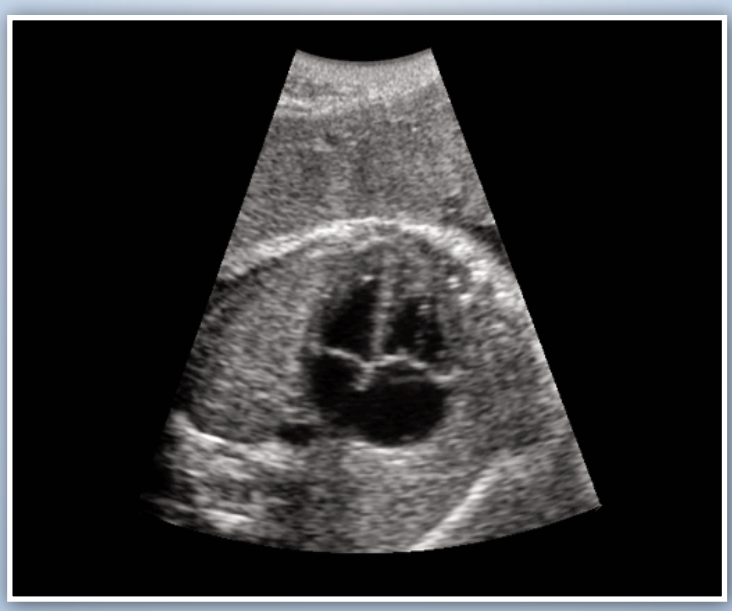
AIUM Practice Parameter for the Performance of

Fetal Echocardiography

Parameter developed in conjunction with the American College of Obstetricians and Gynecologists (ACOG), the Society for Maternal-Fetal Medicine (SMFM), and the American Society of Echocardiography (ASE), and endorsed by the American College of Radiology (ACR).



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The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary association dedicated to advancing the safe and effective use of ultrasound in medicine through professional and public education, research, development of parameters, and accreditation. To promote this mission, the AIUM is pleased to publish in conjunction with the American College of Obstetricians and Gynecologists (ACOG), the Society for Maternal-Fetal Medicine (SMFM), and the American Society of Echocardiography (ASE) this *AIUM Practice Parameter for the Performance of Fetal Echocardiography*. Additionally, this parameter is endorsed by the American College of Radiology (ACR).

The AIUM represents the entire range of clinical and basic science interests in medical diagnostic ultrasound, and, with hundreds of volunteers, this multidisciplinary organization has promoted the safe and effective use of ultrasound in clinical medicine for more than 50 years. This document and others like it will continue to advance this mission.

Practice parameters of the AIUM are intended to provide the medical ultrasound community with parameters for the performance and recording of high-quality ultrasound examinations. The parameters reflect what the AIUM considers the minimum criteria for a complete examination in each area but are not intended to establish a legal standard of care. AIUM-accredited practices are expected to generally follow the parameters with recognition that deviations from these parameters will be needed in some cases, depending on patient needs and available equipment. Practices are encouraged to go beyond the parameters to provide additional service and information as needed.

The clinical aspects contained in specific sections of this practice parameter (Introduction, Indications, Specifications of the Examination, and Equipment Specifications) have been developed by the AIUM, ACR, ACOG, SMFM, and ASE.

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I. Introduction

Congenital heart disease is a leading cause of infant morbidity and mortality from birth defects with an estimated incidence of 6 per 1000 live births for moderate to severe forms.[1,2] Accurate prenatal diagnosis offers potential clinical benefit with regard to infant outcome, especially in those cases that are likely to require prostaglandin infusion to maintain patency of the ductus arteriosus.[3–5] Fetal echocardiography is broadly defined as a detailed sonographic evaluation that is used to identify and characterize fetal heart anomalies before delivery. This specialized diagnostic procedure is an extension of the "basic" and "extended basic" fetal cardiac screening parameters that have been previously described for the 4-chamber view and outflow tracts.[6,7] It should be performed only when there is a valid medical reason, and the lowest possible ultrasonic exposure settings should be used to gain the necessary diagnostic information. While it is not possible to detect every abnormality, adherence to the following parameter will maximize the probability of detecting most cases of clinically significant congenital heart disease.

