Fetal Echocardiography and the Routine Obstetric Sonogram

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Congenital heart disease (CHD) is the most common severe congenital abnormality and accounts for half of all congenital disease. The incidence of CHD is about 4.1/1000 up to 12/1000 live births. It is for this reason that early detection of CHD is important. With appropriate scanning techniques, the fetal heart can be evaluated for structural characteristics during the routine obstetric sonogram. The four-chamber view has been an accepted part of the guidelines for screening obstetric sonograms since the late 1980s. This review helps the sonographer understand that many more cardiac abnormalities can be identified prenatally by identifying the cardiac outflow tracts along with the four-chamber heart. Early detection of CHD allows for the medical needs of the baby, as well as the emotional and financial needs of the family, to be addressed prior to birth.

Key words: fetal echocardiography, outflow tracts, basic cardiac sonogram, congenital heart disease

To limit the number of missed cardiac malformations on the routine obstetric sonogram examination, it is essential that a complete basic fetal cardiac evaluation is performed. Competency in the basic cardiac evaluation can be achieved through education, training, and practice. The incidence of congenital heart disease (CHD) is about 4.1/1000 to 12/1000 live births.[1] Many cardiac malformations are incidentally found during a routine obstetric sonogram. For this reason, it is important to identify the majority of fetuses with CHD.[2] Once an abnormality is suspected, the patient can be referred to a maternal fetal medicine specialist and/or pediatric cardiologist for a detailed fetal echocardiogram.[3]

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The cardiac views that should be included in the routine screening obstetric sonogram have been the topic of discussion for many years. It has been an accepted standard since the late 1980s to incorporate the four-chamber view in the routine obstetric sonogram examination.[4] However, numerous publications since the late 1980s have supported imaging the outflow tracts and great arteries in addition to the four-chamber view as a screening tool for CHD.[5–9] Many cardiac abnormalities such as large septal defects, hypoplastic ventricles, stenosis or atresia of the atrioventricular valves, atrioventricular canal defect, Ebstein's anomaly, and single ventricle can be recognized by imaging the four-chamber view. However, cardiac malformations such as transposition of the great arteries, truncus arteriosus, double outlet ventricles, and tetralogy of Fallot can go undiagnosed without visualization of the outflow tracts.

The American Institute of Ultrasound in Medicine (AIUM) states that the most optimal time to visualize the fetal heart anatomy is between 18 and 22 weeks' gestation.[10] At this gestational age, the fetus should be of adequate size, allowing the best access to the heart; however, it is important to note that uncontrollable variables can interfere with the visualization of fetal cardiac anatomy. These limitations can occur due to maternal body habitus, fetal position, fetal gestational age, polyhydramnios, oligohydramnios, and poor sonographic transmission. Due to some of these variables, it may be necessary to change patient position to align the fetal anatomy as close to the sonographic beam as possible. Because of the rapid movement and small size of the fetal heart, a high-resolution real-time sonography machine is needed.[11–13] Enlarging the heart on the sonographic screen and adjusting gain settings can help to visualize small heart structures.

Scanning Techniques

The importance of taking the additional views of the outflow tracts is made evident by updates in examination guidelines. The AIUM and the American College of Radiology (ACR) both recommend that the basic obstetric examination include a four-chamber view of the heart. The AIUM and the ACR also suggest documenting the outflow tracts, if technically feasible.[10,14] The American Society of Echocardiography (ASE) states that the addition of right and left ventricular outflow tracts, as well as great artery visualization, improves the potential diagnosis of CHD.[15]

The basic cardiac study of the fetus can be accomplished by following the criteria outlined in Table 1 (see also Fig. 1). To estimate the cardiac axis on a cross-sectional image at the level of the chest, draw an imaginary line anterior to and posterior from

