and a posterior placenta
 - i) Reverse Trendelenberg position may assist visualization of internal os
 - b) Endovaginal
 - i. Most accurate approach
 - c) Relationship of placental edge to internal os
 - i. Measurement of distance of edge of placenta to center of internal os
- b. Abnormal placental attachment
- 1) Abnormal adherence of all or part of placenta to myometrium
 - 2) Classifications
 - a) Accreta
 - b) Increta
 - c) Percreta
 - 3) Risk factors
 - a) Placenta previa
 - b) Previous cesarean section
 - c) Advanced maternal age
 - d) Prior uterine surgery
 - 4) Sonographic evaluation
 - a) Most common insertion site is lower uterine segment in patients with placenta previa
 - b) Absent or thin hypoechoic interface between placenta and myometrium
 - c) Color Doppler can identify increased vascularity at abnormal insertion site
 - d) Translabial approach may be useful for evaluation of lower uterine segment in third trimester
 - e) MRI frequently used imaging adjunct
 - 5) Maternal consequences
 - a) Placenta may not expel causing excessive hemorrhage
 - b) High maternal mortality rate with increta and percreta without pre-natal diagnosis
9. Developmental variants and abnormalities
- a. Succenturiate Placenta
 - 1) Presence of one or more accessory lobes connected to placenta by blood vessels
 - 2) Sonographic considerations
 - a) Connection with placenta by vascular band
 - b) Color Doppler
 - 3) Associated with vasa previa

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- b. Circumvallate/circummarginate placenta
 - 1) Abnormal attachment of placental membranes to fetal placental surface
 - 2) Sonographic considerations
 - a) Elevated and thickened placental margin
 - 3) Clinical risks
 - a) Premature rupture of membranes
 - b) Premature labor
 - c) Placental abruption
 - d) Intrauterine growth restriction
 - e) Fetal anomalies
 - c. Abnormal chordal attachments
 - 1) Battledore placenta
 - a) Umbilical cord attaches to placental margin
 - b) Clinical consequences
 - 2) Velamentous placenta
 - a) Umbilical cord inserts at margin of placenta beneath membranes
 - b) Area of cord closest to placenta is not covered by Wharton's jelly
 - c) Association with fetal intrauterine growth restriction (IUGR)
 - d. Masses and Lesions
 - 1) Chorioangioma
 - a) Most common benign tumor of placenta
 - b) Sonographic presentation
 - i. Located just beneath chorionic plate
 - ii. Small in size
 - iii. Well-circumscribed solid mass
 - iv. Variable echogenicity
 - c) Fetal consequences
 - i. IUGR
 - ii. Polyhydramnios
 - iii. Cardiomegaly
 - iv. Hydrops
 - v. Demise
 - 2) Less common masses
 - a) Hemangioma
 - b) Teratoma
 - c) Thrombosis
 - d) Hematoma
10. Placental Abruption
- a. Premature separation of placenta from endometrial surface
 - 1) Clinical symptoms
 - a) Vaginal bleeding
 - b) Pain
 - c) Tense uterine wall
 - d) Shock
 - e) Preterm labor

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- b. Risk factors
 - 1) Previous history of abruption
 - 2) Trauma
 - 3) History of placenta previa
 - 4) Maternal hypertension
 - 5) Uterine leiomyoma
 - 6) Short umbilical cord
 - 7) Methamphetamine use
 - c. Types
 - 1) Retroplacental
 - a) Results from rupture of spiral arteries
 - b) High-pressure bleed
 - c) Sonographic presentation
 - i. Thickened placenta
 - ii. Retroplacental clot may be visualized
 - 2) Marginal
 - a) Rupture of marginal vein
 - b) Low-pressure bleed
 - c) Sonographic presentation
 - i. Anechoic or hypoechoic subchorionic area
 - d. Fetal consequences
 - 1) Premature labor or delivery
 - 2) Fetal demise
 - e. OB emergency
11. Fetal membrane abnormalities
- a. Amniotic band syndrome
 - 1) Malformations caused by fibrous strands entangling or trapping fetal parts
 - 2) Fetal anomalies associations
 - a) Craniofacial defects
 - b) Limb defects
 - c) Visceral defects
 - b. Amniotic sheets
 - 1) Associated with intrauterine synechiae
 - 2) Clinical significance is unclear
- C. Umbilical Cord
- 1. Embryology
 - 2. Wharton's jelly
 - 3. Anatomy
 - a. One umbilical vein
 - 1) Function
 - b. Two umbilical arteries
 - 1) Derived from fetal internal iliac arteries
 - 2) Function
 - c. Sonographic assessment

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- 1) Transverse section of umbilical cord
 - 2) Arteries adjacent to fetal bladder
 - 3) Cord insertion into fetal abdomen
 - 4) Cord insertion into placenta
 - 5) Coiling
4. Abnormalities
- a. Single umbilical artery
 - 1) Sonographic presentation
 - a) Transverse view demonstrates two vessels
 - b) One umbilical artery lateral to fetal bladder
 - 2) Associations
 - a) Congenital anomalies
 - b) Chromosomal anomalies
 - c) Intrauterine growth restriction
 - d) Premature delivery
 - e) Perinatal death
 - b. Short umbilical cord
 - 1) Cord length less than 35 centimeters (cm)
 - 2) Associated with:
 - a) Oligohydramnios
 - b) Restricted amniotic space
 - c) Intrinsic fetal anomaly
 - d) Cord compression
 - e) Fetal distress
 - c. Long umbilical cord
 - 1) Cord length greater than 80 cm
 - 2) Associations
 - a) Polyhydramnios
 - b) Nuchal cord
 - c) True cord knots
 - d) Fetal distress
 - e) Cord stricture of torsion due to excessive fetal motion
 - d. Cord masses
 - 1) Omphalomesenteric cyst
 - 2) Allantoic cyst
 - 3) Hemangioma
 - 4) Thrombosis
 - 5) Herniation
 - e. Cord knots
 - 1) True
 - 2) False
 - f. Nuchal cord
 - g. Vasa previa
 - 1) Presence of umbilical cord vessels across internal os
 - 2) Risk factors
 - a) Abnormal fetal position

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- b) Long umbilical cord
 - c) Polyhydramnios
 - d) Velamentous insertion of cord
 - e) Marginal insertion of cord into low-lying placenta
 - f) Succenturiate lobe
 - 3) Sonographic presentation
 - a) Presence of vessels in lower uterine segment
 - b) Color Doppler
 - 4) Fetal consequences
 - a) Fetal exsanguination with vaginal delivery
 - b) Premature rupture of membranes
 - 5. Umbilical artery Doppler
 - a. Indications
 - 1) Intrauterine growth restriction
 - 2) Abnormal biophysical profile
 - 3) Abnormal amniotic fluid index
 - 4) Multiple gestation
 - b. Sonographic technique
 - 1) Color Doppler useful adjunct
 - 2) Pulsed wave Doppler/sample gate placement
 - 3) Waveform analysis
 - a) Diastolic component
 - i. Low resistant
 - ii. Abnormal characteristics
 - i) Decreased
 - ii) Absent
 - iii) Reversed
 - c. Calculations
 - 1) Systolic /diastolic ratio
 - 2) Resistive index
 - 3) Correlation to gestational age
- D. Amniotic Fluid
- 1. Structures responsible for production
 - a. Amniotic membrane
 - b. Umbilical cord
 - c. Lungs
 - d. Skin
 - e. Kidneys
 - 2. Functions
 - a. Cushion to protect fetus
 - b. Allows for activity and movement
 - c. Prevents adherence of amnion to embryo
 - d. Promotes lung growth
 - e. Regulates temperature
 - f. Reservoir for fetal metabolites

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3. Fluid regulation
 - a. First trimester
 - 1) Membranes
 - 2) Lungs
 - 3) Skin
 - a) Non-keratinization
 - b. Second and third trimesters
 - 1) Urine
 - 2) Fetal swallowing
4. Fluid volume
 - a. Correlation to gestational age
 - b. Qualitative assessment
 - 1) Subjective evaluation by sonographer
 - a) Excessive fluid
 - b) Decreased fluid
 - c. Quantitative methods
 - 1) Amniotic fluid index (AFI)
 - a) Sonographic technique
 - i. Maternal sagittal plane
 - ii. Four quadrants
 - b) Calculation
 - c) Criteria for oligohydramnios and polyhydramnios
 - d) Reproducibility
 - e) Gestational age related
 - 2) Single pocket assessment
 - a) Maximum vertical pocket (MVP)
 - b) Sonographic technique
 - i. Maternal sagittal plane
 - c) Criteria for oligohydramnios and polyhydramnios
5. Abnormal fluid volume
 - a. Polyhydramnios
 - 1) Defined as an amniotic fluid volume greater than 2000 ml
 - 2) Associated anomalies
 - a) Gastrointestinal
 - b) Central Nervous system
 - c) Cardiovascular system
 - d) Twin-to-twin transfusion
 - e) Skeletal system
 - f) Respiratory system
 - g) Maternal diabetes
 - h) Chromosomal abnormalities
 - i) Other
 - b. Oligohydramnios
 - 1) Reduction in amount of amniotic fluid
 - 2) Associated conditions
 - a) Abnormalities

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- i. Genitourinary
 - i) Most common
 - ii. Chromosomal anomalies
- b) Intrauterine growth restriction (IUGR)
- c) Ruptured membranes
- d) Post-term pregnancy
- e) Hypertension
- 3) Fetal risks
 - a) Dependent on timing and severity of onset of oligohydramnios
 - b) Consequences may include:
 - i. Skeletal and facial deformities
 - ii. Pulmonary hypoplasia
 - c) Associated with fetal demise

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SECTION IV: Assess Abnormal Fetal Growth

1. Discuss clinical indications and manifestations of intrauterine growth restriction
2. Identify etiologies of intrauterine growth restriction
3. Differentiate sonographic findings of symmetric intrauterine growth restriction and asymmetric intrauterine growth restriction
4. Explain parameters evaluated during performance of a biophysical profile
5. Discuss role of Doppler in fetal well-being assessment

IV. Assess Abnormal Fetal Growth

A. Intrauterine Growth Restriction

1. Defined as a fetal weight at or below 10th percentile for a given gestational age
2. Clinical associations
 - a. Small for gestation age (SGA)
 - 1) Fundal height
 - b. Maternal hypertension
 - c. Decreased fetal movement
3. Types
 - a. Symmetric
 - 1) Physical parameters are decreased in size
 - 2) Associated with severe insult in first trimester
 - 3) Etiology
 - a) Chromosomal abnormality
 - b) Fetal alcohol syndrome
 - c) Intrauterine infection
 - d) Severe maternal malnutrition
 - e) Intrauterine infection
 - f) Genetic defects
 - g) Chromosomal aberrations
 - h) Microcephaly
 - i) Skeletal dysplasias
 - b. Asymmetric
 - 1) Etiologies and risk factors
 - a) Maternal
 - i. Poor nutrition
 - ii. Adverse social-economic conditions
 - iii. Tobacco
 - iv. Drug use
 - v. Alcoholism
 - vi. Heart condition
 - vii. Anemia
 - viii. Diabetes (Type I)

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- ix. History of small for gestational age (SGA)
 - x. Post-maturity
 - xi. Irradiation
 - xii. High altitude
 - xiii. Under age 17 and over age 35
 - xiv. Chronic renal disease
 - b) Placenta
 - i. Placental insufficiency
 - ii. Abruption
 - iii. Infarcts
 - iv. Placental neoplasm(s)
 - c) Fetal
 - i. Isoimmunization
 - ii. Multiple gestation
 - iii. Congenital anomalies
 - iv. Other
 - c. Clinical associations
 - 1) Small for uterine size (also known as size smaller than dates)
 - 2) Maternal hypertension
 - 3) Pre-eclampsia
 - d. Sonographic assessment
 - 1) Abdominal circumference small for gestational age
 - 2) Head circumference/ abdominal circumference ratio
 - a) Brain-sparing effect
 - 3) Fetal weight
 - 4) Placenta
 - a) May be associated with thin placenta
 - b) Advanced grade of placenta may be seen prematurely
 - c) Amniotic fluid volume may be decreased
 - 5) Serial examinations are required for accurate assessment with prior dating
 - e. Postpartum risks and complications of fetus and neonate
 - 1) Asphyxia
 - 2) Meconium aspiration
 - 3) Low birth weight
 - 4) Decreased Apgar score
 - 5) Stillbirth
- B. Macrosomia
- 1. Birth weight of 4000 grams, greater than 4500 grams, above 90th percentile for gestational age
 - 2. Risk factors
 - a. Gestational diabetes mellitus
 - b. Type 1 or type 2 diabetes
 - c. Multiparity
 - d. Advanced maternal age

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- e. Excessive maternal weight gain and/or obesity
 - f. Post-term delivery
 - g. History of large for gestational age (LGA) fetus
3. Sonographic assessment
 - a. Abdominal circumference
 - 1) Most reliable
 - b. BPD
 - 1) Non-reliable predictor
 - c. Chest circumference
 - d. Overall sonographic prediction is poor
 4. Complications
 - a. Fetal shoulder dystocia
 - b. Increased mortality and morbidity
- C. Assessment of Fetal Well-Being
1. Biophysical profile
 - a. Assessment of fetal well-being or fetal distress
 - b. Performance criteria
 - 1) Gross body movement
 - 2) Fetal tone
 - 3) Maximum vertical pocket (MVP) or AFI
 - 4) Breathing
 - 5) Nonstress test
 - c. Scoring method
 - d. Time limit
 2. Doppler flow studies
 - a. Umbilical artery
 - 1) Systolic-to-diastolic ratio
 - 2) Resistive index
 - 3) Waveform analysis
 - b. Middle cerebral artery (MCA)
 - 1) Indications
 - a) Fetal anemia
 - b) IUGR
 - c) Hydrops
 - d) Isoimmunization
 - 2) Sonographic technique
 - a) Axial plane
 - b) Color Doppler
 - c) Spectral Doppler
 - i. Output power considerations
 - ii. Direction and waveform characteristics
 - iii. Pulsatility index
 - iv. Peak systolic velocity
 - c. Ductus venosus

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- 1) Sonographic technique
 - a) Color Doppler for identification
 - b) Spectral Doppler
 - i. Venous pulsations
 - i) First trimester
(1) Pulsations seen
 - ii. Second and third trimester
 - i) Waveform transitions from pulsations to continuous
- 2) Venous pulsations associations
 - a) IUGR
 - b) Congenital heart disease
 - c) Congestive heart failure
 - d) Increased mortality

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SECTION V: High Risk Obstetrics

1. Define terminology associated with multifetal fertilization and development
2. Discuss sonographic approach in assessment of multifetal gestations
3. Describe risks associated with individual classifications of zygosity
4. List risks to fetuses of mothers with maternal illnesses or diseases
5. Differentiate fetal risks between maternal diabetes mellitus and gestational diabetes

V. High Risk Obstetrics

A. Multifetal Gestation

1. Incidence of multiple gestation
 - a. Age
 - b. Race
 - c. Heredity
 - d. Assisted reproductive technology
 - e. Ovulation induction agents
2. Clinical associations
 - a. Size greater than dates
 - b. Elevation of maternal serum alpha-fetoprotein (MSAFP)
3. Terminology (twins)
 - a. Zygosity - number of ovum fertilized
 - 1) Monozygotic
 - 2) Dizygotic
 - b. Chorionicity - number of placentas
 - 1) Monochorionic
 - 2) Dichorionic
 - c. Amnionicity - number of amniotic sacs
 - 1) Monoamniotic
 - 2) Diamniotic
4. Classifications
 - a. Monozygotic
 - 1) Frequency of occurrence
 - 2) Development combinations
 - a) Diamniotic, dichorionic
 - i. Division of zygote within first three days after conception
 - b) Diamniotic, monochorionic
 - i. Division of zygote between day 4 and day 8 after conception
 - c) Monoamniotic, monochorionic
 - i. Division of zygote after day 8 from conception
 - d) Conjoined
 - i. Division of zygote after day 13 may result in conjoined twins
 - b. Dizygotic gestations
 - 1) Frequency of occurrence

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- 2) Non-identical fetuses
- 3) Diamniotic, dichorionic development
5. Sonographic assessment for classification
 - a. First trimester
 - 1) Number of gestational sacs and placenta(s)
 - 2) Twin-peak sign
 - a) Four membranes
 - b. Second and third trimester
 - 1) Membrane
 - 2) Number of placenta(s)
 - 3) Gender
6. Sonographic growth assessment of multifetal gestation
 - a. Number of fetuses
 - b. Fetal lie
 - c. Number of placentas
 - d. Presence or absence of membrane
 - e. Measurements obtained are same as with singletons
 - f. Evaluation of normal fetal growth parameters
 - g. Documentation of fetal heart rates
 - h. Qualitative assessment of amniotic fluid or MVP
 - i. Discordance
 - 1) Definition
 - 2) Calculation
 - 3) Significance
 - j. Principally similar for higher order multiple pregnancies
7. Risks and complications
 - a. Pregnancy induced hypertension
 - b. Premature rupture of membranes
 - c. Intrauterine growth restriction
 - d. Fetal Papyraceous
 - e. Monochorionic twin syndromes
 - 1) Increased risk for fetal anomalies
 - 2) Increased risk for fetal demise
 - 3) Twin-to-twin transfusion syndrome (TTTS)
 - a) Abnormal arteriovenous shunt
 - b) Discordant growth
 - i. Donor twin
 - ii. Recipient twin
 - c) Treatment
 - i. Amniotic fluid reduction
 - ii. Laser ablation of arterial venous communication
 - 4) Twin reverses arterial profusion (TRAP)
 - a) Acardiac twin
 - f. Monoamniotic risks
 - 1) Conjoined twins
 - a) Classifications

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- i. Thoracopagus
 - ii. Omphalopagus
 - iii. Thoraco-omphalopagus
 - iv. Craniopagus
 - v. Pygopagus
 - vi. Ischiopagus
- 2) Cord Entanglement
- a) High risk of fetal demise