II. Qualifications and Responsibilities of Personnel

Performance and interpretation of fetal echocardiography require a unique set of advanced skills and knowledge. Specific training requirements and maintenance of competency parameters have been developed by the AIUM[8,9] as well as the ASE in conjunction with the American Heart Association, the American College of Cardiology, and the American Academy of Pediatrics.[10,11] Appropriately trained obstetricians, maternal-fetal medicine specialists, pediatric cardiologists, and radiologists with special expertise in fetal imaging who have acquired the appropriate knowledge base and skills as outlined in these statements may perform fetal echocardiography.

III. Indications

Indications for fetal echocardiography are often based on a variety of parental and fetal risk factors for congenital heart disease.[12,13] However, most cases are not associated with known risk factors. Common indications for a detailed scan of the fetal heart include but are not limited to the following:

A. Maternal Indications
- Autoimmune antibodies, anti-Ro (SSA)/anti-La (SSB);
- Familial inherited disorders (eg, 22q11.2 deletion syndrome);
- In vitro fertilization;
- Metabolic disease (eg, diabetes mellitus and phenylketonuria); and
- Teratogen exposure (eg, retinoids and lithium).

B. Fetal Indications
- Abnormal cardiac screening examination;
- First-degree relative of a fetus with congenital heart disease;
- Abnormal heart rate or rhythm;
- Fetal chromosomal anomaly;
- Extracardiac anomaly;
- Hydrops;
- Increased nuchal translucency; and
- Monochorionic twins.

IV. Written Request for the Examination

The written or electronic request for an ultrasound examination should provide sufficient information to allow for the appropriate performance and interpretation of the examination.

A request for the examination must be originated by a physician or other appropriately licensed health care provider or under the provider's direction. The accompanying clinical information should be provided by a physician or other appropriate health care provider familiar with the patient's clinical situation and should be consistent with relevant legal and local health care facility requirements.

V. Specifications of the Examination

The following section describes required and optional elements for fetal echocardiography.

A. General Considerations

Fetal echocardiography is commonly performed between 18 and 22 weeks' gestational age. Some forms of congenital heart disease may even be recognized during earlier stages of pregnancy.[14] Optimal views of the heart are usually obtained when the cardiac apex is directed toward the anterior maternal wall. Technical limitations (eg, maternal obesity, prone fetal position, and late gestation) can make a detailed heart evaluation very difficult due to acoustic shadowing, especially during the third trimester. It may be necessary to examine the patient at a different time if the heart is poorly visualized. The examiner can optimize sonograms by appropriate adjustment of technical settings, such as acoustic focus, frequency selection, signal gain, image magnification, temporal resolution, harmonic imaging, and Doppler-related guidelines (eg, velocity scale, frequency wall filter, and frame rate). Because the heart is a dynamic structure, a complete evaluation can only be made if real-time imaging with acquisition of analog recordings or digital video clips is used as a standard part of every fetal echocardiogram.

B. Cardiac Imaging Guidelines: Basic Approach

The fetal echocardiogram is a detailed evaluation of cardiac structure and function. This method typically involves a sequential segmental analysis of 3 basic areas that include the atria, ventricles, and great arteries and their connections.[15–17] A segmental analysis includes an initial assessment of fetal right/left orientation, followed by an assessment of the following segments and their relationships:

- Visceral/abdominal situs:
  - Stomach position; and
  - Cardiac apex position;
- Atria:
  - Situs;
  - Systemic and pulmonary venous connections;
  - Venous anatomy; and
  - Atrial anatomy (including septum);
- Ventricles:
  - Position;
  - Atrial connections;
  - Ventricular anatomy (including septum);
  - Relative and absolute size;
  - Function; and
  - Pericardium; and
- Great arteries (aorta, main and branch pulmonary arteries, and ductus arteriosus):
  - Position relative to the trachea;
  - Ventricular connections; and
  - Vessel size, patency, and flow (both velocity and direction).

