IMAGING TOOLS FOR HEART FAILURE IN 2018

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Disclosures

• I am not an imaging cardiologist
Imaging tools in heart failure

Finding clues to improve patient management
Imaging tools in heart failure

Avoiding risks and noise by using the best evidence
Case: Baseline information

• 73 year-old male
• Past medical history:
  – Recently diagnosed diabetes type 2, non-pharmacologically treated
  – Hypertension
  – Long-life non-smoker
  – Very functional, lived with and took care of his wife who was wheel-chair bound
Case: Heart failure

• 5-day history of cough, running nose and diarrhea that resolved completely

• Presented to ED few days later with
  – Increasing exertional dyspnea (to NYHA class III)
  – Orthopnea
  – Paroxysmal nocturnal dyspnea
  – Peripheral edema
  – Normal blood pressure, tachycardia, afebrile, normal oxygen saturation at room air
Case: Chest x-ray at admission

- Cardiomegaly
- Upper lobe venous redistribution with prominent pulmonary vasculature
- Bilateral small pleural effusions
Case: Blood work at admission

- Mild anemia: Hemoglobin 135 g/L
- Normal creatinine
- Increased BNP (1300 pg/ml)
- Normal HS-troponin
- Increased LDL-cholesterol (2.8 mmol/L)
- Increased Hemoglobin A1c 10.4%
Case: ECG at admission

- Normal sinus rhythm (88 bpm)
- ST&T abnormalities: possible infero-lateral ischemia
Case: Echocardiogram at admission

- Biventricular dysfunction
- LVEF 20%
- Biventricular dilation (LVEDd 6.5cm)
- Global hypokinesis
- No significant valvulopathies
- No intra-cardiac clots
- No pericardial effusion
Case: Admitting diagnosis

- Decompensated heart failure due to newly diagnosed dilated cardiomyopathy
- Plan:
  - Therapy: IV diuresis, initiation of HF meds
- Diagnosis
  - ?
Diagnosis

• What test would you consider next?

  a) Coronary angiogram
  b) Myocardial perfusion scan
  c) Cardiac magnetic resonance
  d) Endomyocardial biopsy
  e) All of the above
Case: Cardiac magnetic resonance (CMR)

- Prominently dilated LV (161 ml/m$^2$) with severely impaired global LV dysfunction (EF=17%)
- No focal wall thinning
- No myocardial edema (T2)
- No hyperemia (T1)
- Patterns of non-ischemic LGE: septal mid-wall, small single spot in infero-lateral wall
- Small pericardial effusion
- **Impression: Post-infectious myocarditis**
CMR in myocarditis: Lake-Louise criteria

• Acute changes:
  1. Edema: T2
  2. Hyperemia: global relative early gadolinium enhancement (T1)

• Subacute and chronic changes
  3. Necrosis and scar: late gadolinium enhancement in mid-wall or sub-epicardial distribution (frequency: 40% to 85%)
  4. Pericardial effusion and LV dysfunction

Abdel-Aty et al. JACC 2005
Accuracy of CMR for myocarditis

• Sensitivity (based on 2 of 3 components: T1, T2 and LGE)
  – Acute (<14 days from onset of symptoms)= 81%
  – Chronic (>14 days)= 63%
  – Overall = 76%

• Negative predictive value
  – Acute (<14 days from onset of symptoms)= 55%
  – Chronic (>14 days)= 50%
  – Overall = 54%
Myocarditis

• Frequent cause of dilated cardiomyopathy
  – Incidence 9-16%  
  
Felker et al. *Medicine* 1999

• Variable clinical presentation
  – Sudden cardiac death, acute coronary syndrome, 
    new onset heart failure, asymptomatic

• Endomyocardial biopsy (EMB) is considered 
  the gold standard diagnostic test
Sensitivity of endo-myocardial biopsy (EMB)

- 1 sample = 22%
- 8 samples = 48%
- >15 samples = 78%
- RV sample (~6 samples) = 8%
- LV sample (~6 samples) = 19%
- Bi-V sample (~11 samples) = 73%
- 1% complication rate