B. Maternal Illnesses

1. Diabetes mellitus
 - a. Type I
 - b. Type 2
 - c. Associated fetal effects
 - 1) Macrosomia
 - 2) Spontaneous abortion
 - 3) Polyhydramnios
 - 4) Placentomegaly
 - 5) Congenital malformations
 - a) Cardiovascular
 - b) Caudal regression syndrome
 - c) Renal
 - d) Gastrointestinal
 - e) Neural tube defects
 - 6) Stillbirth
2. Gestational diabetes
 - a. Onset with pregnancy
 - b. Diagnosis
 - c. Sonographic associations
 - 1) Macrosomia
 - 2) Polyhydramnios
 - 3) Placentomegaly
3. Hypertension
 - a. Elevated blood pressure
 - 1) Types
 - a) Chronic hypertension
 - b) Pregnancy induced
 - i. Preeclampsia
 - i) Edema
 - ii) Rapid weight gain
 - iii) Proteinuria
 - iv) Hypertension
 - ii. Eclampsia
 - i) Seizures
 - ii) Headaches
 - iii) Blurred vision

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- iv) Coma
- v) Death
- b. Fetal associations
 - 1) Oligohydramnios
 - 2) IUGR
 - 3) Premature labor
 - 4) Increased incidence of abruptio placenta
 - 5) Placental infarcts
 - 6) Small or thin placenta
 - 7) Stillbirth
- c. Treatment
 - 1) Bedrest
 - 2) Medication for hypertension
- 4. TORCH
 - a. Acronym for a group of maternal infections
 - 1) Toxoplasmosis
 - 2) Others
 - 3) Rubella
 - 4) Cytomegalovirus
 - 5) Herpes simplex virus
 - b. Role of sonography
 - 1) Fetal growth assessment
 - 2) Amniotic fluid assessment
 - 3) Fetal well-being
 - 4) Calcifications
 - 5) Hydrops
- 5. Isoimmunization
 - a. Etiology
 - 1) Rh isoimmunization
 - 2) Rh- patient carrying an Rh+ fetus
 - 3) Fetal hemolysis
 - 4) First pregnancy versus subsequent pregnancies
 - a) RhoGAM
 - b. Fetal consequences
 - 1) Fetal anemia
 - 2) Congestive heart failure
 - 3) Hydrops fetalis
 - c. Sonographic assessment
 - 1) Percutaneous umbilical blood sampling (PUBS)
 - 2) Fetal hydrops
 - 3) Guidance for intrauterine transfusions
 - 4) MCA velocity
 - 5) Amniocentesis
 - d. Treatment
 - 1) Intra-uterine blood transfusion
- 6. Thrombophilias

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- a. Consequences
 - 1) DVT
 - 2) Fetal loss
 - 3) Placental abruption
 - 4) IUGR
- 7. Other maternal infections

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SECTION VI: Fetal Structural Abnormalities

1. Discuss various fetal abnormalities and their sonographic appearances
2. Define terminology and associations of fetal face abnormalities
3. Define terminology and associations of skeletal anomalies
4. Correlate clinical assessments with fetal abnormalities

VI. Fetal Structural Abnormalities

A. Fetal Face

1. Terminology and associations
 - a. Hypotelorism
 - 1) Associated with holoprosencephaly
 - b. Hypertelorism
 - 1) Associations
 - a) Cephaloceles
 - b) Craniosynostosis
 - c) Median cleft syndrome
 - d) Trisomy 18
 - c. Anophthalmia
 - d. Macroglossia
 - 1) Associated with Trisomy 21
 - 2) Beckwith Wiedemann syndrome
 - e. Micrognathia
 - 1) Associations:
 - a) Pierre Robin syndrome
 - b) Trisomy 13
 - c) Trisomy 18
 - d) Musculoskeletal syndromes
2. Cleft lip and palate
 - a. Most common facial abnormality
 - b. Two major groups
 - 1) Upper lip and anterior maxilla with or without involvement of soft and/or hard palate
 - 2) Cleft involving hard and soft without cleft lip
 - 3) Bilateral versus unilateral
 - c. Association with other anomalies
 - 1) Trisomy 13
 - 2) Anencephaly
 - 3) Holoprosencephaly
 - 4) Autosomal dominant syndromes
 - 5) Autosomal recessive syndromes
 - d. Sonographic assessment

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- 1) Cleft lip
- 2) Cleft palate
- 3) Role of 3-D

B. Fetal Neck

1. Cystic hygroma
 - a. Etiology
 - 1) Lymphatic system
 - b. Locations
 - c. Associations
 - 1) Chromosomal
 - a) Turner's syndrome
 - b) Down's syndrome
 - 2) Fetal
 - a) Congenital heart defects
 - b) Hydrops fetalis
 - c) Edema
 - d. Sonographic presentation
 - 1) Cystic structure posterior neck
 - 2) Septations
 - 3) Size
 - 4) Potential regression
 - 5) Oligohydramnios
 - 6) Presents at <20 weeks GA

C. Fetal Head and Brain

1. Clinical associations
 - a. Elevated maternal alpha-fetoprotein (MSAFP)
 - b. Increased fundal height
2. Head shape abnormalities
 - a. Lemon shape
 - b. Strawberry shape
 - c. Brachycephaly
 - d. Dolichocephaly
 - e. Cloverleaf shape
3. Ventriculomegaly
 - a. Measurement criteria
 - b. Hydrocephalus
 - c. Pathogenesis
 - 1) Stenosis of aqueduct of Sylvius
 - 2) Excess cerebrospinal production
 - 3) Decreased cerebrospinal absorption
 - 4) Cerebral atrophy
 - 5) Primary failure of brain growth
 - 6) Communicating hydrocephalus
 - 7) Abnormal karyotypes

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- 8) Dandy-Walker syndrome
- 9) Spinal abnormalities
- d. Sonographic criteria and findings
 - 1) Presence of excess fluid in lateral and 3rd ventricles
 - 2) Evaluate brain texture
 - 3) Atria of lateral ventricle exceeds 10mm
 - 4) Associated findings may include:
 - a) Polyhydramnios
 - b) Abnormal fetal lie
 - c) Fetal hydrops
 - d) Meningomyelocele
 - e) Other cranial or spinal anomalies
4. Anencephaly and acrania
 - a. Description
 - 1) Anencephaly is absence of skull and cerebral hemispheres
 - 2) Acrania is absence of skull
 - b. Sonographic considerations
 - 1) Acrania
 - a) Absence of skull
 - b) Presence of brain
 - i. Atrophic changes
 - 2) Anencephaly
 - a) Rudimentary brain tissue
 - b) Bulging fetal orbits giving a frog-like appearance
 - c) Presence of facial bones
 - 3) Polyhydramnios
 - 4) Increased fetal activity
5. Cephalocele
 - a. Description
 - 1) Herniation of intracranial structures through a defect in cranium
 - b. Terminology
 - 1) Cranial meningocele
 - 2) Encephalocele
 - c. Locations of defect
 - 1) Posterior aspect of skull
 - a) Most common
 - 2) Parietal suture
 - 3) Frontal suture
 - d. Anomaly associations
 - e. Sonographic presentation
 - 1) Bony defect in skull
 - 2) Extracranial mass
 - 3) Ventriculomegaly
 - 4) Microcephaly
6. Holoprosencephaly
 - a. Abnormality in development of forebrain

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- b. Chromosomal associations
 - 1) Trisomy 13
- c. Classifications
 - 1) Alobar
 - 2) Semilobar
 - 3) Lobar holoprosencephaly
- d. Sonographic appearance and associations
 - 1) Large, midline, cystic space with peripheral cerebral tissue
 - 2) Absence of falx and corpus callosum
 - 3) Facial anomalies
 - a) Hypotelorism
 - b) Cyclopia
 - c) Midline facial clefts
 - 4) Hydrocephalus
 - 5) Microcephaly
- e. Prognosis
 - 1) Dependent on classification and severity
- 7. Dandy-Walker Complex
 - a. Etiology
 - 1) Dysgenesis of cerebellar vermis
 - 2) Cisterna magna enlargement
 - 3) Fourth ventricle is continuous with a cystic space
 - b. Sonographic appearance
 - 1) Large, cystic structure in posterior fossa
 - a) Continuous with enlarged fourth ventricle
 - 2) Enlargement of posterior fossa
 - 3) Cerebellar hemispheres may be separated and flattened
 - 4) Ventriculomegaly
 - 5) Polyhydramnios
- 8. Arnold Chiari Type II malformation
 - a. Displacement of posterior fossa structures into cervical canal
 - 1) Anatomic involvement
 - a) Pons
 - b) Fourth ventricle
 - c) Medulla
 - d) Cerebellum
 - b. Sonographic findings
 - 1) Cerebellum and 4th ventricle displacement
 - 2) Cisterna magna obliteration
 - 3) Frontal horns of lateral ventricles
 - c. Associated with spinal dysraphia
- 9. Hydranencephaly
 - a. Etiology
 - 1) Destructive insult to brain
 - b. Sonographic appearance
 - 1) Macrocephaly

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- 2) Large anechoic area in cranial vault surrounding midbrain and basal ganglia
 - 3) Occasionally absent falx
 - 4) Variable presence of 3rd ventricle
 - 5) Tentorium separating normal posterior fossa from anterior and middle cranial fossae
 - 6) Polyhydramnios
 - 7) Occasionally small portions of occipital lobes
 - c. Differential diagnosis
10. Microcephaly
- a. Definition
 - 1) Small head with more than 3 standard deviations below normal
 - b. Associations
 - 1) Intrauterine infections
 - 2) Aneuploidy
 - 3) Central nervous system anomalies
 - c. Sonographic criteria
 - 1) Small BPD (other parameters are normal)
 - 2) Increased or decreased HC/AC ratio
 - 3) Poor cranial growth on serial sonograms
 - 4) Abnormal intracranial architecture
 - 5) High false positive rate
11. Agenesis of corpus callosum
- a. Description
 - 1) Failure of development of part or all of corpus callosum
 - b. Associated with:
 - 1) Trisomy 13
 - 2) Trisomy 18
 - 3) Holoprosencephaly
 - 4) Median facial clefts
 - 5) Dandy-Walker syndrome
 - a. Sonographic appearance
 - 1) Absence of all or part of corpus callosum
 - 2) Absence of cavum septum pellucidum
 - 3) Elevation and dilation of 3rd ventricle
 - 4) Widely separated lateral ventricular frontal horns
 - 5) Colpocephaly
 - 6) Ventricles may demonstrate teardrop shape
12. Vein of Galen aneurysm
- a. Rare arteriovenous malformation
 - b. Sonographic assessment
 - 1) Cystic space in midline of brain
 - 2) May be irregular in shape
 - 3) Color Doppler confirms vascular and turbulent nature
 - c. May also be associated with:

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- 1) Cardiomegaly
 - 2) Nonimmune hydrops
 - 3) Ventriculomegaly
13. Schizencephaly
- a. Characterized by clefts in cerebral cortex
 - b. Sonographic assessment
 - 1) Fluid filled-cleft(s) in cerebral cortex
 - 2) Unilateral or bilateral
 - 3) Associated with
 - a) Absence of cavum septum pellucidum
 - b) Absence of corpus callosum
14. Lissencephaly
- a. Brain surface is smooth without normal sulci and gyri
 - b. Sonographic assessment
 - 1) Difficult to diagnose until third trimester when sulci and gyri may be seen
 - 2) Ventriculomegaly
 - c. Associated with:
 - 1) Agenesis of corpus callosum
 - 2) Dandy-Walker malformation
 - 3) Colpocephaly
 - 4) Other syndromes
15. Porencephalic Cysts
- a. Cysts filled with cerebrospinal fluid that communicate with ventricular system
 - b. Sonographic assessment:
 - 1) Cyst in brain parenchyma
 - 2) Cyst communicates with ventricular system or subarachnoid space
 - 3) May be asymptomatic
- D. Spinal abnormalities
1. Spina bifida
 - a. Terminology
 - 1) Spina bifida
 - 2) Spina bifida occulta
 - 3) Meningocele
 - 4) Myelomeningocele
 - 5) Rachischisis
 - b. Pathogenesis
 - 1) Multifactorial genetic
 - 2) Folic acid deficiency
 - 3) Maternal diabetes
 - 4) Trisomy 18
 - c. Clinical associations
 - 1) Elevated MSAFP
 - 2) Elevated acetyl cholinesterase (ACHE)

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- 3) May be large for gestational age if polyhydramnios is present
- d. Sonographic assessment
 - 1) Lumbar region is most common
 - 2) Posterior transaxial scan
 - 3) Position of laminae and pedicles
 - 4) Level of defect
 - 5) Cleft in skin
 - 6) Mass extending of spine
 - 7) Upper and lower limb movement
 - 8) Evaluate fetal head for shape anomalies
 - a) Lemon sign
 - b) Banana sign
 - 9) Evaluate skeletal system for talipas, leg movement
- e. Associated cranial anomalies
 - 1) Hydrocephalus
 - 2) Encephalocele
 - 3) Arnold Chiari II malformation
- f. Fetal surgery has been proposed
- 2. Scoliosis and kyphosis
 - a. Scoliosis
 - b. Kyphosis
 - c. Anomaly associations
 - 1) Spina bifida
 - 2) Abdominal wall defects
 - 3) Skeletal dysplasia
 - d. Sonographic assessment
 - 1) Scoliosis
 - a) Lateral longitudinal view
 - 2) Kyphosis
 - a) Coronal plane
 - b) Posterior longitudinal
- 3. Caudal regression
 - a. Sequence of anomalies
 - 1) Femoral hypoplasia
 - 2) Leg anomalies
 - 3) Sacral agenesis
 - 4) Lumbar spine abnormalities
 - b. Associated with diabetes mellitus
 - c. Sonographic appearance
 - 1) Short femurs
 - 2) Sacral agenesis
 - 3) Legs may be flexed and abducted at hips
- 4. Sirenomelia
 - a. Pathogenesis
 - 1) Arterial insufficiency to lower limbs
 - 2) Fusion of legs with deformed or absent feet

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- b. Sonographic findings
 - 1) Oligohydramnios
 - 2) Fusion of legs
 - 3) Single foot or absence of feet
 - c. Prognosis
 - 1) Usually fatal due to pulmonary hypoplasia sequential to oligohydramnios
 - 5. Sacrococcygeal teratoma
 - a. Incidence
 - b. Gender tendency
 - c. Etiology
 - 1) Contains all three germ layers
 - d. Sonographic assessment
 - 1) Mass in buttocks area adjacent to spine
 - 2) Solid or complex appearance
 - 3) Calcifications frequently present
 - 4) External mass is most common presentation
 - 5) Functional AV fistula
 - a) Hydrops
 - b) High flow
 - 6) Fetal surgery has been proposed
- E. Fetal Thorax
- 1. Congenital diaphragmatic hernia
 - a. Protrusion of abdominal contents into thorax through a defect in diaphragm
 - b. Pathophysiology:
 - 1) Results from failure of pleuroperitoneal membrane
 - 2) Usually occurs on left
 - 3) Loops of bowel or most of abdominal contents may herniate
 - 4) Compression of lung may cause pulmonary ipsilateral hypoplasia and respiratory distress
 - c. Sonographic appearance
 - 1) Displaced heart
 - 2) Cystic mass (stomach) in thorax
 - 3) Absence of intraabdominal stomach
 - 4) Bowel in chest
 - a) Hypoechoic or cystic in appearance
 - b) Fetal surgery
 - 2. Fetal hydrothorax
 - a. Pleural effusion
 - b. Common associations
 - 1) Hydrops fetalis
 - 2) Congestive heart failure
 - 3) Chromosomal anomalies
 - c. Sonographic appearance

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- 1) Anechoic area in one or both sides of chest
 - 2) Depending on size of effusion, compression of lung can result in pulmonary hypoplasia and displace heart
 - d. Fetal shunting
 3. Cystic adenomatoid malformation (CAM)
 - a. Benign tumor of lung
 - b. Usually a unilateral finding involving a single lobe
 - c. Types and sonographic appearances
 - 1) Type I
 - a) Single or multiple large cysts measuring 2 cms or greater
 - 2) Type II
 - a) Multiple small cysts less than 1 cm in diameter
 - 3) Type III
 - a) Multiple tiny cysts giving a bulky hyperechoic appearance
 - 4) May be spontaneous
 - d. Associated findings
 - 1) Polyhydramnios
 - 2) Mediastinal shift
 - 3) Hydrops fetalis
 4. Bronchopulmonary sequestration
 - a. Pulmonary mass separate from normal tracheobronchial tree
 - b. Sonographic appearance
 - 1) Well-defined echogenic mass
 - 2) Usually triangular in shape
 - c. Differentials
 - 1) CAM
 - 2) Mediastinal teratoma
 5. Pulmonary hypoplasia
 - a. Underdevelopment of fetal lungs
 - b. Factors associated with normal lung growth
 - 1) Adequate amniotic fluid
 - 2) Adequate thoracic space
 - 3) Lung fluid
 - 4) Fetal breathing movements
 - c. Manifestations of abnormal lung growth
 - 1) Oligohydramnios
 - 2) Skeletal dysplasias
 - 3) Decreased chest circumferences
 - 4) Congenital diaphragmatic hernia
 - 5) Pulmonary mass
- F. Cardiac Anomalies
1. Most common major fetal anomaly
 2. Can be an isolated finding or associated with other anomalies, particularly abnormal karyotypes
 3. Congenital defects

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- a. Valvular
 - 1) Epstein's anomaly
 - 2) Valvular atresia
 - b. Septal
 - 1) Ventricular septal defect
 - 2) Atrial septal defect
 - 3) Atrioventricular septal defect
 - c. Great vessel
 - 1) Transposition of great vessels
 - a) Great vessels may give a parallel appearance
 - 2) Truncus Arteriosus
 - a) Single common arterial trunk
 - 3) Double outlet right ventricle
 - d. Tetralogy of Fallot
 - 1) Most common form of cyanotic heart disease
 - 2) Criteria
 - a) Perimembranous ventricular septal defect
 - b) Outlet of conal ventricular defect
 - c) Pulmonic stenosis
 - d) Pulmonary artery hypoplasia
 - e) Right ventricular hypertrophy
 - e. Hypoplastic ventricle
 - 1) Hypoplasia
 - 2) Underdevelopment of either right or left ventricle
 - 3) Results in a non-functional ventricle
4. Cardiac masses
- a. Rhabdomyoma
 - 1) Echogenic mass(es) within fetal heart
 - 2) May be associated with hydrops
 - 3) Etiology may be tuberous sclerosis
5. Arrhythmias
- a. Types
 - 1) Tachycardia
 - 2) Bradycardia
 - 3) Irregular
 - b. Sonographic assessment
 - 1) M-Mode placement though atria and ventricle simultaneously
 - 2) Hydrops
- G. Fetal Abdominal Wall Defects
1. Gastroschisis
- a. Description
 - 1) Defect of abdominal wall adjacent to insertion of umbilical cord
 - b. Pathogenesis
 - c. Sonographic appearance
 - 1) Free-floating loops of bowel in amniotic fluid

