ROLE OF IMAGING
Evaluation of cardiomyopathies (hypertrophic-dilated)

2017

Division of Inherited Cardiac Diseases
Heart Center for the Young and Athletes
A’ Dpt. of Cardiology – University of Athens
• Young man that plays football
• Age: 17 years old
• Asymptomatic
• o/e = Normal
• Personal history (-)
• Family history (-)
Clinical evaluation

Pedigree
Signs
Symptoms
ECG
Echo
CMR
Laboratory

Diagnostic red flags

Features suggesting a specific disease?

yes
Further specialised tests & multidisciplinary input

no

Genetic Testing

Genetic testing

Definite disease causing sarcomere protein gene mutation

or

No definite disease causing sarcomere protein identified

Specific genetic/acquired disorder

Reconsider other genetic/non-genetic causes

ESC
HCM GUIDELINES
2014
**MRI IN HCM**

- **GUIDELINES 2014**

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class $^a$</th>
<th>Level $^b$</th>
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<tr>
<td>In the absence of contraindications, CMR with LGE should be considered in patients fulfilling diagnostic criteria for HCM, to assess cardiac anatomy, ventricular function, and the presence and extent of myocardial fibrosis.</td>
<td>IIIa</td>
<td>B</td>
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CMR – how to use information

Fibrosis in Hypertrophic Cardiomyopathy—does it have prognostic implications?

In 2/3 of HCM pts there is myocardial fibrosis
ESC GUIDELINES IN HCM 2014

LA >45mm
HYPERTROPHIC CARDIOMYOPATHY

INTERVENTION IN SYMPTOMATIC CASES

HOCM
DDDR
ABLATION
MYECTOMY
2D and Doppler echocardiography at rest, Valsalva and standing

- Maximum provoked peak LVOTO ≥50 mm Hg
  
  see 9.1 Treatment of left ventricular outflow tract obstruction

- Maximum provoked peak LVOTO <50 mm Hg
  
  Asymptomatic*
  
  Repeat echocardiography 1 year

  Symptomatic
  
  Exercise stress echocardiography
  
  - Maximum provoked peak LVOTO ≥50 mm Hg
    
    see 9.1 Treatment of left ventricular outflow tract obstruction

  - Maximum provoked peak LVOTO <50 mm Hg
    
    Medical therapy (see 9. Management of symptoms and complications)
PROVOKED LVOT gradient
70% HCM pts
The echocardiographer challenge

First branch

Second branch
LVOT gradient before and after the procedure

F/U
MR
BEFORE AND AFTER SEPTAL ABLATION

F/U
Recommendations on transoesophageal echocardiography

MV STRUCTURAL ABNORMALITIES

TOE should be considered in patients with LVOTO if the mechanism is unclear, or when assessing the mitral valve apparatus before a septal reduction procedure, or when severe mitral regurgitation, caused by intrinsic valve abnormalities, is suspected.

ESC HCM GUIDELINES 2014
Guiding the myectomy
The Diagnosis of inherited cardiac disease concerns the Patient and the Family

HYPERTROPHIC CARDIOMYOPATHY

- Cardiology
- Pediatrics
- Genetics

MOLECULAR CARDIOLOGY

Family Screening

Typical form

Subclinical form

Gene carrier

Follow up every year

Relatives that have not been genotyped >20 years of age Follow up every 3 years
SUBCLINICAL FORM OF HCM DUE TO EVOLUTION
Mutation: Arg286Cys

CONCEALED FORM OF HCM DUE TO SUBCLINICAL EXPRESSION
CMR With Late Gadolinium Enhancement in Genotype Positive–Phenotype Negative Hypertrophic Cardiomyopathy

Ethan J. Rowin et al., JACC, 2012

In G+P- HCM patients, cardiac magnetic resonance (CMR) identified substantial late gadolinium enhancement (LGE) indicative of myocardial fibrosis (structural abnormality)
Figure 7 Flow chart for ICD implantation.

