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Pediatric Echo Review

Pediatric Echocardiography A Q&A Review for the ARDMS Specialty Exam

Continuing Education Activity

SDMS-Approved **12** CME Credits

HUI GAO | PIERRE C. WONG | NOVEL A. CASTILLO

Pediatric Echocardiography Review

A Q&A REVIEW FOR THE ARDMS PEDIATRIC ECHOCARDIOGRAPHY EXAM

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Preface

THIS MOCK EXAM is a question/answer/reference review of Pediatric Echocardiography for those candidates who plan to take the PE specialty examination for the Registered Diagnostic Cardiac Sonographer (RDCS) credential administered by the American Registry for Diagnostic Medical Sonography (ARDMS). Those sitting for the Registered Cardiac Sonographer (RCS) exam administered by Cardiac Credentialing International (CCI) will likewise find that these items will bolster and solidify their preparation. Designed as an adjunct to your regular study, this mock exam will help you precisely determine your strengths and weaknesses so that you can study more effectively. This mock exam is also an SDMS-approved CME activity worth 12 credits (see Part 8).

Facts about *Pediatric Echocardiography Review*

- ▶ This mock exam covers the material on the ARDMS exam content outline in effect as of 2019–2020. Readers are advised to check the ARDMS website, www.ardms.org, for the latest updates. The mock exam itself is continuously updated and revised as necessary, and readers can check Davies’ website for the latest Study Alerts and other product updates by visiting <http://www.daviespublishing.com/Product-Updates-C220.aspx>.
- ▶ The mock exam focuses exclusively on the Pediatric Echocardiography (PE) specialty exam to ensure thorough coverage of even the smallest subtopic and clinical task on the exam. (For those preparing for the Sonography Principles and Instrumentation exam, see Davies’ *Ultrasound Physics Review: SPI Edition*, available in either print or interactive format at www.daviespublishing.com.)
- ▶ We use the most current ARDMS content outline as a guideline for coverage. It is, in fact, the foundation for our table of contents.
- ▶ This mock exam contains 603 questions, many of which are accompanied by sonographic and other images, anatomic illustrations, and schematics—more than 150 image-based cases. More than 60 of these are real-time video clips accessible by registering your book with Davies at our website.
- ▶ Items are presented in ARDMS exam format to give you an educational tool that will exercise those neural pathways in more than one direction. Registry candidates who master these items at an average rate of 1 minute apiece will be exceptionally well prepared for the actual exam.
- ▶ The answer key located in Part 7 contains not only the answers but also concise explanations that are abundant, clear, and authoritatively referenced for further study. We recommend that you have a copy of a standard pediatric echocardiography review text at your side when using this mock exam to study for the PE exam—you will see several of these referenced in both the answer section and the “Suggested Readings” in Part 9.

- ▶ This mock examination has been approved by the Society of Diagnostic Medical Sonography (SDMS) as a CME activity. A CME application form, quiz, and full submission instructions are included in Part 8. Passing this quiz will qualify the applicant for 12 CME credits. A modest administrative processing fee applies at the time of submission, and more than one sonographer may use the forms in this book to submit this activity for CME credit. These credits are accepted by ARDMS, APCA, CCI, the American Registry of Radiologic Technologists (ARRT), and other organizations toward meeting their CME requirements. Some credentials carry stipulations regarding specialty areas in which CME credits may be earned. Always check with the organization that governs your credential(s). All the credits in this activity may be applied to maintain the ARDMS RDCS credential.
- ▶ The expanded ARDMS exam content outline, complete with all questions that apply to specific clinical tasks, appears in Part 10. Under each task we have indexed the question numbers in this mock exam that are related to that task, for your convenience in targeting your study on specific exam topics. (To ensure that your study is targeted at the most current examination outline, be sure to visit the ARDMS website at www.ardms.org.)