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- 2) Defect adjacent to umbilical cord
 - a) Defect to right of umbilical cord most common
 - 3) Associated with IUGR and oligohydramnios
- d. Prognosis
 - 1) Usually good
 - 2) Isolated defect
2. Omphalocele
 - a. Definition
 - 1) Pathologic herniation of abdominal contents into umbilical cord
 - b. Pathogenesis
 - c. Association with chromosomal abnormalities or complexes
 - 1) Trisomies
 - 2) Pentology of Cantrell
 - 3) Beckwith-Weidemann syndrome
 - d. Sonographic appearance
 - 1) Herniated mass is contiguous with umbilical cord
 - 2) Herniated contents are covered by membrane
 - 3) Herniated abdominal contents may include:
 - a) Bowel
 - b) Liver
 - c) Mesentery
 - d) Omentum
 - e) Pancreas
 - f) Spleen
 - e. Prognosis
 - 1) Organ involvement
 - a) Bowel containing omphaloceles carry increased risk for chromosomal anomalies
 - b) Good when isolated
3. Pentalogy of Cantrell
 - a. Five abnormalities
 - 1) Anterior diaphragmatic hernia
 - 2) Omphalocele
 - 3) Cardiac anomalies
 - 4) Defect of diaphragmatic pericardium
 - 5) Lower sternal defect
 - a) Ectopia cordis
 - b. Prognosis
 - 1) Universally fatal
4. Limb-body wall complex
 - a. Structures involved
 - 1) Limb defects
 - 2) Anterior body defects
 - 3) Encephalocele
 - 4) Internal organ malformations
 - 5) Very short or absent umbilical cord

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- b. Prognosis
 - 1) Universally fatal
- 5. Bladder and cloacal exstrophy
 - a. Midline defects of infraumbilical anterior abdominal wall
 - b. Bladder exstrophy
 - 1) Inappropriate eversion of bladder mucosa
 - 2) Usually isolated
 - 3) Sonographic findings
 - a) Inability to identify fetal bladder
 - b) Lower anterior abdominal soft-tissue mass
 - c. Cloacal exstrophy
 - 1) More complex due to lack of separation of urogenital septum from rectum
 - 2) May result in two hemibladders
 - 3) Frequently associated with other anomalies

H. Gastrointestinal Abnormalities

- 1. Esophageal atresia
 - a. Congenital atresia of esophagus
 - b. Usually associated with a tracheo-esophageal fistula (TEF)
 - c. Types
 - 1) Type A
 - a) Esophageal atresia without TEF
 - 2) Type B
 - a) Esophageal atresia with TEF at proximal esophageal segment
 - 3) Type C
 - a) Esophageal atresia with TEF to distal esophageal segment
 - b) Most common presentation
 - 4) Type D
 - a) Esophageal atresia with TEF to both proximal and distal esophageal segments
 - b) segments
 - 5) Type E
 - a) Tracheoesophageal fistula without esophageal atresia
 - d. Sonographic assessment
 - 1) Visualization and size of stomach depends on presence of TEF
 - 2) Polyhydramnios
 - 3) Difficult diagnosis to make
- 2. Duodenal atresia
 - a. Obstruction of duodenum of varied etiology
 - b. Sonographic appearance
 - 1) Classic double-bubble sign representing stomach and proximal portion of duodenum
 - 2) Polyhydramnios
 - c. Association with Trisomy 21
- 3. Meconium ileus

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- a. Obstruction due to impaction of meconium
- b. Association with cystic fibrosis
- c. Sonographic findings
 - 1) Dilatation of small bowel
 - 2) Large bowel is decreased in size
 - 3) Echogenic bowel
- 4. Hirschsprung's disease
 - a. Rare disorder of functional bowel obstruction
 - b. Sonographic findings:
 - 1) Multiple dilated loops of bowel
 - 2) Polyhydramnios

I. Genitourinary Abnormalities

- 1. Sonographic approach to evaluation of genitourinary abnormalities
 - a. Kidneys
 - 1) Presence and number of kidneys
 - 2) Shape
 - 3) Size
 - 4) Echogenicity
 - 5) Renal pelvis
 - a) Dilatation
 - b. Ureter
 - 1) Non-visualized
 - 2) Dilated
 - c. Bladder
 - 1) Presence or absence
 - 2) Size
 - d. Amniotic fluid volume
 - 1) Normal versus oligohydramnios
 - e. Identification of fetal gender
- 2. Renal agenesis
 - a. Bilateral
 - 1) Associated with
 - a) Oligohydramnios
 - b) Pulmonary hypoplasia
 - c) Facial anomalies
 - d) Incompatible with life
 - b. Sonographic presentation
 - 1) Severe oligohydramnios after mid-second trimester
 - 2) Absent kidneys and bladder
 - 3) Fetal adrenals may mimic kidneys
 - 4) Color Doppler used to confirm absence of renal arteries
 - c. Unilateral
 - 1) Sonographic findings:
 - a) Presence of one kidney
 - b) Normal bladder appearance

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- c) Normal amniotic fluid volume
- 3. Potter's classifications
 - a. Type I: Infantile Polycystic Kidney Disease (ARPKD)
 - 1) Autosomal recessive
 - 2) Sonographic presentation
 - a) Enlarged kidneys bilaterally
 - b) Increased echogenicity of kidneys with loss of corticomedullary differentiation
 - c) Bladder may be small or absent
 - d) Oligohydramnios
 - b. Type II: Multicystic Dysplastic Kidney (MCDK)
 - 1) Incidence
 - a) Most common form of renal cystic disease in infants and neonates
 - 2) Sonographic appearance
 - a) Enlarged kidney with multiple cysts of varying size
 - b) If unilateral
 - i. Normal bladder
 - ii. Normal amniotic fluid volume
 - c) If bilateral
 - i. Non-functioning bladder
 - ii. Oligohydramnios
 - c. Type III: Adult Polycystic Kidney Disease (ADPKD)
 - 1) Autosomal dominant
 - 2) Family history
 - 3) Sonographic findings
 - a) May have normal appearing kidneys
 - b) Can appear echogenic or enlarged
 - c) Bladder will be present
 - d) Normal amniotic fluid volume
 - d. Type IV: Obstructive Cystic Dysplasia
 - 1) Etiology
 - a) Onset in first or early second trimester
 - b) Bladder obstruction
- 4. Obstructive urinary tract abnormalities
 - a. Terminology
 - 1) Hydronephrosis
 - 2) Pyelectasis
 - b. Ureteral obstruction
 - 1) Ureteropelvic junction (UPJ)
 - a) Renal pelvis will be dilated
 - 2) Ureterovesical junction (UVJ)
 - a) Renal pelvis and ureter will be dilated
 - c. Bladder outlet obstruction
 - 1) Bilateral hydronephrosis and dilated ureters
 - 2) Posterior urethral valve (PUV)
 - a) Most common male fetus

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- 3) Bladder dilatation with a keyhole resembling appearance
 - 4) Oligohydramnios
 - d. Sonographic assessment
 - 1) Amniotic fluid volume
 - a) Indirect assessment of renal function
 - b) Pulmonary hypoplasia
 - 2) Renal pelvis measurements
 - 3) Level of obstruction
 - 4) Fetal gender
 - 5) Bladder appearance
 - 6) Renal parenchyma
 - 7) Fetal therapy proposed
 5. Prune Belly syndrome
 - a. Complex malformation
 - 1) Anterior abdominal wall distension
 - 2) Urinary tract obstruction
 - 3) Cryptorchidism
 - b. Pathophysiology
 - c. Sonographic appearance
 6. Testicular hydrocele
 - a. Description
 - 1) Accumulation of fluid in tunica vaginalis
 - b. Sonographic criteria
 - 2) Fluid surrounds entire testicle
 7. Ovarian cyst
 - a. Functional
 - b. Sonographic appearance
- J. Musculoskeletal Abnormalities
1. Abnormalities of cartilage and/or bone growth and development
 2. Most common types
 - a. Achondrogenesis
 - b. Thanatophoric dysplasia
 - c. Camptomelic dysplasia
 - d. Osteogenesis imperfecta
 - e. Achondroplasia
 - f. Talipes
 - g. Many others
 - 1) Isolated to bone
 - 2) Associated anomalies
 - h. Many genetic
 - 1) Dominant
 - 2) Recessive
 3. Terminology
 - a. Rhizomelia
 - b. Mesomelia

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- c. Micromelia
- d. Acromelia
- e. Talipes equinovarus
- f. Syndactyly
- g. Polydactyly
- 4. Clinical management
 - a. Family history
 - b. Serial sonograms for growth
- 5. Sonographic assessment
 - a. Amniotic fluid volume
 - b. Limb length
 - 1) Proximal segments
 - 2) Distal bone segments
 - c. Bone mineralization
 - d. Bone appearance
 - 1) Fractures
 - 2) Curvature
 - 3) Bowing
 - e. Skull shape
 - 1) Kleeblattschädel
 - 2) Craniosynostosis
 - 3) Frontal bossing
 - 4) Facial features
 - f. Thorax
 - 1) Size
 - a) Pulmonary hypoplasia
 - 2) Rib length
- 6. Skeletal dysplasias
 - a. Thanatophoric dysplasia (two types)
 - 1) Key features
 - a) Rhizomelia
 - b) Bowed long bones
 - c) Narrow thorax
 - d) Normal trunk length
 - e) Large head size
 - f) Severely flattened vertebral bodies
 - g) Association with pathologic anomalies
 - i. Horseshoe kidney
 - ii. Atrial septal defects
 - iii. Imperforate anus
 - iv. Cloverleaf skull
 - 2) Sonographic appearance
 - a) Short-limbed dwarfism
 - b) Cloverleaf skull
 - c) Hypoplastic thorax
 - d) Polyhydramnios

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- 3) Prognosis
 - a) Lethal
 - b) Dominant
- b. Achondrogenesis
 - 1) Failure of ossification process
 - 2) Two types
 - a) Type I (Parenti-Fraccaro)
 - i. Key features
 - i) Incomplete ossification of skull
 - ii) Rib fractures
 - iii) Extreme dwarfism
 - iv) Arms extremely short and stubby
 - v) Head proportional to trunk
 - b) Type II (Langer-Saldino)
 - i. Key features
 - i) Head large compared to body
 - ii) Prominent skin folds over a short neck
 - iii) Small chest
 - iv) Distended abdomen
 - v) Short limbs held away from body
 - 3) Sonographic appearance
 - a) Severely shortened limbs
 - b) Lack of vertebral ossification
 - c) Large head with normal to slightly decreased ossification of cranium
 - 4) Prognosis
 - a) Lethal
 - b) Recessive type I; type II dominant
 - c. Achondroplasia
 - 1) Types
 - 2) Sonographic appearance
 - a) Rhizomelia
 - b) Macrocephaly
 - c) Trident hands
 - d) Depressed nasal bridge
 - e) Frontal bossing
 - f) Presents in mid-to-late second trimester
 - 3) Prognosis
 - a) Non-lethal
 - b) Dominant
 - d. Osteogenesis Imperfecta
 - 1) Pathophysiology
 - a) Disorder of production, secretion or function of collagen
 - b) Hypomineralization
 - 2) Multiple types exist
 - a) Type I

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- i. Autosomal dominant
 - ii. Normal to decreased bone echogenicity
 - iii. Innumerable fractures
 - iv. Severe bone shortening
- b) Type IIB
 - i. Autosomal recessive
 - ii. Normal bone echogenicity
 - iii. Numerous fractures
 - iv. Moderate femur shortening
- c) Type IIC
 - i. Autosomal recessive
 - ii. Normal bone echogenicity
 - iii. Numerous fractures
 - iv. Moderate shortening of all extremity bones
- d) Type III
 - i. Autosomal recessive
 - ii. Decreased bone echogenicity
 - iii. Numerous fractures
 - iv. Moderate femur bone shortening
 - v. Severe handicaps
- e) Type IV
 - i. Autosomal dominant
 - ii. Normal bone echogenicity
 - iii. Isolated fractures
 - iv. Absence of bone shortening
- 3) Prognosis
 - a) Lethal
 - i. Types IIB, IIC
- e. Camptomelic dysplasia
 - 1) Characterized by bent or bowed limbs
 - 2) Associated anomalies
 - a) Congenital heart disease
 - b) Hydronephrosis
 - c) Hydrocephalus
 - 3) Sonographic appearance
 - a) Bowing of long bones
 - i. Lower limb most commonly affected
 - b) IUGR
 - c) Female genitalia with XY karyotype
- f. Dysostosis
 - 1) Absence or malformation of individual bones
 - 2) Prenatal diagnosis is difficult except in cases of cloverleaf skull
- g. Talipes (equinovarus)
 - 1) Inversion of foot and flexion of sole
 - 2) Causes
 - a) Oligohydramnios

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- b) Amniotic band syndrome
- c) Uterine tumors
- d) Spina bifida
- e) Chromosomal abnormalities
- f) Isolated
- g) Other
- 3) Sonographic appearance
 - a) Orientation of foot and leg bones
- 7. Postural/Movement abnormalities

K. Other

- 1. Fetal hydrops
 - a. Definition
 - 1) Condition characterized by excessive fluid accumulation in fetal extravascular compartments, body cavities, and subcutaneous tissues
 - b. Other findings
 - 1) Polyhydramnios
 - 2) Enlarged fetal liver and/or spleen
 - 3) Subcutaneous edema and thickening
 - 4) Enlarged cord
 - c. Types
 - 1) Nonimmune hydrops fetalis pathology associations
 - a) Fetal anomalies
 - i. Cystic hygromas
 - ii. Diaphragmatic hernia
 - iii. Neoplasms
 - iv. Fetal anemia
 - v. Chromosomal anomalies
 - vi. Cardiovascular malformations
 - vii. Infections
 - viii. Cardiac failure
 - ix. Arrhythmias
 - b) Placental abnormalities
 - i. Chorioangioma
 - ii. Twin to twin transfusion
 - c) Other
 - 2) Immune hydrops fetalis
 - a) Erythroblastosis fetalis
 - b) Caused by immunologic response
 - c) Isoimmunization
 - i. Rhesus (Rh)
 - ii. Other

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SECTION VII: Genetic abnormalities and syndromes

- A. List maternal serum markers associated with chromosomal anomalies
- B. Characterize sonographic findings with genetic syndromes

VII. Genetic abnormalities and syndromes

- A. Maternal Serum Markers for Screening
 - 1. Alpha fetoprotein (AFP)
 - 2. Triple screen
 - 3. Quad screen
 - 4. First trimester
- B. Genetics
 - 1. Terminology
 - a. Karyotype
 - b. Autosomal recessive
 - c. Autosomal dominant
 - d. Mosaicism
 - e. Translocation
 - f. Multifactorial
- C. Sonographic Markers
 - 1. Nuchal translucency
 - a. Measurement technique
 - 1) Gestational age
 - b. Abnormal criteria
 - c. Associations
 - 1) Aneuploidy
 - 2) Fetal cardiac anomalies
 - 3) Cystic hygroma
 - 2. Second trimester Down's syndrome markers
 - a. Nuchal fold
 - b. Choroid plexus cyst
 - c. Echogenic bowel
 - d. Pylectasis
 - e. Shortened long bones
 - f. Echogenic intra-cardiac focus
 - 3. Second trimester NTD findings
 - a. Elevated MSAFP
 - b. NTD
 - c. Ventral wall defect
 - d. Poor outcome
 - 1) IUGR

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- 2) Stillbirth
- 3) Pre-eclampsia

D. Chromosomal anomalies

1. Down's syndrome
 - a. Trisomy 21
 - b. Sonographic associations
 - 1) Duodenal atresia (third trimester)
 - 2) Heart defects
 - a) Ventricular septal defect
 - b) Atrioventricular canal defect
 - 3) Mild ventriculomegaly
2. Edwards syndrome
 - a. Trisomy 18
 - b. Sonographic associations
 - 1) Heart defects
 - 2) Clenched hands
 - 3) Omphalocele
 - 4) Micrognathia
 - 5) Talipes
 - 6) Choroid plexus cysts
 - 7) Renal anomalies
 - 8) Cleft lip and palate
 - 9) Congenital diaphragmatic hernia
 - 10) Cerebellar hypoplasia
 - 11) Meningomyelocele
 - 12) SUA
 - 13) IUGR and hydramnios
3. Patau's syndrome
 - a. Trisomy 13
 - b. Sonographic associations
 - 1) Heart defects
 - 2) Omphalocele
 - 3) Polydactyly
 - 4) Talipes
 - 5) Cleft lip and palate
 - 6) Renal anomalies
 - 7) Meningomyelocele
 - 8) Micrognathia
 - 9) Holoprosencephaly
4. Turner's syndrome
 - a. XO syndrome
 - b. Occurs in females only
 - c. Sonographic associations
 - 1) Cystic hygroma
 - 2) Heart defects

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- a) Coarctation of aorta
- 3) Hydrops
- 4) Renal anomalies
- d. Prognosis
 - 1) High risk for in utero demise
 - 2) Survivors have ovarian dysgenesis and short stature
- 5. Triploidy
 - a. Complete extra set of chromosomes
 - b. Vast majority spontaneously abort prior to 20 weeks
 - c. Sonographic associations
 - 1) Heart defects
 - 2) Omphalocele
 - 3) Renal anomalies
 - 4) Cranial defects
 - 5) Facial defects
- 6. VACTERL
 - a. Grouping of complex anomalies
 - 1) Vertebral defects
 - 2) Anal atresia
 - 3) Cardiac anomalies
 - 4) Transesophageal fistula
 - 5) Renal anomalies
 - 6) Limb dysplasia

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SECTION VIII: Interventional Procedures

1. List invasive and interventional techniques utilized in obstetrics
2. Discuss indications for invasive diagnostic procedures utilized in obstetrics
3. Discuss role of sonography with interventional procedures

VIII. Interventional Procedures

A. Chorionic Villus Sampling (CVS)

1. Biopsy of chorionic villi or placenta
2. Indications
 - a. Increased risk of diagnosable genetic disorders
 - b. Advanced maternal age
3. Risk associations
 - a. Transcervical approach increases risk of infection
 - b. Slightly higher fetal loss as compared to amniocentesis
 - c. Possible limb reduction if performed earlier than 8-10 weeks
4. Sonographic assessment
 - a. Gestational age criteria
 - b. Transabdominal approach
 - c. Transcervical approach
 - d. Placental localization