In addition to a segmental analysis, the following connections should be evaluated:

- Atrioventricular junction: anatomy, size, and function of atrioventricular (eg, mitral and tricuspid) valves; and
- Ventriculoarterial junction: anatomy, size, and function of semilunar (eg, aortic and pulmonary) valves, including assessment of both the subpulmonary and subaortic regions.

C. Grayscale Imaging (Required)

Key scanning planes can provide useful diagnostic information about the fetal heart (Figures 1–3).[18–23] Evaluation should include the following criteria, noting abnormalities of the heart and pericardium:

- Four-chamber view;
- Left ventricular outflow tract;
- Right ventricular outflow tract;
- Three-vessel and trachea view;
- Short-axis views ("low" for ventricles, "high" for outflow tracts);
- Long-axis view;
- Aortic arch view;
- Ductal arch view; and
- Superior and inferior vena cava views.

D. Color Doppler Sonography (Required)

Color Doppler sonography should be used to evaluate the following structures for potential flow disturbances[24–26]:

- Systemic veins (including superior and inferior vena cava and ductus venosus);
- Pulmonary veins;
- Foramen ovale;
- Atrioventricular valves;
- Atrial and ventricular septa;
- Semilunar valves;
- Ductal arch;
- Aortic arch; and
- Umbilical vein and artery (optional).

In addition, pulsed Doppler sonography should be used as an adjunct to evaluate the following:

- Atrioventricular valves;
- Semilunar valves;
- Ductus venosus;
- Umbilical vein and artery (optional);
- Cardiac rhythm disturbance; and
- Any structure in which an abnormality on color Doppler sonography is noted.

E. Heart Rate and Rhythm Assessment

Documentation of the heart rate and rhythm should be made by cardiac cycle length measurements obtained by the Doppler technique or M-mode interrogation. A normal fetal heart rate at mid-gestation is 120 to 180 beats per minute. If bradycardia or tachycardia is documented, or if the rhythm is noted to be irregular, simultaneous assessment of atrial and ventricular contraction should be performed using either simultaneous Doppler sonography of the mitral inflow–aortic outflow or superior vena cava–ascending aorta or by M-mode sonography of the atrium and ventricle to determine the underlying mechanism. An alternative approach using tissue Doppler sonography of the atrium and ventricle has also been described.[27]

F. Cardiac Biometry (Optional But Should Be Considered for Suspected Structural or Functional Anomalies)

Normal ranges for fetal cardiac measurements have been published as percentiles and *z* scores that are based on gestational age or fetal biometry.[28–35] Individual measurements can be determined from 2-dimensional images or M-mode images in some situations and may include the following parameters:

- Aortic and pulmonary valve annulus in systole and tricuspid and mitral valve annulus in diastole (absolute size with comparison of left- to right-sided valves; left-sided valves measure equal or slightly smaller than right-sided valves);
- Right and left ventricular length (should measure equal);
- Aortic arch and isthmus diameter measurements;
- Main pulmonary artery and ductus arteriosus measurements;
- End-diastolic ventricular diameter just inferior to the atrioventricular valve leaflets;
- Thickness of the ventricular free walls and interventricular septum just inferior to the atrioventricular valves;
- Cardiothoracic ratio; and
- Additional measurements if warranted, including:
  - Systolic dimensions of the ventricles;
  - Transverse dimensions of the atria; and
  - Diameters of branch pulmonary arteries.