ARDMS Advanced Item Type (AIT) Questions

All the ARDMS exams now include Advanced Item Type (AIT) questions that assess practical instrumentation skills. For the PE specialty exam, these AIT questions include what ARDMS calls “Hotspot” questions. Hotspot items display an image with the question and ask you to indicate the correct answer by marking directly on the image using your cursor; this type of question is called “advanced” because it involves a higher level of thinking and processing than you perform when answering a conventional multiple-choice question. In Davies’ mock exam, similar questions are identified as “AIT—Hotspot” questions. These items ask you to identify what an arrow in the image is pointing at or to indicate the label on an image that corresponds to the correct answer.

Another type of AIT question, the Semi-Interactive Console (SIC) item, requires the examinee to use a semi-interactive console to correct a problem with the image presented. Currently these items do not appear on the PE exam, but as a bonus feature we have identified such items as “AIT—SIC” questions.

Finally, PACSim items—case-based Picture Archive and Communication Simulation questions—are not included in this mock exam because currently this type of question is specifically designed for and limited to the Physician in Vascular Interpretation (PVI) and the Ob/Gyn exams—the former under the jurisdiction of the Alliance for Physician Certification and Advancement (APCA).

How to Use This Mock Exam

Pediatric Echocardiography Review effectively simulates the content of the Pediatric Echocardiography (PE) exam. Current ARDMS standards call for 150 multiple-choice questions to be answered during a three-hour period. That is, you will have an average time of approximately one minute to answer each question. Timing your practice sessions according to the number of questions you need to finish will help you prepare for the pressure experienced by PE candidates taking this exam. It also helps to ensure that your practice scores accurately reflect your strengths and weaknesses so that you can study more efficiently in the limited time you are able to devote to preparation.

Important note: Although many of our customers remark on similarities between our questions and those of the actual exam, do not be misled into thinking you should memorize these questions and answers. They are here to give you practice, to teach you things you may not know, and to reveal your strengths and weaknesses so that you know where to put your energy as you prepare for the exam. They also provide a means of assessing your progress as you study.

ARDMS test results are reported as a “scaled” score that ranges from a minimum of 300 to a maximum of 700. A scaled score of 555 is the passing score—the “passpoint” or “cutoff score” for all ARDMS examinations. The scaled score is simply a conversion of the number of correct answers that also, in part, takes into account the difficulty of a particular question. You can search on the Internet for the “Angoff scoring method” if you want to learn more about scaled scoring. Suffice it to say that it helps to ensure the fairness of the exams.

We include below and strongly recommend that you read *Taking and Passing Your Exam*, by Don Ridgway, RVT, who offers useful tips and practical strategies for taking and passing the ARDMS examinations.

Finally, you have not only our best wishes for success but also our admiration for taking this big and important step in your career.

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PART 1

Anatomy and Physiology

Refer to video PER-Q28.

28. The patient in this video clip has transposition of the great arteries (d-TGA). Which anatomic structure is the arrow pointing to?
- Single left coronary artery
 - Circumflex from the right coronary artery
 - Conal branch off the right coronary artery
 - Posterior descending coronary artery

AIT—Hotspot

29. In this image, which aortic anatomic structure is the arrow pointing to?



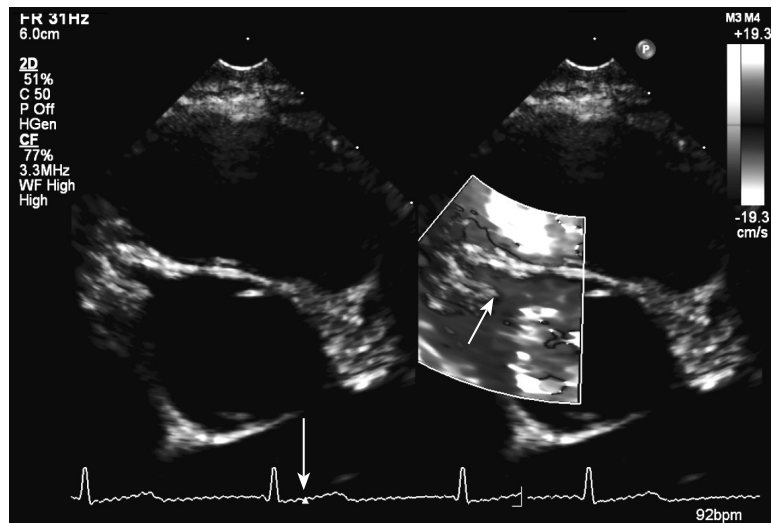
- Left coronary cusp (LCC)
- Right coronary cusp (RCC)
- Right and left commissural post
- Noncoronary cusp (NCC)