B. Amniocentesis

1. Indications
 - a. Genetic assessment
 - 1) Performed after 14 weeks gestation
 - 2) Advanced maternal age
 - 3) History of fetal karyotype abnormality
 - 4) Abnormal prenatal genetic screening
 - 5) Either parent with known balanced rearrangement
 - b. Lung maturity
 - 1) Performed in mid to late third trimester
 - 2) Indicated when premature delivery is contemplated
 - c. Fetal infections
 - d. Isoimmunization
2. Risk associations
3. Technique
 - a. Sonography is performed before amniocentesis to confirm
 - 1) Gestational age
 - 2) Fetal viability
 - 3) Position of placenta
 - 4) Localize amniotic fluid pocket to avoid placenta, fetus, and cord
 - b. Sonography during procedure:
 - 1) Localize pocket of fluid with sonography under sterile technique

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- 2) Visualize needle for insertion and placement into amniotic fluid
 - 3) For genetic testing 20-30 cc of fluid is removed and sent for cell culture, karyotyping, and biochemical analysis
 - c. Sonography after procedure
 - 1) Fetal heart-rate
- C. Percutaneous Umbilical Blood Cord Sampling (PUBS)
1. Cordocentesis
 - a. Sonography-guided sampling of umbilical cord blood in utero
 2. Indications
 - a. Diagnostic
 - 1) Evaluation of fetal hematocrit
 - 2) Genetic testing
 - 3) Fetal blood analysis
 - b. Therapeutic
 - 1) Blood transfusion
 - 2) Administration of fetal drugs in utero
 3. Risks
 - a. Risks greater than with CVS or amniocentesis
 - b. Fetal maternal hemorrhage
 - c. Trauma
 - d. Infection
 - e. Premature rupture of membranes
 - f. Premature labor
 - g. Fetal distress
 4. Technique
 - a. Sterile technique
 - b. Localization for needle insertion site
 - c. Post procedure monitoring
- D. Advanced in utero treatments can be performed for
1. Bladder obstruction
 2. Fetal thoracentesis
 3. Laser ablation for twin-to-twin transfusion syndrome (TTTS)
 4. Shunt placement
 5. Other

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SECTION IX: Post Partum Complications

1. Discuss role of sonography in post-partum period
2. Discuss role of sonography in post-partum infection
3. List causes for post-partum hemorrhage

IX. Post Partum Complications

A. Hemorrhage

1. Causes
 - a. Abnormal attachment of placenta to myometrium
 - 1) Placental accreta
 - 2) Placental increta
 - 3) Placental percreta
 - b. Lacerations of vagina and cervix
 - c. Retained products of conception
 - 1) Sonographic appearance
 - d. Uterine atony
 - e. Coagulopathy
2. Risks
 - a. Decreased hematocrit
 - b. Hypotension
 - c. Hysterectomy
 - d. Renal failure
 - e. Shock
 - f. Death

B. Infection

1. Increased risk with Cesarean section delivery
2. Endometritis
 - a. Description
 - 1) Infection of endometrium with potential extension into myometrium and parametrial tissues
 - b. Clinical associations
 - 1) Fever
 - 2) Uterine tenderness
 - 3) Abnormal bleeding
 - 4) Odorous lochia
 - c. Sonographic appearance

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SECTION X: Prudent Use

1. Discuss mechanisms to use sonography prudently in obstetrics
2. Describe emerging technologies used in obstetrics

X. Prudent Use

A. Prudent Use and Bioeffects

1. Equipment presets
 - a. Output power
 - 1) Relative intensities of 2-D versus Doppler
 - 2) Mechanical index (MI)
 - 3) Thermal index (TI)
 - b. Fetal heart rate and documentation
 - 1) Relative intensities of M-Mode versus Doppler
 - 2) Spectral and color Doppler
 - a) Not recommended for first trimester
 - b) Indications for performance in 2nd and 3rd trimesters
 - c) Benefits outweighs risk
 - c. As low as reasonably achievable (ALARA)
 - 1) Time efficiency
 - 2) Diagnostic indications only
2. Professional organization position statements

B. Emerging Technologies

1. 3-D
 - a. Multi-planar concepts
 - b. Advantages
 - c. Diagnostic role
2. 4-D
 - a. Surface rendering techniques
 - b. Image manipulation

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SECTION XI: Performance standards and documentation

1. Discuss minimum requirements in performance of obstetrical sonograms specific to first trimester, second and third trimesters
2. A clinical history and indications for examination should be documented for all examinations

XI. Performance standards and documentation

A. First Trimester

1. Sonograms can be performed either transabdominal approach, endovaginal approach, or use of both techniques
 - a. Anatomy should be evaluated and documented
 - 1) Visualization and location of gestation sac
 - 2) Presence or absence of yolk sac
 - 3) Identification of embryo
 - 4) Presence or absence of cardiac activity
 - 5) Gestational age determination
 - a) Mean sac diameter if no embryo present
 - b) Crown-rump length
 - 6) In multiple gestation: fetal number, chorionicity and amnionicity
 - 7) Uterine, adnexal, and cul-de-sac assessment

B. Second and Third Trimester

1. Fetal number
2. Fetal position
3. Fetal viability and M-Mode for heart rate
4. Fetal measurements for size and growth
 - a. Biparietal diameter
 - b. Head circumference
 - c. Abdominal circumference
 - d. Femur length
 - e. Estimated fetal weight (EFW)
5. Fetal anatomy
 - a. Lateral ventricle
 - b. Choroid plexus
 - c. Cisterna magna
 - d. Cerebellum
 - e. Upper lip
 - f. Midline falx
 - g. Cavum septum pellucidum
 - h. Spine
 - i. Heart
 - 1) 4-chamber
 - 2) outflow tracts

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- j. Stomach
- k. Kidneys
- l. Bladder
- m. Umbilical cord insertion
 - 1) Number of vessels
- n. Extremities
- 6. Gender, if medically indicated
- 7. Placenta
 - a. Position
 - b. Appearance
 - c. Relationship to internal os
- 8. Amniotic fluid
- 9. Maternal anatomy
 - a. Uterus
 - b. Adnexa
 - c. Cervix

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Rationale: Accurate assessment and performance of gynecologic/female pelvis sonograms requires sonographers to assemble a comprehensive knowledge of the anatomy, physiology, pathophysiology, and sonographic appearances of the female reproductive system. An understanding of the embryologic development, pre-menarchal, menarchal, and postmenopausal female reproductive system is essential for the performance of high quality examinations.

SECTION XII: Gynecology - Anatomy, Physiology, and Pathology

1. Describe the embryology, anatomy, function, and normal sonographic appearances of the female pelvis
2. Discuss the sonographic techniques, including emerging technologies, used to evaluate the female pelvis
3. Identify the clinical indications and laboratory values associated with abnormalities and diseases of the female reproductive system
4. Describe congenital abnormalities and pathology in terms of sonographic appearance, sequelae, and associated pathologies

XII. Anatomy, Physiology, and Pathology

A. Normal Pelvic Anatomy

1. Embryology
 - a. Uterus, fallopian tubes and vagina formed by fusion of Mullerian ducts
 - b. Ovaries develop from external cortex of gonadal ridge
2. Uterus
 - a. Hollow, pear-shaped muscular organ with a network of arteries and veins
 - 1) Cervix
 - a) Proximal portion of uterus
 - 2) Isthmus
 - a) Narrow portion connecting body/corpus with cervix
 - 3) Corpus
 - a) Largest portion of the uterus
 - 4) Fundus
 - a) Distal portion containing cornua housing interstitial portion of fallopian tubes
 - b. Tissue layers
 - 1) Serosa
 - a) Surrounds uterus
 - b) Not sonographically distinct
 - 2) Myometrium
 - a) Muscular middle layer
 - 3) Endometrium
 - a) Innermost layer; highly vascular
 - b) Consists of basal and functional layers

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- c) Endometrial canal contiguous with vagina and fallopian tubes
- c. Location
 - 1) In true pelvis posterior to urinary bladder and anterior to rectum
 - 2) Aligned with mid-sagittal plane
 - 3) Body and fundus are loosely held in place by broad and round ligaments
 - 4) Uterosacral ligaments hold cervix in place
- d. Size
 - 1) Related to age, menstrual status, and parity status
 - 2) Measure length, width, height
 - a) Positions of the uterus
 - 3) Most common axis is antverted/anteflexed with non-distended bladder
 - 4) Variations in uterine position
 - a) Retroverted
 - b) Retroflexed
 - c) Dextroposition
 - d) Levoposition
 - e) Dextroflexed
 - f) Levoflexed
- e. Sonographic appearance
 - 1) Myometrium
 - a) Typically homogeneous
 - b) Mid-level gray echogenicity
 - c) Peripheral anechoic structures (vessels)
 - 2) Endometrium
 - a) Varies in echogenicity and thickness cyclically
 - b) Varies in thickness with menopausal status
 - c) Measurement of thickness
- 3. Vagina
 - a. Vagina extends from vulva to the uterus
 - b. Consists of muscular layers and inner mucosa
 - c. Relational anatomy
 - d. Sonographic appearance
 - 1) Highly reflective
- 4. Ovaries
 - a. Location
 - 1) Lateral to uterus
 - 2) Posterior and distal to fallopian tubes
 - 3) Posterior to broad ligament
 - 4) Not covered by peritoneum
 - 5) Anterior to internal iliac vessels
 - b. Connections
 - 1) Mesovarium ligament to broad ligament
 - 2) Inferior to uterus by utero-ovarian ligament
 - 3) To fallopian tube by fimbriae ovarica

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- 4) Lateral pelvis by suspensory ligaments
- 5) Medial, lateral, and posterior borders of each ovary are free
- c. Description
 - 1) Oval/almond-shaped structures
 - 2) May assume more elongated or rounded shape
 - 3) Outer cortex and inner medulla
 - 4) Surface smooth early in life, becoming markedly pitted or puckered with years of ovulatory activity
 - 5) Atrophy following menopause
- d. Size
 - 1) Length, width, depth
 - 2) Volume
 - a) Premenarchal
 - b) Menstruating
 - c) Postmenopausal
- e. Sonographic appearance
 - 1) Solid structure with peripheral anechoic follicles
 - 2) Low to medium-level echogenicity
 - 3) Dominant follicle (graafian follicle) identified prior to ovulation
5. Fallopian tubes
 - a. Description
 - 1) Paired muscular tubular structures
 - 2) Extends from cornua of uterus laterally
 - b. Size
 - 1) Length
 - 2) Diameter
 - c. Divisions
 - 1) Interstitial
 - 2) Isthmus
 - 3) Ampulla
 - 4) Infundibulum
 - a) Contains fimbriae (includes fimbriae ovarica)
 - d. Layers
 - 1) Serosa
 - 2) Middle muscular layer
 - 3) Internal circular layer of muscular fibers
 - e. Sonographic appearance
 - 1) Normal fallopian tube not visualized
6. Supporting Pelvic Structure
 - a. Bones
 - 1) Sacrum
 - 2) Coccyx
 - 3) Two innominate bones
 - a) Ilium
 - b) Pubis
 - c) Ischium

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- b. Regions
 - 1) Greater or false pelvis
 - 2) Lesser or true pelvis
- c. Ligaments
 - 1) Broad ligament
 - 2) Round ligament
 - 3) Cardinal ligament
 - 4) Uterosacral ligament
- 7. Pelvic musculature
 - a. Psoas major muscle
 - b. Iliopsoas muscle
 - c. Obturator internus
 - d. Piriformis
 - e. Levator ani
 - f. Rectus abdominis muscle
- 8. Potential Spaces
 - a. Posterior cul-de-sac
 - b. Anterior cul-de-sac
- 9. Pelvic Vasculature
 - a. Abdominal aorta bifurcates into right and left common iliac arteries
 - 1) Bifurcate into external and internal iliac arteries
 - b. External iliac artery is in the false pelvis
 - 1) Becomes femoral artery
 - c. Internal iliac artery
 - 1) Also known as: hypogastric artery
 - 2) Subdivides into varying number of branches including uterine and ovarian arteries
 - d. Uterine vasculature
 - 1) Venous drainage of uterus is analogous with arterial supply
 - 2) Uterine arteries
 - a) Arises from internal iliac artery
 - 2) Arcuate arteries
 - 3) Radial arteries
 - a) Penetrate myometrium
 - 4) Straight arteries
 - a) Basal layer of endometrium
 - 5) Spiral arteries
 - e. Ovarian arterial supply comes from abdominal aorta
 - 1) Ovarian/gonadal arteries
 - 2) Branch of uterine artery
 - 3) Ovary has dual blood supply
 - f. Ovarian venous drainage
 - 1) Right ovarian vein drains into IVC
 - 2) Left ovarian vein drains into left renal vein
 - g. Vaginal blood supply
 - 1) Vaginal branches of uterine artery

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- 2) Venous drainage is analogous to arterial supply
 - h. Fallopian tubes are supplied by anastomosed ovarian and uterine branches
 - 10. Doppler evaluation
 - a. Endovaginal imaging
 - b. Angle independent waveform analyses
 - 1) A/B ratio
 - 2) Resistive index (RI)
 - 3) Pulsatility index (PI)
 - c. Normal uterine Doppler
 - 1) Demonstrates high resistance flow
 - d. Reproductive age female
 - 1) Ovarian arterial flow varies with menstrual cycle
 - 11. Related imaging studies
 - a. Abdominal sonography
 - b. Computed tomography (CT)
 - c. Magnetic resonance imaging (MRI)
 - d. Radiographic procedures
 - 1) Intravenous pyelography (IVP)
 - 2) Voiding cystourethrogram (VCUG)
 - 3) Barium studies
 - 4) Hysterosalpingography (HSG)
- B. Physiology
- 1. Endocrine Cycle
 - a. Menstrual cycle, ovarian cycle, and endometrial changes
 - 1) Controlled by hormones
 - b. Menstrual cycle depends on functional integrity of three endocrine sources
 - 1) Hypothalamus
 - a) Produces follicle stimulating hormone releasing factor (FSHRF) and luteinizing hormone releasing factor (LHRF)
 - 2) Pituitary gland
 - a) Produces follicle stimulating hormone (FSH) and luteinizing hormone (LH)
 - i. FSH responsible for ripening of graafian follicle
 - ii. LH induces ovulation
 - 3) Ovarian axis
 - a) Secretes estrogen and progesterone
 - b) Contributes to the amount of FSH and LH produced and secreted by pituitary
 - c. Estrogen
 - 1) Principle modulator of hypothalamus-pituitary activity
 - 2) Stimulates endometrial growth
 - 3) Sensitizes the muscle to induce rhythmic contractions of fallopian tubes
 - 4) Stimulates cervical mucous secretion
 - 5) Induces proliferation of vaginal epithelium

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- 6) Stimulates growth of breast duct system
- 7) Responsible for development of female body contours
- d. Progesterone
 - 1) Increases rapidly after ovulation
 - 2) Peaks about seven days post ovulation
 - 3) Is secreted by the corpus luteum during second half of cycle
 - a) Corpus luteum regresses without fertilization
 - b) Progesterone level decreases
 - i. Decreased estrogen and progesterone leads to disintegration of endometrial lining and menstruation occurs
 - 4) Functions
 - a) Induction of secretory activity in endometrial glands
 - b) Desensitizes myometrium to oxytocic activity
 - c) Modifies histological appearance of vaginal epithelium
 - d) Inhibits secretory activity of cervical glands
 - e) Increases basal body temperature
 - f) Stimulates development of alveolar system
 - g) Inhibits secretion of LH, thus inhibiting ovulation
2. Ovarian Cycle
 - a. At birth, each ovary contains approximately 200,000 primary follicles
 - b. Around first day of menstrual cycle four or five primary follicles begin to grow
 - 1) Follicle growth produces low levels of estrogen and minute amounts of progesterone
 - c. At approximately fourth to fifth day, one follicle develops into secondary follicle
 - d. Preovulatory phase
 - 1) Day six to thirteen
 - 2) Secondary follicle matures into graafian follicle
 - 3) Other maturing follicles undergo atresia
 - e. Ovulation occurs approximately on day 14
 - 1) Mature ovum is expelled
 - 2) Ruptured graafian follicle is healed by capillary bleeding and is absorbed
 - f. Luteal phase
 - 1) Day 15 to day 28
 - 2) Follicular cells transform into a golden-colored body called corpus luteum
 - a) Corpus luteum grows for seven to eight days
 - b) Secretes estrogen and increasing amount of progesterone
 - c) Prepares endometrium to receive fertilized ovum
 - d) Without fertilization corpus luteum regresses
 - i. Menstruation occurs
 - ii. Cycle is repeated
3. Menstrual and/or Endometrial Cycle
 - a. Periodic discharge of blood, mucous, tissue, fluid, and epithelial cells

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- b. Rhythmic cycle based on approximately 28 days
 - 1) Menses
 - a) Days one to five
 - 2) Postmenstrual phase
 - a) Days six to nine
 - b) Thin endometrium
 - 3) Proliferative phase
 - a) Days six to thirteen
 - b) Increased thickness of the mucosa
 - 4) Secretory phase
 - a) Days 13 to 28
 - b) Thickening of endometrium
- 4. Pregnancy Test
 - a. Beta human chorionic gonadotropin (β hCG)
 - b. Derived from trophoblast
 - c. Urine pregnancy test
 - 1) False negatives
 - 2) False positives
 - d. Serum pregnancy test
 - 1) More sensitive than urine
 - 2) Use when considering ectopic pregnancy
 - 3) Standards for reporting β hCG Milli-international units (mIU)
 - a) International reference preparation (IRP)
 - b) Second international standard (2nd IS)
 - 4) Sonographic correlation with BhCG levels
- 5. Human chorionic gonadotropin (hCG)
 - a. Produced by trophoblast
 - b. Forms basis of most pregnancy tests
 - c. Rises rapidly after sixth week of gestation
 - d. Peaks at tenth to twelfth week
 - e. Decreases and plateaus at 18-20 weeks
 - f. Levels diminish following parturition
- 6. Fertilization
 - a. Sperm motility
 - b. Sperm dissolves portion of ovum membrane
 - c. Fertilization usually occurs in distal portion of the fallopian tube
 - d. Fertilized ovum develops zona pellucida
 - 1) The fertilized ovum called a zygote
 - e. Zygote
 - f. Cleavage
 - g. Morula
 - h. Blastocyst
 - 1) Differentiation
 - i. Implantation

