Cardiovascular Imaging Studies
To the Heart of the Matter

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Disclosures

I have no financial or professional disclosures pertaining to this presentation.
Anatomy

- Optical Coherence Tomography
- Cardiac Computed Tomography
- Cardiac Magnetic Resonance Imaging

Function

- Intravascular Ultrasound
- Echocardiography TEE/TTE
- Intracardiac Echocardiography
- Nuclear Imaging
Simply complex - Advances

- Ability to see region of interest in more detail and less invasively.
- Potential for the same or a more defined diagnosis with less risk to patients.
- Ability to communicate images and findings quickly and effectively (procedural/team).
• Cardiovascular imaging modalities available and how to utilize them.
  – MRI
  – Computed Tomography
  – Echocardiography
    • TTE/TEE/IVUS
  – Nuclear Imaging
  – Procedural guidance
CARDIAC MAGNETIC RESONANCE IMAGING
Magnetic Resonance Imaging (MRI)
Cardiac MRI – When is it useful?

- Congenital heart disease
- Vascular – Aorta
- Diseases of myocardium
- Diseases of pericardium
- Viability
- Left and right ventricular function – gold standard
- Shunts

- Cardiac stress testing – dobutamine/adenosine
- Coronary artery disease – imaging of coronaries
MRI

• Advantages
  – View of whole heart (not limited by bones/etc)
  – No radiation
  – Calcium does not cause artifact

• Disadvantages
  – Magnet (PM-limited, ICDs, clips -> artifacts)
  – Claustrophobia
  – Expensive
  – Long acquisition time – may take hours
  – Nephrogenic systemic fibrosis (gadolinium)
  – Long post-processing time
  – Limited by arrhythmias
  – Patient must be able to follow breathing instructions (CT and MRI)-translators if necessary
Non-contrast. Signal to Noise
Flow through ASD- Phase Contrast
MRI Stress Test - Normal wall motion

Rest function

Stress function
Normal Rest Perfusion

Gated image during contrast delivery
Pharmacologic Stress

- Adenosine agonist
  - Dipyridamole, Adenosine, Regadenoson
Stress impairs vessel dilation

Flow impairing plaque impairs vessel dilation

Less dilation — less flow
56 yo F with LAD lesion

Less flow, less blood, less contrast
Delayed enhancement - Scar
Whole Heart MRI

• Uses gating of breathing and heart rate.
• No prolonged breath holds.
• Potential for clinical assessment of coronary artery disease – if resolution improved.
Pacemaker and MRI

• Potential risks
  – Lead heating
  – Unintended cardiac stimulation
  – Device interactions

• System includes leads/PM
• No ICDs – yet...
Conduit from ascending aorta to descending aorta.
Cardiac CT – When is it useful?

• Chest pain syndrome
  – Exclude CAD (99% NPV)
  – CP in Emergency room
• Equivocal stress test
• Non-coronary artery cardiac surgery
  – Exclude CAD
• Prior bypass surgery
  – Determine patency of grafts (not great for severe native disease)
• Congenital anomalies of the coronary circulation
• Coronary or pulmonary venous anatomy
Cardiac Computed Tomography

• Advantages
  – Anatomic advantages similar to MRI
  – High resolution coronary artery angiography
  – Rapid acquisition time
  – Pacemakers/ICDs are safe (although with artifact)

• Disadvantages
  – Ionizing radiation
  – Patient must be able to follow breathing instructions (CT and MRI)-translators if necessary
  – Post-processing required
  – Potential renal injury
  – Does not assess flow (yet...)
Third Generation CT

- Arc of detector elements
- Wider fan beam
- Translation of tube and detector
- Faster scan speed
More coverage with larger detectors

$64 \times 0.625 = 40\text{mm}$

$128 \times 0.625 = 80\text{mm}$

$320 \times 0.625 = 200\text{mm}$
More coverage with larger detectors

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More coverage with larger detectors

64 x 0.625 = 40mm
128 x 0.625 = 80mm
320 x 0.625 = 200mm
The average person in the U.S. receives an effective background dose of about 2.5 – 3 mSv per year.

Relative Radiation Dose
Real World Results Vary Widely
High Pitch Coronary CT Scanning
Male patient (183 cm, 78 kg, heart rate 54 b.p.m.).

