CT in CHD: Current Status and Scan Protocols to Reduce Radiation

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Objectives

- To describe various indications for pediatric cardiac CT and scan protocols
- To describe technical aspects of cardiac CT for optimal image quality at low radiation dose
Introduction

- Echocardiography
- CT scan – radiation risk
- New generation CT scanners
- MRI
Current status of CT

- CT scan - increasingly used in cardiovascular imaging
- Faster scanning - no need for sedation
- Advanced CT scanner with proper technical parameters can routinely achieve ED of less than 1 mSv - 8 to 15 fold less radiation exposure than cardiac catheterization for assessment of CHD

Mousily et al. - 0.8 ± 0.39 mSv (range 0.4–1.5 mSv)

Jadhav et al. - 0.46 ± 0.19 mSv (range 0.18–0.82 mSv)

Faster injection, 1st pass imaging, lower mA


ALARA

- As Low As Reasonably Achievable
- Regulatory requirement for all radiation safety programs
Current generation of CT scanners

- Dual source
- Wide (320) detector scanner
Dual source CT scanners

- 2 simultaneous x-ray sources (dual source) coupled with two corresponding detectors
- Short rotation time of 0.25 seconds
- Temporal resolution of 66 msec

Second generation - *high pitch helical (HPH) mode*. Pitch increased up to 3.4 → high temporal resolution and short scan time
Wide (320) detector CT scanners

- Enables volumetric scanning of 16 cm craniocaudal length in a single rotation.
- Temporally uniform images with homogeneous contrast enhancement.
Current generation of CT scanners

- These scanners enable complete image acquisition within one cardiac cycle.

- By reducing or doing away with overlapping helical imaging, result in very low radiation exposure

- 60% to 80% less than 64-detector scanners

Current generation of CT scanners

- Have obviated the need for breath holding and sedation for most indications even in neonates and infants
- Need for beta-blockers to reduce high heart rates significantly reduced - gating feasible for heart rates of up to 160 bpm.
CT Denoising with AIDR

Adaptive Iterative Dose Reduction
Pre-requisites for optimal CT scan

- Planning
- Acquisition
- Processing
- Interpretation
Pre-requisites for optimal CT scan

- Patient selection
- Good IV – lower extremity has added advantage
- Patient motion – need for sedation/anesthesia
- Breath-holding
Pre-requisites for optimal CT scan

- Contrast dose

- Contrast timing – peak enhancement, bolus tracking

- CT dose parameters – kV, mA
  - square root of the tube voltage
  - tube current times the duration of exposure (mAs)

- Gating
Cardiovascular CT - techniques

- Invariably some form of gating is needed
- Congenital heart disease – prospective gating
- Coronary imaging – retrospective gating
- Vascular ring – ungated dynamic airway protocol
- Radiation dose using ‘target mode’ prospective EKG gating is the same as an ungated study
Target mode prospective EKG gated imaging - unique capability available with volumetric acquisition, but not on helical imaging

- Allows for cardiac motion compensation without the dose penalty associated with conventional EKG gating with padding
- Ability to choose multiple phases around the target phase allows for free-breathing, unsedated acquisition at high heart rates
Target mode prospective gating

- 40% Target mode prospective gating without padding
- 75% Conventional prospective gating with padding
## Indications and vascular targets

<table>
<thead>
<tr>
<th>Age</th>
<th>Disease</th>
<th>Indication</th>
</tr>
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<tbody>
<tr>
<td>Neonate</td>
<td>Pulmonary atresia</td>
<td>MAPCA vs ductal dependent pulmonary flow</td>
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<td></td>
<td>Heterotaxy</td>
<td>Ao arch, pulmonary veins, Pas prior to modified BTT shunt</td>
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<tr>
<td>Infants</td>
<td>TOF</td>
<td>Branch pulmonary artery stenosis</td>
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<td></td>
<td>Anomalous pulm. venous return</td>
<td>Mixed TAPVR, obstructed TAPVR, repaired TAPVR, Scimitar syn</td>
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<td></td>
<td>Coarctation</td>
<td>Diffuse hypoplasia arch, atypical coarctation</td>
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<tr>
<td></td>
<td>Vascular ring/sling</td>
<td>Type, airway status</td>
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</tbody>
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Moss and Adams’ Heart Disease in Infants, Children, and Adolescents including the fetus and young adult. LWW; Ninth edition (March 11, 2016)
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<tr>
<td>Older child</td>
<td>Coarctation - post repair</td>
<td>Aortic arch, collaterals, stent related complications</td>
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<td>Vascular mediated airway compromise</td>
<td>Fixed vs dynamic airway stenosis, offending vessel</td>
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<td></td>
<td>Anomalous origin of coronary artery</td>
<td>Type, presence and length of intramurality, ostial stenosis, relation to commissure</td>
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<td>Aortopathy</td>
<td>Aortic dissection</td>
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Case examples
Pulmonary atresia with ductal dependent flow

2 day old
80 kV
60 mA
ED 0.28 mSv
15 day old
80 kV
80 mA
ED 0.82 mSv
MAPCA evaluation

90 day old
80 kV
80 mA
ED 0.62 mSv
TOF with absent pulmonary valve
Dynamic CTA for pulmonary vein stenosis

• Severity characterized by:
  • Redistribution of pulmonary blood flow to normal segments
  • Poor parenchymal perfusion
  • Delayed wash in and wash out
Materials & Methods

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Newer generation CT scanners in conjunction with indication-based scan parameters and a first-pass contrast enhancement protocol, provides diagnostic studies in free-breathing neonates and infants with adequate cardiac and respiratory motion compensation at low radiation dose.
Cardiovascular CT scan is here to stay and will only increase with newer scanners and dose reduction techniques.
THANK YOU