SPR 2013 Cardiac Session
Pediatric Cardiac MRI: The What, How, Why and Why Nots
May 18, 2013
SAM Questionnaire

Black Blood Imaging

Taylor Chung, MD

1. For black blood imaging using the time-of-flight effect with Spin Echo, it is best to set the TE to shortest possible time on your MR scanner.

A. True
B. False

Correct Answer: B

2. For black blood imaging using inversion recovery technique, it is best to have a single inversion pulse to null the blood as there is enough difference between the T1 of myocardium and blood such that the myocardium will be seen well.

A. True
B. False

Correct Answer: B

References

1. Mulkern RV, Chung T. From signal to image: magnetic resonance imaging physics for cardiac MR. Pediatr Cardiol 2000; 21:5-17
2. Simonetti OP et al. "Black Blood" T2-weighted inversion-recovery MR imaging of the heart. Radiology 1996; 199:49-57.

Dynamic Bright Blood Imaging

Amol Pednekar

3. What is the main cause of the bright blood signal in cardiac gradient echo images?

A. Small flip angle used in gradient echo
B. Longer T1 and T2 of the blood with respect to myocardium
C. Saturation of static tissue relative to moving blood
D. Gradient echo uses non-selective RF pulses

Correct Answer: C

4. What is required for the good cine cardiac imaging?

A. Rapid data acquisition
B. Cardiac synchronization
C. Respiratory synchronization or compensation
D. All of the above

Correct Answer: D

References

1. Cine MR imaging: potential for the evaluation of cardiovascular functionU Sechtem, PW Pflugfelder, RD White, RG Gould, W Holt, MJ Lipton, CB Higgins American Journal of Roentgenology. 1987;148:239-246. 10.2214/ajr.148.2.239
2. Cineangiography of the heart in a single breath hold with a segmented turbo-FLASH sequence. Atkinson DJ, Edelman RR. *Radiology* 1991; 178:357–360
3. Functional cardiac MR imaging with steady-state free precession (SSFP) significantly improves endocardial border delineation without contrast agents . Thiele, H., Nagel, E., Paetsch, I., Schnackenburg, B., Bornstedt, A., Kouwenhoven, M., Wahl, A., Schuler, G. and Fleck, E. J. Magn. Reson. Imaging, 14: 362–367.

3D SSFP

Raja Muthupillai, PhD

5. A typical coronary MR angiography protocol:

A. Acquires coronary artery anatomy as a series of 2D slices over multiple breathholds
B. Uses respiratory compensation methods such as respiratory navigators
C. Includes Magnetization preparation methods such as T_2 preparation and fat suppression to maximize contrast
D. (a) and (b) only
E. Both (b) and (c)

Correct Answer: E

References

1. Stuber et al.: J Am Coll Cardiol; 34(2):524-531 (1999).
2. Flamm SD, and Muthupillai R, J Magn Reson Imaging. 2004 Jun;19(6):686-709.

Assess Segmental Cardiac Anatomy
Shi Joon Yoo, MD

6. Among the following options, which is the most predictive of the atrial situs or arrangement?

A. Aortic position relative to trachea
B. Bronchial branching pattern
C. Heart position
D. Liver configuration
E. Stomach position

Correct Answer: B

Reference
1. Yoo SJ, MacDonald C, Babyn P. Sequential segmental approach to congenital heart disease. In: Chest radiographic interpretation in pediatric cardiac patients. Thieme Medical Publishers, Inc. 2010, pages 22-30.

7. In a newborn infant with biliary atresia, which of the followings can be associated?

A. Congenital heart block
B. Intestinal malrotation
C. Polysplenia
D. None of the above
E. All of the above

Correct Answer: E

Reference
1. Yoo SJ, MacDonald C, Babyn P. Sequential segmental approach to congenital heart disease. In: Chest radiographic interpretation in pediatric cardiac patients. Thieme Medical Publishers, Inc. 2010, pages 22-30.

