

**Cardiac Radiology
In-Training Test Questions
for Diagnostic Radiology Residents**



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1. Concerning cardiac magnetic resonance imaging, which of the following are absolute contraindications?
- A. Coronary artery stents
 - B. Septal closure devices
 - C. Metallic bullet fragments in the chest wall
 - D. **Patient with absolute pacemaker dependence**

Rationale:

A. In general it is recommended to wait six weeks after stent placement before performing MRI. This is to allow endothelialization which, in theory, prevents stent dislodgement. risk of thrombosis. However, there are many studies in the literature which demonstrate Stent migration is thought to allow increased exposure of the stent metal to platelets and increase the no adverse effects in patients who had MR imaging at a shorter interval after stent placement.

B. Studies have demonstrated the safety of occluder devices used to repair atrial septal defects or patent foramen ovale in MR fields up to 3T in vivo. However, artifacts for the septal repair implants may present problems if the anatomical region of interest is in or near the area where these implants are located.

C. Provided these are not comprised of steel and are not located near vital structures, MR imaging can be performed. It should be noted that there may be artifact in the region of the metal, however.

D. Non pacemaker dependent patients may undergo cardiac and non-cardiac MR imaging provided certain precautions are taken. The duration of radiofrequency pulse should be minimized as much as possible to avoid radiofrequency related thermal myocardial injury by limiting scan time and specific absorption rate values. The pacemaker should be reprogrammed to a sense-only mode or to asynchronous pacing, depending on the individual's heart rate, to avoid competitive rhythms in patients with high intrinsic heart rate, and gradient field-induced inhibition in patients with low intrinsic heart rates. Patients should undergo continuous electrocardiographic monitoring throughout the procedure and an electrophysiologist and full resuscitation facilities should be available in the MRI suite.

Reference:

Gerber TC, Fasseas P, Lennon RJ et al. **Clinical safety of magnetic resonance imaging early after coronary artery stent placement.** J Am Coll Cardiol. 2003 Oct 1; 42(7):1295-8.

Shellock FG, Valencerina S. **Septal repair implants: evaluation of magnetic resonance imaging safety at 3 T.** Magn Reson Imaging. 2005 Dec;23(10):1021-5. Epub 2005 Nov 28.

Teitelbaum GP, Yee CA, Van Horn DD. **Metallic ballistic fragments: MR imaging safety and artifacts.** Radiology. 1990 Jun; 175(3):855-9.

Sommer T, Naehle CP, Yang A et al. **Strategy for safe performance of extrathoracic magnetic resonance imaging at 1.5 tesla in the presen** Circulation. 2006 Sep 19; 114(12):1285-92.

Narazian S, Roguin A, Zviman MM et al. **Clinical utility and safety of a protocol for noncardiac and cardiac magnetic resonance imaging of p** Circulation. 2006 Sep 19; 114(12):1277-84.

www.mrisafety.org

2. Concerning endoleaks of the aorta, which of the following statements is true?
- A. Type I is the most common type of endoleak
 - B. Type II leaks are the most likely to rupture
 - C. Type III endoleaks are due to graft porosity
 - D. **Type I endoleak results from device failure**

Rationale:

- A. Type II endoleaks are the most common and occur when blood flows into the aneurysm sac in a retrograde direction through normal branches of the excluded aortic segment. This occurs most commonly with the inferior mesenteric artery or a lumbar artery. Accessory renal arteries can also lead to type II endoleaks. Type II endoleaks were reported in 8 - 12% at 1 month, 5 - 32% at 12 months, and 13 - 26% at 24 months in the literature. The incidence of type I endoleaks varies between 4 - 6% at 1 month, between 1 - 4% at 12 months, and between 1 - 3% at 24 months follow-up.
- B. Type II endoleaks have not been reported in association with aortic rupture. Type I and III endoleaks have been reported in association with aortic rupture.
- C. Type IV endoleaks are due to graft porosity. Type III endoleaks are due to a structural failure of the endovascular device. Type III endoleaks can be subdivided into three groups: type IIIA endoleaks are due to disruptions or holes in the fabric of the device, type IIIB endoleaks arise from separation of modular devices and junctions, and type IIIC endoleaks are due to suture holes in the fabric.
- D. Type I leaks are subdivided into Type IA, which occur at the aortic neck attachment site and Type IB, which occur at the distal iliac attachment site.

