Newborn CTA
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Goals of imaging in the neonatal period
Van Praagh’s segmental approach to diagnosis

- 3 major cardiac segments: atria, ventricles and great arteries
- Connecting segments: AV canal and Conotruncus
- Associated anomalies: septum, valves, extracardiac vasculature
- Function

Accurate anatomical and physiological diagnosis allows selection of therapeutic options: medical, surgical, or both
Neonatal imaging: Cardiac Morphology

- Atrial, ventricular and great arterial situs
- Segmental connections
- Status of the atrial and ventricular septum
- Cardiac valves
- Ventricular function
- Myocardium

• Echo is very successful in delineating intra-cardiac pathology in the neonate
Neonatal Imaging: Extra-cardiac vasculature and viscera

- Aorta and aortic arch
- Pulmonary veins
- Systemic venous anomalies
- Branch pulmonary arteries
- Coronary arteries
- Visceral anatomy
- Airway anatomy

• Relatively higher incidence of failure of echo to characterize extra-cardiac vascular pathology adequately, due to the small size of the structures, atypical morphology, or lack of acoustic windows
Indications for MRI and CT

MRI and CT are indicated when surgically relevant data cannot be obtained by echo.

**Surgery: Initial palliation**

First stage surgical procedures that are done immediately after birth to stabilize the patient with CHD.
Pulmonary Veins
Inadequate echo

- All pulmonary veins not visualized
- Course of anomalous pulmonary vein(s) not well-delineated
- Suspected pulmonary vein stenosis
- Post operative evaluation after anomalous PV repair to rule out stenosis

MRI and CT have similar efficacy for evaluation of pulmonary veins
Infradiaphragmatic TAPVR to the portal vein.

Supracardiac TAPVR to the left SVC with a large varix
Pulmonary veins: Scimitar syndrome
Pulmonary Arteries
Pulmonary Artery: Indications for MRI and CT

- **Pulmonary atresia - Source of pulmonary blood flow**
  - Ductal dependent
  - Major aortopulmonary collaterals (MAPCAS)

- **Diagnose and grade branch pulmonary artery stenosis in the setting of RVOT**
  - Tetralogy of Fallot, truncus
  - Single ventricle setting, prior to placement of a modified Blalock Taussig shunt to augment pulmonary blood flow

*CT preferred to MRI for evaluation of MAPCAS and dual vascular supply of lung segments*
Pulmonary Artery: Ductal dependent PBF

Associated branch pulmonary artery stenosis
Pulmonary Artery: Source of pulmonary blood flow in pulmonary atresia
Toole BJ, Crystal M, McKenzie DE, Krishnamurthy R. Comparison of cardiac catheterization versus computed tomography angiography in comparing major aortopulmonary collateral arteries in children with pulmonary atresia and ventricular septal defect. JACC. 2012;59;E808

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age @Cath</th>
<th>Age @CTA</th>
<th>Confluent Pulmonary Arteries</th>
<th># Collaterals Cath</th>
<th># Collaterals CTA</th>
<th># Pulmonary Segments w/ Identified Blood Supply Cath</th>
<th># Pulmonary Segments w/ Identified Blood Supply CTA</th>
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<td>Cath=Y  CTA=Y</td>
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</table>
Results: Status of Mediastinal Branch PA

- Pulmonary artery anatomy (confluent vs. non-confluent) was correctly identified in 9/9 patients by CTA and in 8/9 patients by catheterization as confirmed at time of surgery.

- In the one patient that differed, native pulmonary arteries were not seen by cardiac catheterization, but were identified by CTA.
Results: Status of MAPCAs

- CTA was equivalent to cath in identification of MAPCAs
- An identical number of MAPCAs was identified by both catheterization and CTA in 6/9 patients

<table>
<thead>
<tr>
<th>Mean # Collaterals Identified</th>
<th>CATH</th>
<th>CTA</th>
<th>95% P-VALUE</th>
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<tr>
<td>3.4 collaterals/study</td>
<td>3.1 collaterals/study</td>
<td>$p=0.67$</td>
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Results: Status of Segmental PBF

<table>
<thead>
<tr>
<th>Mean # Pulmonary Segments w/ Identified Blood Supply</th>
<th>CATH</th>
<th>CTA</th>
<th>95% P-VALUE</th>
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<tbody>
<tr>
<td>17.5 Pulmonary Segments/Study</td>
<td>19.5 Pulmonary Segments/Study</td>
<td>$p = 0.006$</td>
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</table>