C. Infertility/Endocrinology

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1. Methods of contraception
 - a. Hormonal
 - 1) Oral contraceptives
 - 2) Depo-medroxyprogesterone acetate
 - 3) Levonorgestrel implants
 - 4) Post-coital hormonal contraception
 - b. Barrier method
 - 1) Diaphragm
 - 2) Cervical cap
 - 3) Condoms
 - c. Intrauterine contraceptive device (IUD)
 - 1) Foreign body (usually T-shaped) placed in fundal portion of endometrial cavity
 - 2) Ovulation and corpus luteum formation are not impaired
 - 3) Risks
 - 4) Sonographic appearance
 - a) Highly reflective structure
 - b) Entrance-exit reflections
 - c) Posterior shadowing
 - d) Radiograph may be performed when not identified sonographically
 - d. Vaginal ring
2. Surgical fertility control
 - a. Bilateral tubal ligation
 - b. Hysterectomy
 - c. Elective abortion
 - d. Micro-inserts into fallopian tubes
3. Infertility
 - a. Definition
 - 1) Pregnancy does not result after one year of normal sexual activity without contraception
 - b. Incidence
 - c. Causes
 - d. Patient management
 - e. Medications
 - f. Assisted reproductive technology (ART) and sonographic guidance
 - 1) Techniques
 - a) Gamete Intrafallopian Transfer (GIFT)
 - b) Zygote Intrafallopian Tube Transfer (ZIFT)
 - c) In Vitro Fertilization (IVF)
 - 2) Patient physiologic changes
 - 3) Sonographic role of monitoring of ART
 - a) Follicular study

D. Postmenopausal

1. Appearance
 - a. Uterus decreases in size

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- b. Ovaries decrease in size
- 2. Hormonal changes due to estrogen deficiency
 - a. Vagina loses rugosity
 - b. Endocervical cells produce less cervical mucous
 - c. Hormone replacement therapy
 - 1) Estrogen
 - 2) Progesterone

E. Pelvic Pathology

- 1. Uterus
 - a. Pediatric pelvis
 - 1) Precocious puberty
 - a) Abnormal early development of sexual maturity
 - 2) Abnormal fluid collections due to obstruction of genital tract
 - a) Hydrometra
 - i. Abnormal collection of fluid within uterine cavity
 - ii. Occurs most commonly in premenarchal patients
 - iii. Etiology
 - i) Imperforate vaginal hymen
 - ii) Congenital vaginal atresia
 - b) Pyometra
 - i. Fluid collection that is mucinous and infectious
 - c) Hydrometrocolpos
 - i. Fluid accumulation in vagina and uterus
 - d) Hematometrocolpos
 - i. After menarche, the menses accumulate within vagina and uterine cavity
 - ii. Older women may experience fluid and/or menses accumulation within uterine cavity secondary to cervical obstruction due to malignancy or cervical stenosis
 - e) Symptoms
 - i. Vague pelvic discomfort
 - ii. Pain with defecation and/or urination
 - iii. May be asymptomatic
 - f) Sonographic appearance
 - i. Anechoic and distended uterine cavity and cervical canal
 - ii. With hematometra or pyometra, cavity may contain echogenic fluid-debris levels
 - 3) Sexual ambiguity
 - a) Etiology
 - i. Male pseudohermaphroditism (46, XY)
 - ii. Female pseudohermaphroditism (46, XX)
 - iii. True hermaphroditism (46, XX or 46, XY)
 - iv. Chromosomal abnormalities
 - b) Treatment
- b. Congenital uterine anomalies (may have associated renal anomalies)

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- 1) Uterus didelphys
- 2) Bicornuate uterus
 - a) Uterus bicornuate bicollis
 - b) Uterus bicornuate unicollis
- 3) Uterus septus
 - a) Subseptus
- 4) Uterus unicornuate
- 5) Uterine aplasia
- c. Endometrial hyperplasia
 - 1) Abnormal thickening of endometrium due to estrogen over-stimulation
 - 2) Associated with tamoxifen
 - 3) Clinical symptoms
 - a) Uterine bleeding
 - 4) Sonographic appearance
 - a) Thickened endometrium
- d. Endometrial polyps
 - 1) Overgrowth of endometrial tissue
 - 2) Clinical symptoms
 - a) Abnormal vaginal bleeding
- e. Endometrial carcinoma
 - 1) Associated with estrogen stimulation
 - 2) Clinical symptoms
 - a) Postmenopausal vaginal bleeding
 - 3) Sonographic appearance
 - a) Normal endometrium (rare)
 - b) Thickened endometrium with or without focal irregularity
 - c) Enlarged uterus with endometrium demonstrating a mixed echogenicity in later stages
- f. Leiomyoma
 - 1) Most common benign gynecological tumor
 - a) Single or multiple
 - b) Degeneration
 - c) May enlarge over time
 - 2) Signs and symptoms
 - a) Asymptomatic
 - b) Pelvic pain
 - c) Menorrhagia
 - d) Enlarged uterine size
 - e) Menstrual irregularity
 - 3) Classifications
 - a) Intramural
 - b) Subserosal
 - c) Submucosal
 - d) Pedunculated
 - 4) Sonographic appearance
 - a) Variable echogenicity

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- i. Hypoechoic
 - ii. Homogeneous
 - iii. Heterogeneous
- b) Shadowing
- c) Well-defined borders
- d) Solid
- e) Doppler
 - i. Stalk
- g. Adenomyosis
 - 1) Endometrial implants lie within myometrium
 - 2) Signs and symptoms
 - a) Pelvic cramping
 - b) Dysmenorrhea
 - c) Uterine enlargement
 - 3) Sonographic appearance
 - a) Hypoechoic uterus
 - b) Heterogeneous myometrium
 - c) Diffusely enlarged
 - d) Myometrial cysts
- h. Nabothian cyst
 - 1) Benign cervical cyst
- i. Cervical carcinoma
 - 1) Etiology unknown
 - 2) Risk factors
 - a) Early sexual encounters
 - b) Multiple sexual partners
 - c) Sexually transmitted infection
 - d) Exposure to human papilloma virus (HIV)
 - 3) Peak incidence post-pubescent women
 - 4) Squamous cell carcinoma most common
 - 5) Signs and symptoms
 - a) Vaginal discharge
 - b) Bleeding
 - c) Malodorous discharge
 - d) Palpable pelvic mass
 - 6) Sonographic appearance
 - a) Normal
 - b) Enlarged, bulky cervix
 - c) Solid mass in cervix
 - d) Hematometra or pyometra with cervical stenosis
 - e) Extension of disease to pelvic sidewalls, bladder, and rectum
- j. Leiomyosarcoma
 - 1) Rare malignant tumor
 - 2) Signs and symptoms
 - a) Asymptomatic
 - b) Uterine bleeding

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- 3) Sonographic appearance
 - a) Similar to leiomyoma
 - b) Cystic degeneration
 - c) Inhomogeneous uterine mass
 - d) Local invasion or distant metastases
2. Ovarian
 - a. Functional masses
 - 1) Follicular cyst
 - a) Occurs when dominant follicle fails to ovulate
 - b) May lead to menstrual irregularities
 - c) Sonographic appearance
 - i. Anechoic
 - ii. Thin wall
 - iii. Posterior enhancement
 - 2) Corpus luteum cyst
 - a) Forms after the dominant follicle ruptures and ova is expelled
Excessive hemorrhage occurs at rupture site
 - b) Signs and symptoms
 - i. Pelvic pain
 - ii. Nausea and vomiting
 - iii. Enlarged, tender ovary
 - c) Sonographic appearance
 - i. Complex cyst
 - d) Corpus luteum cyst of pregnancy
 - i. Supports early pregnancy
 - ii. Sonographic appearance
 - i) Thin-walled
 - ii) Unilateral
 - iii) Fluid in posterior cul-de-sac with rupture
 - 3) Theca lutein cysts
 - a) Develop with high levels of human chorionic gonadotropin (hCG)
 - b) Associations
 - i. Gestational trophoblastic neoplasia
 - ii. Ovarian hyperstimulation syndrome
 - iii. Multiple pregnancy and singleton gestations
 - c) Sonographic appearance
 - i. Bilateral
 - ii. Large, multilocular cysts
 - b. Benign
 - 1) Paraovarian cysts
 - a) Arise from Gartner's duct remnants or from hydatid of Morgagni
 - b) Found within broad ligament
 - c) Sonographic appearance
 - i. Thin-walled
 - ii. Anechoic
 - iii. Variable size

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- 2) Serous cystadenoma
 - a) Common, benign epithelial tumor
 - b) Sonographic appearance
 - i. Unilateral
 - ii. Cystic structure with low-level debris
 - iii. Smooth walls
 - iv. May contain septae
- 3) Mucinous cystadenoma
 - a) Benign epithelial tumor
 - b) Sonographic appearance
 - i. Multi-septate tumor
 - ii. Large
- 4) Mature cystic teratoma
 - a) AKA dermoid
 - b) Germ cell tumor
 - c) Usually seen in young women of reproductive age
 - d) Signs and symptoms
 - i. Mild to acute pain
 - ii. Adnexal fullness
 - iii. Pressure symptoms
 - e) Sonographic appearance
 - i. Cystic to complex
 - ii. Calcification with shadowing
- 5) Fibroma
 - a) Stromal tumor
 - b) Associated with Meigs' syndrome
 - i. Pelvic mass
 - ii. Hydrothorax
 - iii. Ascites
 - c) Signs and symptoms
 - i. Local pelvic pain
 - ii. Pressure symptoms when large
 - iii. Asymptomatic when small
 - d) Sonographic appearance
 - i. Solid
 - ii. Hyperechoic
- 6) Theca cell tumor
 - a) Benign, solid, unilateral mass most commonly found in menopausal or postmenopausal women
 - b) Signs and symptoms
 - i. Pelvic pain
 - ii. Pressure
 - c) Sonographic appearance
 - i. Ovarian enlargement
 - ii. Solid
 - iii. Attenuating

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- iv. Calcifications may be seen
- v. Cystic degeneration may occur
- 7) Brenner tumor
 - a) Uncommon, solid mass
 - b) May be associated with Meigs' syndrome
 - c) Rarely malignant
- 8) Endometrioma
 - a) Large cysts filled with dark brown fluid
 - b) Occurs with endometriosis
 - i. Ectopic endometrial tissue found on structures within abdominal-pelvic cavity
 - c) Signs and symptoms
 - i. Dyspareunia
 - ii. Metromenorrhagia
 - iii. Dysmenorrhea
 - d) Sonographic appearance
 - i. Well defined
 - ii. Low-level echogenicity
 - iii. Cystic mass filled with low-level echos
 - iv. Punctate calcifications
- c. Malignant
 - 1) Epithelial ovarian cancer
 - a) Most common type of ovarian cancer
 - b) More common in postmenopausal women
 - c) Risk factors
 - i. Age
 - ii. Family history of ovarian or breast cancer
 - iii. Nulliparity
 - iv. Infertility
 - v. Late menopause
 - vi. Prolonged ovulatory activity
 - d) Clinical signs and symptoms
 - i. Abdominal pain
 - ii. GI symptoms
 - iii. Pressure
 - iv. Vaginal bleeding
 - v. Weight change
 - vi. Endocrine imbalance
 - vii. Elevated CA 125
 - e) Sonographic appearance
 - i. Ovarian mass
 - ii. Cystic components
 - iii. Thick septations
 - iv. Mural nodules
 - v. Calcifications with or without shadowing
 - vi. Low-level echoes within cystic component

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- vii. Decreased vascular impedance
- viii. Extra-ovarian findings
- 2) Germ cell
 - a) Dysgerminoma
 - i. Frequency of occurrence
 - i) Rare, malignant epithelial tumor
 - ii. Sonographic appearance
 - i) Solid
 - ii) Homogeneous
 - iii) Irregularly defined
 - iv) May see cystic degeneration
 - b) Immature/malignant teratoma
 - i. Frequency of occurrence
 - i) Rare malignant tumor
 - ii) Occurring more frequently in children and young adults
 - ii. Sonographic appearance
 - i) Unilateral
 - ii) Solid
 - iii) Well-defined
 - iv) Variable echogenicity
 - v) Cystic degeneration may be seen
- 4) Sex cord stromal tumors
- 5) Metastasis
 - a) Krukenburg's tumor
 - i. Secondary ovarian carcinoma from primary neoplasm of gastrointestinal tract
- d. Ovarian torsion
 - 1) Partial or complete rotation of pedicle secondary to ovarian mass or cyst
 - a) Occlusion or decrease of blood inflow and outflow
 - 2) Signs and symptoms
 - a) Sudden onset of severe pelvic pain
 - b) Nausea, vomiting
 - c) Palpable adnexal mass
 - 3) Sonographic appearance
 - a) Ovarian enlargement
 - b) Hyperechoic ovary
 - c) Heterogeneous
 - d) Dilated vessels on periphery of ovary
 - e) Doppler may demonstrate absent or decreased blood flow
- e. Polycystic ovarian disease
 - 1) Identified in young women
 - 2) Stein-Leventhal syndrome
 - a) Polycystic ovaries
 - b) Hirsutism
 - c) Amenorrhea

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- d) Enlarged ovaries
- e) Obesity
- f) Impaired fertility
- 3) Sonographic appearance
 - a) Bilaterally, mildly enlarged ovaries
 - b) Multiple peripheral small cysts
- 3. Pelvic inflammatory disease (PID)
 - a. Inflammatory condition of uterus, cervix, ovaries, fallopian tubes, and peritoneal surfaces
 - b. Etiology
 - 1) Sexually-transmitted infection (STI)
 - 2) Intrauterine device (IUD) use
 - 3) Extension of lower abdominal and/or pelvic abscesses
 - 4) Complication of postabortion or childbirth
 - c. Classifications
 - 1) Acute
 - 2) Chronic
 - d. Signs and symptoms
 - 1) Severe pelvic pain
 - 2) Fever
 - 3) Shaking/chills
 - 4) Leukocytosis
 - 5) Vaginal discharge
 - 6) Irregular vaginal bleeding
 - 7) Rebound tenderness
 - 8) Pain with cervical manipulation
 - 9) Dyspareunia
 - e. Complications
 - 1) Endometritis
 - a) Sonographic appearance
 - i. Normal
 - ii. Thickened endometrium
 - iii. Air or fluid in endometrial cavity
 - iv. Increased vascularity
 - 2) Salpingitis
 - a) Sonographic appearance
 - i. Distended fallopian tubes with thickened walls and pyosalpinx in acute phase
 - ii. Hydrosalpinx in chronic phase
 - 3) Tubo-ovarian abscess (TOA)
 - a) Result of very severe pelvic infection
 - b) Signs and symptoms
 - i. High fever
 - ii. Elevated WBC
 - iii. High erythrocyte sedimentation (ESR)
 - iv. Severe lower abdominal pain

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- v. Nausea and vomiting
 - vi. RUQ pain
 - vii. Possible peritonitis
 - viii. Fitz-Hugh-Curtis Syndrome
4. Doppler flow studies
 - a. Uterine artery Doppler
 - 1) Uterine neoplasms
 - b. Ovarian Doppler
 - 1) Ovarian neoplasms
 - c. Endometrial
 5. Correlative and/or prior imaging
 - a. Sonographic procedures
 - 1) Sonohysterography
 - b. Radiographic procedures
 - 1) Fluoroscopic studies
 - 2) Intravenous urogram (IVU)
 - 3) Voiding cystourethrogram (VCUG)
 - 4) Hysterosalpingography (HSG)
 - c. Computed tomography (CT)
 - d. Magnetic resonance (MRI)

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SECTION XIII: Gynecology - Patient Care and Imaging Techniques

1. List pertinent information derived from the patient interview and/or review of medical chart that is obtained prior to the sonogram
2. Describe the sonographic techniques, including emerging technologies, used to evaluate the female pelvis
3. Describe the protocol and procedure for transabdominal and endovaginal female pelvis sonograms

XIII. Patient Care and Imaging Techniques

A. Patient Assessment

1. Patient history
 - a. Menstrual history
 - 1) Implantation break-through bleeding
 - b. History of pain/fever
 - c. Pregnancy test and type of test
 - d. History of vaginal bleeding
 - e. Abdominal and pelvic surgeries
 - f. IUD usage
 - g. Reason for referral
 - h. History of smoking and alcohol use
 - i. Medications
 - j. Pertinent laboratory tests
 - k. Palpable pelvic mass
 - l. Obstetrical history
 - m. History of disease and/or anomaly
 - n. History of assisted reproduction
 - 1) Pertinent family history

B. Scanning Techniques

1. Transperineal scanning
2. Transabdominal imaging
 - a. Adequate filling of urinary bladder
 - b. Patient supine
 - c. Transducer selection
3. Endovaginal imaging
 - a. Empty urinary bladder
 - b. Lithotomy position
 - c. Transducer selection and disinfection
 - d. Transducer covers
 - 1) Latex
 - 2) Non-latex
 - e. Lubricants

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4. Anatomical evaluation and documentation
 - a. Gynecologic examination
 - 1) Bladder
 - a) Anechoic
 - b) Size, shape
 - c) Bladder wall
 - d) Distention
 - 2) Uterus
 - a) Endometrium
 - b) Myometrium
 - c) Borders
 - d) Position
 - e) Echogenicity
 - f) Measurements
 - i. Length
 - ii. Width
 - iii. Height
 - g) Cervix
 - 3) Ovaries
 - a) Echogenicity
 - b) Location
 - c) Size
 - d) Measurements (length, width, depth)
 - e) Adjacent adnexa
 - 4) Potential spaces
 - 5) Evaluation of anomalies
 - a) Location
 - b) Size
 - c) Borders
 - d) Contents
 - e) Presence of ascites
 - f) Evaluate kidneys if needed

C. Procedures

1. Sonohysterography
2. Follicular aspiration
3. Abscess drainage

D. Emerging Technologies

1. 3-D imaging
2. Volume rendering
3. Focused ultrasonic ablation of tumors
4. Guidance for cryoablation

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ABBREVIATIONS

A

AC	Abdominal Circumference
AFI	Amniotic Fluid Index
AFP	Alpha Feto Protein
ALARA	As Low As Reasonably Achievable
ADPKD	Adult Dominant Polycystic Kidney Disease
ART	Assisted Reproductive Technology

