Coronary CT Angiography: Protocols
Contrast Media Optimization

James A. Brink, M.D.
Yale University
School of Medicine
Cardiac CT Angiography

- **Intravenous Contrast Material**
  - Flow Rate
  - Concentration
  - Type
  - Duration (Volume)
  - Scan Delay
Iodine Concentration in Blood/Tissue

Concentration (I mg/cc)

Tissue Concentration (I mg/ml)

25 HU per mg I / ml
Peak Enhancement vs. Flow Rate

Computer Simulation
Increase in blood flow caused by the injection

Injection Duration

Recirculation

Time after the start of injection (sec)  Courtesy of Ty Bae
Injection Duration

Porcine Model

Computer Simulation

Bae KT. Radiology 2003;227:809-816
Duration
(Volume)
IV Contrast for CTA

Injection Duration = Scan Duration
Aortic Enhancement (HU)

Time after the start of injection (sec)

Injection Duration
- 1-sec
- 3-sec
- 5-sec
- 8-sec
- 12-sec
- 20-sec
- 30-sec

8 sec
16DCT

30 sec
4DCT
IV Contrast for CTA

SDCT and 4DCT:
\[ \text{Injection Duration} = \text{Scan Duration} \]

16DCT and 64DCT:
\[ \text{Injection Duration} = \text{Scan Duration} + 10 \]
Saline Flush

- Facilitated with double-barrel injector
- Eliminates messy loading of saline on top of contrast in single-barrel systems
Saline Flush

- Eliminates excess contrast in tubing
- Flushes contrast from peripheral veins into central veins
- Permits reduction in contrast volume by about 20 to 40%
- Reduces beam hardening artifact in RCA
64DCT – Uni Flow

• 2 Injection Phases:
  • Contrast
  • Saline
• Less contrast material, but no visualization of right heart w/ dilute contrast
• Better definition / segmentation of left heart and coronary arteries
64DCT – Uni Flow
64DCT – Uni Flow (Yale)

- 2 Injection Phases: (Iodixanol 320, 5ml/s)
  - Contrast 70 ml (14s)
  - Saline 30 ml (6s)

- Scan duration = 3-5 sec
- Injection duration = 14 sec
- Injection duration = Scan duration + 10 sec
64DCT -- Dual Flow

• 3 Injection Phases:
  • Contrast
  • Contrast + Saline
  • Saline

• Permits visualization of right heart and interventricular septum w/ dilute contrast
64DCT Dual Flow
64DCT -- Dual Flow

RCA

LAD

LCX
64DCT -- Dual Flow (Yale)

- **3 Injection Phases:** (Iodixanol 320, 5ml/s)
  - Contrast
    - 60 ml (12s)
  - Contrast(60%) + Saline(40%)
    - 50 ml (10s)
  - Saline
    - 40 ml (8s)

- Scan duration = 3-5 sec
- ‘Effective’ Injection duration = 18-22 sec
  ‘Effective’ ID = SD + 15 sec
'Effective' Injection Duration

<table>
<thead>
<tr>
<th>Duration</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-sec</td>
<td>red</td>
</tr>
<tr>
<td>3-sec</td>
<td>yellow</td>
</tr>
<tr>
<td>5-sec</td>
<td>green</td>
</tr>
<tr>
<td>8-sec</td>
<td>purple</td>
</tr>
<tr>
<td>12-sec</td>
<td>magenta</td>
</tr>
<tr>
<td>20-sec</td>
<td>gray</td>
</tr>
<tr>
<td>30-sec</td>
<td>dashed</td>
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Aortic Enhancement (HU)

Time after the start of injection (sec)
64DCT – Dual Flow

- Right heart visualization
  - Right heart mass
  - Valve disease
- Prolonged injection duration:
  - Triple Rule-Out
  - Complete thorax (CABG)
64DCT – Dual Flow – Triple R/O

Prospective Gating

(100 kV; 5-7 mSv)
Scan Delay
Scan Delay for Cardiac CTA

- **Scan Delay**
  - May be fixed for patients presumed to have normal cardiac output - risky

- **Pitfall**
  - Abnormal cardiac output --> marked delay in vascular enhancement
    - test bolus or bolus tracking
Cardiac Output --> Aortic Enhancement

Test Bolus

• **Measure circulation time**
  - 20 ml @ 5 ml/sec (4 sec inj.)
  - Scan at carina (Asc. Aorta & PAs):
    - 10 - 30 sec q 1-2 sec
  - Plot enhancement curve and find peak
    - If no peak, change arm position, repeat
Test Bolus

Time (sec)

Enhancement (HU)
Timing for Dual Flow 64DCT CCTA

Peaks + 4-8 sec
3-5 sec 64DCT

Aortic Enhancement (HU)

Time after the start of injection (sec)

‘Effective’ Injection Duration

- 1-sec
- 3-sec
- 5-sec
- 8-sec
- 12-sec
- 20-sec
- 30-sec

3-5 sec 64DCT
Bolus Tracking

- ROI in aorta (usually descending aorta)
- Low-dose monitoring scans q 1-2 sec
- Trigger when enhancement > 100 HU
  - Absolute value of 150 HU
- Add delay to initiate scanner, breath-hold patient, and allow adequate enhancement
Timing for Dual Flow 64DCT CCTA

‘Effective’ Injection Duration

- 1-sec
- 3-sec
- 5-sec
- 8-sec
- 12-sec
- 20-sec
- 30-sec

Contrast + Scan Duration

3-5 sec
64DCT

Aortic Enhancement (HU)

Time after the start of injection (sec)
Triple Rule-Out: Test Bolus

Scan delay is mid-point between time to peak in PA and Aorta
Triple Rule-Out: Dual Flow 64DCT

Pulmonary Artery

Aorta

‘Effective’ Injection Duration: 20 sec
### Cardiac CTA: Protocol Development

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<tr>
<td>Concentration</td>
<td>320-370 mgI/ml</td>
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<tr>
<td>Volume</td>
<td>70(100%), 30(NS)</td>
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<tr>
<td>Scan Delay</td>
<td>Test Bolus + 4-8 sec*</td>
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* Bolus Tracking:
  Contrast Arrival + Injection Duration - Scan Duration
## Cardiac CTA: Protocol Development

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