HF update

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Imaging in cardiology

Finding clues to improve patient management
Imaging in cardiology

Minimizing uncertainty by using the best evidence
Case

• 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 due to previous stroke
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
Chest x-ray at admission

- Cardiomegaly
- Upper lobe venous redistribution with prominent pulmonary vasculature
- Bilateral small pleural effusions
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 umol/L)
• Increased Hemoglobin A1c 10.4%
ECG at admission

- Normal sinus rhythm (87bpm)
- ST&T abnormalities: possible infero-lateral ischemia
Echocardiogram at admission
- Biventricular dysfunction
- LVEF 20%
- Biventricular dilation (LVEDd 6.5cm)
- Global hypokinesis
- No significant valvulopathies
- No intra-cardiac clots
- No pericardial effusion
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 MRI
   d) Cardiac biopsy
   e) All of the above
Cardiac magnetic resonance

- Prominently dilated LV with severely impaired global LV dysfunction (EF=17%)
- Patterns of non-ischemic LGE
- Small pericardial effusion
- Impression: Post-infectious myocarditis vs. primary dilated cardiomyopathy

AlJaroudi et al. JACC 2013
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 of sub-epicardial distribution (frequency: 40% to 85%)
  4. Pericardial effusion and LV dysfunction

Abdel-Aty et al. JACC 2005
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 CMR

- 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%

Lurz et al. JACC 2012
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
EMB nowadays

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

**Incidence of myocarditis**

- Total number of patients:
  - 1800 patients
  - 900 patients

**Number of EMBs**

- Number of cases having myocardial biopsy:
  - 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 information

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

Better  Prognosis  Worse

- 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%

Combined end point of death, ICD, HF or SCD

In this case, CMR provided important diagnostic and prognostic information

- Myocarditis
- High probability of LV function recovery
- LGE in anteroseptal wall = 10% mortality at 10 years
However...

• Out 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
Coronary angiography

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

- Diffuse CAD
- Critical multi-vessel disease

RCA = 100%
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 Euroscore 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:
- 30-day mortality: 4% CABG vs. 1% Med Rx (HR 3.1; 1.3-.3)
- Death or hospitalization (0.84, 0.71-0.98)

Velazquez et al. *NEJM* 2011
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)

ARD = ~12%

Velazquez et al. NEJM 2011
17% cross-over – randomized to Med Rx had CABG

CABG at randomization (exclusion of cross-over pts)

All-cause mortality

HR = 0.76 (0.52 – 0.82)

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
Viability and revascularization

HR = 0.30 (0.24 – 0.37)
Absence of Viability and revascularization

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

STICH sub-analysis on 601 patients

A. Without Myocardial Viability

- Medical therapy (33 deaths)
- CABG (25 deaths)

B. With Myocardial Viability

- Medical therapy (95 deaths)
- CABG (83 deaths)

C. Subgroup Analysis

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No.</th>
<th>Deaths</th>
<th>Hazard Ratio (95% CI)</th>
<th>P Value for Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without viability</td>
<td>114</td>
<td>58</td>
<td>0.70 (0.41–1.18)</td>
<td>0.53</td>
</tr>
<tr>
<td>With viability</td>
<td>487</td>
<td>178</td>
<td>0.86 (0.64–1.16)</td>
<td></td>
</tr>
</tbody>
</table>

Bonow et al. *NEJM* 2011
Inducible ischemia versus viability

- Normal motion ➔ Hypokinesia ➔ Akinesia
- Normal contractile reserve ➔ no contractility
- No LGE ➔ LGE <50% ➔ LGE >50%

Stress studies ➔ CMR or Tallium ➔ Infarction

At risk ➔ Infarct
CMR = gold standard to detect viability

No LGE in bases

LGE>50% mid and apical anterior and septal walls

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

* 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 positron emission tomography scanning;
  – Reversible ischemia or > 20% of the left ventricle shown as viable using dobutamine stress echo;
  – Less than 50% wall thickness scarring shown by LGE on CMR imaging
Repeat cardiac magnetic resonance after 4 months

- Improved LV function (EF=40%) and size (90ml/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 Euroscore 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
Follow up

• Over next 4 months, medical therapy titrated
  – ASA 81 mg/d
  – Bisoprolol 10 mg/d
  – Ramipril 10mg/d
  – Spironolactone 25 mg/d
  – Furosemide 20 mg/d
  – Atorvastatin 80 mg/d
  – Empagliflozin 10 mg/d

• NYHA II

• BNP <100 pg/dl
Follow-up

- Underwent 4-vessel CABG
- Uncomplicated OR

- Discharged home 8 days later

- LVEF 48%