B

β hCG	Beta-Human Chorionic Gonadotropin
BPD	Biparietal Diameter

C

CAM	Cystic Adenomatoid Malformation
CI	Cephalic Index
CRL	Crown Rump Length
CT	Computerized Axial Tomography

E

ESR	Erythrocyte Sedimentation Rate
ESW	Estimated Fetal Weight

F

FL	Femur Length
FSH	Follicle Stimulating Hormone
FSHRF	Follicle Stimulating Hormone Releasing Factor

G

GA	Gestational Age
GIFT	Gamete Intrafallopian Transfer
GTN	Gestational Trophoblastic Neoplasia
GTT	Glucose Tolerance Test

H

hCG	Human Chorionic Gonadotropin
HIV	Human Papilloma Virus
HSG	Hysterosalpingography

I

IOD	Inner Orbital Diameter
IRP	International Reference Preparation
IRPKD	Infantile Recessive Polycystic Kidney Disease
IUD/IUCD	Intrauterine Contraceptive Device
IUGR	Intrauterine Growth Restriction

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IVC	Inferior Vena Cava
IVF	In Vitro Fertilization
IVU	Intravenous Urogram
<u>L</u>	
LGA	Large for Gestation Age
LH	Lutinizing Hormone
LHRF	Lutinizing Hormone Releasing Factor
LMP	Last Menstrual Period
<u>M</u>	
MA	Menstrual Age
MCDK	Multicystic Dysplastic Kidney
MHZ	Megahertz
MI	Mechanical Index
MIU	Milli-International Units
MRI	Magnetic Resonance Imaging
MSAFP	Maternal Serum Alpha-Feto Protein
MSD	Mean Sac Diameter
MVP	Maximum Vertical Pocket
<u>O</u>	
OFD	Occipital Frontal Diameter
OOD	Outer Orbital Diameter
<u>P</u>	
PI	Pulsatility Index
PID	Pelvic Inflammatory Disease
PUBS	Percutaneous Umbilical Blood Sampling
PUV	Posterior Urethral Valve
<u>R</u>	
RI	Resistive Index
<u>S</u>	
2ndIS	Second International Standard
SGA	Small for Gestation Age
S/D ratio	Systolic/Diastolic Ratio
SHG	Sonohysterography
STI	Sexually Transmitted Infection
SUA	Single Umbilical Artery
SVC	Superior Vena Cava
<u>T</u>	
TI	Thermal Index
TOA	Tubo-Ovarian Abscess

Obstetrics/Gynecology

TRAP
TTTS

Twin Reversed Arterial Perfusion
Twin-to-Twin Transfusion Syndrome

U
UPJ
UVJ

Ureteropelvic Junction
Ureterovesical Junction

V
VCUG

Voiding Cystourethrogram

Z
ZIFT

Zygote Intrafallopian Tube Transfer

Obstetrics/Gynecology

UTILIZED REFERENCES

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ARDMS Obstetrics and Gynecology Content Outline

ARRT Sonography content outline

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Vascular Technology

Rationale: Accurate, appropriate, noninvasive vascular examinations require knowledge of sonography physical principles and instrumentation, hemodynamics, and the pathophysiology and treatment of vascular disease. The application of this knowledge to standardized diagnostic test protocols, correlation of test data with other recognized imaging modalities, and an ongoing quality assurance program is requisite to quality patient care.

SECTION I: Fluid Dynamics

1. Define power, work, and energy
2. Describe the differences between potential and kinetic energy
3. Explain the importance of hydrostatic pressure in the human circulatory system
4. Describe the relationship between volumetric flow and blood flow velocity
5. Define capacitance and compliance
6. Explain the impact of variations in fluid viscosity on blood flow
7. Describe the components of Poiseuille's law and Bernoulli's principle

I. Fluid Dynamics

A. General Description

1. Flow and related terms
2. Power, work, and energy
3. Potential and kinetic energy
4. Hydrostatic pressure
5. Volumetric flow
6. Velocity
7. Capacitance
8. Compliance
9. Fluid viscosity

B. Derivation of Equations

1. Describe
 - a. Resistance equation
 - b. Volumetric flow equation (continuity equation)
 - c. Simplified law of hemodynamics
 - d. Pressure/flow relationships
 - 1) Poiseuille's law
 - 2) Bernoulli's principle
 - a) Conservation of energy
 - b) Bernoulli's equation
 - i. Equation with hydrostatic pressure term
 - ii. Equation with heat term
 - 3) Reynold's number
 - e. Relationship of equation components to each other

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- C. Description of Steady Flow
 - 1. Rigid tube
 - 2. Curved tube

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SECTION II: Physiology and Hemodynamics

1. Explain the relationship between pressure, flow, and resistance
2. Define and describe high resistance and low resistance flow profiles
3. Relate the difference between steady and pulsatile flow
4. Describe the changes in pulsatility of flow that occur with vasoconstriction and vasodilation
5. Describe normal and abnormal flow profiles that occur in the arterial and venous systems
6. Correlate flow profiles to pressure, flow, and resistance
7. Define systemic versus autoregulatory control of peripheral resistance

II. Physiology and Hemodynamics (Pulmonary versus Systemic)

A. Pressure and Flow Resistance

1. Left heart
 - a. Stroke volume
 - b. Cardiac output
 - 1) Ejection fraction
 - 2) Pre-load and after-load
 - c. Cardiac cycle
 - d. Electrical conductivity
 - 1) Relation to waveform morphology
2. Peripheral arterial system
 - a. Vessel sizes
 - b. Arterial resistance
 - 1) High resistance
 - 2) Low resistance
 - c. Volume flow changes
 - 1) Effects of vessel diameter
 - 2) Anatomy
 - 3) Pathology
 - 4) End-organ perfusion
 - d. Effective resistance in peripheral arterial system
 - 1) Arteries
 - 2) Arterioles
 - 3) Capillaries
3. Peripheral venous system
 - a. Vessel diameter
 - b. Anatomy
 - c. Pathology
 - d. Effective resistance in the peripheral venous system
 - 1) Vena cava
 - 2) Peripheral veins
 - 3) Venules

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4. Right and left heart
 - a. Effects on peripheral flow patterns
 - b. Pulmonary hemodynamics
5. Cardiovascular system
 - a. Velocity versus cross-sectional area
 - b. Pressure changes in arterial system
 - 1) Arteriolar regulation
 - 2) Change in pulsatility waveforms
 - 3) Vasoconstriction/vasodilation
 - c. Pressure changes in venous system
 - 1) Venous pressure
 - 2) Venous capacitance and static filling pressure
 - 3) Hydrostatic pressure
 - 4) Calf muscle pump
 - 5) Respiratory related changes
 - 6) Venous resistance and transmural pressure
 - 7) Venous hypertension and edema

B. Arterial Hemodynamics

1. Total energy
 - a. Potential
 - 1) Hydrostatic
 - 2) Gravitational
 - b. Kinetic
 - c. Conservation of energy
2. Energy gradient
 - a. Definition
 - b. Effects on flow
 - c. Effects of cardiac output and peripheral resistance
3. Resistance
 - a. Effects of viscosity, friction, inertia
 - b. Blood in a non-Newtonian fluid
 - c. Autoregulatory versus sympathetic
4. Application of pressure/flow relationship
 - a. Poiseuille's law
 - 1) Vessel length
 - 2) Vessel radius
 - b. Reynolds number
5. Application of flow/pressure/velocity relationship
 - a. Bernoulli's principle
6. Steady versus pulsatile flow
7. Doppler flow profiles
 - a. Flow patterns
 - 1) Laminar
 - a) Plug
 - b) Parabolic

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- 2) Disturbed
 - 3) Turbulent
 - b. Waveform morphology
 - 1) Triphasic
 - 2) Biphasic
 - 3) Monophasic
 - c. Pressure pulse distortion
 - 8. Effects of stenosis/occlusion on flow characteristics
 - a. Definition of hemodynamic significant stenosis
 - 1) Flow versus pressure gradient
 - b. Direction of flow, turbulence, disturbed flow
 - c. Velocity acceleration/deceleration
 - d. Entrance/exit effects
 - e. Diameter reduction
 - f. Peripheral resistance
 - g. Collateral effects
 - h. Effects of exercise
 - i. Effects of occlusion
- C. Venous Hemodynamics
- 1. Total energy
 - a. Potential
 - 1) Hydrostatic
 - 2) Gravitational
 - b. Kinetic
 - c. Conservation of energy
 - 2. Venous resistance
 - 3. Pressure/volume relationships
 - a. Pressure gradient
 - b. Respiriophasicity
 - c. Effects of calf muscle pump mechanism
 - 1) Rest
 - 2) Contraction
 - 3) Relaxation
 - d. Obstruction/resistance
 - e. Venous insufficiency
 - 1) Duration of reflux
 - 2) Venous hypertension
 - f. Cardiac cycle
 - 4. Effects of edema
 - 5. Doppler flow profiles
 - a. Continuous/non-phasic
 - b. Phasic
 - 1) Respiration
 - 2) Heartbeat

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SECTION III: Physical and Electrical Principles

1. Relate the difference between ultrasound energy and power
2. Describe the types of graphic recording used in noninvasive vascular testing
3. Explain methods for calibrating sonographic imaging systems and plethysmographic instruments
4. Define alternating current (AC) versus direct current (DC) coupling, and explain the potential artifacts associated with inappropriate use
5. List the most common units of measure associated with noninvasive vascular testing
6. Describe the most common tests used for evaluation of tissue mechanics and pressure transmission in the peripheral venous and arterial systems
7. List the types of plethysmography and pressure assessments used for evaluation of the peripheral arteries and veins
8. Explain the relationship between Ohm's Law and hemodynamics

III. Physical and Electrical Principles

A. General

1. Energy
2. Power
 - a. Relationship to flow dynamics
3. Ohm's Law
 - a. Description
 - b. Relationship to flow dynamics
4. Graphical recording
 - a. Sweep speed
5. Calibration and optimization
 - a. Duplex
 - b. Continuous wave Doppler
 - c. Plethysmographs
 - d. Strip chart
6. Zero-crossing detector
 - a. AC/DC coupling
7. Information displays
 - a. Monitors
 - b. Strip chart
8. Picture archiving communication system (PACS)
 - a. Digital imaging and communications in medicine (DICOM)

B. Units of Measure

1. Peak-systolic velocity (PSV)
2. End-diastolic velocity (EDV)
3. Pulsatility index (PI)
4. Resistive index (RI)
5. Frequency (kilo Hertz, mega Hertz)

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6. Centimeters or meters per second
 7. Distance
 8. Ratios
- C. Tissue Mechanics/Pressure Transmission
1. Venous occlusion by limb positioning
 2. Superficial venous occlusion by tourniquets
 3. Volume changes by inflow/outflow
 4. Arterial occlusion by cuffs
- D. Plethysmography
1. Volume displacement (pneumatic cuff)
 2. Photoplethysmography (PPG)
 - a. Venous
 - b. Arterial
- E. Pressure Measurements
1. Palpatory
 2. Auscultatory
 3. Continuous Wave (CW)-Doppler (flow meter)
 4. Segmental pressure measurements
 - a. Cuff size artifact
- F. Other
1. Skin temperature
 2. Transcutaneous oximetry (TCPO₂)
 3. Laser Doppler
- G. Oculopneumoplethysmography (historical)
1. OPG-Gee

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SECTION IV: Cerebrovascular

1. Identify the vessels in the extracranial and intracranial cerebrovascular system
2. Explain the effects of collateral flow on cerebral hemodynamics
3. List the risk factors and mechanism for cerebrovascular disease
4. Describe the evolution of atherosclerotic plaque
5. Define transient ischemic attack (TIA), reversible ischemic neurologic deficit (RIND), stroke, and vertebrobasilar insufficiency (VBI)
6. Describe the capabilities, limitations, protocol/techniques, waveforms, and diagnostic criteria for cerebrovascular circulation test procedures
7. Describe the effects of stenosis and occlusion on flow characteristics in the extracranial cerebrovascular system
8. Define standard contrast, digital subtraction, computed tomographic arteriography, and magnetic resonance arteriography
9. List the current treatment options for patients with cerebrovascular disease

IV. Cerebrovascular

A. Anatomy

1. Aortic arch
 - a. Components
 - 1) Ascending
 - 2) Transverse
 - 3) Descending
 - b. Major branches
 - 1) Innominate artery (braciocephalic)
 - 2) Left common carotid artery
 - 3) Left subclavian artery
 - c. Origination and termination of vessels
 - d. Relational anatomy of vessels
 - 1) Principal arch anomalies
 - e. Collateral pathways
2. Carotid artery (extracranial)
 - a. Components
 - 1) Common carotid artery (CCA)
 - 2) Carotid bulb
 - 3) Internal carotid artery (ICA)
 - a) Carotid siphon
 - b) Ophthalmic artery - 1st intracranial branch
 - 4) External carotid artery (ECA)
 - a) Superior thyroid artery
 - b) Ascending pharyngeal
 - c) Lingual
 - d) Occipital
 - e) Facial

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- f) Posterior auricular
 - g) Maxillary
 - h) Superficial temporal
 - b. Origination and termination of vessels
 - c. Relational anatomy
 - d. Collateral pathways
 - 3. Vertebral artery (Vert)
 - a. Segments
 - 1) Pre-vertebral
 - 2) Cervical
 - 3) Horizontal (Atlantic)
 - 4) Intracranial
 - b. Origination and termination
 - c. Relational anatomy
 - d. Collateral pathways
- B. Intracranial Circulation
- 1. Components
 - a. Circle of Willis and contributing arteries
 - 1) Terminal ICA
 - 2) Middle cerebral artery (MCA)
 - 3) Anterior cerebral artery (ACA)
 - 4) Anterior communicating artery (ACoA)
 - 5) Posterior communicating arteries (PCoA)
 - 6) Posterior cerebral arteries (PCA)
 - 7) Basilar artery (Bas)
 - b. Terminal vertebral artery
 - 2. Origination and termination
 - 3. Relational anatomy
 - 4. Collateral pathways
- C. Common Congenital Anomalies
- D. Risk Factors
- 1. Controllable
 - a. Diabetes
 - b. Hyperlipidemia
 - c. Hypertension
 - d. Smoking
 - 2. Uncontrollable
 - a. Age
 - b. Gender
 - c. Family history
 - d. Hypercoagulopathy
- E. Mechanisms of Disease

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1. Atherosclerosis
 - a. Definition/characteristics
 - b. Common locations
 - c. Plaque evolution
 - 1) Endothelial injury
 - 2) Sub-endothelial deposit of lipids
 - 3) Inflammatory response; smooth muscle cell proliferation
 - 4) Plaque formation
 - a) Hemorrhage
 - b) Necrosis
 - c) Ulceration
 - d) Embolization/thrombosis
 2. Aneurysm
 - a. Definition/characteristics
 - 1) True aneurysm
 - a) Fusiform
 - b) Saccular
 - 2) Dissecting (arterial)
 - 3) Pseudoaneurysm
 - b. Common locations
 3. Thromboembolic events
 - a. Definition/characteristics
 4. Carotid body tumor
 - a. Definition/characteristics
 5. Fibromuscular dysplasia (FMD)
 - a. Definition/characteristics
 - b. Common locations
 6. Subclavian (vertebral) steal
 - a. Definition/characteristics
 7. Neointimal hyperplasia
 - a. Definition/characteristics
 - b. Common locations
- F. Types of Stroke
1. Hemorrhagic
 2. Ischemic
 3. Lacunar
- G. Signs and Symptoms
1. Transient symptoms
 - a. Transient ischemic attack (TIA)
 - b. Vertebrobasilar insufficiency (VBI)
 2. Non-localizing (non-focal) symptoms
 3. Stroke
 - a. Minor
 - b. Major

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- H. Physical Examination
 - 1. Palpation of pulses
 - a. Locations
 - b. Relevance
 - 2. Auscultation – bruits
 - a. Definition
 - b. Location
 - c. Relevance
 - 3. Bilateral brachial systolic pressure measurements
 - a. Indication
 - b. Relevance
- I. Noninvasive Test Procedures
 - 1. Duplex sonography
 - a. Patient positioning
 - b. Choice of instrumentation/transducer frequencies
 - c. Examination protocol
 - d. Imaging and spectral Doppler techniques
 - e. 2-D interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Diameter versus area
 - b) Intimal medial thickness (IMT)
 - c) Aneurysm size
 - f. Spectral Doppler interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Peak systolic velocity
 - b) ICA/CCA ratio
 - c) End diastolic velocity
 - d) Pitfalls of measurements
 - e) Current diagnostic criteria
 - g. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
 - a) Aliasing
 - b) Bruit
 - h. Capabilities
 - i. Limitations
 - 2. Intraoperative duplex sonography
 - a. Indications
 - b. Capabilities

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- c. Limitations
- 3. Transcranial Doppler (TCD)/Transcranial Imaging (TCI) Examination
 - a. Patient positioning
 - b. Choice of instrumentation/transducer frequency
 - 1) Imaging
 - 2) Non-imaging
 - c. Examination protocol
 - 1) Acoustic windows
 - 2) Vessel depth
 - 3) Signal traceability
 - 4) Sample volume size
 - 5) Transmit frequency/power
 - d. Imaging and spectral Doppler techniques
 - e. Spectral Doppler interpretation
 - 1) Normal characteristics
 - a) Flow direction
 - b) Flow pattern
 - c) Velocity ranges
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Maximum of the mean velocity
 - b) Peak systolic velocity
 - c) End diastolic velocity
 - d) ICA/MCA ratio
 - e) Pulsatility index
 - f) Pitfalls of measurements
 - g) Embolic showers
 - f. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
 - g. Capabilities
 - 1) Current clinical use
 - h. Limitations
- J. CW Doppler
 - 1. Patient positioning
 - 2. Examination protocol/technique
 - 3. Interpretation
 - a. Normal characteristics
 - b. Abnormal characteristics
 - c. Measurements
- K. Correlative and/or Prior Imaging
 - 1. Conventional arteriography
 - a. Interpretation

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- 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
 2. Digital subtraction arteriography (DSA)
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
 3. Computed tomography arteriography (CTA)
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
 4. Magnetic resonance arteriography (MRA)
 - a. Current clinical use
 - b. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - c. Limitations
- L. Treatment
1. Indications
 2. Medical control and reduction of risk factors
 - a. Lifestyle
 - b. Pharmacologic control
 - 1) Hypertension
 - 2) Cholesterol
 - 3) Clotting factors
 3. Endovascular
 - a. Percutaneous transluminal angioplasty (PTA)
 - b. Stent
 4. Surgical
 - a. Endarterectomy
 - b. Bypass graft
 5. Acute thrombolytic therapy

