**PRACTICAL CARDIAC CT**

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Stanford Computed Tomography

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**Stanford CT Scanners**

**HOSPITAL**

- CT1: GE LightSpeed Ultra (GE-8)  
- CT3: GE LightSpeed 16 (GE-16)  
- CT2: GE LightSpeed VCT (GE-64)

**Outpatient Scanners**

- Blake: Siemens Sensation 64 (S-64)  
- SMOC: Siemens AS+ (S-AS)  
- SMIC: Siemens Dual-Source GE LightSpeed VCT (GE-64)

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**Coronary CTA Protocols**

**GE VCT (SUH CT2)**

5.27 SNAPSHOT PULSE SMALL PATIENT 30–74 BPM 75–130 LBS PROSPECTIVE  
5.28 SNAPSHOT PULSE MEDIUM PATIENT 30–74 BPM 131–240 LBS PROSPECTIVE  
5.29 SNAPSHOT PULSE LARGE PATIENT 30–74 BPM 240+ LBS PROSPECTIVE  
5.23 SNAPSHOT SEGMENT SMALL PATIENT 30–74 BPM 75–130 LBS RETROGATING  
5.24 SNAPSHOT SEGMENT MEDIUM PATIENT 30–74 BPM 131–240 LBS RETROGATING  
5.25 SNAPSHOT SEGMENT LARGE PATIENT 30–74 BPM 240+ LBS RETROGATING

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**GE VCT (CT 2)**

**Step by Step Coronary CTA**

- Scout  
- Calcium scoring from carina to apex  
- Coronary CTA

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**General Electric VCT**

(Stanford Hospital, CT2)

- Single x-ray tube (100 kW, 20–800 mA)  
- Detector bank 64 × 0.625 mm [40 mm]  
- Gantry rotation: 350 msec (⇒~175 ms temp.res.)

64 × 0.625 mm  
64 × 0.63 mm  
32 × 1.25 mm

(← total detector width 40 mm →)
**SmartScore Protocol**  
*(prospective)*

- Non-contrast calcium scoring
- Scanning range:
  - Carina → apex
- mA: 300 for small  
  350 for average  
  450 for large pts.
- DFOV: 25 cm *(Do NOT CHANGE)*
- GIVE NITRO AFTER SmartScore

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**Coronary CTA Scanning Range**  
**Snapshot Pulse** • **Snapshot Segment**

- 20mm above left main coronary artery 20mm below apex of heart  
  (or from 10mm below carina to apex)
- default mA (can be adjusted):
  - small 450 mA
  - average 550 mA
  - large 750 mA
- SmartPrep 8 s diagnostic delay
- ROI in ascending aorta, at level where scan starts
- 40mA; monitoring delay 8s, ISD 2.0; 80 HU

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**INJECTION PROTOCOL**

- CONTRAST: *(Isovue 370)*
- Injection (~1.1 mL/kgBW in 15s) + Saline Flush
- Scan Time: approx. 5 seconds [or 7s for 4 heart beats]

<table>
<thead>
<tr>
<th>Weight Range</th>
<th>mL</th>
<th>mL/s</th>
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<tbody>
<tr>
<td>&lt;121 lbs (~55 kg)</td>
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<tr>
<td>121–143 (~65 kg)</td>
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<td>4.5</td>
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<td>143–187 (~75 kg)</td>
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<td>5.0</td>
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<tr>
<td>187–209 (&gt;85 kg)</td>
<td>85</td>
<td>5.5</td>
</tr>
<tr>
<td>&gt;209 lbs (&gt;95 kg)</td>
<td>90</td>
<td>6.0</td>
</tr>
<tr>
<td>XXL</td>
<td>110</td>
<td>6.0</td>
</tr>
</tbody>
</table>

- and increase diag. delay to 11s

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**Prospective Gating**  
**Coronary CTA**

- Step-and-Shoot (every other heart beat)
  - 3 scans (~12cm): 5 heartbeats → ~5 sec
  - 4 scans (~16cm): 7 heartbeats → ~7 sec
- Sequential Acquisition as fast as helical
- Substantially less radiation dose (~5mSv)
  
  (1/3rd to 1/4th)
- ECG Triggers the scan ~ every other heart beat
- Need a low and steady heart rate !!
  