G. Cardiac Function Assessment (Optional But Should Be Considered for Suspected Structural or Functional Cardiac Anomalies)

Right and left heart function should be qualitatively assessed in all studies. Signs of cardiomegaly, atrioventricular valve regurgitation, and hydrops fetalis should be noted. If abnormal ventricular function is suspected, quantitative assessment of heart function should be considered and can include measures such as fractional shortening,[36] ventricular strain,[37,38] and the myocardial performance index.[39–42]

H. Complementary Imaging Strategies (Optional)

Other adjunctive imaging modalities, such as 3- and 4-dimensional sonography, have been used to evaluate anatomic defects and to quantify fetal hemodynamic parameters, such as cardiac output.[43–46] Adjunctive Doppler modalities that have been used include tissue and continuous wave Doppler.[47–50]

VI. Reporting and Documentation

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the fetal echocardiographic examination and its interpretation. Motion video clips, in conjunction with still images, are an essential part of the documentation of a fetal echocardiogram. Motion analog recordings or digital video clips, in conjunction with still images, are an essential part of the documentation of a fetal echocardiogram. Digital video clips should include at least the 4-chamber view, left and right ventricular outflow tracts, 3-vessel and trachea view, and sagittal aortic and ductal arches using both real-time grayscale and color Doppler techniques. Variations from normal size should be accompanied by measurements. Images should be labeled with the patient identification, facility identification, examination date, and side (right or left) of the anatomic site imaged. An official interpretation (final report) of the diagnostic findings should be included in the patient's medical record. Retention of the sonographic examination should be consistent both with clinical need and with relevant legal and local health care facility requirements. Reporting should be in accordance with recognized practice parameters for documentation and communication of diagnostic ultrasound findings.[51–53]

VII. Equipment Specifications

A sonographic examination of the fetal heart should be conducted using a real-time scanner. Sector, curvilinear, and endovaginal transducers are used for this purpose. The transducer or scanner should be adjusted to operate at the highest clinically appropriate frequency, realizing that there is a trade-off between resolution and beam penetration. With modern equipment, fetal imaging studies performed from the anterior abdominal wall can usually use frequencies of 5.0 MHz or higher, whereas scans performed from the vagina should be performed using frequencies of 7 MHz or higher. Acoustic shadowing and maternal body habitus may limit the ability of higher-frequency transducers from providing greater anatomic detail for the fetal heart.

VIII. Quality Control and Improvement, Safety, Infection Control, and Patient Education

Policies and procedures related to quality control, patient education, infection control, and safety should be developed and implemented in accordance with the AIUM *Standards and Guidelines for the Accreditation of Ultrasound Practices*. The potential benefits and risks of each examination should be considered. The ALARA (as low as reasonably achievable) principle should be observed when adjusting controls that affect the acoustic output and by considering transducer dwell times. Further details on ALARA may be found in the AIUM publication *Medical Ultrasound Safety,* Third Edition. Equipment performance monitoring should be in accordance with the AIUM *Standards and Guidelines for the Accreditation of Ultrasound Practices*.

Acknowledgments

This parameter was developed by a Fetal Echocardiography Task Force under the auspices of the AIUM Clinical Standards Committee (Leslie Scoutt, MD, *chair*) in collaboration with the American College of Obstetricians and Gynecologists (ACOG), the Society for Maternal Fetal Medicine (SMFM), and the American Society of Echocardiography (ASE) according to the process described in the *AIUM Clinical Standards Committee Manual*. The American College of Radiology (ACR) has endorsed this document. Appreciation is particularly extended to Kathi Keaton Minton, MA, RDMS, RDCS, for her administrative assistance during the development of this document and to Victoria Webster, MA, RT(MR), CNMT, RDMS, for her development of the illustrations.