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SECTION V: Peripheral Venous

1. Identify the central, upper, and lower extremity deep and superficial veins, and list the major perforating veins in the lower extremity
2. Describe the function of vein valve leaflets in venous physiology in the normal patient and the patient with venous insufficiency
3. List the components of Virchow's Triad, and relate how these impact venous pathophysiology
4. Describe risk factors for venous thrombosis
5. Relate the mechanisms of disease associated with acute and chronic deep vein thrombosis, superficial thrombophlebitis, venous insufficiency, and pulmonary embolism
6. Define the clinical signs associated with acute and chronic deep vein thrombosis and superficial thrombophlebitis
7. Describe the role of the calf muscle pump in venous physiology
8. Relate the pathological findings associated with venous stasis and venous insufficiency
9. Describe the capabilities, limitations, patient positioning, protocol/techniques, and diagnostic criteria for the following venous examinations: duplex sonography, color flow imaging, and venous refill plethysmography
10. Define correlative imaging technologies
11. List the current treatment options for patients with deep vein thrombosis or superficial thrombophlebitis

V. Peripheral Venous

A. Anatomy

1. Upper extremity deep veins
 - a. Components
 - 1) Deep digital and deep palmar
 - 2) Radial and ulnar
 - 3) Brachial
 - 4) Axillary
 - 5) Subclavian
 - 6) Brachiocephalic (innominate)
 - 7) Neck – Internal jugular, external jugular
 - b. Origination and termination of vessels
 - c. Anatomic anomalies
 - d. Relational anatomy of vessels
 - e. Collateral pathways
2. Upper extremity superficial veins
 - a. Components
 - 1) Cephalic
 - 2) Basilic
 - 3) Median cubital

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- b. Origination and termination of vessels
- c. Anatomic anomalies
- d. Relational anatomy of vessels
- e. Collateral pathways
- 3. Lower extremity deep veins
 - a. Components
 - 1) Deep digital and metatarsal
 - 2) Calf veins
 - a) Soleal veins
 - b) Gastrocnemius (sural) veins
 - c) Tibial
 - d) Peroneal
 - e) Posterior tibial
 - f) Anterior tibial
 - 3) Popliteal
 - 4) Femoral (FV)
 - 5) Deep femoral (profunda femoris)
 - 6) Common femoral (CFV)
 - 7) External and internal iliac (hypogastric)
 - 8) Common iliac
 - 9) Inferior vena cava
 - b. Origination and termination of vessels
 - c. Anatomic anomalies
 - d. Relational anatomy of vessels
 - 1) Significance of left common iliac vein location
 - e. Collateral pathways
- 4. Lower extremity superficial veins
 - a. Components
 - 1) Great saphenous
 - 2) Small saphenous
 - b. Origination and termination of vessels
 - c. Anatomic anomalies
 - d. Relational anatomy of vessels
 - e. Collateral pathways
- 5. Lower extremity perforating veins
 - a. Origination and termination of vessels
- 6. Central venous system
 - a. Components
 - 1) Vena cava
 - a) Superior vena cava
 - b) Inferior vena cava (IVC)
 - 2) Portal, hepatic, renal, and mesenteric
 - b. Origination and termination of vessels
 - c. Anatomic anomalies
 - d. Relational anatomy of vessels
 - e. Collateral pathways

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7. Vein walls and valve leaflets
 - a. Intima
 - b. Media
 - c. Adventitia
 - d. Valve leaflets
 - 1) Location and number of valves

B. Risk Factors

1. Pre-disposing
 - a. Age
 - b. Cancer
 - c. Prolonged bed rest or inactivity
 - d. Prior episode of DVT
 - e. Trauma
 - f. Hormones
 - g. Paraplegia
 - h. Surgery
 - i. Pregnancy
 - j. Thrombophilias
2. Virchow's triad
 - a. Stasis
 - b. Hypercoagulability
 - c. Vessel wall injury

C. Mechanisms of Disease

1. Acute deep venous thrombosis
2. Chronic deep venous thrombosis
 - a. Post-thrombotic syndrome
3. Chronic venous insufficiency
 - a. Valvular incompetence
 - b. Outflow obstruction
 - c. Stasis ulceration
 - d. Ambulatory venous hypertension
4. Varicose veins
 - a. Primary venous insufficiency
 - b. Secondary venous insufficiency
5. Congenital
 - a. Absence of valves
 - b. Hypercoagulability
6. Pulmonary embolism (PE)

D. Signs and Symptoms

1. Acute deep venous thrombosis
 - a. Phlegmasia alba dolens
 - b. Phlegmasia cerula dolens
2. Chronic deep venous thrombosis

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3. Venous ulceration/stasis ulcers
 - a. Chronic venous insufficiency (CVI)
 - 1) Clinical etiologic anatomic pathologic classification (CEAP)
 - a) Venous ulcer, venous stasis
- E. Noninvasive Test Procedures for Upper and Lower Extremities Venous Thrombosis
 1. Duplex imaging
 - a. Patient positioning
 - b. Choice of instrument/transducer frequencies
 - c. Examination protocol
 - d. Imaging and spectral Doppler techniques
 - e. 2-D interpretation
 - 1) Thrombus characteristics
 - a) Acute
 - b) Chronic
 - 2) Normal characteristics
 - 3) Abnormal characteristics
 - f. Spectral Doppler interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Flow characteristics
 - g. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
 - 4) Recanalization
 - 5) Collateralization
 - h. Capabilities
 - i. Limitations
 2. CW Doppler (historical)
- F. Noninvasive Test Procedures for Chronic Venous Insufficiency
 1. Duplex imaging/color flow imaging
 - a. Identification of valvular incompetence
 - 1) Spectral Doppler
 - 2) Color Doppler
 - 3) Duration of retrograde flow
 - b. Identification of perforator incompetence
 - 1) Spectral Doppler
 - 2) Color Doppler
 - c. Venous obstruction
 2. Reflux plethysmography
 - a. Photoplethysmography (PPG)
 - 1) Venous refill time (VRT)
 - a) Deep versus superficial venous incompetence

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- b) Tourniquet application/location
- b. Air plethysmography

G. Correlative and/or Prior Imaging

1. Conventional venography
 - a. Ascending
 - b. Descending
2. Magnetic resonance venography (MRV)
3. Computed tomography venography (CTV)

H. Other Diagnostic Testing

1. Ventilation perfusion lung scan
2. D-dimer assay
3. CTA

I. Treatment

1. Indications for treatment
2. Anticoagulation
3. Thrombolytic therapy
4. Vena caval filters
5. Compression stockings
6. Surgery
 - a. Ligation of perforating veins
 - b. Stripping or local excision of varicosities
 - c. Sclerotherapy
 - d. Radiofrequency/laser ablation of incompetent saphenous veins

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SECTION VI: Peripheral Arterial

1. Identify the major arteries of the upper and lower extremities and the branches of the abdominal aorta
2. Differentiate between arterial and venous wall anatomy at the microscopic level
3. List the risk factors and mechanisms for arterial disease
4. List the most common sites for arterial disease in the peripheral arterial system
5. Differentiate fusiform, saccular, and dissecting aneurysms
6. List common nonatherosclerotic vascular disorders
7. Differentiate the symptoms of acute arterial occlusion and chronic arterial occlusive disease
8. Relate the difference between primary and secondary Raynaud's syndrome
9. Describe the capabilities, limitations, protocols/techniques, and diagnostic criteria for noninvasive peripheral arterial test procedures
10. Define correlative imaging techniques
11. Describe the current treatment options for patients with peripheral arterial disease

VI. Peripheral Arterial

A. Anatomy

1. Upper extremity arteries
 - a. Components
 - 1) Subclavian
 - 2) Axillary
 - 3) Brachial
 - 4) Radial
 - 5) Ulnar
 - 6) Palmar (volar) arches
 - a) Deep
 - b) Superficial
 - 7) Digital
 2. Abdominal aorta
 - a. Functional division
 - 1) Supra-renal
 - 2) Infra-renal
 - b. Branches
 - 1) Phrenic
 - 2) Celiac
 - 3) Superior mesenteric (SMA)
 - 4) Renal
 - 5) Gonadal
 - 6) Inferior mesenteric (IMA)
 - 7) Lumbar
 3. Lower extremity arteries
 - a. Components
 - 1) Common iliac

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- 2) External iliac
 - 3) Internal iliac (hypogastric)
 - 4) Common femoral (CFA)
 - 5) Superficial femoral (SFA)
 - 6) Deep femoral (profunda femoris)
 - 7) Popliteal
 - 8) Anterior tibial
 - 9) Tibioperoneal trunk
 - 10) Posterior tibial
 - 11) Peroneal
 - 12) Plantar arteries
4. Microscopic anatomy of the arterial wall, capillaries, arterioles
- B. Risk Factors
1. Controllable risk factors
 - a. Diabetes
 - b. Hypertension
 - c. Hyperlipidemia
 - d. Smoking
 2. Uncontrollable risk factors
 - a. Age
 - b. Gender
 - c. Family history
 - d. Thrombophilia
- C. Mechanisms of Disease
1. Atherosclerosis
 - a. Plaque evolution
 2. Embolization
 3. Aneurysm
 - a. Fusiform
 - b. Saccular
 - c. Dissecting (arterial)
 - d. Pseudoaneurysm
 4. Nonatherosclerotic lesions
 - a. Arteritis
 - 1) Types
 - 2) Common locations
 - b. Vasospastic disorders
 - 1) Raynaud's syndrome
 - a) Primary – Raynaud's disease
 - b) Secondary – Raynaud's phenomenon
 - c. Aortic coarctation
 - 1) Etiology and characteristics
 - d. Entrapment syndromes
 - 1) Popliteal artery entrapment

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- 2) Thoracic outlet compression syndrome (TOS)
- e. Popliteal cystic disease

D. Signs and Symptoms

- 1. Chronic occlusive disease
 - a. Claudication
 - b. Ischemic rest pain
 - c. Trophic changes
 - 1) Gangrene
 - 2) Ulcers
- 2. Acute arterial occlusion
 - a. Embolic
 - b. Thrombotic
 - c. Trauma
 - d. Six P's
 - 1) Pain
 - 2) Pallor
 - 3) Pulselessness
 - 4) Paresthesia
 - 5) Paralysis
 - 6) Poikilothermia
- 3. Vasospastic disorders
 - a. Digital cold sensitivity
- 4. Physical examination
 - a. Skin (dermal) changes
 - 1) Color
 - 2) Temperature
 - 3) Thickened nails; scaly, thin, transparent-appearing skin; loss of hair
 - b. Palpation of pulses
 - c. Auscultation of pulses

E. Noninvasive Test Procedures

- 1. Indirect (physiologic) testing
 - a. Segmental systolic pressure measurements
 - 1) Rationale
 - 2) Cuff sizes
 - 3) Extremity
 - a) 3-cuff versus 4-cuff techniques
 - b) Advantages and disadvantages
 - 4) Digital
 - 5) Penile
 - 6) Examination protocols
 - 7) Interpretation of pressures
 - a) Normal pressure gradients
 - b) Abnormal pressure gradients
 - 8) Capabilities

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- 9) Limitations
- b. Constant-load treadmill exercise testing
 - 1) Rationale
 - 2) Examination protocol
 - a) Placement of blood pressure cuffs
 - b) Walking speed and elevation
 - c) Claudication distance
 - 3) Interpretation of post-exercise ankle pressure response
 - a) Normal
 - b) Abnormal
 - i. Duration of reduced pressures (time to reconstitution of pressure)
- c. Reactive hyperemia
 - 1) Rationale
 - 2) Examination protocol
 - a) Cuff sizes
 - b) Placement of pressure cuffs
 - c) Cuff pressure
 - d) Duration of cuff inflation
 - 3) Interpretation of post-inflation pressure response
 - a) Normal
 - b) Abnormal
 - i. Duration of reduced pressure (time to reconstitution of pressure)
 - 4) Capabilities
 - 5) Limitations
- d. Plethysmography
 - 1) Pulse volume recording
 - a) Rationale
 - b) Patient positioning
 - c) Examination protocol
 - i. Cuff sizes and placement
 - ii. Pressure and volume calibration
 - d) Interpretation of plethysmographic waveforms
 - i. Normal
 - ii. Abnormal
 - e) Capabilities
 - i. Location of segmental flow-reducing obstruction
 - ii. Assessment of collateral flow
 - f) Limitations (potential sources of error)
 - i. Inappropriate cuff size/calibration
 - ii. Obesity
 - iii. Edema
 - iv. Resting muscle tremors (waveform artifact)
 - 2) Photoplethysmography
 - a) Rationale

Vascular Technology

- b) Clinical uses
 - i. Digital pressures and waveforms
 - ii. Assessment of skin perfusion (wound healing potential)
 - iii. Digital cold sensitivity testing
 - c) Examination protocol
 - i. Sensor placement
 - d) Interpretation of PPG waveforms
 - i. Normal
 - ii. Abnormal
 - e) Capabilities
 - i. Arterial pressures
 - ii. Assessment of skin perfusion
 - f) Limitations
 - i. Qualitative assessment only
 - ii. Temperature
 - iii. Vasodilation/vasoconstriction
2. Direct testing
- a. Continuous wave (CW) Doppler evaluation
 - 1) Analogue waveforms
 - a) Qualitative interpretation
 - b) Quantitative interpretation
 - i. Pulsatility index
 - ii. Acceleration time
 - 2) Zero crossing detector
 - b. Duplex imaging/color flow imaging
 - 1) Patient positioning
 - 2) Choice of instrumentation/transducer frequencies
 - 3) Examination protocol
 - 4) Imaging and spectral Doppler techniques
 - 5) 2-D Interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Diameter versus area
 - 6) Spectral Doppler interpretation
 - a) Normal flow characteristics
 - i. Native arteries
 - ii. Bypass grafts/stents
 - b) Abnormal flow characteristics
 - i. Stenosis
 - ii. Occlusion
 - iii. Bypass grafts/stents
 - iv. Aneurysms
 - v. Pseudoaneurysms
 - vi. Trauma
 - c) Qualitative interpretation

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- i. Phasicity
- ii. Spectral broadening
- iii. Turbulence
- d) Quantitative interpretation
 - i. Peak systolic velocity
 - ii. End-diastolic velocity
 - iii. Velocity ratio
 - iv. Pulsatility index
 - v. Resistive index
 - vi. Acceleration time
- e) Pitfalls of measurements
- 7) Color Doppler interpretation
 - a) Presence/absence of flow
 - b) Direction of flow
 - c) Flow characteristics
- 8) Capabilities
- 9) Limitations

F. Correlative and/or Prior Imaging

- 1. Conventional arteriography
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
- 2. Digital subtraction angiography
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
- 3. Computed tomographic arteriography
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
- 4. Magnetic resonance angiography
 - a. Current clinical use
 - b. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - c. Limitations

G. Treatment

Vascular Technology

1. Indications for treatment
2. Medical
 - a. Control and reduction of risk factors
 - b. Exercise
 - c. Pharmacologic
 - 1) Blood pressure
 - 2) Cholesterol
 - 3) Clotting factors
 - d. Drug therapy
3. Surgical
 - a. Thrombectomy
 - b. Embolectomy
 - c. Endarterectomy
 - d. Bypass graft
 - 1) In situ saphenous
 - 2) Reversed saphenous
 - 3) Non-reversed translocated saphenous
 - 4) Prosthetic
 - 5) Cryo-preserved grafts
 - 6) Anastomoses
 - a) End-to-side
 - b) End-to-end
 - i. Interposition graft
 - c) Side-to-side
 - e. Amputation
 - f. Fasciotomy
 - g. Split-thickness skin grafts
4. Endovascular
 - a. Percutaneous transluminal angioplasty (PTA)
 - b. Stent
 - c. Endograft
 - d. Atherectomy
5. Compression/thrombin injection
 - a. Pseudoaneurysm repair

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SECTION VII: Abdominal/Visceral

1. Identify the arteries and veins of the abdomen and list the major branches of the abdominal aorta
2. List the common risk factors for abdominal arterial and venous disorders
3. Describe the mechanisms of disease for renovascular hypertension, renal fibromuscular dysplasia, abdominal aortic aneurysm, portal hypertension, and chronic mesenteric ischemia
4. Describe the variations in vascular resistance in the mesenteric arterial system during fasting and post-prandial states
5. Relate the clinical presentation of patients with abdominal aortic aneurysm, portal hypertension, and chronic mesenteric ischemia
6. Describe the capabilities, limitations, patient positioning, protocols/techniques, and current diagnostic criteria for duplex sonography of the abdominal aorta, renal and mesenteric arteries, and the hepatoportal system
7. Differentiate normal and abnormal Doppler spectral waveforms from the hepatic and portal veins and the inferior vena cava
8. Describe the correlating imaging modalities used for confirmation of abdominal vascular disease
9. Describe the current treatment options for patients with renovascular hypertension, mesenteric ischemia, abdominal aortic aneurysm, and portal hypertension

VII. Abdominal/Visceral

A. Anatomy

1. Abdominal pelvic arterial
 - a. Components
 - 1) Aorta
 - 2) Celiac artery (trunk, axis)
 - a) Hepatic arteries
 - b) Splenic artery
 - c) Left gastric
 - 3) Superior mesenteric artery (SMA)
 - 4) Renal arteries
 - 5) Inferior mesenteric artery (IMA)
 - 6) Gonadal arteries
 - 7) Iliac arteries
 2. Abdominal pelvic venous
 - a. Components
 - 1) Iliac veins
 - 2) Gonadal veins
 - 3) Inferior mesenteric vein (IMV)
 - 4) Renal veins
 - 5) Splenic vein
 - 6) Superior mesenteric vein (SMV)

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- 7) Portal vein tributaries
 - a) Superior mesenteric vein
 - b) Splenic vein
 - i. Inferior mesenteric vein
- 8) Hepatic veins
- 9) Inferior vena cava (IVC)

B. Common Congenital Anomalies

C. Risk Factors

- 1. Arterial
 - a. Diabetes
 - b. Hypertension
 - c. Hyperlipidemia
 - d. Smoking
 - e. Atrial fibrillation
- 2. Venous
 - a. Prior thrombosis
 - b. Malignancy
 - c. Liver disease