  (for GE-VCT: <60; ±5)
- No dynamic information (no 4D)

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**GE VCT ‘PADDING’**
**GE VCT (CT 2)**

*Coronary CTA Image Reconstruction*

**PROSPECTIVE:**
- Default: 75% (diastolic)
- Additional: ~65% – 85% (in 3% intervals, depends on padding)

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**33 yo man with atypical chest pain (ER)**

**Coronarily Gated Coronary CTA**

(betablocker, HR 62 bpm)

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**CORONARY CTA RETROSPECTIVE GATING SNAPSHOT SEGMENT**

- Helical Acquisition
- Low Pitch, redundant scanning
- ECG signal is recorded, does not trigger scan
- Can Reconstruct 10 phases (0%-90%)
- Robust for faster Heart Rates
- > 65 bpm
- More Radiation Dose

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**59 yo woman**

hx of MI, LAD sten.

HR: 91 bpm

→ retrosp. gating

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**56 yo man with chest pain (ER)**

Prospectively Gated Coronary CTA (betablocker, HR 62 bpm)
59 yo woman
hx of MI, LAD sten.
HR: 91 bpm
→ retrosp. gating

RCA 3-chamber view (10 phases [0-90% RR])

Comparison / Range of Radiation Doses

What was the radiation dose in this case?

Retrospective Gating:
- 120kVp
- CTDIvol: 51.7 mGy (DLP 879 mGy\text{cm})
- ~14 mSv effective dose

Recent Example:
Low dose prospectively gated CTA
- 100kVp (slim patient)
- 3 seq. scans at 650mA
- CTDIvol: 18.8 mGy (DLP 225 mGy\text{cm})
- ~3.8 mSv effective dose

Patient Preparation

- Patient into Gown, Proper IV access
- Oral Beta blocker 1-3 hours before scan
- Keep Patient in Quiet environment
- Sublingual Nitroglycerine ~3-5 min before CTA

Communicate with your patient

Explain

BREATHING INSTRUCTIONS

- Inspiration: BREATHING instructions: (‘stop breathing’)
- “Take in a breath, STOP BREATHING”
- Importance of “Not Bearing Down”
- Coach the Patient a few times before scan
Wrong way to attach leads

Proper way to attach Leads

Make the patient comfortable
Create a quiet environment
Keep the lights low, decrease background noise

Tips and Tricks
CHECK ECG Trace (quality, readjust leads if necessary, wipe skin before placing leads etc., check heart rate and heart rate variability)

ECG-Gated Cardiovascular CT – Workshop
Lucas Learning Center - Stanford Radiology
June 6, 2009

THANK YOU ....
**PRACTICAL CARDIAC CT: Siemens Sensation 64**

Mark Bieler

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**Siemens Sensation 64**

(Blake Wilbur)

- x-ray Tube: single tube (85kW, 665mA)
- gantry rotation: 330 msec (temp.res.—175ms)
- Detector bank (for coronaries)
  32 rows × 0.6 mm thickness [19.2 mm]
  but it's still a 64-slice scanner!