**PRIMARY PREVENTION**

- Recommended assessment:
  - History
  - 2-D/Doppler echocardiogram
  - 48-hour ambulatory ECG

- HCM Risk-SCD variables:
  - Age
  - Family history of sudden cardiac death
  - Unexplained syncope
  - Left ventricular outflow gradient
  - Maximum left ventricular wall thickness
  - Left atrial diameter
  - NSVT

  HCM-Risk SCD Score

  - LOW RISK 5-year risk <4%
    - ICD generally not indicated
  - INTERMEDIATE RISK 5-year risk ≥4%–<6%
    - ICD may be considered
  - HIGH RISK 5-year risk ≥6%
    - ICD should be considered

**SECONDARY PREVENTION**

- Cardiac arrest due to VT or VF
- Spontaneous sustained VT causing syncope or haemodynamic compromise

  Life expectancy >1 year

  ICD recommended
Holds for typical hypertrophic cardiomyopathy > 16 years of age and not for special types of HCM - phenocopies

**ESC GUIDELINES IN HCM 2014**

**Modifiers**
- MRI – Fibrosis
- Apical aneurysm
- EF < 50%
- Double mutation
- Abnormal blood pressure response
- Electrophysiological Test (EPS)

**HCM Risk-SCD variables:**
- Age
- Family history of sudden cardiac death
- Unexplained syncope
- Left ventricular outflow gradient
- Maximum left ventricular wall thickness
- Left atrial diameter
- NSVT

**HCM Risk-SCD Score**

- **LOW RISK** 5-year risk < 4%
  - ICD generally not indicated

- **MEDIUM RISK**

- **HIGH RISK** 5-year risk ≥ 6%
  - ICD should be considered

**PRIMARY PREVENTION**

Recommended assessment:
- History
- 2D/Doppler echocardiogram
- 48-hour ambulatory ECG

- MRI – Fibrosis
- Apical aneurysm
- EF < 50%
- Double mutation
- Abnormal blood pressure response
- Electrophysiological Test (EPS)
Magnetic resonance imaging (MRI) in hypertrophic cardiomyopathy (HCM) involves several key considerations:

- **Guidelines 2014**
  - Late gadolinium enhancement (LGE) > 15-20% is considered significant.

Moon JC, Reed E, Sheppard MN, Elkington AG, Ho SY, Burke M, Petrou M, Pennell DJ. The histologic basis of late gadolinium enhancement cardiovascular magnetic resonance in hypertrophic cardiomyopathy. J Am Coll Cardiol 2004;43:

**CMR in HCM 2 Standard Deviation Technique**

LGE > 15-20% Significant

B Maron 2014
DCM
EVALUATION OF GLOBAL BIVENTRICULAR FUNCTION

EF, LV VOLUME, LV MASS

In DCM, LV ejection fraction is the strongest predictor of progression to heart failure, while LV volume and mass are independently correlated with mortality and morbidity; therefore accurate quantification of all these parameters is essential for adequate pts evaluation.
DD OF LGE AT CARDIAC MRI BY LOCATION

RadioGraphics 2009; 29:89–103 • Published online 10.1148/rg.291085052

Mesocardial
- Hypertrophic cardiomyopathy
- Dilated cardiomyopathy
- Pulmonary hypertension

Subendocardial
- Vascular
  - Infarction
- Non-vascular
  - Amyloid
  - Hypereosinophilic syndrome
  - Histiocytoid cardiomyopathy
  - Cardiac transplant

Patchy
- Sarcoid
- Amyloid
- Myocarditis

Subepicardial
- Myocarditis (most common)
- Sarcoid

Transmural
- Infarction (most common)
- Myocarditis, severe
- Sarcoid, chronic
Stress ECHO and CRT

Ejection fraction < 35%

Stress echo viability

Viability + present >5 segments “responders”

Good response to:
1. Revascularization
2. Resynchronization
3. Medical therapy

Viability absent

Bad response to:
1. Revascularization
2. Resynchronization
3. Medical therapy

Heart transplantation

Stress ECHO and CRT

In patients with depressed ejection fraction, lack of a substantial (five segments or more) viability response to dobutamine stress echocardiography is invariably associated with a lack of response to CRT.