AIT—Hotspot

30. Which of these imaging methods, when paired with 2D imaging, helps locate the origins of the coronary artery?
- Spectral Doppler
 - Power Doppler
 - Color flow Doppler
 - M-mode
31. Left main coronary artery filling is best seen during:
- Diastole
 - Aortic valve opening
 - Mitral valve closure
 - Systole

32. This image demonstrates the right coronary artery (arrow) filling during which phase of the cardiac cycle?

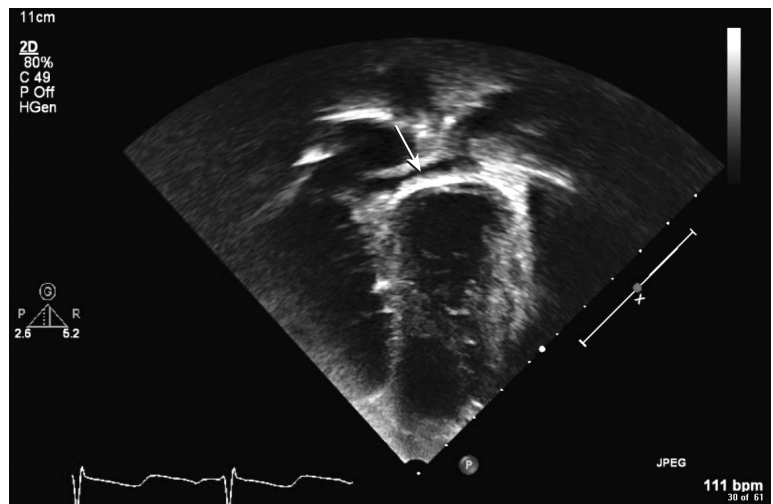
See Color Plate 1
on page xv.



- A. Isovolumic relaxation
- B. Early diastolic filling
- C. Late diastolic filling (atrial contraction)
- D. Systole

AIT—Hotspot

33. The arrow in this image is pointing to the:

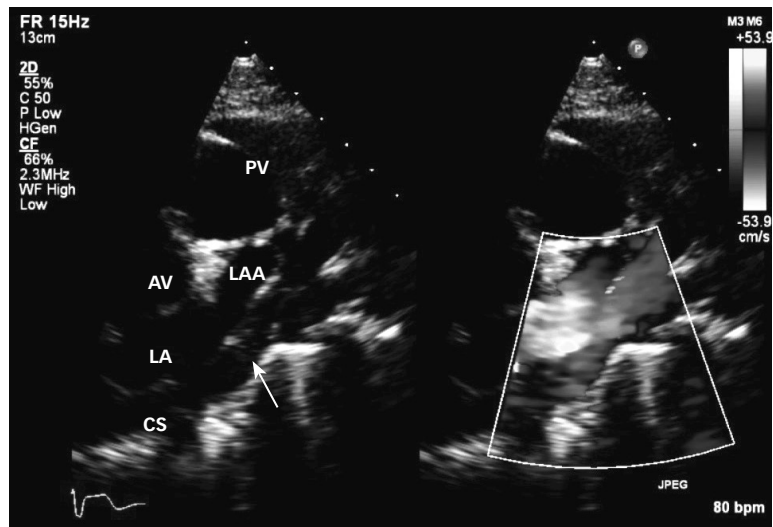


- A. Left atrium
- B. Coronary sinus
- C. Thebesian valve
- D. Circumflex coronary artery