TABLE 1.
Features of a Normal Basic Cardiac Study of the Fetus

- The heart should point to the left side, and the stomach should be seen on the same side below the diaphragm on a cross-sectional image.
- The cardiac axis should be approximately 45 ± 20 degrees from midline.
- The heart should be approximately one third the size of the fetal chest.
- There should be two atria of equal size and two ventricles of equal size.
- The foramen ovale flap should open into the left atrium.
- The moderator band (striated muscle across the apex) should be seen in the right ventricle.
- The descending thoracic aorta should be seen to the left of the spine on a cross-sectional thoracic image.
- There should be two atrioventricular valves present: the left-sided mitral valve and the right-sided tricuspid valve (communication between the atria and the ventricles).
- The right and left ventricular outflow tracts should be seen to originate from their respected ventricles and crisscross perpendicularly, with the right being anterior to the left.

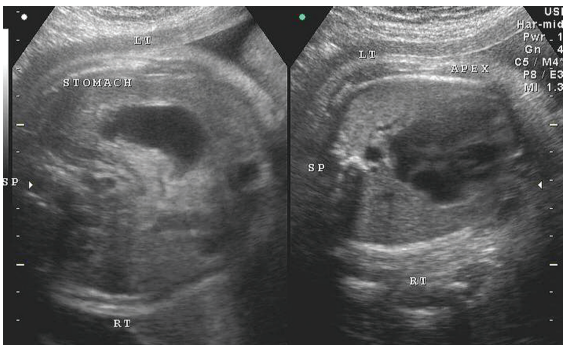

FIG. 1. Correct orientation. Transverse image at the level of the fetal stomach (LT) and transverse image at the level of the fetal chest, showing the apex of the heart pointing toward the same side as the left-sided stomach (RT). SP, spine; LT, left; RT, right; APEX, apex of the fetal heart.

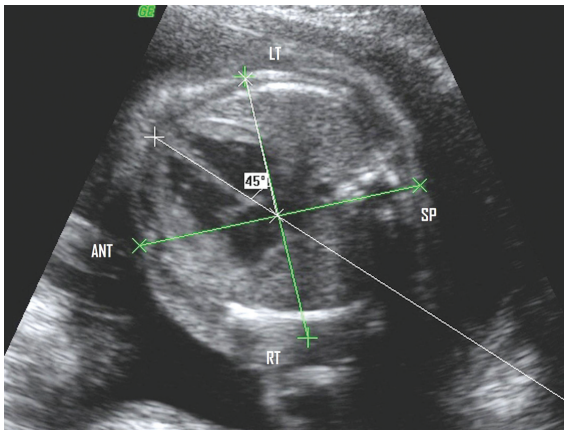

FIG. 2. Cardiac axis. Transverse image at the level of the four-chamber heart in the fetal chest showing the measured cardiac axis at a 45-degree angle to midline. SP, spine; LT, left; RT, right; ANT, anterior.

TABLE 2.
Cardiac Anomalies Identified by Visualization of a Four-Chamber View

Large septal defects
Hypoplastic right or left ventricles
Stenosis or atresia of the atrioventricular valves
Single ventricle
Ebstein's anomaly
Atrioventricular canal defect

TABLE 3.
Four-Chamber View

Approach:
Either apically or subcostally, find the heart and lay out all four chambers

Structures seen:
1. All four chambers of the heart: left ventricle, right ventricle, left atrium, and right atrium
2. Atrioventricular valves: mitral valve and tricuspid valve
3. Interventricular septum and interatrial septum
4. Pulmonary veins
5. Foramen ovale
6. Moderator band in right ventricle
7. Apex
8. Papillary muscles and chordal attachments

This image is acquired subcostally (long) or apically.