ECG gating:
- retrospective, tube current modulation
- (no prospective)

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**64 - Channel (Slice) CT Systems**

**GE LightSpeed VCT**
Matrix Detector

- 64 × 0.625 mm
- Gantry rot: 350ms, z-Resolution ~0.625

**(Siemens Sensation 64)**
Hybrid Detector

- 32 × 0.6 mm → 64 × 0.6 mm channels
- Gantry rot: 330ms, z-Resolution ~0.4

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**Stanford CTA Protocols**

(Siemens Sensation 64, Blake Wilbur)

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**CaScoring and Coronary CTA below 50 bpm HR**

- Calc. Scoring w/t 50% chance of positive and 50% chance of negative
Calcium Scoring and Coronary CTA

Indication:
rule out Coronary Artery Disease

Patient preparation:
320kV Iv contrast, oral or Iv B-Blocker and sublingual nitroglycerine as per protocol

Patient positioning:
- head flat, arms above head
- C-Spine/chin under neck
- ECG leads
- Prone or half-Arm

Comment:
- make sure the ECG display shows a clean signal with well-identified R-peaks; this protocol should be used for heart rates below 100 bpm. Use ECG-knobs, especially in younger patients.

Siemens Sensation 64 (Blake Wilbur)
Tips and Tricks

- ECG lead placement on table /w arms above head
- Check ECG tracing
- Hairy Chest
- Practice breathing
- Shoulder position

Coronary CTA Protocol

A. Cineangiographic Acquisition and Scanning/Change

<table>
<thead>
<tr>
<th>Program</th>
<th>Ref.</th>
<th>Adj.</th>
<th>Scan</th>
<th>Pitch</th>
<th>Rate</th>
<th>Ti</th>
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<td>150</td>
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<td>150</td>
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<td>60</td>
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B. Scanning Parameters

<table>
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<tr>
<th>z</th>
<th>EF</th>
<th>Ref. Ti</th>
<th>Adj</th>
<th>TR</th>
<th>Pitch</th>
<th>Rate</th>
<th>Scan</th>
<th>Column</th>
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<tr>
<td>100</td>
<td>1.2</td>
<td>150</td>
<td>120</td>
<td>1.0</td>
<td>150</td>
<td>150</td>
<td>60</td>
<td>1.0 cm</td>
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</table>

C. Contrast Medium Injection Parameters

<table>
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<th>Protocol</th>
<th>Ti</th>
<th>Ref. Ti</th>
<th>Adj</th>
<th>TR</th>
<th>Pitch</th>
<th>Rate</th>
<th>Scan</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>150</td>
<td>120</td>
<td>1.0</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>60</td>
<td>1.0 cm</td>
</tr>
</tbody>
</table>

48 y/o business-executive w equivocal stress-echo (posteroinf. wall-motion abnormality?)

64 x 0.6mm
12s scan-time

100mL CM,
5mL / s (20s)
Delay: CTR + 8
(Care-bolus)
**Troubleshooting**

- Use own judgement to assess patient: weight, age, general health, ... (general protocol applicable? i.e. test bolus vs. tracking?)
- Post Processing ECG Editing and Sync Adaptation
Siemens Definition (Dual Source) (Stanford Medicine Imaging Center - SMOC)

- Two x-ray Tubes (2x100kW, 20–800 mA)
- Two detector banks (each bank same as Blake)
  2 x 32 x 0.6 mm [19.8 mm]
  (2 x 64 channels)

Molvin, L
Alkhadra, F

Stanford Computed Tomography

Coronary CTA Protocols
(Siemens Definition – DualSource, SMIC)

- (Prospective gating) detector smaller than GE-VCT or Siemens AS+ (SMOC)
- Retrospective Protocols
  - Small (100kV)
  - Medium
  - Large (more mA for less temp.res)
- ECG tube current modulated based on heart rate
  - min-dose, 70% of RR only
  - min-dose, 30–70% of RR
Retrospectively Gated Coronary CTA
(Siemens Definition - DualSource, SMIC)

- at low heart rate (<65 bpm) reliable still phase during diastolic phase of heart (diastolic: 70% or RR interval (65–75)) → full dose only at 70% of RR interval

- at higher heart rates (>65 bpm) need end systolic (30%RR) through diastolic (70%RR) → full dose from 30%–70% RR

don–modulate mA to 4% during non-diagnostic phases of cardiac cycle (minDose)