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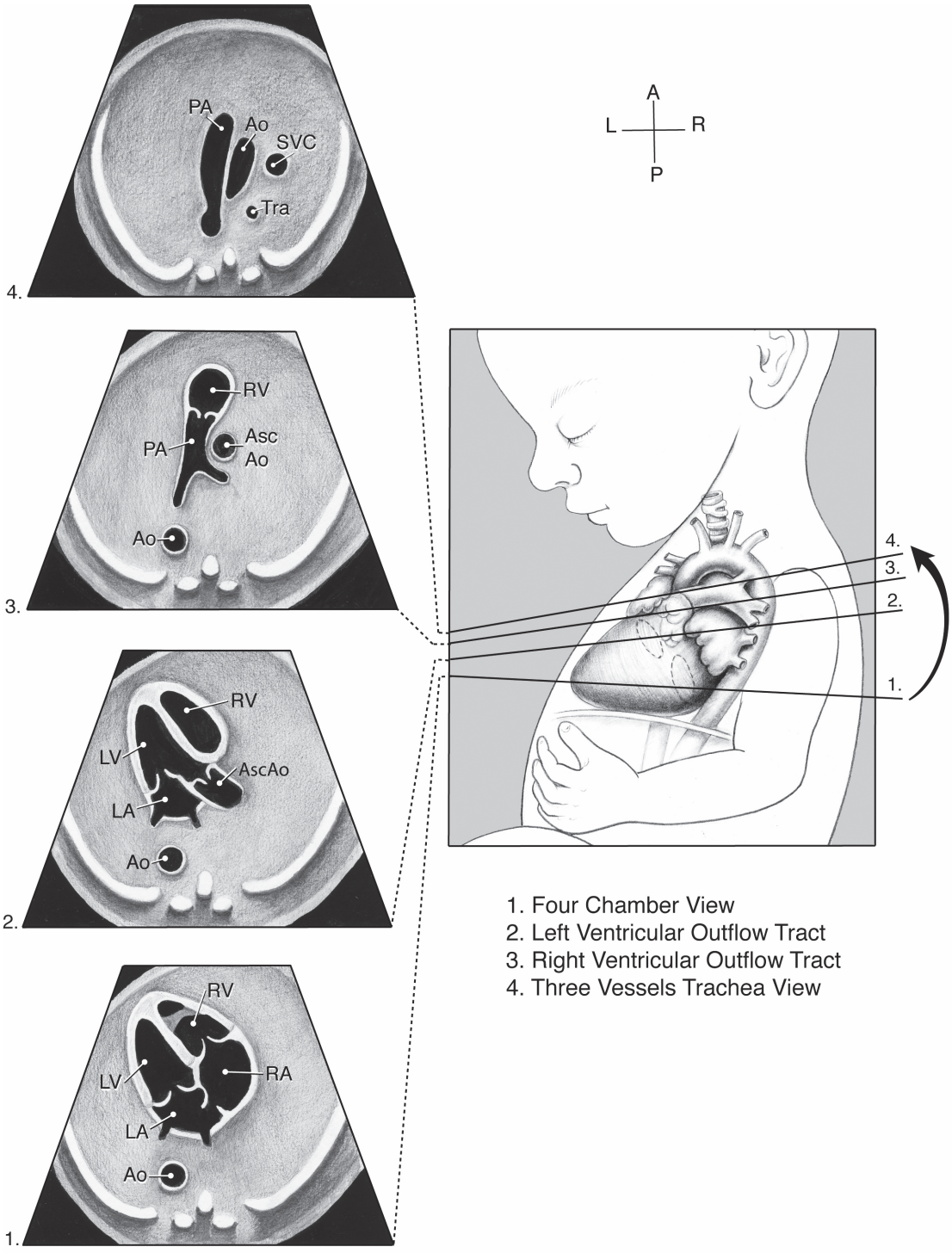


Figure 1. Standardized transverse scanning planes for fetal echocardiography include an evaluation of the 4-chamber view (1), arterial outflow tracts (2 and 3), and the 3-vessel and trachea view (4). Ao indicates descending aorta; Asc Ao, ascending aorta; LA, left atrium; LV, left ventricle; PA, pulmonary artery; RA, right atrium; RV, right ventricle; and Tra, trachea.