What to look for:
1. Chamber size: The ventricles should be close to equal in size, as well as the atria
2. Apex of the heart: Normal position (points to the left side of fetal body)
3. Foramen ovale to open into the left atrium
4. Atrial septal defects, abnormal opening between the atria, in addition to the foramen ovale
5. Ventricular septal defects, abnormal opening between the ventricles

the sternum to the vertebral body and a second imaginary line perpendicular to the first, forming a 90-degree angle transversely across the chest. Finally, a third imaginary line is drawn through the apex of the heart and ends at the intersection of the first two lines (Fig. 2).[16–18]

Depending on how the fetus is lying, the four-chamber view will be seen in an apical or subcostal angle. The differences are due to the orientation of the heart relative to the sonogram beam. To obtain either of these four-chamber views, start at the transverse view of the abdomen used for measuring the abdominal circumference, without changing transducer angulation or rotation, and slide the transducer toward the fetal chest until the four-chamber heart is in view. The apical view is obtained when the sonographic beam is parallel with the interventricular septum (Fig. 3). The apical approach permits the best inspection of the ventricles, atria, and atrioventricular (AV) valves. However, dropout artifacts can occur in the interventricular septum with this approach, which can lead to overdiagnosis of ventricular septal defects. To help exclude false-positive ventricular septal defects, an additional subcostal four-chamber view is helpful. The subcostal approach is obtained when the fetal spine is either on the left or right side of the sonographic field (approximately 3 or 9 o'clock). The sonographic beam is perpendicular to the interventricular septum (Fig. 4). This approach provides good visualization of the atrial and ventricular septae and the foramen ovale flap. Cardiac anomalies that can be readily identified by inspection of the four-chamber view are listed in Table 2. Outlined in Table 3 are the structures identified with the four-chamber view and their characteristics.[17]

Following a detailed inspection of the four-chamber heart to include the atria, ventricles, sepatae, AV valves, and the foramen ovale flap, the ventricular outflow tracts should be identified. The outflow tracts should be seen to crisscross at a perpendicular angle. The ascending aorta arises from the left

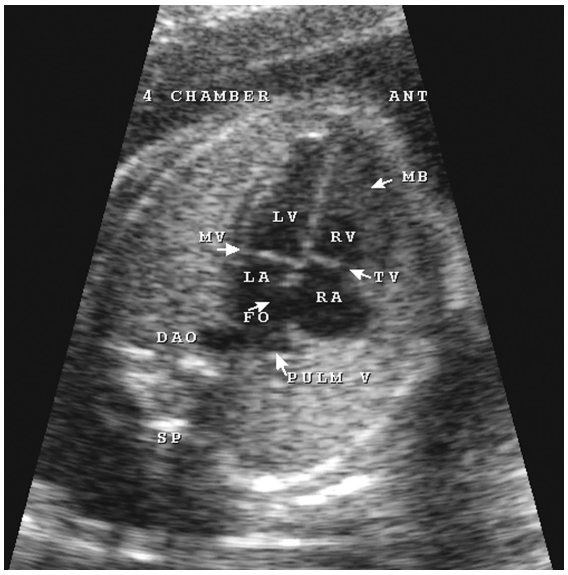

FIG. 3. Four-chamber heart (apical). Transverse image of the fetal chest at the level of the four-chamber heart. There are two atria (LA, RA) and two ventricles (LV, RV) of equal size. The RV is closest to the anterior chest wall, and the LA is closest to the spine. The moderator band can be seen in the RV near the apex, the pulmonary veins can be seen coming into the LA, the FO can be seen opening into the LA, the DAO is seen to the left of the spine, and the MV and TV are noted between the atria and ventricles. The IVS and IAS can be seen dividing the ventricles and atria into left and right sides. RV, right ventricle; LV, left ventricle; RA, right atrium; LA, left atrium; DAO, descending thoracic aorta; SP, spine; FO, foramen ovale; MV, mitral valve; TV, tricuspid valve; ANT, anterior; IVS, interventricular septum; IAS, interatrial septum; MB, moderator band; PULM V, pulmonary vein.

