What the Cardiologist needs to know from Medical Images

Gerald Maurer

Department of Cardiology
Medical University of Vienna
What kinds of Cardiologists

• Plumbers
• Electricians
• Photographers
• And then there's another kind…..
Reaching a diagnosis

- History: Listen to the patient
- Physical: Examine the patient
- EKG
- Laboratory: blood, urine,…
  - Biomarkers: BNP, Troponin…
- Imaging
Imaging: Cardiologist’s Wish List...

- Morphology and function
- Hemodynamics and flow patterns
- Tissue characteristics and metabolism
- Interventional imaging
- Prognosis and Outcome
Imaging: Cardiologist’s Wish List…

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Function

Normal

Abnormal
HFrEF

HFpEF
Amazingly detailed new HEART SCANS help doctors spot trouble without surgery. How technology could save your life.
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Aortic Stenosis
Measurement of Severity of Disease

Transaortic Pressure Gradients: CW-Doppler
Simplified Bernoulli equation:
\[ \partial P = 4v^2 \]

Mean Gradient = \[ \Sigma \frac{\partial p}{\partial t} \]
Aortic Stenosis
Continuity Equation: Calculation of valve area

\[
\text{AVA} = \frac{\text{LVOT Area} \times \text{LVOT Vel}}{\text{AV Vel}}
\]
Hemodynamic Information
“Echo Right Heart Catheterization”

Kirkpatrick: JACC 2007;50:381
Doppler Color Flow Mapping
4D Flow CMR Imaging: Altered aortic shape in bicuspid aortic valve relatives influences blood flow patterns

<table>
<thead>
<tr>
<th>no helix and no vortex</th>
<th>mild helix</th>
<th>moderate helix</th>
<th>severe helix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AAO</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>DAA</td>
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</tbody>
</table>

**Velocity [m/s]**

- 1.00
- 0.75
- 0.50
- 0.25
- 0.00

Schnell: Eur Heart J Cardiovasc Imaging 2016
Imaging: Cardiologist’s Wish List…

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3 - vessel - disease
LV short axis, basal slice

18 FDG-PET
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Guidance to Interventions

• Indication
• Timing
• Type
• Follow-up
• Intraprocedural guidance
Percutaneous Interventions

TAVI
MitraClip
ASD/PFO
Valvuloplasty
Watchman / LAA occluders
Other occluders (paravalvular leak)
Vessel size vs. sheath size (ID vs. OD)

- 18F (~21F): 6.9 mm (CoreValve)
- 22F (25F): 8.3 mm (23 mm Edwards Sapien)
- 24F (28F): 9.2 mm (26 mm Edwards Sapien)
CT in TAVI
Percutaneous Mitral Valve Approaches

Coronary sinus annuloplasty

Direct Annuloplasty

Mitraclip

Chamber + annular remodeling
Mitral valve clip
Interventional Echo - Clip
Transcatheter Mitral Annuloplasty
Cardioband Percutaneous Mitral Repair System

Nickenig: J Am Coll Cardiol Intv. 2016;9:2039
Interventional MRI

McGuirt T: Rad Techn 2016;87:622
Interventional MRI – Fusion Imaging
Closure of Gerbode Defect

Rogers T: Curr Cardiol Report 2015;17:31
Impact of Imaging?

• Detailed morphologic, functional, hemodynamic, metabolic and molecular information

• These tools can be used in patients but also for screening healthy populations

• Improved understanding of disease processes, risk stratification

• Basis for developing rational treatment algorithms that *should* improve outcome
Do they??
Concerns and Pitfalls

• Sensitive technologies may detect subclinical disease that should be left alone
• Overinterpretation
• Detection of non-target findings that may not have clinical relevance but require additional testing
• Risk from invasive or semi-invasive procedures
• Radiation exposure
• Contrast agents – adverse effects
• Cost
Incidence of Mitral Valve Prolapse
1982 vs. 2014

14.2% for 1982
2.4% for 2014
Imaging: Cardiologist’s Wish List…

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Prognostic Information
Prognostic Information of Echo in CHF Val-Heft Trial

n=5010 Pts.

Wong M: JACC 2004;43:2022
Asymptomatic Aortic Stenosis


Event-free Survival (%) for AV-Vel categories:
- AV-Vel > 4 m/s
- AV-Vel 3-4 m/s
- AV-Vel < 3 m/s
Revascularization vs. Medical Rx in PTS. with no prior CAD undergoing stress SPECT

![Graph showing risk of death vs. total ischemic myocardium percentage.]