AIT—Hotspot

34. In this image, what vascular structure is the arrow pointing to?

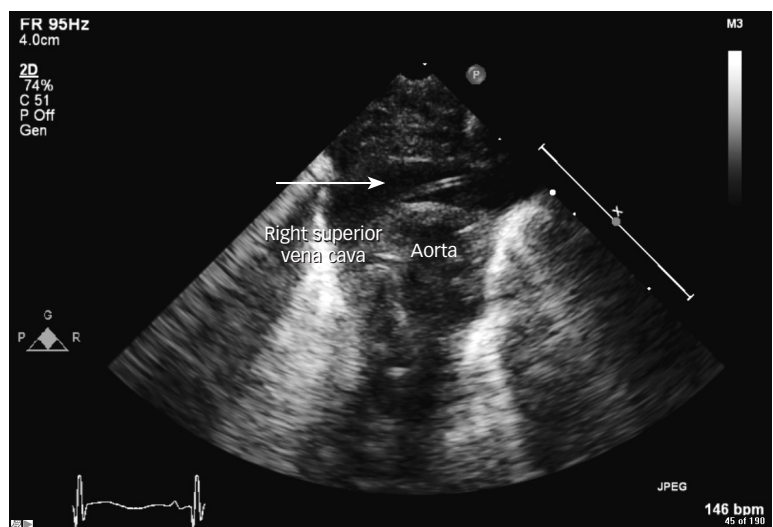
See Color Plate 2 on page xv.



- A. Left superior vena cava
- B. Subclavian vein
- C. Azygos vein
- D. Hemiazygos vein

AIT—Hotspot

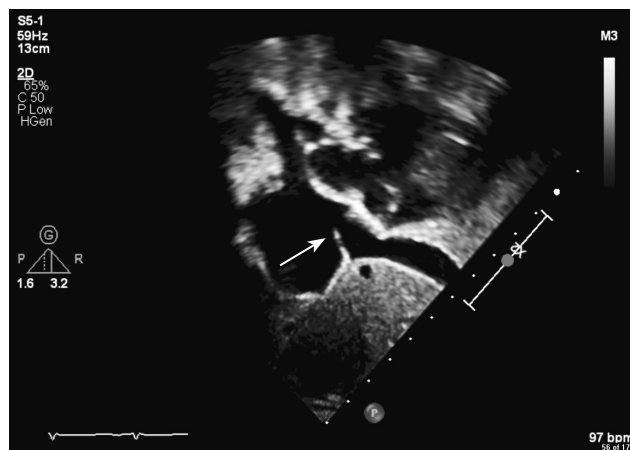
35. In this image, what vascular structure is the arrow pointing to?



- A. External jugular vein
- B. Innominate vein
- C. High intercostal vein
- D. Innominate artery

AIT—Hotspot

36. Which anatomic structure is best visualized from the apical four-chamber view with posterior angulation of the transducer?
- Superior vena cava
 - Circumflex coronary artery
 - Left anterior descending coronary artery
 - Coronary sinus
37. During embryologic development, the left horn of the sinus venosus eventually develops into which structure of the normal four-chambered heart?
- Eustachian valve
 - Coronary sinus
 - Levoatrial cardinal vein
 - Superior vena cava
38. During embryologic development, the right horn of the sinus venosus eventually develops into which structure of the normal four-chambered heart?
- Left atrium
 - Pulmonary veins
 - Right atrium
 - Left atrial appendage
39. Which structure is the arrow in this image pointing to?