Reference:

- Heikkinen MA, Arko FR, Zarins CK. **What is the significance of endoleaks and endotension?** Surg Clin North Am. 2004 Oct; 84(5):1337-52, vii.
- Mita T, Arita T, Matsunaga M et al. **Complications of endovascular repair for thoracic and abdominal aortic aneurysm: an imaging spectrum** Radiographics. 2000 Sep-Oct; 20(5):1263-78.

3. Regarding total anomalous pulmonary venous return, which of the following is true?
- A. Infracardiac venous return occurs through a persistent left SVC
 - B. Pulmonary edema is rare in the presence of obstruction of pulmonary venous return
 - C. The "snowman sign" indicates infracardiac venous return
 - D. **Atrial septal defect or patent foramen ovale allow admixed blood to enter the left heart**

Rationale:

- A. In infracardiac total anomalous pulmonary venous return, the venous return occurs through a venous channel connecting the common pulmonary vein to the portal vein or its tributaries or the ductus venosus after traversing the diaphragm.
- B. In the presence of obstruction of pulmonary venous return, pulmonary edema is almost always present.
- C. The "snowman sign," which is formed by the combination of an anomalous left vertical vein and an enlarged right SVC atop the cardiac silhouette is characteristic of supracardiac total anomalous pulmonary venous return.
- D. In cases of total anomalous pulmonary venous return, the pulmonary venous return empties into the right heart. For survival to be possible, a right to left shunt must be present, which generally occurs via an ASD or patent foramen ovale, through which admixed blood (a combination of pulmonary and systemic venous return) passes.

Reference:

- Miller SW, et al. **Cardiac Imaging: The Requisites**. Mosby, Inc. Philadelphia 2005;2nd Ed. p. 245.
Miller SW, et al. **Cardiac Imaging: The Requisites**. 2nd Ed. p. 245. Mosby, Inc. Philadelphia, 2005.

4. Concerning the morphologic right ventricle, which of the following is the MOST reliable indicator?
- A. Anterior location of the ventricle
 - B. Trabeculation of the ventricular wall
 - C. **Separation of the inflow and outflow valves by a muscular infundibulum**
 - D. The ventricle receives blood from the right atrium

Rationale:

- A. Incorrect. Normally, the right ventricle receives blood from the right atrium, lies anterior to and is more trabeculated than the left ventricle. The inflow and outflow valves of the right ventricle are separated by the muscular infundibulum in contrast to the left ventricle where the valves are contiguous. In complex congenital cardiac anomalies, the separation of the inflow and outflow valves is the most reliable indicator of the morphologic right ventricle.
- B. Incorrect. Normally, the right ventricle receives blood from the right atrium, lies anterior to and is more trabeculated than the left ventricle. The inflow and outflow valves of the right ventricle are separated by the muscular infundibulum in contrast to the left ventricle where the valves are contiguous. In complex congenital cardiac anomalies, the separation of the inflow and outflow valves is the most reliable indicator of the morphologic right ventricle.
- C. Correct. Normally, the right ventricle receives blood from the right atrium, lies anterior to and is more trabeculated than the left ventricle. The inflow and outflow valves of the right ventricle are separated by the muscular infundibulum in contrast to the left ventricle where the valves are contiguous. In complex congenital cardiac anomalies, the separation of the inflow and outflow valves is the most reliable indicator of the morphologic right ventricle.
- D. Incorrect. Normally, the right ventricle receives blood from the right atrium, lies anterior to and is more trabeculated than the left ventricle. The inflow and outflow valves of the right ventricle are separated by the muscular infundibulum in contrast to the left ventricle where the valves are contiguous. In complex congenital cardiac anomalies, the separation of the inflow and outflow valves is the most reliable indicator of the morphologic right ventricle.