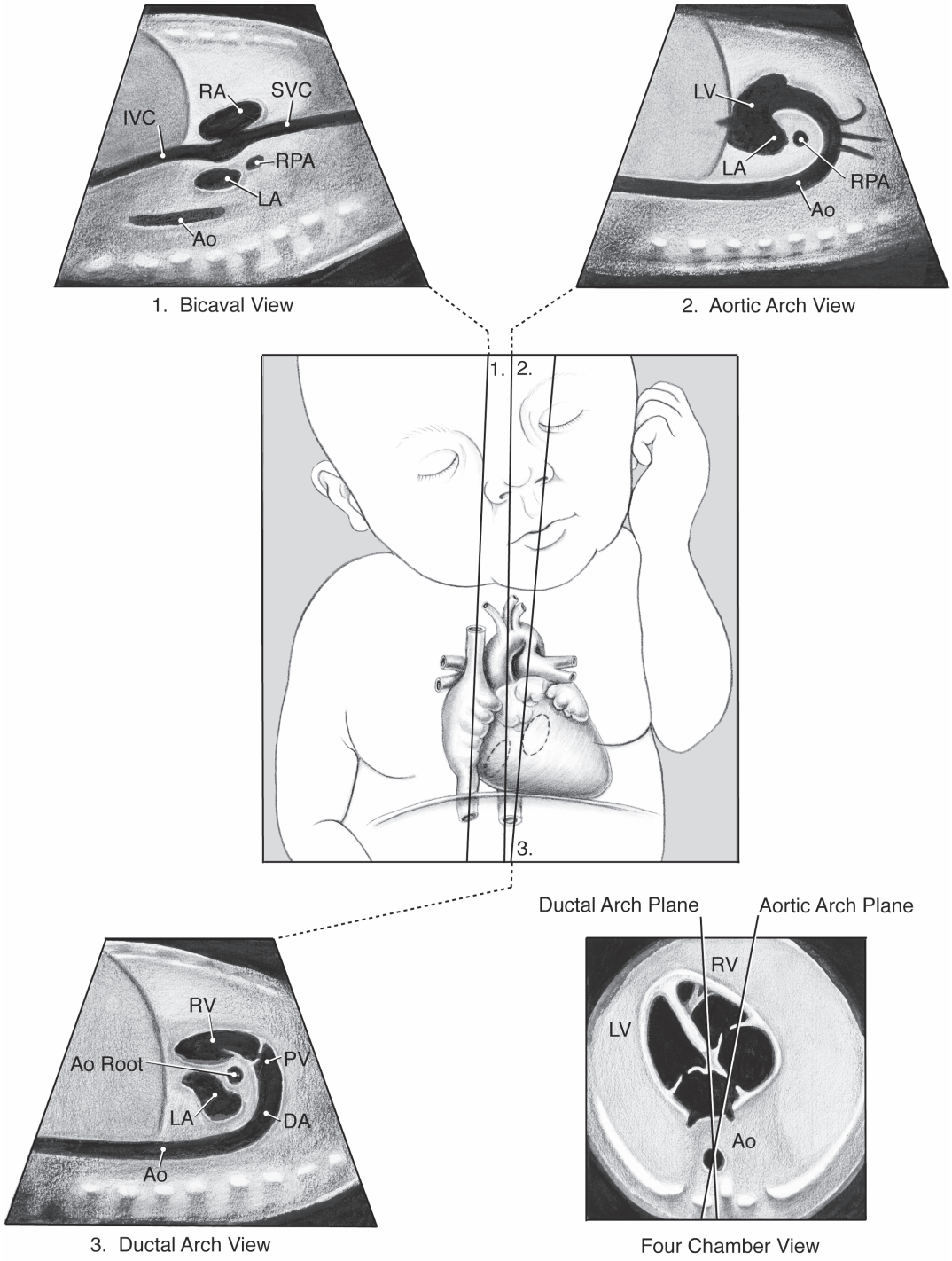
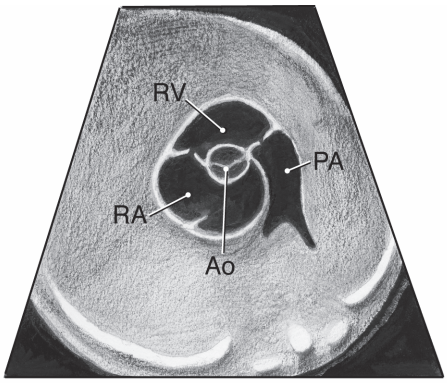
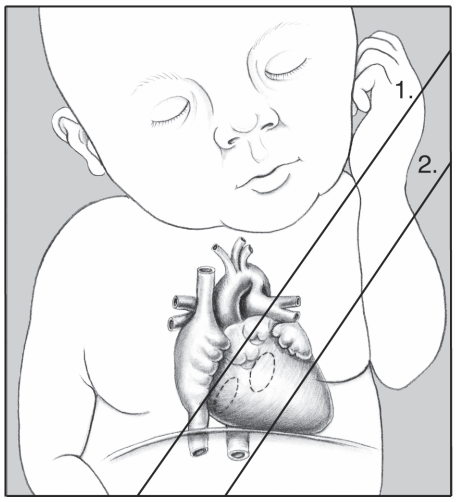