Retrospectively gated cardiac CT
EKG Modulation of Tube Current

- 100% max mA: full RR min mA: 100%
- 20% max mA: 30–70%RR min mA: 70%RR
- 100% max mA: 30–70%RR min mA: 70%RR
- 4% max mA: 30–70%RR min mA: 70%RR

30% Phase Mindose Dose Modulation
50% Dose Reduction

- 50% Dose Reduction

Image Reconstruction

High HR (>65%) (30–70%RR):
- Recon 1: ‘BestDiast’
- Recon 2: ‘BestSyst’
- Recon 3: 0–90% (10 phases)

Low Heart rate (<65%) (70% RR)
- Recon 1: ‘BestDisat’
- Recon 2: 0–95% RR (20ph.) functional matrix
EKG Troubleshooting: Manual Editing

Image Reconstruction

High HR (>65%) (30–70% RR):
- Recon 1: 'BestDiast'
- Recon 2: 'BestSyst'
- Recon 3: 0–90% (10 phases)

Low Heart rate (<65%) (70% RR)
- Recon 1: 'BestDiast'
- Recon 2: 0–95% RR (20 ph.) functional matrix

Reconstruction: 'Functional Matrix'
(256x256, 2mm STh, 20 phases)
PRACTICAL GATED CT:

Siemens Definition AS+

Wendy Earle, RT
(SMOC – Stanford Medicine Outpatient Clinic)

- Single X Ray Tube: 100 kW, 20–800 mA
- Gantry Rotation: 300 msec
  → temporal Resolution: 150 msec
- Detector Bank:
  - 64 rows x 0.6 mm (total width: 38.4 mm)
  → double focal spot: 128 channel scanner
Siemens Definition AS+

Matrix Detector

\[ 64 \times 0.6 \text{ mm} \]

Channels

\[ \text{ Siemens Flying Focal Spot: '2 Scans per Rotation'} \]

Siemens Definition AS+

- Single X Ray Tube: 100 kW; 20–800 mA
- Gantry Rotation: 300 msec
  \( \rightarrow \) temporal Resolution: 150 msec
- Detector Bank:
  - 64 rows x 0.6 mm (total width: 38.4 mm)
  \( \rightarrow \) double focal spot: 128 channel scanner
- Gantry Aperture: 78 cm
- Weight Limit: 480 lbs
  - with bariatric table–top: 660 lbs

Siemens Definition AS+

**ECG Gating**

- Prospective:
  - Sequential
  - R–peak triggers scan
- Retrospective:
  - Spiral
  - Tube Current Modulation

What is the difference between a coronary CTA and a gated Chest?

- Coverage: entire chest ± A/P
- Main focus: aortic root (not coronaries)
- need to see aortic valve open, closed, and in between (throughout cardiac cycle)
- WHICH GATING TECHNIQUE CAN DO THIS ??

Siemens Definition AS+

**Setting the Pulsing Range**

Points to Consider:

- The range from one R–peak to the next is 100%
- Diastole usually occurs within 65 to 75%
- Systole usually occurs within 30 to 40%
- A Range of 30 to 70% includes both Diastole and Systole
**ECG Tube Current Modulation**

*“Pulsing”*

- **Auto**
  - 20% residual dose; scanner selects RR range
- **Manual**
  - 20% residual dose; technologist selects 30–70% RR
- **MinDose – Auto**
  - 4% residual dose; scanner selects RR range
- **MinDose – Manual**
  - 4% residual dose; technologist selects RR range
- **Pulsing Off**
  - 100% dose

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**Siemens Definition AS+**

*Gated Chest Image Reconstructions*

- **Best Phase**
  - Best Diastole for HR < 60 bpm
  - Best Systole for HR > 80 bpm
  - (either for HRs in the 70’s)
- **Multiphase**
  - 0 – 90%

