CTA Throughout the Ages

Suhny Abbara, MD
Associate Professor, Harvard Medical School
Director of Education, Cardiac MRCT Program
Director Cardiovascular Imaging Fellowship, Massachusetts General Hospital

SAbbara@Partners.org

1971 1st CT scanner
1972 1st patient
1973 Commerically available (EMI)

The Electric and Musical Industries Ltd (EMI) formed in March 1931 from a merger of the UK Columbia Graphophone Company and the Gramophone Company. EMI office at Abbey Road

Four Generations of CT Scanners

1st Generation
Four Generations of CT Scanners

No longer produced commercially for medical use

4th - not be practical as a multislice

A 3rd Generation Gantry (LightSpeed)

Spiral CT
Pitch = table feed relative to gantry rotation

Pitch = 1.0 → no overlap, no gap
Standard acquisition

Pitch = 1.5 → 50% gap
Fast scan for large volumes (vascular studies)

Pitch = 0.3 → 70% overlap
Used in conventional retrospectively gated CT
**Pitch** = table feed relative to gantry rotation

Pitch = 3.0 → 200% gap
No image reconstruction on single source CT

**High Pitch Mode**

Pitch = 3.0 on Dual Source CT system
Second tube offset by 90° (‘fills gap’), therefore image reconstruction is possible

**MultiDetector CT Scanners**
Multi Detector Row CT Generations

1998
4×4 mm

2002
16×17 mm (1.2 cm)

2004
32x.6mm (2 cm)

2005
64x.6 mm (4 cm)

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Slice Race - 256 Detector-Row CT

Only one beat for 4D cardiac CT

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256 Detector-Row CT

0.5 mm x 256 slices, 0.5 sec/rotation

Second generation DSCT - Half Scan @ 75ms
Sub-second Spiral Acquisition with Pitch>3

DSCT “Flash Spiral”

DSCT allows for pitch of 3.2
→ Table speed = 43 cm/sec
→ Coronary imaging @<1mSv, without breath hold

Images Courtesy of Christianne Leidecker, PhD
Dual-energy CT
Iodine maps

80kV 140kV

Improved In-Plane Resolution
or Dual-energy

Increased number of Projections per Rotation
→ better Resolution

Alternatively
alternating kV
→ Dual energy

Resolution Race – Flat Panel CT System

Detector
2.5mm stent with simulated neointimal hyperplasia

Ex vivo Human Coronary Artery

Courtesy Jennifer Linauskas, PhD

fpCT

IVUS

CTA
Single detector row scanners - limitations

- Cannot image entire lower extremity inflow / runoff due to time restriction:
  - To cover aortic bifurcation to feet at 2.5mm slices:
    - $1000 \text{mm} / 2.5 = 400 \text{slices}$
  - @ pitch of 2, 0.75s rotation time $\rightarrow 150s$ acquisition time
  - @ 3cc/sec $\rightarrow$ 400-450cc of contrast required
  - Thinner slices, larger coverage and higher injection rates desired $\rightarrow$ longer scan time and more contrast

4-slice CT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning coverage (mm)</td>
<td>1,223 ± 98 (988-1,410)</td>
</tr>
<tr>
<td>Scanning duration (sec)</td>
<td>66 ± 5.2 (53-75)</td>
</tr>
<tr>
<td>Number of transverse sections</td>
<td>908 ± 96 (766-1,129)</td>
</tr>
<tr>
<td>Iodine dose (g)</td>
<td>55.2 ± 1.8 (52.3-60.0)</td>
</tr>
<tr>
<td>Volume of contrast medium (mL)</td>
<td>184 ± 5.9 (175-200)</td>
</tr>
<tr>
<td>Contrast medium injection rate (mL/sec)</td>
<td>3.5 ± 0.3 (2.8-4.0)</td>
</tr>
<tr>
<td>Injection duration (sec)</td>
<td>53 ± 6.3 (48-73)</td>
</tr>
<tr>
<td>Scanning-to-injection duration ratio</td>
<td>0.81 ± 0.08 (0.66-0.95)</td>
</tr>
<tr>
<td>Delay between contrast medium initiation and scanning (sec)</td>
<td>22.1 ± 3.7 (18-30)</td>
</tr>
</tbody>
</table>

Rubin et al. Radiology 2001
MDCT angiography of lower extremity arterial inflow and runoff: initial experience.

