Role of Imaging in Arrhythmia Evaluation Post Sudden Death

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Conflicts of interest

none relevant
Summary

- Ejection fraction --- sudden death
- Fibrosis as a predictor of sudden death
- CMR in out-of-hospital cardiac arrest survivors
Sudden death registries

Oregon Sudden Unexpected Death Study
- 48% had normal LVEF
- 22% had mild to moderately reduced LVEF
- 30% had severely reduced LVEF

Maastricht Circulatory Arrest Registry

<table>
<thead>
<tr>
<th>LVEF</th>
<th>n=9258</th>
<th>n=200a</th>
<th>%*</th>
<th>p</th>
<th>n=81b</th>
<th>%*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–30</td>
<td>508</td>
<td>38</td>
<td>7.5</td>
<td>.000</td>
<td>26</td>
<td>5.1</td>
<td>.000</td>
</tr>
<tr>
<td>31–40</td>
<td>628</td>
<td>32</td>
<td>5.1</td>
<td></td>
<td>14</td>
<td>2.2</td>
<td></td>
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<tr>
<td>41–50</td>
<td>1050</td>
<td>29</td>
<td>2.8</td>
<td></td>
<td>12</td>
<td>1.2</td>
<td></td>
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<tr>
<td>&gt;50</td>
<td>7072</td>
<td>101</td>
<td>1.4</td>
<td></td>
<td>29</td>
<td>0.41</td>
<td></td>
</tr>
</tbody>
</table>

*% of SCA cases per LVEF class is presented.

a n=200 all SCA cases with echo data on LVEF.
b n=81 SCA cases, with echo taken between 1997–2000.
Ejection Fraction and Sudden Death

Not the ideal parameter
Not the only parameter
Myocardial Fibrosis

Hematoxylin and eosin staining from endomyocardial biopsies in Aortic Stenosis patients

No Fibrosis  Mild Fibrosis  Severe Fibrosis

Circulation. 2009;120:577-584
Fibrosis and Arrhythmias in HCM

87 HCM patients - AF

177 HCM patients - VEs

Papavassiliu T et al.
JCMR 2009;11:34

Adabag AS et al.
JACC 2008;51:1369-74
Fibrosis – Ejection Fraction

• Fibrosis - Ejection Fraction, not a good correlation!
Detection of Myocardial Fibrosis

Echocardiographic parameters

• Backscatter
• Subclinical systolic / diastolic dysfunction (TDI, strain)

Nuclear Methods

• SPECT molecular labeling
• PET-perfusable tissue index

Endomyocardial Biopsy

Invasive
Sampling error
Cannot assess the entire heart
Detection of Myocardial Fibrosis

Cardiac Magnetic Resonance (CMR)

• Late Gadolinium Enhancement (LGE)

• T1 Mapping

• Extracellular volume (ECV) imaging
Scar presence & Outcome in CAD

11,636 patients - follow-up of 32 months

857 patients follow-up 4.4 years


Circulation 2009; 120: 2069-2076
Late Gadolinium Enhancement
Fibrosis patterns

Ischemic
A Subendocardial Infarct
B Transmural Infarct

Nonischemic
A Mid-wall HE
- Idiopathic Dilated Cardiomyopathy
- Myocarditis
- Hypertrophic Cardiomyopathy
- Right ventricular pressure overload (e.g., congenital heart disease, pulmonary HTN)
- Sarcoïdosis
- Myocarditis
- Anderson-Fabry
- Chagas Disease

B Epicardial HE
- Sarcoïdosis, Myocarditis, Anderson-Fabry, Chagas Disease

C Global Endocardial HE
- Amyloidosis, Systemic Sclerosis, Post cardiac transplantation

Karamitsos T.
JACC 2009;54:1407
Dilated Cardiomyopathy – Fibrosis

Gulati A et al. JAMA 2013
Fibrosis in HCM
Extent of late gadolinium enhancement and sudden cardiac death events in **1293 patients with HCM**

- Extensive LGE provides additional information for assessing SCD event risk among HCM patients, particularly patients otherwise judged to be at low risk

Chan et al. Circulation. 2014;130:484-495
2750 people with HCM over 2 years, followed up for up to 5 years
Across a wide spectrum of patients with DCM, the presence of LGE is associated with a significant increase in the occurrence of VAs or sudden death.

The association between LGE and the arrhythmic outcome was independent of other covariates, including LVEF.
Mid-Wall Fibrosis and Sudden Death in mild/moderate DCM

Association between mid-wall LGE and the pre-specified primary composite outcome of SCD or aborted SCD amongst consecutive referrals with DCM and LVEF≥40% who did not have a pre-existing indication for ICD implantation

- **399 patients**
  - 145 women
- **Median LVEF 50%** (IQR:46-54%
- **Mid-wall LGE was present in 25%**

*Circulation* May 2, 2017, Volume 135, Issue 18
LGE predicts adverse cardiovascular outcomes in nonischemic cardiomyopathy

1488 patients

*p-values are for the significance of the annualized event rate difference between LGE+ and LGE- subjects.

Circ Cardiovasc Imaging 2014;7:250-8
Survivors of out-of-hospital cardiac arrest
Acute coronary angiographic findings in survivors of out-of-hospital cardiac arrest

Most (63.9%) OHCA survivors had angiographic coronary artery disease (≥1 lesion >50%), but only a minority (37.5%) had clinical or angiographic evidence of an acute coronary syndrome due to either an acute occlusion (16.7%) or an irregular lesion suggestive of ruptured plaque or thrombus (25.0%)

Am Heart J 2009;157:312-8
Retrospective review of all survivors of sudden cardiac death who were referred for CMR
1) Out of 174 OHCA survivors referred for CMR, 110 patients (63%, 84 male) had an inconclusive angiogram

2) CMR identified a pathologic substrate in 69% of the population: ischemic heart disease 41% and non-ischemic disease 28%. A structurally normal heart was found in 25 patients (23%) and non-specific findings in 9 (8%)

3) CMR had a clinical impact in more than two thirds of patients
   – New diagnosis or change of management
   – CMR identified ischemic myocardial damage in 11 patients (15%) with unobstructed coronaries on angiogram

Resuscitation 2017 (in press)
Limitations of Late Gadolinium Imaging

- Needs **contrast**
  - Renal dysfunction
  - Allergy

- **Diffuse, homogenously distributed fibrosis?**
Native T1 Mapping – Correlation with Histology

- 109 patients with moderate and severe Aortic stenosis
- 33 controls

Heart. 2013; 99: 932–937
CMR for Comprehensive Fibrosis Imaging

MYOCARDIAL FIBROSIS

Infarct Fibrosis  Replacement Fibrosis  Diffuse Fibrosis
Take Home Messages

Sudden death prediction

• Ισχαιμική μυοκαρδιοπάθεια
• Σε μη ισχαιμικής αιτιολογίας μυοκαρδιοπάθειες, η αποκάλυψη ινώσης στη μαγνητική τομογραφία φαίνεται να είναι ανεξάρτητος προγνωστικός δείκτης εμφάνισης αρρυθμιών και αιφνιδίου θανάτου

Out of Hospital Cardiac Arrest Survivors

• Αν δεν υπάρχουν σαφή κλινικά, ΗΚΓ και αγγειογραφικά στοιχεία οξέος ισχαιμικού συνδρόμου, η διενέργεια μαγνητικής τομογραφίας καρδιάς μπορεί να βοηθήσει στην αποκάλυψη της αιτίας