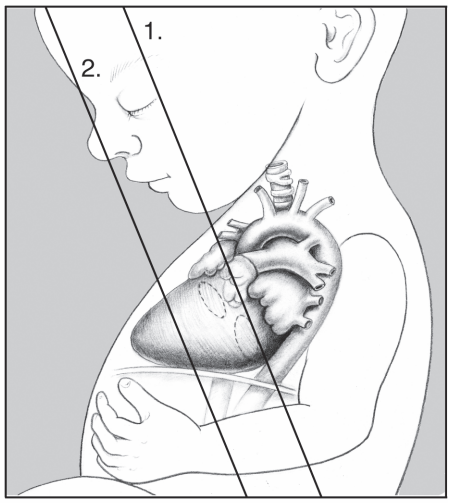
Figure 2. Sagittal views of the superior and inferior venae cavae (1), aortic arch (2), and ductal arch (3). The scan angle between the ductal arch and thoracic aorta ranges between 10° and 19° during pregnancy, as illustrated by the 4-chamber view diagram (Espinoza J, et al. *J Ultrasound Med* 2007; 26:437–443). Ao and Desc Ao indicate descending aorta; Ao Root, aortic root; DA, ductus arteriosus; IVC, inferior vena cava; LA, left atrium; LV, left ventricle; PV, pulmonary valve; RA, right atrium; RPA, right pulmonary artery; RV, right ventricle; and SVC, superior vena cava.



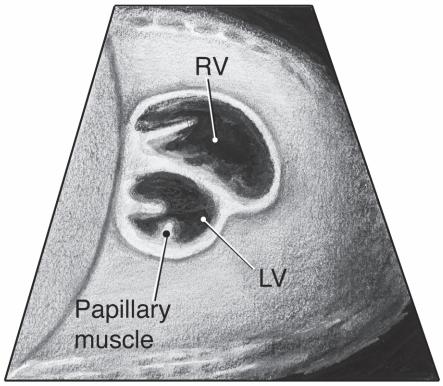
1. High Short Axis View - Great Arteries



Fetal Heart - Coronal View



Fetal Heart - Sagittal View



2. Low Short Axis View - Ventricles

Figure 3. Low and high short-axis views of the fetal heart. Ao indicates aortic valve; LV, left ventricle; PA, pulmonary artery; RA, right atrium; and RV, right ventricle.

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