- Coumadin ridge
- Thebesian valve
- Eustachian valve
- Crista terminalis

40. Azygos continuation of the inferior vena cava (IVC) occurs when there is:
- A. Interruption of the hepatic portion of the IVC
 - B. Interruption of the left vitelline vein
 - C. Interruption of the levoatrial cardinal vein
 - D. Interruption of the right anterior cardinal vein
41. You are scanning a newborn baby. You start with your subcostal views and pulsed-wave Doppler evaluation of the abdominal aorta and find prominent diastolic flow reversal. What do you suspect you will encounter during the remainder of the exam?
- A. Significant coarctation of the aorta (CoA)
 - B. Unicuspid aortic valve with severe stenosis
 - C. Bicuspid aortic valve (BAV) with mild stenosis
 - D. Patent ductus arteriosus (PDA)
42. You are performing echocardiography on a patient in the neonatal intensive care unit and note a right-sided aortic arch with an aberrant left subclavian artery. Which of the following options would result in a vascular ring?
- A. A patent ductus arteriosus on the same side as the aortic arch
 - B. A right-sided patent ductus arteriosus
 - C. A left-sided patent ductus arteriosus
 - D. A patent ductus arteriosus originating from the left innominate artery
43. Left atrial morphology is best established by which of the following characteristics?
- A. Site of pulmonary venous connection
 - B. Crista terminalis
 - C. Finger-like appendage
 - D. Septum secundum
44. Which situs of the abdominal viscera is characterized by a right-sided liver, left-sided stomach, left-sided spleen, and right-sided cecum?
- A. Situs totalis
 - B. Situs inversus
 - C. Situs ambiguus
 - D. Situs solitus

Answers, Explanations, and References

Anatomy and physiology

Pathology and pathophysiology

Congenital anomalies

Postoperative anatomy

Clinical standards and guidelines

Measurement techniques and quantification

30. C. Color flow Doppler.

Coronary artery imaging is one of the most challenging parts of echocardiographic evaluation, and one should use all the appropriate tools available. The use of 2D imaging and color flow Doppler imaging in combination is the best way to identify coronary artery origins.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, p 587.

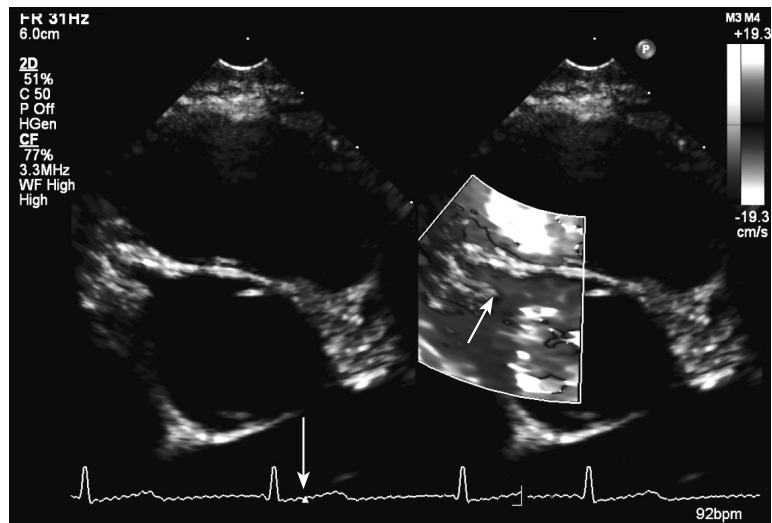
31. A. Diastole.

Left main coronary artery filling occurs primarily during diastole.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, p 586.

32. D. Systole.

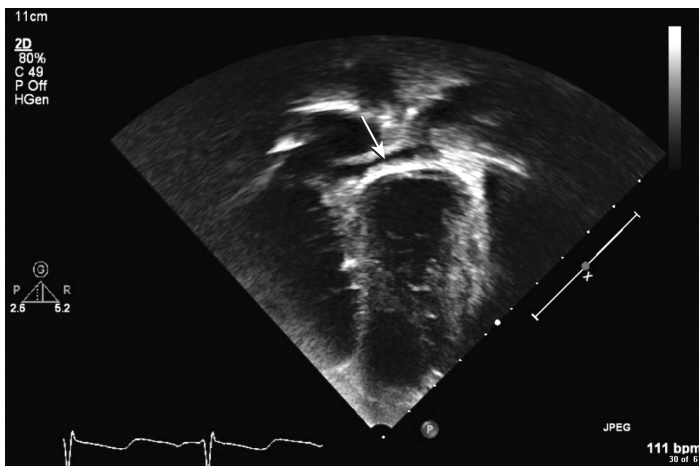
See Color Plate 1
on page xv.