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**Siemens Definition AS+**

*Gated Chest Protocols*

- **Routine**
- **Gated Chest with Abd/Pel CTA**
- **Gated Chest with Routine Abd/Pel**

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**Siemens Definition AS+**

*Routine Gated Chest Injection Protocol*

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>Flow Rate</th>
<th>Volume Calculation</th>
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<tbody>
<tr>
<td>&lt;121 lbs</td>
<td>4.0</td>
<td>(scan time + 8) x 4.0</td>
</tr>
<tr>
<td>121 – 143</td>
<td>4.5</td>
<td>(scan time + 8) x 4.5</td>
</tr>
<tr>
<td>143 – 187</td>
<td>5.0</td>
<td>(scan time + 8) x 5.0</td>
</tr>
<tr>
<td>187 – 209</td>
<td>5.5</td>
<td>(scan time + 8) x 5.5</td>
</tr>
<tr>
<td>&gt; 209 lbs</td>
<td>6.0</td>
<td>(scan time + 8) x 6.0</td>
</tr>
</tbody>
</table>

Bolus triggering, 8s Delay

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**Siemens Definition AS+**

*Gated Chest with A/P CTA Injection Protocol*

**BIPHASIC INJECTION**

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>Phase I</th>
<th>Phase II</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;121 lbs</td>
<td>20 ml @ 4.0</td>
<td>(scan time + 5) x 3.2</td>
</tr>
<tr>
<td>121 – 143</td>
<td>23 ml @ 4.5</td>
<td>(scan time + 5) x 3.6</td>
</tr>
<tr>
<td>143 – 187</td>
<td>25 ml @ 5.0</td>
<td>(scan time + 5) x 4.0</td>
</tr>
<tr>
<td>187 – 209</td>
<td>28 ml @ 5.5</td>
<td>(scan time + 5) x 4.4</td>
</tr>
<tr>
<td>&gt; 209 lbs</td>
<td>30 ml @ 6.0</td>
<td>(scan time + 5) x 4.8</td>
</tr>
</tbody>
</table>

Injection duration = scan–time+10s; Bolus triggering, 5s Delay

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**Siemens Definition AS+**

*Gated Chest with Abd/Pel CTA*

- **Two Scan Ranges:**
  - Both ranges have 0.3 rotation time
  - Same FOV for both
  - Minimal time gap between ranges
  - Single breathhold
- **Abd/Pel CTA:**
  - Begin scan 0.7 mm below end of chest
  - 6 second scan time

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**Siemens Definition AS+**

*Gated Chest Image Reconstructions*

- **Best Phase**
  - Best Diastole for HR < 60 bpm
  - Best Systole for HR > 80 bpm
  - (either for HRs in the 70’s)
- **Multiphase**
  - 0 – 90%
Siemens Definition AS+
**Gated Chest with Routine Abd/Pel**

- Two Scan Ranges with the Same FOV
- **Gated Chest:**
  - 0.3 rotation time
- **Routine Abd/Pel:**
  - 0.5 rotation time
  - Begin scan above dome of liver
  - Calculate delay to begin scan 70 seconds following injection

**Gated Chest with Routine A/P Injection Protocol**

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>Volume@Flow Rate</th>
</tr>
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<tbody>
<tr>
<td>&lt;121 lbs</td>
<td>90 @ 4.0</td>
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<tr>
<td>121 – 143</td>
<td>105 @ 4.5</td>
</tr>
<tr>
<td>143 – 187</td>
<td>120 @ 5.0</td>
</tr>
<tr>
<td>187 – 209</td>
<td>135 @ 5.5</td>
</tr>
<tr>
<td>&gt; 209 lbs</td>
<td>150 @ 6.0</td>
</tr>
</tbody>
</table>

Bolus triggering, 8s Delay, A/P ~40s Delay

63 y/o man
**gated chest + routine AP**

**THANK YOU....**

Stanford Computed Tomography