D. Mechanisms of Disease

- 1. Renovascular hypertension
 - a. Consistent clinical features
 - 1) Hypertension
 - 2) Renal artery stenosis/occlusion/fibromuscular dysplasia
 - 3) Renal ischemia
 - b. Etiology
 - 1) Atherosclerosis
 - 2) Fibromuscular dysplasia
 - 3) Arteritis
 - 4) Post-irradiation fibrosis
 - 5) Neurofibromatosis
 - 6) Thrombosis/embolism
- 2. Mesenteric angina/ischemia
 - a. Chronic celiac, SMA, IMA stenosis or occlusion
 - 1) Consistent clinical features
 - a) Post prandial pain
 - b) "Fear of food" syndrome
 - c) Weight loss
 - 2) Etiology
 - a) Atherosclerosis
 - b) Thrombosis/embolism
 - b. Acute mesenteric ischemia
 - 1) Consistent clinical features
 - a) Acute, severe abdominal pain

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- b) Result of delayed diagnosis
 - i. Potential for catastrophic gastrointestinal ischemia
 - 2) Etiology
 - a) Embolism
 - b) Thrombosis
 - 3. Portal hypertension
 - a. Portal splenic vein thrombosis
 - b. Cirrhosis
 - c. Budd-Chiari syndrome
 - 4. Abdominal aortic aneurysm
 - a. Size
 - b. Location
 - c. Classification
 - 1) Fusiform
 - 2) Saccular
 - 3) Dissecting
 - 4) Mycotic
 - d. Etiology
 - 1) Atherosclerosis
 - 2) Aging
 - 3) Infection/inflammation
 - 4) Trauma
 - 5) Congenital anomalies
 - a) Ehler-Danlos syndrome
 - b) Marfan's syndrome
 - c) Others
 - 6) Medial degeneration
 - 7) Arteritis
- E. Signs and Symptoms
 - 1. Arterial
 - a. Acute mesenteric ischemia
 - 1) Abrupt onset of severe abdominal pain
 - 2) Gastrointestinal tissue injury
 - b. Chronic mesenteric ischemia
 - 1) Triad of symptoms
 - c. Renal
 - 1) Renovascular hypertension
 - 2) Renal artery stenosis/occlusion
 - 3) Renal ischemia
 - d. Aneurysm
 - 1) Incidental finding
 - 2) "Pulsatile abdominal mass"
 - 3) Abdominal or back pain
 - 4) Embolization/blue toe syndrome
 - a) Digital arteries

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- b) End-arterial occlusion
 - 2. Venous
 - a. Portal
 - 1) Portal hypertension
 - a) Cirrhosis
 - b) GI Bleed
 - c) Ascites
 - d) Jaundice
 - b. Hepatic
 - 1) Budd-Chiari syndrome
 - a) Hepatomegaly
 - b) Ascites
 - c) Abdominal pain
 - d) Portal hypertension
 - c. IVC
 - 1) Lower extremity edema
- F. Noninvasive Test Procedures
- 1. Direct-duplex imaging/color flow imaging
 - a. Patient positioning
 - b. Examination protocol
 - c. Imaging and spectral Doppler techniques
 - 1) Aorta
 - 2) Celiac, splenic, and hepatic arteries
 - 3) Mesenteric arteries
 - 4) Renal arteries
 - 5) IVC
 - 6) Hepatic veins
 - 7) Portal, splenic, and mesenteric veins
 - 8) Renal veins
 - d. 2-D interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Diameter versus area reduction
 - e. Spectral Doppler interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Peak systolic velocity
 - b) End diastolic velocity
 - c) Velocity ratio
 - d) Pitfalls of measurements
 - f. Waveform analysis
 - 1) Triphasic
 - 2) Biphasic

Vascular Technology

- 3) Monophasic
 - 4) Continuous, non-phasic
 - 5) Pulsatile
 - g. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
 - h. Capabilities
 - i. Limitations
- G. Correlative and/or Prior Imaging
- 1. Conventional arteriography
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
 - 2. Digital subtraction arteriography
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
 - 3. Computed tomographic arteriography
 - a. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - b. Limitations
 - 4. Magnetic resonance arteriography (MRA)
 - a. Current clinical use
 - b. Interpretation
 - 1) Stenosis
 - 2) Occlusion
 - 3) Collaterals/intracranial cross-filling
 - c. Limitations
- H. Treatment
- 1. Indications for treatment
 - 2. Medical
 - a. Antihypertensives
 - b. Anticoagulation
 - 3. Surgical
 - a. Bypass graft
 - b. Endarterectomy

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4. Endovascular
 - a. Aortic endograft (stent graft)
 - b. Angioplasty/stent
 - c. IVC interruption device (filter)
 - d. Transjugular intrahepatic porto-systemic shunt (TIPS)

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SECTION VIII: Miscellaneous Conditions/Tests

1. Describe the protocols and techniques used for preoperative mapping of the extremity veins, and the radial, internal mammary, and epigastric arteries
2. Differentiate the anatomy and blood flow patterns of pseudoaneurysms and arteriovenous fistulae
3. Relate the technical protocols for assessment of dialysis access grafts and fistulae
4. Detail the sonographic evaluation of liver, pancreas, and renal transplants
5. Describe the tests procedures and modalities used for evaluation of vasculogenic impotence
6. Relate the noninvasive vascular test procedures and provocative maneuvers used for detection of thoracic outlet syndrome
7. Describe the capabilities and limitations of duplex sonography for identification of temporal arteritis
8. Define the test procedures used for evaluation of arterial injury
9. Differentiate the signs and symptoms of congenital and acquired lymphedema and deep vein thrombosis

VIII. Miscellaneous conditions/tests

- A. Preoperative Venous and Arterial Mapping
 1. Potential vessels for use as bypass conduits
 - a. Saphenous veins, cephalic, and basilic veins
 - b. Radial artery
 - c. Internal mammary artery
 - d. Epigastric artery
 2. Patient positioning
 3. Examination protocols
 4. Imaging and spectral Doppler techniques
 5. 2-D interpretation
 - a. Normal characteristics
 - b. Abnormal characteristics
 - c. Measurements
 - 1) Diameter
 - 2) Length
 6. Spectral Doppler interpretation
 - a. Normal characteristics
 - b. Abnormal characteristics
 - c. Measurements/waveform analysis
 - 1) Venous
 - a) Phasic versus non-phasic
 - 2) Arterial
 - a) Triphasic/biphasic/monophasic
 - b) Peak systolic velocity
 - c) End-diastolic velocity

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- d) Velocity ratios
 - d. Pitfalls of measurements
 - 7. Color Doppler interpretation
 - a. Presence/absence of flow
 - b. Direction of flow
 - c. Flow characteristics
 - 8. Capabilities
 - 9. Limitations
- B. Pseudoaneurysm/Arteriovenous Fistula
- 1. Pseudoaneurysm
 - a. Direct–duplex scanning and color flow imaging
 - 1) Patient positioning
 - 2) Examination protocols
 - 3) Imaging and spectral Doppler techniques
 - a) Sonography-guided probe compression repair
 - b) Sonography-guided thrombin injection repair
 - 4) 2-D interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - i. Multilobar
 - ii. Concomitant arteriovenous fistula
 - c) Measurements
 - i. Pseudoaneurysm diameter
 - ii. Neck length and diameter
 - 5) Spectral Doppler interpretation
 - a) Characteristics of flow
 - b) Measurements/waveform analysis
 - i. Characteristic to-fro Doppler signal
 - ii. Proximal and distal atrial flow signals
 - c) Pitfalls of measurements
 - 6) Color Doppler interpretation
 - a) Presence/absence of flow
 - b) Direction of flow
 - c) Flow characteristics
 - 7) Capabilities
 - 8) Limitations
 - 2. Arteriovenous fistula
 - a. Classification
 - 1) Traumatic
 - 2) Congenital
 - b. Noninvasive test procedure
 - 1) Direct-duplex scanning and color flow imaging
 - c. Patient positioning
 - d. Examination protocols
 - e. Imaging and spectral Doppler techniques

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- f. 2-D interpretation
 - 1) Characteristics
 - 2) Measurements
 - a) Location
 - b) Diameter/length
- g. Spectral Doppler interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements/waveform analysis
 - a) Characteristic low resistance Doppler signal
 - b) Proximal and distal venous flow signals
- h. Pitfalls of measurements
- i. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
- j. Capabilities
- k. Limitations
- 3. Dialysis access
 - a. Noninvasive test procedure
 - 1) Direct–duplex scanning and color flow imaging
 - a) Patient positioning
 - b) Examination protocols
 - i. Pre-operative mapping of inflow and outflow vessels
 - ii. Dialysis fistulae
 - i) Brescia Cimino
 - iii. Dialysis grafts
 - i) Straight
 - ii) Looped
 - iv. Catheters
 - i) Short-term access
 - c) Imaging and spectral Doppler techniques
 - d) 2-D interpretation
 - i. Normal characteristics
 - ii. Abnormal characteristics
 - iii. Measurements
 - e) Spectral Doppler interpretation
 - i. Normal characteristics
 - ii. Abnormal characteristics
 - iii. Measurements/waveform analysis
 - i) Peak systolic velocity
 - ii) End diastolic velocity
 - iii) Velocity ratios
 - iv) Flow volume
 - f) Pitfalls of measurements
 - g) Color Doppler interpretation

Vascular Technology

- i. Presence/absence of flow
- ii. Direction of flow
- iii. Flow characteristics
- h) Capabilities
- i) Limitations

C. Organ Transplants

- 1. Types
 - a. Kidney
 - b. Liver
 - c. Pancreas
- 2. Noninvasive test procedures
 - a. Patient positioning
 - b. Examination protocols
 - c. Imaging and spectral Doppler techniques
 - d. 2-D interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Length
 - b) Width
 - e. Spectral Doppler interpretation
 - 1) Normal characteristics
 - 2) Abnormal characteristics
 - 3) Measurements
 - a) Peak systolic velocity
 - b) End diastolic velocity
 - c) Velocity ratios
 - d) Pitfalls of measurements
 - f. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
 - g. Capabilities
 - h. Limitations

D. Impotence Testing

- 1. Noninvasive test procedures
 - a. Indirect
 - 1) Pressures
 - a) Penile-brachial index
 - b. Direct-Duplex sonography and color flow imaging
 - 1) Patient positioning
 - 2) Examination protocols
 - 3) Imaging and spectral Doppler techniques
 - a) Techniques for cavernosal artery injection

Vascular Technology

- i. Papaverine
 - ii. Prostaglandin
 - 4) 2-D interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Pre and post-injection
 - ii. Anterior-posterior dimensions
 - i) Cavernosal arteries
 - ii) Deep dorsal vein
 - 5) Spectral Doppler interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Post-injection timing
 - ii. Peak systolic velocity
 - i) Pre-injection
 - ii) Post-injection
 - iii. End diastolic velocity
 - i) Pre-injection
 - ii) Post-injection
 - iv. Duration of erection
 - v. Pitfalls of measurements
 - c. Color Doppler interpretation
 - 1) Presence/absence of flow
 - 2) Direction of flow
 - 3) Flow characteristics
 - d. Capabilities
 - e. Limitations
- E. Thoracic Outlet Syndrome Evaluation
 - 1. Noninvasive test procedures
 - a. Indirect
 - 1) Plethysmography
 - a) Pulse volume recording
 - b) Digital photoplethysmography
 - 2) Upper extremity systolic pressures
 - 3) Patient positioning
 - 4) Examination protocol
 - a) Provocative maneuvers
 - 5) Techniques for indirect assessment
 - a) Arterial inflow
 - b) Arterial outflow
 - 6) Interpretation of waveforms and pressures
 - a) Normal characteristics
 - b) Abnormal characteristics

Vascular Technology

- c) Measurements
 - i. Qualitative
 - ii. Quantitative
- b. Direct-duplex sonography with color flow imaging
 - 1) Patient positioning
 - 2) Examination protocols
 - 3) Imaging and spectral Doppler techniques
 - 4) 2-D interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Arterial/venous diameter proximal to thoracic outlet
 - ii. Arterial/venous diameter distal to thoracic outlet
 - 5) Spectral Doppler interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Peak systolic velocity
 - ii. End diastolic velocity
 - iii. Velocity ratio
 - iv. Pitfalls of measurements
 - 6) Color Doppler interpretation
 - a) Presence/absence of flow
 - b) Direction of flow
 - c) Flow characteristics
 - 7) Capabilities
 - 8) Limitations
- F. Giant Cell Arteritis
 - 1. Classification
 - a. Temporal arteritis
 - b. Takayasu's arteritis
 - 2. Noninvasive test procedures
 - a. Direct-Duplex sonography with color flow imaging
 - 1) Patient positioning
 - 2) Examination protocol
 - 3) Imaging and spectral Doppler techniques
 - 4) 2-D Interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - i. Halo sign
 - c) Measurements
 - i. Anterior-posterior diameter
 - ii. Transverse diameter
 - iii. Residual lumen diameter
 - 5) Spectral Doppler interpretation

Vascular Technology

- a) Normal characteristics
- b) Abnormal characteristics
- c) Measurements
 - i. Peak systolic velocity
 - ii. End diastolic velocity
 - iii. Velocity ratio
 - iv. Pitfalls of measurements
- 6) Color Doppler interpretation
 - a) Presence/absence of flow
 - b) Direction of flow
 - c) Flow characteristics
- 7) Capabilities
- 8) Limitations

G. Trauma/Arterial Injury

- 1. Noninvasive test procedures
 - a. Indirect testing
 - 1) CW Doppler
 - 2) Plethysmography
 - b. Direct testing-Duplex sonography with color flow imaging
 - 1) Patient positioning
 - 2) Choice of instrumentation and transducer frequencies
 - 3) Examination protocol
 - 4) Imaging and spectral Doppler techniques
 - 5) 2-D Interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Diameter
 - ii. Length
 - 6) Spectral Doppler interpretation
 - a) Normal characteristics
 - b) Abnormal characteristics
 - c) Measurements
 - i. Peak systolic velocity
 - ii. End diastolic velocity
 - iii. Velocity ratio
 - iv. Pitfalls of measurements
 - 7) Color Doppler interpretation
 - a) Presence/absence of flow
 - b) Direction of flow
 - c) Flow characteristics
 - 8) Capabilities
 - 9) Limitations

H. Lymphedema

Vascular Technology

1. Definition
2. Classification
 - a. Congenital/primary
 - b. Acquired/secondary
3. Treatment

I. Sonographic-Guided Procedures

Vascular Technology

SECTION IX: Quality Measurements

1. Explain importance of test validation
2. Define sensitivity, specificity, positive and negative predictive values, accuracy, and disease prevalence
3. State the statistical equations sensitivity, specificity, positive and negative predictive values, accuracy, and disease prevalence
4. Describe the methods used to measure diameter and area reduction
5. Relate the difference between the angiographic measurements used in the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and European Carotid Surgery Trial (ECST)

IX. Quality Measurements

A. Statistics

1. Chi square
2. Sensitivity
3. Specificity
4. Positive predictive value
5. Negative predictive value
6. Overall accuracy
7. Prevalence

B. Measurement of Stenosis

1. Diameter versus area reduction
 - a. Diameter reduction
 - b. Area reduction
2. Angiographic determination of severity
 - a. NASCET
 - b. ECST

Vascular Technology

SECTION X: Sonography Safety

1. Evaluate sonographic image and Doppler spectral quality, and recognize the importance of preventive maintenance of the sonographic system
2. Define and discuss the biological effects associated with the use of medical sonography
3. Relate the As Low As Reasonably Achievable (ALARA) principle

X. Sonography Safety

A. Instrument Performance

1. Evaluation of image quality
2. Evaluation of Doppler quality
3. Preventive maintenance

B. Biological Effects

1. Minimizing exposure time
 - a. ALARA principle/Prudent use statement
2. Mechanisms of production
 - a. Mechanical index
 - b. Thermal index
3. Scientific data
4. Preventing electrical hazards

Vascular Technology

ABBREVIATIONS

A

AC	Alternating Current
ACA	Anterior Cerebral Artery
ACoA	Anterior Communicating Artery

B

Bas	Basilar Artery
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C

CCA	Common Carotid Artery
CEAP	Clinical Etiologic Anatomic Pathologic Classification
CFA	Common Femoral Artery
CFV	Common Femoral Vein
CRT	Cathode Ray Tube
CTA	Computed Tomographic Angiography
CTV	Computed Tomographic Venography
CVA	Cerebrovascular Accident
CVI	Chronic Venous Insufficiency
CW	Continuous Wave Doppler

D

DC	Direct Current
DICOM	Digital Imaging and Communications in Medicine
DSA	Digital Subtraction Angiography

E

ECA	External Carotid Artery
ECST	European Carotid Surgery Trial
EDV	End-Diastolic Velocity

F

FMD	Fibromuscular Dysplasia
FV	Femoral Vein

I

ICA	Internal Carotid Artery
IMA	Inferior Mesenteric Artery; Internal Mammary Artery
IMT	Intimal Medial Thickness
IMV	Inferior Mesenteric Vein
IVC	Inferior Vena Cava

M

MCA	Middle Cerebral Artery
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Vascular Technology

MRA	Magnetic Resonance Arteriography
MRV	Magnetic Resonance Venography
<u>N</u>	
NASCET	North American Symptomatic Carotid Endarterectomy Trial
<u>O</u>	
OPG-Gee	Oculopneumoplethysmography-Gee
<u>P</u>	
PACS	Picture Archiving Communication System
PCA	Posterior Cerebral Artery
PCoA	Posterior Communicating Artery
PE	Pulmonary Embolism
PI	Pulsatility Index
PPG	Photoplethysmography
PSV	Peak Systolic Velocity
PTA	Percutaneous Transluminal Angioplasty
PW	Pulsed Wave Doppler
<u>R</u>	
RI	Resistive Index
RIND	Reversible Ischemic Neurologic Deficit
<u>S</u>	
SFA	Superficial Femoral Artery
SMA	Superior Mesenteric Artery
<u>T</u>	
TCD	Transcranial Doppler
TCI	Transcranial Imaging
TCPO ₂	Transcutaneous Oxygen
TGC	Time Gain Compensation
TIA	Transient Ischemic Attack
TOS	Thoracic Outlet Syndrome
<u>V</u>	
Vert	Vertebral Artery
VBI	Vertebrobasilar Insufficiency
VRT	Venous Refill Time

Vascular Technology

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