Reference:

Boxt LM. Radiology of the right ventricle. Radiol Clin N Am 1999;37:379-400 Baron MG. Anatomy of the heart. In: Elliott LP, ed. Cardiac imaging in infants, children and adults. Philadelphia: J.B. Lippincott Co., 1991:6-18

5. Concerning the location of cardiac valves on a posteroanterior (PA) and lateral chest radiograph, which one is TRUE?
- A. The aortic valve is located superior to the other valves.
 - B. **The tricuspid valve is the most anteriorly located valve.**
 - C. The mitral valve lies inferior to the other valves.
 - D. The aortic valve lies closest to the pulmonary valve.

Rationale:

- A. Incorrect. The aortic valve lies inferior to the pulmonary valve. The pulmonary valve is the most superiorly located valve.
- B. Correct. The tricuspid valve is the most anteriorly located valve.
- C. Incorrect. The mitral valve is the most posteriorly located valve. The tricuspid valve lies inferior to the mitral valve.
- D. Incorrect. The aortic valve is contiguous with the mitral valve and shares a common fibrous skeleton

Reference:

Lipton MJ, Coulden R. Valvular heart disease. Radiol Clin N Am 1999;37:319-339 Baron MG. Anatomy of the heart. In: Elliott LP, ed. Cardiac imaging in infants, children and adults. Philadelphia: J.B. Lippincott Co., 1991:6-18

6. Concerning coronary artery dominance, which one is TRUE?
- A. It is determined by which coronary artery supplies the majority of the heart.
 - B. 85 percent of patients have a codominant system.
 - C. **It is determined by which artery supplies the posterior descending artery.**
 - D. 70 percent of patients have a left dominant system

Rationale:

A. Incorrect. Coronary dominance is determined by which artery supplies the posterior descending artery (PDA). In most patients (85%), the PDA is supplied by the right coronary artery and therefore is a right dominant system. If the PDA is supplied by the circumflex coronary artery, it is considered to be a left dominant system. A codominant system is one in which both the right coronary artery and circumflex coronary artery supply the PDA or when the right coronary artery supplies the PDA and the left circumflex coronary artery supplies the inferior left ventricular wall.

B. Incorrect. Dominance is determined by which artery supplies the posterior descending artery (PDA). In most patients (85%), the PDA is supplied by the right coronary artery and therefore is a right dominant system. If the PDA is supplied by the circumflex coronary artery, it is considered to be a left dominant system. A codominant system is one in which both the right coronary artery and circumflex coronary artery supply the PDA or when the right coronary artery supplies the PDA and the left circumflex coronary artery supplies the inferior left ventricular wall.

C. Correct. Dominance is determined by which artery supplies the posterior descending artery (PDA). In most patients (85%), the PDA is supplied by the right coronary artery and therefore is a right dominant system. If the PDA is supplied by the circumflex coronary artery, it is considered to be a left dominant system. A codominant system is one in which both the right coronary artery and circumflex coronary artery supply the PDA or when the right coronary artery supplies the PDA and the left circumflex coronary artery supplies the inferior left ventricular wall.

D. Incorrect. Dominance is determined by which artery supplies the posterior descending artery (PDA). In most patients (85%), the PDA is supplied by the right coronary artery and therefore is a right dominant system. If the PDA is supplied by the circumflex coronary artery, it is considered to be a left dominant system. A codominant system is one in which both the right coronary artery and circumflex coronary artery supply the PDA or when the right coronary artery supplies the PDA and the left circumflex coronary artery supplies the inferior left ventricular wall.

Reference:

Wicky S, Miller SW. Cardiac Angiography. In: Miller SW, ed. The Requisites: Cardiac Imaging. Philadelphia: Elsevier Mosby, 2005:132-156

7. Concerning pulmonary vein ablation, which one is TRUE?
- A. Accessory pulmonary veins are more common on the left.
 - B. Myocardial sleeves are longest and thickest in the inferior pulmonary veins.
 - C. **The presence of left atrial thrombus is a contraindication.**
 - D. A common pulmonary vein is more common on the right.