Extent and severity of myocardial hypoperfusion as predictors of prognosis in patients with suspected CAD

Ladenheim M: J Am Coll Cardiol 7:464, 1986
Differences in All-Cause Mortality Risk based on CCT Angiography Findings: CONFIRM Registry

Min JK: J Am Coll Cardiol 58:849, 2011
What about Imaging in Ischemic Heart Disease?
Epilogue: What Do Clinicians Expect From Imagers?

Eugene Braunwald, MD, MACC
Boston, Massachusetts

Although the expectations of clinicians caring for patients with coronary artery disease have changed with the advent of new imaging modalities, they are fairly straightforward. Clinicians need assistance in the identification of patients who are at very high risk of developing acute coronary events. In a large proportion of coronary artery imaging.

A number of new potent agents to suppress the inflammation that leads to rupture of vulnerable coronary plaques are now on the horizon, but it is unlikely that their systemic administration will be free of risk and therefore they will have to be used selectively. Other radical strategies to protect "vulnerable patients" could involve the implantation of multiple drug-eluting stents, or even coronary surgery to bypass multiple unstable plaques in the proximal coronary arterial tree. Obviously, careful risk-benefit analyses will need to be carried out with these therapeutic approaches. In the near term, imaging to identify multiple high-risk vulnerable plaques will require an invasive approach to be incorporated into the coronary arteriographic examination. Given the multicentricity of vulnerable plaques, the proximal segments of all three major coronary arteries will have to be examined. This accomplishment appears to be
Need for Clinical Trials of CV Imaging

• So far predominantly cohort studies

• Need for properly designed randomized trials using clinical events as outcomes

• Testing a strategy of imaging versus no imaging

• Comparison between distinct imaging modalities

• Endpoints: death, cardiac death, composite (for example cardiac death and MI...)


OAT (Occluded Artery Trial)
Coronary Intervention After MI

- 2166 patients randomized, SPECT in 589 – viability testing in 124
- Mild to mod. ischemia in 40% of SPECT pts
- Ischemia did NOT alter finding that an open artery did not improve outcome after MI! (however, pts with severe ischemia excluded from trial)

Hochman JS: NEJM 2006;355:2395
INSPIRE Trial

- 728 pts – 205 with large total (≥20%) and ischemic (≥10%) SPECT perfusion defects and an LVEF≥35%

- “SPECT could effectively monitor changes in scintigraphic ischemia after medical or revascularization therapy”

- Intensive medical therapy was comparable to revascularization (no identification by SPECT who would benefit from revascularization)

Mahmalian JJ: JACC 2006;48:2458
COURAGE Trial

- 2287 pts with objective evidence of ischemia and significant CAD

- Randomized to PCI + medical therapy vs. medical therapy alone

- PCI did not reduce the risk of death, MI or other cardiovascular events when added to medical therapy

Boden WE: NEJM 2007;356:1503
COURAGE Trial – Nuclear Substudy

- 314 of 2287 COURAGE pts enrolled
- Benefit of >5% reduction of ischemia (by either method), but prospective testing of this hypothesis still needed
- “…not certain that one would need imaging in clinical practice to achieve the goal of reduced symptoms”

Shaw LJ: Circulation 2008;117:1283
ISCHEMIA Trial - ongoing

- NIH sponsored, ~8000 participants, 500 sites
- Randomized to invasive vs. conservative strategy
- EF>35%, at least moderate ischemia on stress imaging by nuclear (≥10% myocardium), echo or CMR (≥3/16 segments) or perfusion CMR (≥12% myocardium)
- Primary endpoint: time to first occurrence of cardiovascular death or nonfatal MI
Myocardial Viability: Limitations of Cohort Studies

- Decision for CABG may have been influenced by viability status
- No (or inadequate) adjustment for key baseline variables (age, comorbidities)
- Cohort studies carried out before modern aggressive medical therapy
STICH: Myocardial Viability and Mortality

**Without Viability**

- **MED** (33 deaths)
- **CABG** (25 deaths)

**With Viability**

- **MED** (95 deaths)
- **CABG** (83 deaths)

### Subgroup Analysis

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>N</th>
<th>Deaths</th>
<th>HR</th>
<th>95% CI</th>
<th>Interaction P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without viability</td>
<td>114</td>
<td>58</td>
<td>0.70</td>
<td>0.41, 1.18</td>
<td>0.528</td>
</tr>
<tr>
<td>With viability</td>
<td>487</td>
<td>178</td>
<td>0.86</td>
<td>0.64, 1.16</td>
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</tr>
</tbody>
</table>

**Percentage Comparison**

- **Without Viability**: MED 56% vs. CABG 42%
- **With Viability**: MED 35% vs. CABG 31%
Does Imaging Improve Outcome?