The ACC recommends against the performance of routine EMB expect in specific situations where diagnosis may change therapy

EMB is the gold-standard but it has poor performance:
1- Lesions are focal and patchy
2- More frequently localized in the sub-epicardial to mid-myocardial ventricular layers

Chow et al. /JACC 1989
Yilmaz et al. /Circulation 2010
The ACC recommends against the performance of routine EMB expect in specific situations where diagnosis may change therapy

1% complication rate

EMB is the gold-standard but it has poor performance:
1- Lesions are focal and patchy
2- More frequently localized in the sub-epicardial to mid-myocardial ventricular layers
EMB nowadays

- In a U.S. national retrospective study in ~22,000 patients admitted with presumed myocarditis between 1998-2013:

  - Incidence of myocarditis:
    - 900 patients
    - 1800 patients

  - Number of EMBs:
    - 50 EMBs

Elbadawi et al. J Card Failure 2018
EMB nowadays

Frequency of EMBs

- Patient with EMB:
  - Younger
  - Female
  - Kidney dysfunction
  - Diabetes

- Higher risk of
  - Mortality (6% vs 4%)
  - Tamponade (1.5% vs 0.3%)
  - Ventricular arrhythmias (18% vs 6%)
  - Cardiogenic shock (18% vs 5%)
  - Prolonged hospital stay
CMR in myocarditis: prognosis

- Edema: T2 and global relative enhancement (T1)
- Necrosis and scar: late gadolinium enhancement

Overall 80% of patients with myocarditis will recover cardiac function

Abdel-Aty et al. JACC 2005
Prognosis: 80% patients with LVEF >40%

Combined end point of death, ICD, HF, recurrent myocarditis or SCD

Prognosis: Patients with LVEF >50%

In this case, CMR provided important diagnostic and prognostic information

- Myocarditis
- High probability of LV function recovery
- LGE in septal and inferior wall = 10-15% risk of events at 10 years
However...

- Our patient is old and has untreated diabetes
- Ischemic cardiomyopathy is the main cause of dilated cardiopathy
Diagnosis

• What test would you consider next?

  a) Coronary angiogram
  b) Myocardial perfusion scan
  c) All of the above
Case: Coronary angiography

- RCA = 90%
- LAD = 90%
- D2 = 60%
- OM1 = 65%
- RCA = 100%
- Cx = 100%

- Diffuse CAD
- Critical multi-vessel disease
What’s next then?

• Question: What would you recommend?
  a) Multi-vessel PCI
  b) CABG surgery
  c) Medical management

• Question: When?
  a) During admission
  b) After HF meds optimization
  c) If symptoms worsen
Our patient’s calculated perioperative risk for death is 6.5% based on Euro score II due to:
• age (attributable risk ~2%), and
• poor LV function (attributable risk ~4%)

- Patients:
  • 1212 patients with ischemic CMP
  • LVEF <35%, amenable to CABG
  • Mean age 60 yrs, 40% diabetes, 40% NYHA class III-IV
- Randomized to CABG vs. Medical Rx
- Secondary Outcomes:
  • Death or hospitalization (HR 0.84, 0.71-0.98)
  • 30-day mortality: 4% CABG vs. 1% Med Rx (HR 3.1; 1.3-.3)
17% cross-over – randomized to Med Rx had CABG due to worsening symptoms (~70%)

CABG at randomization or within first year follow up

All-cause mortality

HR = 0.70 (0.58 – 0.88)

50%

38%

ARD = ~12%

Velazquez et al. NEJM 2011
**Long-term benefit of revascularization**

STICH long-term follow up
Med 9.8 years

CABG associated with reduced all cause mortality, CV mortality, death or CV hospitalization

Velazquez et al. *NEJM* 2016
What’s next then?