Rationale:

- A. Incorrect. Accessory pulmonary veins are more common on the right.
- B. Incorrect. Myocardium extends 2-17 mm into the pulmonary veins and is called the myocardial sleeve. The myocardial sleeve is thickest at the atriopulmonary venous junction of the left superior vein. The myocardial sleeves are longer in the superior pulmonary veins than in the inferior pulmonary veins.
- C. Correct. Due to the risk of stroke following manipulation of the left atrium, the presence of left atrial thrombus is a contraindication to pulmonary vein ablation.
- D. Incorrect. Pulmonary venous anatomy varies widely. A common variation is a common pulmonary vein draining the entire lung, which typically occurs on the left.

Reference:

Jongbloed MRM, Dirksen MS, Bax JJ, et al. Atrial fibrillation: multi-detector row CT of pulmonary vein anatomy prior to radiofrequency catheter ablation - initial experience. *Radiol Clin N Am* 2005;234:702-709 Cronin P, Sneider MB, Kazerooni EA, et al. MDCT of the left atrium and pulmonary veins in planning radiofrequency ablation for atrial fibrillation: a how-to guide. *Am J Roentgenol* 2004;183:767-778 Ghaye B, Szapiro D, Dacher JN, et al. Percutaneous ablation for atrial fibrillation: the role of cross-sectional imaging. *RadioGraph* 2003;23:S19-S33 Marom EM, Herndon JE, Kim YH, McAdams HP. Variations in pulmonary venous drainage to the left atrium: implications for radiofrequency ablation. *Radiol Clin N Am* 2004;230:824-829 Lacomis JM, Wigginton W, Fuhrman C, Schwartzman D, Armfield DR, Pealer KM. Multi-detector row CT of the left atrium and pulmonary veins before radio-frequency catheter ablation for atrial fibrillation. *RadiogGraph* 2003;23:S35-S50

8. Concerning the Blalock-Taussig shunt, which one is TRUE?
- A. **It connects the subclavian artery to the pulmonary artery.**
 - B. It creates a conduit between the right atrium and the pulmonary artery.
 - C. It creates an atrial switch using an intra-atrial baffle made of pericardium.
 - D. It connects the superior vena cava with the pulmonary artery.

Rationale:

- A. Correct. The Blalock-Taussig shunt creates a connection between the systemic and arterial systems and is a palliative procedure that increases systemic arterial oxygenation by increasing blood flow to the pulmonary artery.
- B. Incorrect. The Fontan procedure creates a conduit between the right atrium and the pulmonary artery.
- C. Incorrect. The Mustard procedure creates an atrial switch using an intra-atrial baffle made of pericardium
- D. Incorrect. The Glenn procedure connects the superior vena cava with the pulmonary artery.

Reference:

May LE, Litwin SB, Tweddell JS, Jaquiss RDB. Pediatric Heart Surgery, Third ed. Milwaukee: Maxicare, 2005:92
Webb GD, Smallhorn JF, Therrien J, Redington AN. Diseases of the Heart, Pericardium, and Pulmonary Vasculature Bed. In: Zipes DP, Libby P, Bonow RO, Braunwald E, eds. Braunwald's Heart Disease. Philadelphia: Elsevier Saunders, 2005:1489 -1552

9. Regarding cardiac transplantation, which one of the following statements is TRUE?
- A. Accelerated atherosclerosis is an early complication.
 - B. Postoperative screening for lymphoproliferative disease is the most common indication for imaging.
 - C. **Cyclosporine results in left ventricular hypertrophy.**
 - D. Cytomegalovirus and Aspergillus species are the most common cause of early postoperative infection.