• Imaging has changed the practice of Cardiology: Essential for obtaining diagnosis, to follow the course of disease, guidance of interventions

• Numerous trials have shown that imaging provides information about prognosis

• Evidence from randomized trials still limited that an imaging test leads directly to improved health outcomes, especially in terms of mortality rate

• However, such trials are difficult, expensive and often inconclusive
The CONSERVE Trial

**CORonary Computed Tomographic ANgiography for SElective Cardiac Catheterization RElation to CardioVascular Outcomes and EConomics**


Severance Cardiovascular Hospital, Yonsei University Health System, Seoul, South Korea; Daloo Institute of Cardiovascular Imaging,

Well Cornell Medical College and New York-Presbyterian Hospital; MDDX; CARE Hospital and FACTS Foundation; Inje University, Ilsan Paik Hospital; Centro Cardiologico Monzino, IRCCS; Pusan National University Hospital; Korea University Guro Hospital; Gangneung Asan Hospital; Ajou University Hospital; Kangwon National University Hospital; Chung-Ang University Hospital; Wonju Severance Hospital; Cardiology Associates of Mobile; Gangnam Severance Hospital; Yeungnam University Hospital; Walter Reed Medical Center; Quanta Dagnostic Nuclear, Curitiba-PR; Institute of Cardiology; University of Minnesota, Minneapolis; VU Medical Center; Asan Medical Center, University of Ulsan College of Medicine; Myongji Hospital, Seonam University College of Medicine; Emory University School of Medicine

ESC CONGRESS

Rome 2016

Hot Line presentation

www.escardio.org/ESC2016
Consort Diagram

- Enrolled (n=1,664)
- Randomized (n=1,631)
  - Follow-Up (Median 12.3 months)
    - Final Analysis (n=1,503)
      - Direct (n=719)
      - Selective (n=784)

- Enrollment Period: 2012 – 2015
- 6 Countries, 18 Sites

- Trial-Assigned Test
  - Direct ICA strategy (ICA): 89% (719/808)
  - Selective ICA strategy (CCTA): 95% (784/83)

- For patients who withdrew test, no difference in demographics / CAD risk factors between Direct ICA versus Selective ICA strategies
## Primary Endpoint (Clinical)

### MACE Rates

<table>
<thead>
<tr>
<th></th>
<th>Direct ICA</th>
<th>Selective ICA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6% (33/719)</td>
<td>4.6% (36/784)</td>
<td></td>
</tr>
</tbody>
</table>

### Hazards Ratio for MACE (p=0.99)

<table>
<thead>
<tr>
<th>Event</th>
<th>Overall</th>
<th>Direct ICA</th>
<th>Selective ICA</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACE (primary)</td>
<td>69 (4.6%)</td>
<td>33 (4.6%)</td>
<td>36 (4.6%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Non-fatal MI</td>
<td>4 (0.3%)</td>
<td>2 (0.3%)</td>
<td>2 (0.3%)</td>
<td>1.00</td>
</tr>
<tr>
<td>UA</td>
<td>17 (1.1%)</td>
<td>8 (1.1%)</td>
<td>9 (1.1%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Urgent / emergent revascularization</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>-</td>
</tr>
<tr>
<td>CV hospitalization</td>
<td>64 (4.3%)</td>
<td>31 (4.3%)</td>
<td>33 (4.2%)</td>
<td>1.00</td>
</tr>
<tr>
<td>CV Death</td>
<td>3 (0.2%)</td>
<td>1 (0.1%)</td>
<td>2 (0.3%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Stroke</td>
<td>4 (0.3%)</td>
<td>2 (0.3%)</td>
<td>2 (0.3%)</td>
<td>1.00</td>
</tr>
</tbody>
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