8. Which of the following structures does not always characterize the morphologically right ventricle?

A. Atrioventricular valve attachment to the septum
B. Conus or infundiblum
C. Moderator band
D. Septomarginal trabecula

Correct Answer: B

Reference

1. Yoo SJ, MacDonald C, Babyn P. Sequential segmental approach to congenital heart disease. In: Chest radiographic interpretation in pediatric cardiac patients. Thieme Medical Publishers, Inc. 2010, pages 22-30.

Assess Ventricular Systolic and Diastolic Function

Robert J. Fleck, MD

9. Choose the statement that best describes the typical MR picture of restrictive cardiomyopathy in children:

A. Increased left ventricular volume with decreased ejection fraction and thickened pericardium
B. Increased left ventricular volume with normal ejection fraction and normal pericardium
C. Normal left ventricular volume with decreased ejection fraction and thickened pericardium
D. Normal left ventricular volume with normal ejection fraction and normal pericardium
E. Normal left ventricular volume with decreased ejection fraction and dilated left atrium

Correct Answer: D

References

1. Caudron J et al. Evaluation of left ventricular diastolic function with cardiac MR imaging. RadioGraphics 2011, 31:239-261
2. Maceira AM et al. Reference left atrial dimensions and volumes by steady state free precession cardiovascular magnetic resonance. JCMR 2010, 12:65.
3. Gupta A, Gulati S, Seth S and Sharma S. Cardiac MRI in restrictive cardiomyopathy. Clinical Radiology 2012, 67:95-105.

Evaluate Valvular Stenosis or Regurgitation

Sadaf T. Bhutta, MD, MBBS

10. The different parameters measured by flow analysis of a vessel include all EXCEPT:

A. Mean velocity
B. Area
C. Peak velocity
D. Pressure gradient
E. Regurgitant fraction

Correct Answer: D

References

1. Myerson SG. Heart valve disease: investigation by cardiovascular magnetic resonance. Journal of Cardiovascular Magnetic Resonance 2012, 14:7

2. Masci PG, Dymarkowski S, Bogaert J. Valvular heart disease: what does cardiovascular MRI add? Eur Radiol. 2008 Feb;18(2):197-208.

Perform Qp:Qs
Randolph K. Otto, MD

11. How is Qp best determined following bidirectional Glenn in the setting of single ventricle?

A. Phase contrast acquisition through the main pulmonary artery
B. Phase contrast acquisitions through the branch pulmonary arteries
C. Qp cannot be determined in this clinical setting
D. Phase contrast acquisitions through the pulmonary veins
E. Phase contrast acquisition of the superior vena cava.

Correct Answer: D

References

1. Kellenberger CJ, Macgowan CK, Roman KS et al. (2005) Hemodynamic evaluation for the peripheral pulmonary circulation by cine phase-contrast magnetic resonance imaging. JMRI 22:780–787
2. Korperich H, Gieseke J, Barth P et al. (2004) Flow volume and shunt quantification in pediatric congenital heart disease by real-time magnetic resonance velocity mapping. Circulation 109:1987–1993

How to Set Up a Contrast -Enhanced MRA
Dianna M.E. Bardo, MD

12. All protocol parameters listed below are important for improving spatial and temporal resolution of contrast enhanced MRA EXCEPT?

A. Sensitivity encoding - parallel imaging techniques
B. Time-resolved imaging sequences
C. Peripheral ordered k-space filling
D. Administration of IV gadolinium
E. ECG and respiratory gating or navigator assisted MRA

Correct Answer: D

References

1. Kim CY. Time-resolved MR Angiography of the central veins of the chest. *AJR* 2008; 191:1581–1588.
2. Liu X et al., Contrast-enhanced whole-heart coronary magnetic resonance angiography at 3.0T: comparison with steady-state free precession technique at 1.5T. *Investigative Radiology* • Volume 43, Number 9, September (2008) 663-668.
3. Niendorf T., Toward single breath-hold whole-heart coverage coronary MRA using highly accelerated Parallel Imaging With a 32-Channel MR System. Magnetic Resonance in Medicine 56:167–176 (2006)167-176.