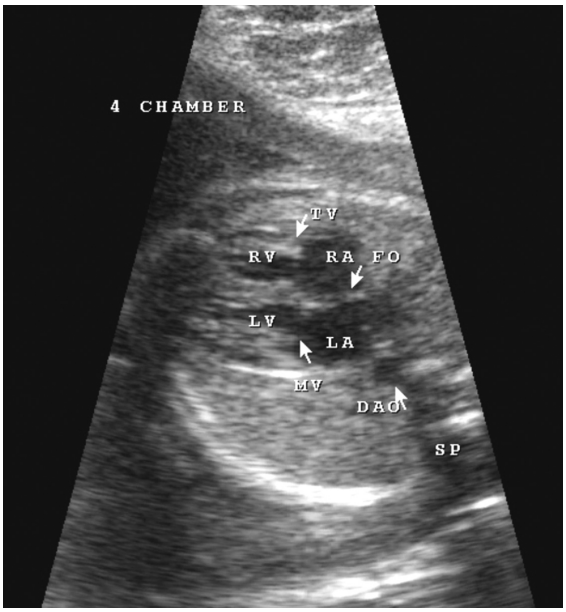

FIG. 4. Four-chamber heart (subcostal). Transverse image of the fetal chest at the level of the four-chamber heart. There are two atria (LA, RA) and two ventricles (LV, RV) of equal size. The RV is closest to the anterior chest wall, the LA is closest to the spine, the FO can be seen opening into the LA, the DAO is seen to the left of the spine, and the MV and TV are noted between the atria and ventricles. The IVS and IAS can be seen between the two ventricles and atria. RV, right ventricle; LV, left ventricle; RA, right atrium; LA, left atrium; DAO, descending thoracic aorta; SP, spine; FO, foramen ovale; MV, mitral valve; TV, tricuspid valve; IVS, interventricular septum; IAS, interatrial septum.

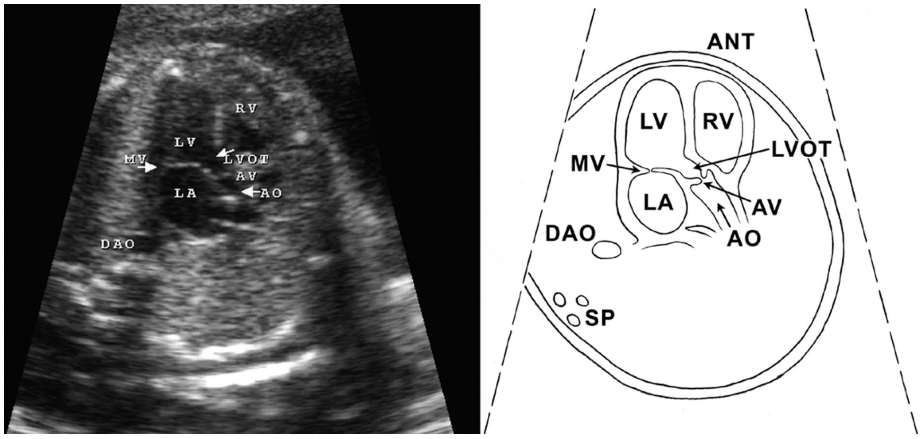

FIG. 5. LVOT (apical). This image of the LVOT was taken from an apical four-chamber view with slight anterior angulation and rotation toward the fetal right shoulder. The LVOT can be seen connected to the LV, with the AV and aorta arising from it. The AV and MV are in fibrous continuity with each other, and a portion of the RV is seen. The DAO is noted posterior to the LA. RV, right ventricle; LV, left ventricle; LA, left atrium; LVOT, left ventricular outflow tract; AV, aortic valve; MV, mitral valve; DAO, descending aorta; ANT, anterior; SP, spine.