Plaque visualization
Acute Chest Pain Syndrome in the ED

• Challenging strain on delivery system
  – 8 million visits annually in the US
  – ACS diagnosis is made in only 10-15% of these patients
    • $10 billion annual cost

• Three recent randomized trials
  – CT vs usual care in the ED in CP patients
  – Low to intermediate risk patients
The CT-STAT (Coronary Computed Tomographic Angiography for Safe Acute) Trial of Acute Coronary Syndromes

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

CT Angiography for Safe Discharge of Patients with Possible Acute Coronary Syndromes

Harold I. Litt, M.D., Ph.D., Constantine Gatsonis, Ph.D., Brad Snyder, M.S., Harjit Singh, M.D., Chadwick D. Miller, M.D., Daniel W. Entrikin, M.D., James M. Leaming, M.D., Laurence J. Gavin, M.D., Charissa B. Pacella, M.D., and Judd E. Hollander, M.D.
What the studies demonstrated

• CTCA in low-to-intermediate risk patients is safe with similar patient outcomes when compared to currently available testing.

• CTCA use results in faster triage in ED.
  – Faster discharge/faster diagnosis/faster admit.

• ER costs are reduced.
  – although no significant overall savings.

• Does not apply to intermediate or high risk patients.

• Safe and quick at about the same cost.
The future of coronary CT?

From: Diagnostic Accuracy of Fractional Flow Reserve From Anatomic CT Angiography

Structural heart disease
Structural heart disease

ASD
Structural heart disease
Structural heart disease

Aorta

ASD

LV
Single breath-hold. Mechanical valve assessment
CT prior to EP ablation
Imaging workhorse.

ECHOCARDIOGRAPHY
Ultrasound

- **Helmet Hertz** – only few years in cardiac imaging. Developed ink-jet technology.
  - Advised Seimens Corporation not to enter cardiac ultrasound because there was not a great future
Echocardiography Methods

- Transthoracic echocardiography
- Transesophageal echocardiography
- Intracardiac echocardiography
- Intravascular echocardiography
Sector Transducers
2D and 3D
TTE
TTE
Transesophageal Echocardiography

- Evaluate for cardiac source of embolism (36%)
- Endocarditis (14%)
- Prosthetic valve function (12%)
- Valvular disease, aortic dissection or aneurysm, tumor, mass or thrombus (6-8% each).
- Congenital heart disease (4%)
- Interventional cardiology guidance
- Intraoperative evaluation cardiothoracic surgery.
Echocardiography Training

Center for Virtual Care

HEARTWORKS
Intracardiac Echocardiography
Intracardiac Echocardiography
Intracardiac echo
NUCLEAR PERFUSION IMAGING
Stress Testing

• Multiple possible modalities
• Major use for nuclear cardiac imaging
• Stress tests indicated for
  – Initial evaluation of suspected ischemic chest pain
  – Significant change in cardiac symptoms
  – Prognosis in patients with known disease
• SPECT, PET/Rb
PET Perfusion Scans

• Higher energy particle (511 keV vs 100).
  – Less attenuation (goes through breast/bone/walls/etc).
  – May be more reliable in obese patients.
  – “easier” to read

• Rb-82.
  – Stress and rest imaging in 30 minutes.

• Allows non-invasive assessment of coronary blood flow – imaging as Rb is injected.

• Typically uses CT for attenuation correction.
PET Rb Imaging
Triple vessel disease
Maximizing success with pre and intra-procedural imaging.

CARDIOVASCULAR IMAGING
PROCEDURAL GUIDANCE
FR 19Hz
8.7 cm

Live 3D
3D 12%
3D 40dB
Gen

PAT T: 37.0°C
TEE T: 39.6°C

91 bpm
<table>
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<tr>
<th>Edwards SAPIEN Valve</th>
<th>RetroFlex 3 Sheath</th>
<th>Minimum Vessel Diameter</th>
<th>RetroFlex 3 Sheath OD</th>
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<td>23 mm</td>
<td>22F</td>
<td>7.0 mm</td>
<td>8.4 mm</td>
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<tr>
<td>26 mm</td>
<td>24F</td>
<td>8.0 mm</td>
<td>9.2 mm</td>
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Matching up C-arm angle – reducing contrast and radiation in the cath lab
Conclusions and Future Directions

- More integration across cardiovascular imaging platforms.
- Radiation exposure will continue to decrease.
- More melding of function with anatomy.
- Imaging will play a more robust role in procedural guidance.
- Keep playing your video games.
Thank you.