• Question: What would you recommend?
  
  a) Multi-vessel PCI
  b) CABG surgery
  c) Medical management
  d) Assessment of viability
Reversible ischemia versus viability

Normal → Ischemia → Viability → Infarction

Myocardial perfusion imaging → CMR or PET

<table>
<thead>
<tr>
<th>Reversible Ischemia</th>
<th>Viability</th>
<th>Infarction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall motion</td>
<td>Hypokinesia</td>
<td>Akinesia</td>
</tr>
<tr>
<td>Metabolism</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Perfusion</td>
<td>Reversible defect</td>
<td>Fixed defect</td>
</tr>
<tr>
<td>LGE</td>
<td>Absence</td>
<td>LGE&lt;50%</td>
</tr>
</tbody>
</table>
CMR = gold standard to detect viability

Dastidar et al. BMJ Heart 2015
CMR in patients undergoing CABG

• Contractility post CABG increased in 78% in myocardial areas without LGE and 2% if LGE >75% of wall
  
  Kim et al. NEJM 2000
  Selvanayagam et al. Circulation 2004

• LGE <25% of wall thickness predicts contractile improvement
  
  Choi et al. Circulation 2001

• LGE <50% of wall thickness predicts improvement in LVEF
  
  Pegg et al. J Cardiovasc Mag Res 2010
  Bingham et al. Circulation 2011
Reversible ischemia and revascularization

HR = 0.30 (0.24 – 0.37)

Ibana et al. J Nucl Cardiol 2012
Absence of ischemia and revascularization

HR = 0.91 (0.77 – 1.08)
Myocardial viability: Reversible ischemia (DSE or SPECT)

STICH sub-analysis on 601 patients

A Without Myocardial Viability

B With Myocardial Viability

C

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No.</th>
<th>Deaths</th>
</tr>
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<tbody>
<tr>
<td>Without viability</td>
<td>114</td>
<td>58</td>
</tr>
<tr>
<td>With viability</td>
<td>487</td>
<td>178</td>
</tr>
</tbody>
</table>

Hazard Ratio (95% CI)

- CABG Better: 0.70 (0.41–1.18)
- Medical Therapy Better: 0.86 (0.64–1.16)

P Value for Interaction: 0.53

Bonow et al. NEJM 2011
3-year mortality risk according to the presence of viability in patients undergoing complete revascularization vs. Med Rx or incomplete revascularization

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No.</th>
<th>Hazard Ratio [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Viability*</td>
<td>43</td>
<td>0.71 [0.18-2.8]</td>
</tr>
<tr>
<td>With Viability</td>
<td>101</td>
<td>4.56 [1.93-10.8]</td>
</tr>
</tbody>
</table>

* Viability = LGE<50% in >4 dysfunctional areas

Gerber et al. JACC 2011
CABG or not: Guideline recommendations

• Patients with HF and reduced LVEF are more likely to experience significant improvement in LVEF after successful coronary revascularization if they have:
  – Reversible ischemia or a large segment of viable myocardium (> 30% of the left ventricle);
  – Reversible ischemia or > 7% hibernating myocardium on PET scan;
  – Reversible ischemia or > 20% of the LV shown as viable using DSE;
  – < 50% LGE on CMR
Case: Follow up

• Over next 4 months, medical therapy titrated
  – ASA 81 mg/d
  – Bisoprolol 10 mg/d
  – Entresto 200 mg/q12h
  – Spironolactone 25 mg/d
  – Atorvastatin 80 mg/d
  – Empagliflozin 10 mg/d

• NYHA II

• BNP <100 pg/dl
Case: Repeat CMR after 4 months

- Improved LV function (EF=40%) and size (120ml/m²)
- Patterns of non-ischemic LGE: linear septal mid-wall enhancement identified from the basal to mid-ventricular location
- Viability in all of the walls (LGE <50%)

Our patient’s calculated perioperative risk for death is 3.3% based on Euro score II ➔ 50% predicted risk reduction by improved LVEF
In this case, CMR provided important diagnostic and prognostic information

- Viability in all areas
- High probability of LV function recovery if revascularized
- Survival benefit with complete revascularization
Case: Follow-up

• Underwent 4-vessel CABG
• Uncomplicated OR
• Discharged home 8 days later
• LVEF 48%
Thanks!
Questions

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