- In 8/9 CTAs, the blood supply to all 20 study-defined pulmonary segments was identified.
- The blood supply to all 20 pulmonary segments was identified in only 1/9 patients via catheterization.
- CTA was better able to delineate segmental pulmonary blood flow than cardiac catheterization ($p = 0.006$).
Aorta
Aorta

- Atypical Coarctation
- Interrupted aortic arch
- Supravalvular aortic stenosis
- Anomalous origin of the coronaries
- Connective tissue disease
- Emergent setting

MRI and CT have similar efficacy for evaluation of the aortic arch, but CT preferred for neck vasculature, coronary origin and emergent situations
Aorta:
Coarctation

- **Severity of coarctation**
  - Especially when echo evaluation is limited by the presence of a large PDA

- **Extent of coarctation**
  - Discrete coarctation versus diffuse hypoplasia of the arch

- **Atypical or syndromic coarctation**
  - PHACE syndrome
  - Interrupted aortic arch

- **Status of head and neck arteries**
Aorta: Coarctation
Aorta: Status of head and neck vessels in interrupted aortic arch
Heterotaxy
Heterotaxy: Indications for MRI and CT

- General survey of cardiovascular anatomy
- Large field of view with MRI allows assessment of entire spectrum of visceral, cardiac and vascular abnormalities in heterotaxy in an efficient and accurate manner

MRI preferred to CT in heterotaxy
Comprehensive evaluation of neonatal heterotaxy with MRI
Vascular mediated airway compromise
Vascular Mediated Airway Compromise

- Cardiovascular cause of airway compromise
  - Vascular Ring
  - Pulmonary Sling
  - Innominate artery compression
  - Enlarged pulmonary artery
  - Midline descending aorta

Nicholas Dodd, RDMS; Karen Lyons, MB BCh BAO; Prakash Masand, MD; Siddharth Jadhav, MD; George Bisset III, MD; Rajesh Krishnamurthy, MD

SPR 2015
Dynamic Volume CT

Effective dose: 0.6 mSv
Dynamic volume CTA for airway/vessel

- Low dose (80 kVp, 20-50 mAs)
- Effective dose 0.5-2.5 mSv depending on age and coverage
- Continuous vs intermittent
- Free breathing
- 5-8 dynamics
- 1.5-2 respiratory cycles
- Allows imaging across normal respiration
- No sedation or intubation

Resp. rate > 30 per min

Resp. rate < 30 per min

Intermittent
1.4 sec
Dynamic volume CTA for airway/vessel

**Detail Information**

1.4D Dynamic Lung - 6 s Intermit

<table>
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<tr>
<th>Procedure</th>
<th>Total mAs</th>
<th>Exposure Time</th>
<th>CTDIvol</th>
<th>DLP</th>
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<td>DVOLUME_CT[5]</td>
<td>70.00</td>
<td>1.75</td>
<td>2.16(Body)</td>
<td>34.50(Body)</td>
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Dynamic Volume Airway/Vessel

1.4D Dynamic Lung - 3s Continuous

<table>
<thead>
<tr>
<th></th>
<th>Total mAs</th>
<th>Exposure Time</th>
<th>CTDiVol</th>
<th>DLP</th>
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<td>104.00</td>
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<td>DVOLUME_CT</td>
<td>94.00</td>
<td>3.15</td>
<td>2.10(Body)</td>
<td>16.70(Body)</td>
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</table>
Pulmonary Sling with complete tracheal rings
Cardiac Morphology
Evaluation of Cardiac Morphology

- Unusual or complex segmental anatomy
  - Criss-cross atrioventricular relationships
  - Ectopia cordis
  - Conjoined twins with thoracopagus
  - Congenital LV aneurysm

- Decision-making regarding single versus 2-ventricle repair
  - Echo may underestimate the measurements of LV volume in patients with borderline hypoplasia of the ventricle
  - DORV in which the aorta is located remotely from the VSD

- Myocardial viability
  - Endocardial fibroelastosis
  - s/p ALCAPA repair
Evaluation of Cardiac Morphology
Indications for MRI and CT

Shone’s syndrome, borderline LV hypoplasia, LV non-compaction, endocardial fibroelastosis