Evaluate the Systemic and Pulmonary Veins
Prakash M. Masand, MD

13. The protocol for imaging the pulmonary veins in pediatric age group, should include bright blood sequences like cine SSFP/ spoiled GRE as well as a post contrast MR angiogram.

A. True
B. False

Correct Answer: A

Reference

1. M. Syed et al, Pulmonary vein imaging: comparison of 3D magnetic resonance angiography with 2D cine MRI for characterizing anatomy and size, Journal of Cardiovascular Magnetic Resonance (2005) 7, 355–360

14. What modality specific study protocol is essential to calculate QP/QS for shunt quantification in a patient with anomalous pulmonary venous connection?

A. CT Angiography with intravenous contrast
B. Cardiac MRI with morphology and without flow quantification
C. Cardiac MRI with morphology and flow quantification
D. MR Angiography with intravenous contrast

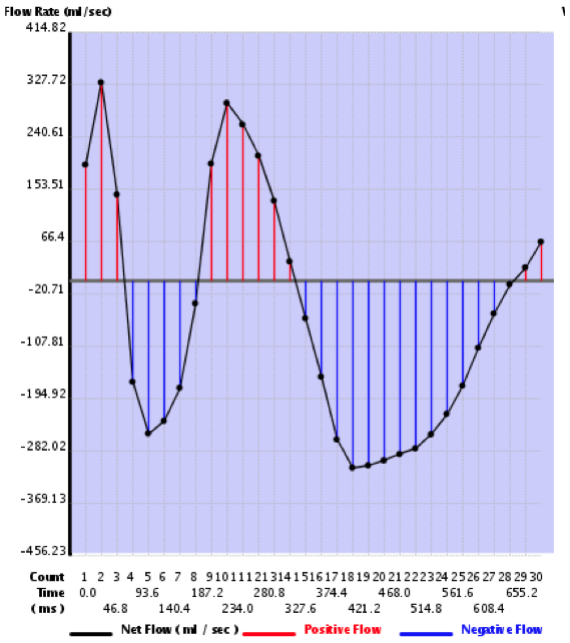
Correct Answer: C

Reference

1. Principles and Practice of Cardiac Magnetic Resonance in Congenital Heart Disease: Form, function and flow by Mark A. Fogel MD, 2010

Evaluate Pulmonary Blood Flow
J. A. Gordon Culham, MD

15. You are shown a plot of pulmonary artery flow from a child who has had surgery for pulmonary valve disease and known Pulmonary Regurgitation. (Fig 1)



The flow profile is best explained by

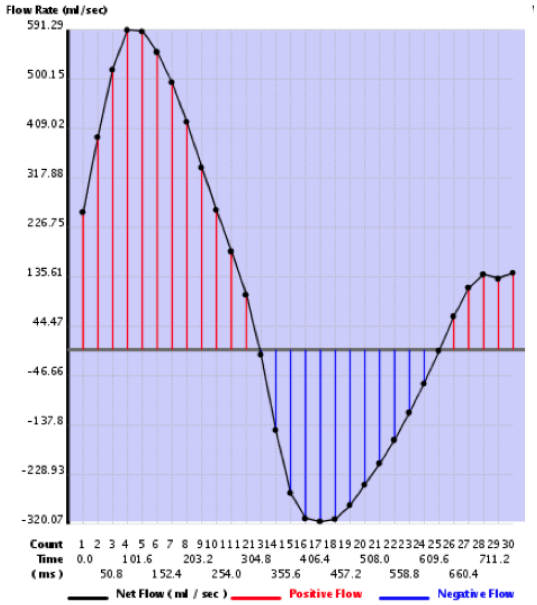
A. Pulmonary Stenosis
B. Pulmonary Hypertension
C. Bigeminy
D. Poor Gating
E. Velocity Encoding too low
F. Velocity Encoding too high

Correct Answer: E

References

1. Lotz J, Meier C, Leppert A, Galanski M. Cardiovascular Flow Measurement with Phase-Contrast MR Imaging: Basic Facts and Implementation. RadioGraphics 2002; 22:651– 671
2. Srichai MB, Lim RP, Wong S, Lee VS. Cardiovascular Applications of Phase-Contrast MRI. AJR 2009; 192:662–675

Here is the flow plot with a higher Velocity Encoding (150 vs 100).