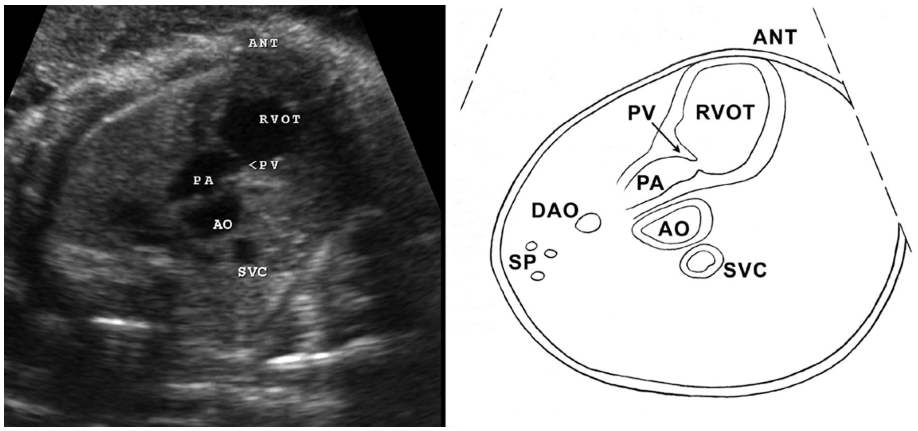

FIG. 6. RVOT (apical). This image of the RVOT was taken from the apical LVOT view with slight anterior angulation and rotation toward the fetal left shoulder. The RVOT can be seen connected to the right ventricle, with the PV and pulmonary artery arising from it. The LA is seen posterior to the PA, and the DAO is posterior to the LA. LA, left atrium; RVOT, right ventricular outflow tract; PV, pulmonary valve; PA, pulmonary artery; DAO, descending aorta; ANT, anterior; AO, aorta; SP, spine; SVC, superior vena cava.

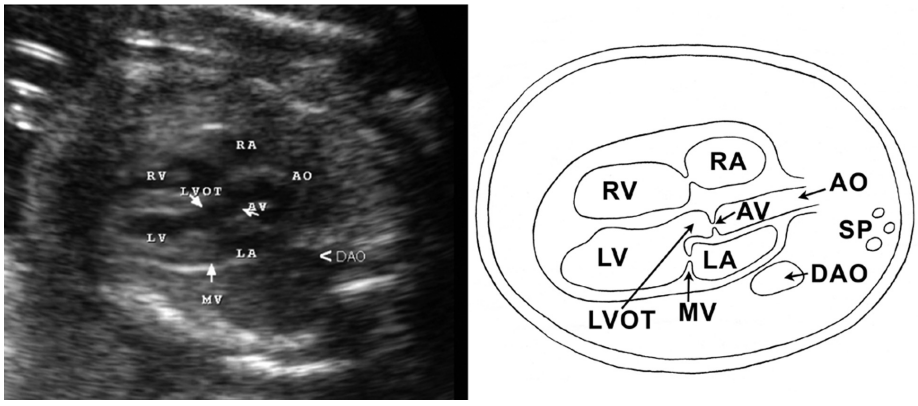

FIG. 7. LVOT (subcostal). This image of the LVOT was taken from a subcostal four-chamber view. The LVOT can be seen connected to the LV, with the AV and aorta arising from it. The AV and MV are in fibrous continuity with each other. The LA and aorta appear to be equal in size. The DAO is seen posterior to the LA. RV, right ventricle; LV, left ventricle; RA, right atrium; LA, left atrium; LVOT, left ventricular outflow tract; AV, aortic valve; MV, mitral valve; DAO, descending aorta; AO, aorta; SP, spine.

ventricular outflow tract (LVOT) off of the left ventricle, and the pulmonary artery arises from the right ventricular outflow tract (RVOT) off of the right ventricle crossing over the ascending aorta anteriorly. From the apical approach, the LVOT can be obtained by angling the transducer slightly anterior and then tilting it toward the fetal right shoulder (Fig. 5). The RVOT can then be displayed by angling the transducer slightly more anterior from the LVOT position and tilting the transducer toward the fetal left shoulder (Fig. 6). From the four-chamber subcostal view, the LVOT can be obtained by rotating the transducer toward the right shoulder and slightly tilting toward the fetal head (Fig. 7). The RVOT can be displayed from this position by slightly tilting the transducer toward the left shoulder angling upward so that the sonographic beam is directed to the fetal back (Fig. 8). Inspection of the RVOT and LVOT allows for identification of the relationship of the aorta and pulmonary artery as well as the relative size of each vessel at its insertion. In the normal relationship between the aorta and pulmonary artery, the pulmonary artery lies anterior to the aorta. Commonly identified cardiac anomalies from the outflow tract views are listed in Table 4. Outlined in Tables 5