- In other words, it is unlikely that home comfort will benefit from a brand-new electric system if there are no walls and no ceiling left.
Few parameters have been identified as good predictors of SCD in DCM pts

- EF
- Syncope

Keogh et al AJC 1990
Knight et al JACC 1999
Task Force on SCD/ESC 2002
Task Force on SCD- Arrhythmia/ESC 2006
MRI in DCM
FIBROSIS AND SUDDEN DEATH

In a large prospective longitudinal study of 472 patients with DCM with a median follow-up of 5.3 years was recently published providing evidence that the assessment of mid-wall fibrosis with LGE-CMR imaging was independent prognostic information beyond LVEF in patients with nonischemic dilated cardiomyopathy (HR, 2.43 (95% CI, 1.50-3.92); \( P < 0.001 \)).
Preclinical or Early phase

(Relative of patients with DCM or Hypokinetic Non Dilated CM)

Clinical phase

Dilated CM

(LV Dilation + Hypokinesia)

(Hypokinesia/no Dilation)

(HNDCM or DCM_{ND-H})

Arrhythmic CM

(Arrhythmias or conduction defect)

(HNDCM or DCM_{ND-H})

(DCM_{D-NH-A/CD}, with or without mut+AHA+)

Isolated Ventricular Dilation

(Dilation/no Hypokinesia)**

(DCM_{D-NH}, with or without mut+AHA+)

No cardiac expression

(Mutation carrier and/or AHA positive)

(no LV abn, no arrhythmia)

(DCM_{ND-NH-Mut+AHA+})

Progressive expression of the phenotype

*Shown by two independent imaging modalities, ^mutation carrier or not; anti-heart autoantibody (AHA) positive or negative
Hypokinetic non-dilated cardiomyopathy

- Left ventricular or biventricular systolic dysfunction without dilatation (defined as LVEF < 45%), not explained by abnormal loading conditions or coronary artery disease.

Note:

- Strictly decreased LVEF is mandatory in index patient with HNDC since no combination with dilatation is mandatory for the diagnosis.
POST MORTEM DATA

NORMAL STRUCTURALLY HEART

NORMAL CORONARY ARTERIES

SEGMENTAL OR REGIONAL FIBROSIS WITHOUT SPECIFIC HISTOLOGICAL FINDINGS

UNEXPLAINED OR VAGUE AETIOLOGY SUDDEN DEATH
Male, 28 years of age

ECG: 3 years ago

PR = 200 msec
FAMILY CLINICOGENETIC APPROACH

- SCD – Rest ECG abnormalities
- Person with indication of cardiomyopathy
- Normal person
+ = Person that was genetically tested and a mutation was identified
- = Person that was genetically tested and a mutation was not identified

Disease causative genetic mutation
p.Arg25Cys
of gene PLN
(phospholabane)

Mild DCM arrhythmogenic
- Concealed phase
- Overt phase
- Advanced disease
PTS CLINICAL PROFILE

ACM / DCM OR MYOCARDITIS?

- INVERTED T WAVES IN INFERIOR/LATERAL LEADS: MINOR
- S-A-ECG (+): MINOR
- SD IN THE FAMILY – FATHER: MINOR
- HOLTER: 600VE’ S/24 h ARRHYTHMIAS: MINOR

- Mild left ventricular dilation and/or systolic impairment
- Early arrhythmogenesis

- PREDOMINANT LV INVOLVEMENT - subepicardial fibrosis

- FAMILIAL ELEMENT
  - SCD
  - MYOCARDITIS
  - ARRHYTHMOGENESIS

ACM /ALVC

Sen-Chowdry et al, JACC 2008
CLINICO – GENETIC APPROACH

- Unaffected person
- Individual with structural abnormalities – myocardial fibrosis
- Mutation positive individual

AEE 44y
73y
SD 14y
SD 43y
60y
SD – CAD? 35y ago 40y

= Unaffected person

= Individual with structural abnormalities – myocardial fibrosis

= Mutation positive individual
2012: 50 VEs/24 h  
2016: 6,000 VEs/24 h
Isolated non ischemic LV LGE with a stria pattern may be associated with life-threatening arrhythmias and sudden death in the athlete.

Because of its subepicardial / midmyocardial location, LV scar is often not detected by echocardiography.

*Circ Arrhythm Electrophysiol. 2016*
TAKE HOME MESSAGE
HCM - DCM

IMAGING ESSENTIAL

► Diagnosis (part of the spectrum)
► Mechanisms of symptoms
► Risk stratification
► Decide how treat symptoms