Evaluate the Neonate with Heterotaxy

Rajesh Krishnamurthy, MD

16. Typical MR indications for evaluating the neonate with heterotaxy include all the following <u>except</u>:

A. Screen for obstruction of anomalous pulmonary vein
B. Assess the status of branch pulmonary arteries prior to modified Blalock Taussig shunt placement
C. Enable treatment planning for single versus two ventricle repair
D. Assess presence, type and severity of aortic arch obstruction
E. Assess hepatic venous anatomy to plan Fontan palliation

Correct Answer: E

Reference:

1. Krishnamurthy R, Chung T. Heterotaxy and other complex cardiovascular malformations. In Fogel M. Ed. MRI of Congenital Heart Disease. 1st edn. Elsevier Publishers, 2010.

s/p TOF repair
Shiraz A. Maskatia, MD

17. Which of the following adults with repaired TOF would meet criteria for intervention based on published guidelines?

A. Mild pulmonary insufficiency with exercise intolerance
B. Severe pulmonary insufficiency with mild tricuspid insufficiency
C. Severe pulmonary insufficiency with moderate aortic root dilation
D. RVOT obstruction, residual VSD with QP:QS 1.2 : 1
E. Severe pulmonary insufficiency with severe RV enlargement (asymptomatic)

Correct Answer: E

Reference
1. 2008 ACC/AHA Guidelines for the Management of Adults with CHD

Why I Do CMR After Arterial Switch Operation for d-TGA
Marc S. Keller, MD

18. Of the following recognized complications after arterial switch operation (ASO) for correcting D-TGA, which one is the most commonly observed?

A. Post-operative coronary artery thrombosis
B. Neoaortic valve insufficiency
C. Supravalvular neopulmonary stenosis
D. Neoaortic root dilation

Correct Answer: C

Reference
1. Rudra HS et al. The Arterial Switch Operation: 25-Year Experience with 258 Patients. Ann Thorac Surg 2011; 92: 1742-1746

s/p Atrial Switch for d-TGA
Jeffrey C. Hellinger, MD

19. Which of the following are predictors for morbidity following Arterial Switch Operation performed for surgical repair of d-Transposition of the Great Arteries (TGA)?

A. Complex TGA
B. Ventricular Septal Defect
C. Coronary Anomalies
D. Left Sided Outflow Obstructive Lesions (e.g. ventricular outflow obstruction, aortic coarctation, aortic arch hypoplasia)
E. Moderate Pulmonary Arterial Stenosis
F. All of the above

Correct Answer: F

References

1. Prifti E, Crucean A, Bonacchi M, et al. Early and long term outcome of the arterial switch operation for transposition of the great arteries: predictors and functional evaluation. European Journal of Cardio-thoracic Surgery 22 (2002) 864–873
2. Popov, AF, Tirilomis T, Giesler M, et al.: Midterm results after arterial switch operation for transposition of the great arteries: a single center experience. Journal of Cardiothoracic Surgery 2012 7:83.

Pre-Glenn and Pre-Fontan

Shaine A. Morris, MD

20. You are performing a cardiac MRI/MRA on a patient with a patient with tricuspid atresia and pulmonary atresia who is status post a right-sided BT shunt. Your flow data is the following:

Ascending aorta:

12 ml/beat
SVC: 3 ml/beat
IVC: 6 ml/beat
RPA: 4 ml/beat
LPA: 3 ml/beat

What is the best explanation of these findings?