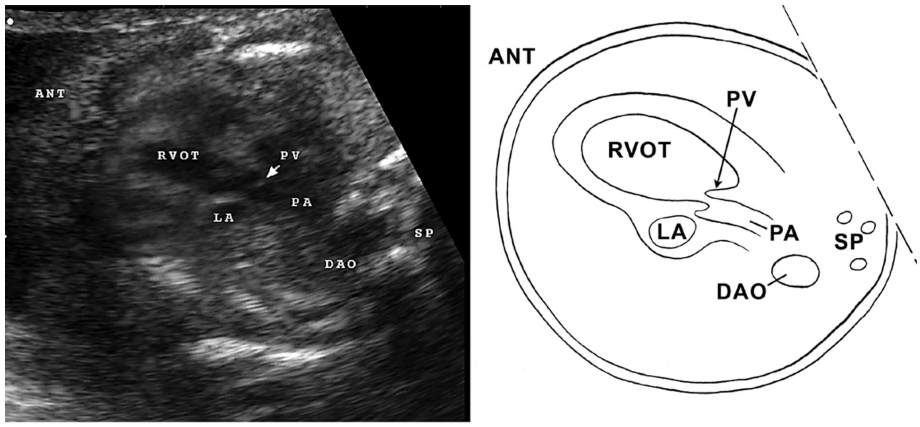

FIG. 8. RVOT (subcostal). This image of the RVOT was taken from the subcostal LVOT view with slight angulation and rotation toward the fetal back and left fetal shoulder. The RVOT can be seen connected to the RV, with the PV and pulmonary artery arising from it. The LA is seen posterior to the PA, and the DAO is posterior to the LA. LA, left atrium; RVOT, right ventricular outflow tract; PV, pulmonary valve; PA, pulmonary artery; DAO, descending aorta; ANT, anterior; SP, spine.

TABLE 4.
Cardiac Anomalies Identified by Visualization of the Outflow Tracts

Transposition of the great vessels
Tetralogy of Fallot
Double outlet right ventricle
Truncus arteriosus
Aortic and pulmonary artery stenosis

TABLE 5.
Left Ventricular Outflow Tract

Approach:
Obtain a four-chamber heart view and rotate the probe slightly anterior, tilting the probe toward the fetal right shoulder (apical) or the fetal head (subcostal) and lay out the left ventricular outflow tract (LVOT).

Structures seen:
1. LVOT
2. Aortic root
3. Aortic valve and mitral valve (MV) continuity
4. Left atrium (LA)
5. MV leaflets
6. Right atrium
7. Right ventricle—partial
8. Descending aorta—behind LA

What to look for:
1. Atrioventricular valve and MV in fibrous continuity with each other
2. Aortic root size compared to LA (should be about equal and seen best on long-axis view)
3. LVOT to be arising from the left ventricle
4. Aortic root and valve to be connected to the LVOT
5. Descending aorta posterior to LA
6. Any widening or narrowing of the LVOT and/or proximal aorta

and 6 are the structures identified with the LVOT and RVOT views and their characteristics.[18]

Conclusion

By adding the two views of the cardiac outflow tracts to the routine obstetric sonogram, the detection rate of CHD can be raised significantly. Heart anomalies such as truncus arteriosus, tetralogy of Fallot, and double outlet ventricles can potentially go undiagnosed by imaging the four-chamber view alone. With improved scanning techniques and technical advances in sonographic equipment, a higher incidence of cardiac malformations can be recognized in the second trimester of pregnancy during a routine obstetric sonogram. Referrals to maternal fetal medicine specialists and/or pediatric cardiologists for a detailed echocardiogram can then be made, thus allowing the management of both mother and