Rationale:

- A. Incorrect. Accelerated atherosclerosis is a late complication and can be detected by coronary angiography.
- B. Incorrect. Infection, especially pulmonary infection, is the most common indication for imaging following cardiac transplantation.
- C. Correct. Ventricular hypertrophy can be caused by cyclosporine immunosuppressive therapy.
- D. Incorrect. Bacteria are the most common cause of early post-operative infection following cardiac transplant. Aspergillus and cytomegalovirus infections occur 2-6 months following transplantation.

Reference:

Attili A, Kazerooni EA. Postoperative cardiopulmonary thoracic imaging. Radiol Clin N Am 42 (2004) 543-564
Knisely BL, Mastey LA, Collins J, et al. Imaging of cardiac transplantation complications. Radiographics 1999;19:321-39. Webb WR & Higgins CB. Thoracic Imaging-Pulmonary and Cardiovascular Radiology. Lippincott Williams & Wilkins 2005 1st Edition

10. Concerning prospective ECG gating in cardiac CT imaging, which of the following is TRUE?

- A. Data is acquired throughout the cardiac cycle.
- B. **Data is acquired only at pre specified points throughout the cardiac cycle.**
- C. It allows for dynamic assessment of the heart and functional status.
- D. It involves more radiation dose to the patient than retrospective gating.

Rationale:

A. Incorrect. In prospective ECG gating (also known as ECG triggering), data acquisition is triggered to the R wave of the ECG, so data is acquired at a pre specified time. The multi detector CT can be set up to record data at a certain time after the last R wave or before the next R wave of the ECG. Alternatively, data can be acquired at a certain percentage of the time between two successive R waves.

B. Correct. Data is ideally only acquired when the heart is relatively motionless, as in diastole. So there are parts of the ECG cycle in which data is not being acquired, namely during systole (when the heart moves more).

C. Incorrect. Because there is "missing" data, one cannot do a volumetric assessment of the left ventricular cavity. In order to calculate ejection fraction, one needs data from both diastole and systole, so retrospective ECG gating is needed.

D. Incorrect. Retrospective ECG gating involves more radiation because data is acquired throughout the cardiac cycle. The patient is receiving ionizing radiation throughout the cardiac cycle. The person interpreting the study selects data from selected portions of the cardiac cycle (such as in diastole, when the heart is relatively motionless).

Reference:

Wintersperger BJ, Nikolaou K. Basics of Cardiac MDCT: techniques and contrast application. European Radiology 2005, 15(2):B2-B9

11. Concerning the use of B Blockers in cardiac CT imaging, which of the following statements is TRUE?
- A. **Heart rates of below 70 beats per minute are optimal.**
 - B. They can be administered to patients with asthma.
 - C. Verapamil is not a useful alternative to beta-adrenergic blocking agents.
 - D. Atrial fibrillation is a contraindication to beta-blocker use.

Rationale:

- A. Correct. Several studies which used 4 and 16 detector row CT have shown consistently that at heart rates of greater than 70 beats a minute, cardiac motion degrades the images.
- B. Incorrect. Asthma is a contraindication to beta blockers. This is because many beta blockers are not cardioselective and block both B1 and B2 receptors. B1 receptors are found in the heart and B2 receptors are found in the airways smooth muscle. Blocking of B2 receptors causes bronchospasm in asthmatics. Even cardioselective beta blockers (such as metoprolol or atenolol) are a relative contraindication in asthmatics and should be avoided.
- C. Incorrect. Verapamil can be used as an alternative to beta blockers, such as in patients with asthma. It is usually given intravenously in cardiac CT.
- D. Incorrect. Atrial fibrillation is not a contraindication to beta blocker use. Although the beta blocker slows the ventricular response rate, it will not be effective in preventing atrial fibrillation. Atrial fibrillation (even with a slow ventricular response rate) is a relative contraindication to ECG gating.

Reference:

(1) Choi HS, Choi BW, Choe KO, Choi D, Yoo KJ, Kim MI, Kim J. Pitfalls, Artifacts and Remedies in Multi Detector Row CT Coronary Angiography. Radiographics 2004;24:787-800 (2) Kumar and Clark, Clinical Medicine, Fifth Edition, Saunders, 2002