MRI superior to CT for evaluation of intracardiac morphology and myocardial characterization
CT for Cardiac Morphology

- CT increasingly being used for assessment of intracardiac and coronary morphology in neonates and infants
- Retrospective EKG gating with higher radiation exposure typically used to evaluate small moving structures
New Generation CT

- **4 Detector**: 0.5mm x 4
- **16 Detector**: 0.5mm x 16
- **64 Detector**: 0.5mm x 64
- **160 Detector**: 0.5mm x 160
- **320 Detector**: 0.5mm x 320

Z-Axis Coverage: 160mm
Helical versus volume CT
Ungated Volume Imaging with Half-scan Reconstruction

Full-scan Reconstruction

Half-scan Reconstruction
Impact of Denoising and Adaptive IR R/O Vascular Ring

DLP: 5.5
Prospective EKG Gating with Target Mode Volumetric Imaging

Similar radiation exposure as ungated study due to lack of padding

40% of cardiac cycle

28% of cardiac cycle
3-day-old female with heterotaxy, asplenia and TAPVR
Target mode volumetric imaging. Effective dose: 0.8 mSv
Comparison of CTDIvol and Effective dose between volumetric target mode and 64-slice helical ungated mode

Jadhav S et al. AJR 2015
Comparison of Contrast, Noise and CNR between volumetric target mode and 64-slice helical ungated mode acquisitions.
Assessment of intracardiac morphology and proximal coronary arteries in infants

Comparison of:
64 detector CT,
Lower dose target mode volumetric CT,
Higher dose target mode volumetric CT,
& Retrospective EKG gated volumetric CT

Keshav Srivaths, Siddharth Jadhav, Prakash Masand, Farahnaz Golriz, Wei Zhang, Rajesh Krishnamurthy

Department of Radiology, Texas Children’s Hospital, Baylor College of Medicine, Houston, TX
## Scan Parameters

<table>
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<tr>
<th></th>
<th>Total</th>
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<th>LT</th>
<th>HT</th>
<th>R</th>
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<tr>
<td><strong>n</strong></td>
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<td>Mean +/- SD</td>
<td>Mean +/- SD</td>
<td>Mean +/- SD</td>
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<tr>
<td><strong>kVp</strong></td>
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<td>107 +/- 9.85</td>
<td>80</td>
<td>100</td>
<td>93.9 +/- 9.6</td>
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<td><strong>mA</strong></td>
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<td>231 +/- 84.4</td>
<td>71.4 +/- 17.5</td>
<td>180 +/- 44.7</td>
<td>155 +/- 64.8</td>
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<td><strong>mAs</strong></td>
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<td>113 +/- 40.7</td>
<td>28.6 +/- 6.99</td>
<td>63 +/- 15.7</td>
<td>64.3 +/- 32.2</td>
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Scan Parameters

- Average effective radiation dose for each technique were:
  - 64: 5.25 +/- 1.3 mSv
  - LT: 0.57 +/- 0.22 mSv
  - HT: 1.48 +/- 0.74 mSv
  - R: 2.75 +/- 2.15 mSv
  - P < 0.001
Results: Coronaries

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<td>LT vs. HT</td>
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<tr>
<td>LT vs. R</td>
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Results: Aortic root and LV

P-Value

HT vs. R 0.49
LT vs. 64 0.53
LT vs. HT 0.52
LT vs. R 0.077
Results: Valves

P-Value

HT vs. R 0.61
LT vs. 64 0.24
LT vs. HT 0.1
LT vs. R 0.01
CT for Cardiac Morphology

- CT increasingly being used for assessment of intracardiac and coronary morphology in neonates and infants
- Retrospective EKG gating with higher radiation exposure typically used to evaluate small moving structures
Use of CT and MR in Neonatal and Infantile Congenital Heart Disease: Change in Practice Patterns with Advent of New Generation CT

Indications for neonatal cardiac imaging by MRI and CT: Results

<table>
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Conclusion

- In the neonate with CHD, the imaging question for CT is quite discrete, usually pertaining to the status of pulmonary and systemic vasculature.
- CT is the non-invasive reference standard for the extracardiac vasculature.
- New generation CT, including volumetric target mode and high pitch helical mode, are important tools to improve image quality and reduce radiation exposure for evaluation of not only the extra-cardiac vasculature, but also intra-cardiac and coronary anatomy in neonates and infants with CHD.