The image shows the right coronary artery (top arrow) filling during systole. The lower arrow marks the point on the electrocardiographic tracing when the image was frozen. According to Lai et al., compressive forces exerted by the right ventricle are ordinarily less than those of the left ventricle; therefore, coronary blood flow to the right ventricle is not interrupted during ventricular systole.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, p 586.

33. B. Coronary sinus.

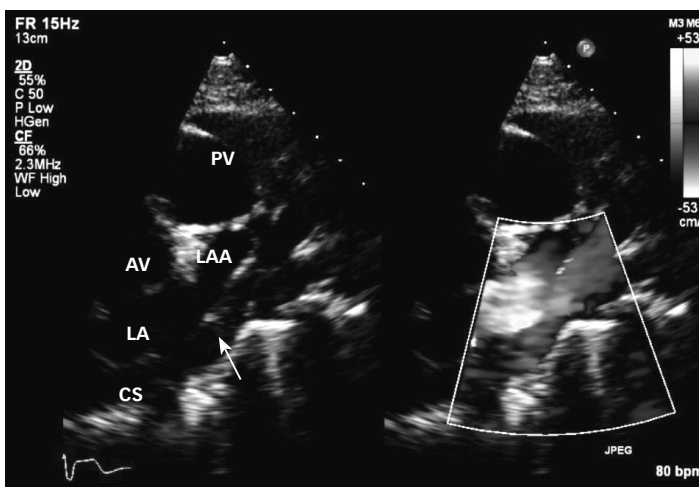


The coronary sinus (arrow) is a posterior structure that can be seen as it drains into the leftward and inferior portion of the right atrium. Additional views to evaluate the coronary sinus are the parasternal long-axis view, with a tilt toward the right hip to visualize the right ventricular inflow, and a subcostal long-axis (four-chamber) view, with posterior angulation.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 47–51.

34. A. Left superior vena cava.

See Color Plate 2 on page xv.

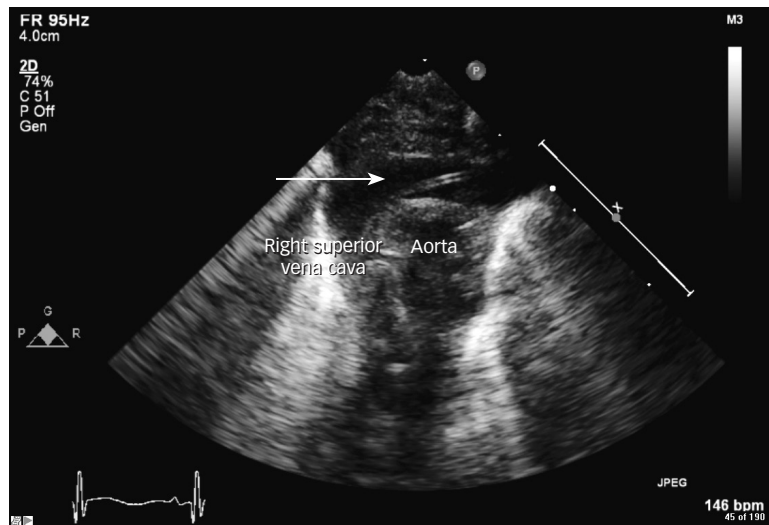


When a left superior vena cava (LSVC) is present, it usually connects to the coronary sinus (CS). In such cases, the CS will be dilated compared to its usual size when an LSVC is not present. Therefore, a clue to a persistent LSVC is a dilated CS. A bridging vein (innominate vein) is usually absent, but rarely it can remain present, connecting right and left SVCs.