TABLE 6.
Right Ventricular Outflow Tract

Approach:
Obtained from the left ventricular outflow tract view with slight angulation anterior and tilted toward the left shoulder (apical) or toward the fetal back (subcostal)

Structures seen:
1. Right ventricular outflow tract (RVOT)
2. Pulmonary valve (PV) leaflets
3. Pulmonary artery (PA) off of the RVOT
4. Left atrium (LA)
5. Descending aorta behind LA

What to look for:
1. RVOT coming off of the right ventricle
2. PA arising from the RVOT
3. PV connected to the RVOT
4. Any narrowing or widening of the RVOT and/or the proximal PA

baby to be addressed prior to birth, ultimately improving neonatal outcomes.

References

1. Hoffman JIE: Incidence, prevalence and inheritance of congenital heart disease, in Moller JH, Hoffman JIE (eds): *Pediatric Cardiovascular Disease*. New York, Churchill Livingstone, 2000, pp 257-262.
2. Quinones MA, Douglas PS, Foster E, et al: ACC/AHA clinical competence statement on echocardiography: VIII. Fetal echocardiography. *J Am Coll Cardiol* 2003; 41:687–708.
3. Cullen S, Sharland GK, Allan LD, Sullivan ID: Potential impact of population screening for prenatal diagnosis of congenital heart disease. *Arch Dis Child* 1992;67:775–778.
4. American College of Obstetrics and Gynecology: Sonogram in pregnancy. Technical bulletin, May 1988.
5. DeVore GR: The aortic and pulmonary outflow tract screening examination in the human fetus. *J Sonogram Med* 1992;11:345–348.
6. Kirk JS, Riggs TW, Comstock CH, Lee W, Yang SS, Weinhouse E: Prenatal screening for cardiac anomalies: the value of routine addition of the aortic root to the four-chamber view. *Obstet Gynecol* 1994;84:427–431.
7. Achiron R, Glaser J, Gelernter I, et al: Extended fetal echocardiographic examination for detecting cardiac malformations in low risk pregnancies. *BMJ* 1992;304:671.
8. Carvalho JS, Mavrides E, Shinebourne EA, Campbell S, Thilaganathan B: Improving the effectiveness of routine prenatal screening for major congenital heart defects. *Heart* 2002;88:387–391.
9. Buskens E, Grobbee DE, Frohn-Mulder IME, et al: Efficacy of routine fetal sonogram screening for congenital heart disease in normal pregnancy. *Circulation* 1996;94:67–72.
10. AIUM practice guideline for the performance of an antepartum obstetric sonogram examination. *J Sonogram Med* 2003;22:1116–1125.
11. Silverman NH, Golbus MS: Echocardiographic techniques for assessing normal and abnormal fetal cardiac anatomy. *J Am Coll Cardiol* 1985;5(suppl):20S.
12. Persutte W: The four-chamber view of the fetal heart: how achievable is it? *J Diagn Med Sonography* 1996;12:69–71.
13. Comstock CH: What to expect from routine midtrimester screening for congenital heart disease. *Semin Perinatol* 2000;24:331–342.
14. American College of Radiology: *Practice Guideline for the Performance of Antepartum Obstetrical Sonogram*. Reston, VA, American College of Radiology, 2003.
15. Rychik J, Ayres N, Cuneo B, et al: American Society of Echocardiography guidelines and standards for performance of the fetal echocardiogram. *J Am Soc Echocardiogr* 2004;17:803–810.
16. Comstock CH: Normal fetal heart axis and position. *Obstet Gynecol* 1987;70:255.
17. Paladini D, Chita SK, Allan LD: Prenatal measurement of cardiothoracic ratio in evaluation of heart disease. *Arch Dis Child* 1990;65:20.
18. Abuhamad A: *A Practical Guide to Fetal Echocardiography*. Philadelphia, Lippincott-Raven, 1997.