4-slice CT

<table>
<thead>
<tr>
<th>Vein</th>
<th>Aneurysm Size</th>
<th>No. of Locations</th>
<th>No. of Legs</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep</td>
<td>&lt; 30</td>
<td>4/180 (2%)</td>
<td>5/48 (1%)</td>
<td>3/24 (31%)</td>
</tr>
<tr>
<td>Superficial</td>
<td>&lt; 30</td>
<td>5/174 (3%)</td>
<td>5/48 (10%)</td>
<td>2/24 (21%)</td>
</tr>
<tr>
<td>All</td>
<td>&lt; 30</td>
<td>9/554 (3%)</td>
<td>9/48 (15%)</td>
<td>5/24 (21%)</td>
</tr>
<tr>
<td></td>
<td>&lt; 30</td>
<td>15/534 (4%)</td>
<td>9/48 (15%)</td>
<td>7/24 (29%)</td>
</tr>
</tbody>
</table>

Rubin et al. Radiology 2001
CTA - Advantages

- Non invasive, readily available, fast
- Moderate cost compared to Angio & MRI
- Excellent spatial resolution / true 3D datasets
  - Great re-test reliability
  - Centerline reconstructions
- Excellent depiction of lumen, mural thrombus, calcifications and side branches
- Alternative diagnoses

CTA - Disadvantages

- Radiation
- Iodinated contrast material required
- Bone hinders MIP images of LE
  - Bone extraction algorithms and Dual Energy
- Contraindications:
  - Contrast allergy, renal failure (Crea. >1.5), pregnancy etc.

CTA - Role

- Initial screening test for suspected symptomatic AAA
- Follow Up of known AAA
  - Radiation & iodinated contrast → does not allow for short intervals!
- Procedure planning!
  - Ideal for surgery and stent placement planning
- Follow Up after treatment
Aortic CTA – Imaging Protocol

- **non-contrast scan**
  - slice thickness 5mm to reduce radiation
  - intramural hematoma
  - displacement of intimal calcifications in dissections

- **CTA acquisition**
  - 100-150cc of nonionic iodinated contrast
  - 3-5cc/second
  - automated threshold triggering (smart prep, care bolus etc.)
  - or: test bolus

- **Delayed scan**
  - thicker collimation
  - 2 minutes following injection
  - false lumen in dissection
  - Extravasations: trauma / aneurysm rupture
  - endoleak following stent-graft for aortic aneurysms

**Why pre-contrast scan?**

- Intramural Hematoma
Intramural Hematoma

Why add Thoracic CTA?

Multiple Aneurysms

Check for Popliteal Artery Aneurysms!
Why delayed Imaging?

Problems:
Bones, clips, & Calcium

Lopera et al. 

Dual Energy Whole Body CTA 
128 slice DSCT 
Collimation 128 x 0.6 mm 
A: 1.3 for 100 kVp 
M: 120 A, 180 
384 x 1440 resolution
Why Gate Thoracic CTA

- Reduces motion artifact in ascending aorta
  - Non-gated MDCT: >84% pulsation artifact*
- Additional information:
  - coronary arteries
  - cardiac function
  - aortic valve

Ko et al. AJR. 2005 Apr;184(4):1225-30

Pseudodissection on non-gated MDCT

Ko et al. AJR. 2005 Apr;184(4):1225-30

Type A Dissection (cardiac gated CT)

Abbara S et al. JCCCT 2007, 1(1): 40-54
Cardiac Gated Thoracic Aortic CTA

- Eliminates pulsation artefact and pseudo-flaps
- Virtually eliminates false positive CTA

Type A Dissection
Flap extends into LM ostium

Thank you!
SAbbara@Partners.org