When a bridging vein is present, its caliber can vary in size but is usually small. When an LSVC is present, care should also be taken to rule out partial pulmonary venous drainage to an LSVC. Color flow imaging and a spectral Doppler profile aid in identifying anomalous pulmonary venous drainage to an LSVC. Other possible reasons for a dilated CS include hepatic veins draining into the CS, total anomalous pulmonary venous connection (TAPVC) to the CS, or CS ostial stenosis. Arrow = left superior vena cava, CS = coronary sinus, PV = pulmonary valve, AV = aortic valve, LAA = left atrial appendage, and LA = left atrium.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 160–166, 182–186.

35. B. Innominate vein.



This image shows the innominate, or brachiocephalic, vein (arrow) in the suprasternal short-axis view. This view was obtained with the transducer in the suprasternal notch with the index marker positioned at 3 o'clock. An additional view to visualize the innominate vein can be acquired with the transducer in the suprasternal notch with the index marker positioned at 1–2 o'clock. In this view you will see the innominate vein superior to the aortic arch.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 54, 56, 184.

36. D. Coronary sinus.

The coronary sinus (CS) is a posterior structure and can be visualized by a posterior angulation of the transducer in the apical four-chamber view. In this view, the CS can be seen perpendicular to the angle of insonation, returning to the right atrium.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, p 49.

37. B. Coronary sinus.

The left horn of the sinus venosus eventually develops into the coronary sinus. The Eustachian valve is a remnant of the right valve of the sinus venosus. The superior vena cava is derived from the right anterior cardinal vein. The levoatrial cardinal vein is not present in the normal four-chambered heart; when present, it is frequently seen in association with hypoplastic left heart syndrome and a restrictive atrial septum.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, p 185.

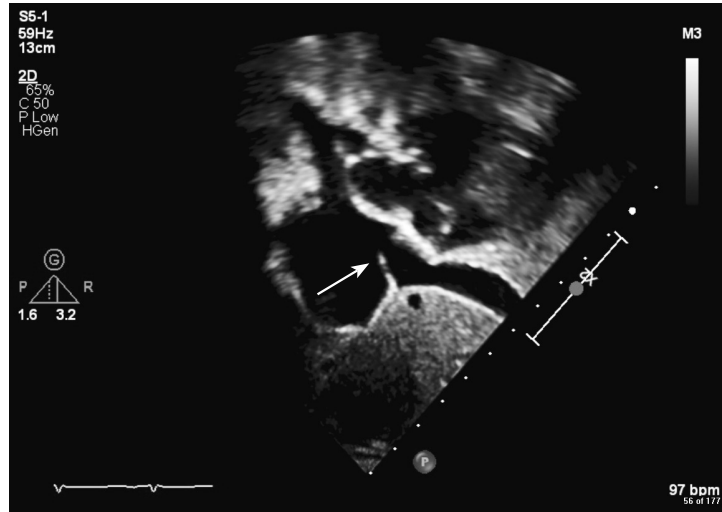
► Moore KL, Persaud TVN, Torchia MG: *The Developing Human: Clinically Oriented Embryology*, 9th edition. Philadelphia, Elsevier Saunders, 2013, pp 292, 305–306.

38. C. Right atrium.

In normal heart development the right horn of the sinus venosus eventually becomes the smooth-walled portion of the right atrium. The pulmonary veins are derived from a common pulmonary vein arising from the primitive lung buds, and this common pulmonary vein eventually forms a portion of the left atrium in conjunction with the embryonic left atrium of the primitive heart tube. The left atrial appendage also derives from the embryonic left atrium.

► Moore KL, Persaud TVN, Torchia MG: *The Developing Human: Clinically Oriented Embryology*, 9th edition. Philadelphia, Elsevier Saunders, 2013, pp 150, 204, 210, 305–306.

39. C. Eustachian valve.



The valve of the inferior vena cava is the Eustachian valve (arrow). Care must be taken to clearly identify this structure because in the setting of an atrial septal defect (ASD) the Eustachian valve can wrongly be identified as an inferior rim of the defect. This is important in the setting of an ASD device closure as well as surgical closure of an ASD.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 207–210, 240.