A. Significant pulmonary overcirculation with Qp:Qs>2
B. A large proportion of pulmonary blood flow is supplied by aortopulmonary collaterals
C. Shunt narrowing
D. Recoarctation of the aorta
E. Partial anomalous return of the pulmonary veins

Correct answer: E

References

1. Brown DW, Gauvreau K, Powell AJ, Lang P, Colan SD, Del Nido PJ, Odegard KC, Geva T. Cardiac magnetic resonance versus routine cardiac catheterization before bidirectional Glenn anastomosis in infants with functional single ventricle: a prospective randomized trial. Circulation. 2007;116(23):2718-25.
2. Fogel MA. Is routine cardiac catheterization necessary in the management of patients with single ventricles across staged Fontan reconstruction? No! Pediatr Cardiol. 2005 Mar-Apr;26(2):154-8.
3. Muthurangu V, Taylor AM, Hegde SR, Johnson R, Tulloh R, Simpson JM, Qureshi S, Rosenthal E, Baker E, Anderson D, Razavi R. Cardiac magnetic resonance imaging after stage I Norwood operation for hypoplastic left heart syndrome. Circulation. 2005; 112: 3256–3263.

Post-Fontan
Cynthia K. Rigsby, MD

21. Following the Fontan operation, under what condition are pulmonary AVM's most likely to form?

A. Pulmonary arterial hypertension
B. Systemic atrioventricular valve regurgitation
C. Asymmetric distribution of IVC blood flow
D. Pulmonary emboli
E. Protein losing enteropathy

Correct Answer: C

References

1. Khanna G. Extracardiac complications of the Fontan circuit. Pediatric Radiology. February 2012, Volume 42, Issue 2, pp 233-241
2. Ashrafian H. The mechanism of formation of pulmonary arteriovenous malformations associated with the classic Glenn shunt (superior cavopulmonary anastomosis). Heart. 2002 December; 88(6): 639.

Anomalous Coronaries
Lorna P. Browne, MBBS

22. Which of the following congenital heart defects have an increased incidence of coronary artery anomalies?

A. Tetralogy of Fallot
B. Truncus Arteriosus
C. Pulmonary valve atresia with Intact IV Septum
D. Transposition of Great Arteries (dTGA and lTGA)
E. All of the above

Correct Answer: E

References

1. Taylor AM, Thorne SA, Rubens MB, et al. Coronary artery imaging in grown up congenital heart disease: complementary role of magnetic resonance and x-ray coronary angiography. Circulation. 2000 Apr 11;101(14):1670-8.
2. Mawson JB. Congenital heart defects and coronary anatomy. Tex Heart Inst J. 2002;29(4):279-89

Vascular Rings and Slings
Prachi P. Agarwal, MD

23. Which of the following is NOT an MRI imaging feature of a double aortic arch with atretic left arch?

A. Diverticulum from proximal descending aorta
B. Extrinsic mass effect on the trachea
C. 4-artery sign
D. Hypointense cord (atretic arch) on T1W image

Correct Answer: D

Reference

1. Schlesinger AE, Krishnamurthy R, Sena LM, Guillerman RP, Chung T, DiBardino DJ, Fraser CD Jr. Incomplete Double Aortic Arch with Atresia of the Distal Left Arch: Distinctive Imaging Appearance. Am J Roentgenol 2005;184(5):1634-9.

Cardiac Tumors
Maryam Ghadimi-Mahani, MD

24. A 12-year-old boy with osteosarcoma has a right atrial mass seen on chest CT. Cardiac MRI is ordered to evaluate the right atrial mass. Which sequence is most helpful to differentiate between a tumor and a thrombus?

A. Cine SSFP sequence
B. T1 weighted TSE sequence before contrast administration
C. Phase contrast image
D. Late gadolinium enhancement image with TI time of 600 ms

Correct Answer: D

References

1. Buckley O, Madan R, Kwong R, Rybicki FJ, Hunsaker A.Cardiac masses, part 1: imaging strategies and technical considerations. AJR Am J Roentgenol. 2011;197(5):W837-41.
2. Ginat DT, Fong MW, Tuttle DJ, Hobbs SK, Vyas RC. Cardiac imaging: Part 1, MR pulse sequences, imaging planes, and basic anatomy. AJR Am J Roentgenol. 2011;197(4):808-15.
3. O'Neill, A., et al., Cardiovascular flashlight. Detection of cardiac tumour-surface thrombus: utilization of cardiac magnetic resonance imaging avascular tissue nulling sequence. Eur Heart J, 2010. 31(11): p. 1421.