40. A. Interruption of the hepatic portion of the IVC.

Interruption of the hepatic portion of the inferior vena cava (IVC) does not mean that all components that form the IVC are missing; only the hepatic segment of the IVC is not present. Study of the embryologic venous system can enhance understanding of hepatic duplication of the inferior vena cava, interruption of the hepatic segment of the IVC, and other systemic venous malformations.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, p 181.

► Moore KL, Persaud TVN, Torchia MG: *The Developing Human: Clinically Oriented Embryology*, 9th edition. Philadelphia, Elsevier Saunders, 2013, pp 292, 295.

41. D. Patent ductus arteriosus (PDA).

A moderate to large sized patent ductus arteriosus (PDA) will generally be associated with prominent reversal of flow within the abdominal aorta. Other examples of cardiac pathology

that can present with prominent diastolic flow reversal include significant aortic regurgitation, aortico–left ventricular tunnel (ALVT), and sinus of Valsalva rupture.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 83, 320, 350.

42. C. A left-sided patent ductus arteriosus.

As a rule of thumb, the aortic arch, descending aorta, and ductus arteriosus should all be on the same side to exclude a vascular ring. Special care must be taken when imaging a right-sided aortic arch, an aberrant left subclavian artery, and a left-sided ductus arteriosus (originating from the left subclavian artery or a diverticulum of Kommerell), which can be a setup for a vascular ring. One exception to this statement would be a right-sided aortic arch and a left-sided patent ductus arteriosus originating from the left innominate (brachiocephalic) artery. In choice D, the patent ductus arteriosus is too far anterior to cause a vascular ring.

► Allen HD, Driscoll DJ, Shaddy RE, et al: *Moss and Adams' Heart Disease in Infants, Children, and Adolescents: Including the Fetus and Young Adult*, 8th edition. Philadelphia, Lippincott Williams & Wilkins, 2013, pp 758–788.

43. C. Finger-like appendage.

Hallmarks of left atrial morphology include a finger-like atrial appendage and the flap valve of the foramen ovale (atrial septum primum). The crista terminalis and septum secundum are characteristics of the morphologic right atrium; these structures cannot be readily visualized on transthoracic echocardiography. The site of pulmonary venous connection is not a reliable marker of left atrial morphology.

► Anderson RH, Baker EJ, Penny D, et al: *Paediatric Cardiology*, 3rd edition. Philadelphia, Churchill Livingstone/Elsevier, 2010, p 21.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 35–37.

44. D. Situs solitus.

A right-sided liver, left-sided stomach, left-sided spleen, and right-sided cecum are all typical of normally positioned abdominal viscera, or situs solitus.

► Lai WW, Mertens LL, Cohen MS, et al (eds): *Echocardiography in Pediatric and Congenital Heart Disease: From Fetus to Adult*, 2nd edition. Chichester, UK, Wiley-Blackwell, 2016, pp 33–35.

Pediatric Echo Review

Pediatric Echocardiography Review illuminates the facts and principles on which candidates for the ARDMS Pediatric Echocardiography exam will be tested. This mock exam covers the material on the exam content outline of the American Registry for Diagnostic Medical Sonography (ARDMS) for the Pediatric Echocardiography specialty exam in effect as of 2019–2020. It contains more than 600 registry-like questions, hundreds of images, and 60+ video clips from echocardiograms, along with answers, explanations, and references for further study. Image-based cases and schematic illustrations prepare those sitting for the exam to understand pediatric echocardiograms, cardiac anatomy, and cardiac pathology for the exam. Coverage includes anatomy and physiology, pathology and pathophysiology, congenital anomalies, postoperative anatomy, clinical standards and guidelines, and measurement techniques and quantification. This mock exam is also approved by the Society of Diagnostic Medical Sonography (SDMS) as a CME activity worth 12 credit hours.

About the authors . . .



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