Hypertrophic Cardiomyopathy (HCM)

Evaluation and Differential Diagnosis
Role of Echocardiography

William K. Freeman, MD, FACC, FASE
DISCLOSURES

Relevant Financial Relationship(s)
None

Off Label Usage
None
Hypertrophic Cardiomyopathy
Echocardiographic Diagnosis

Left Ventricular Hypertrophy $\geq 15$ mm
(Asymmetric $\gg$ Symmetric)

In the absence of another cardiovascular or systemic
disease associated with LVH
or myocardial wall thickening

Gersh, BJ, et al. JACC 2011; 58: e212  ACC/AHA Guidelines
Hypertrophic Cardiomyopathy
Echocardiographic Diagnosis

Not Mandatory for Diagnosis of HCM

- Asymmetric Septal Hypertrophy (ASH)
- Systolic Anterior Motion (SAM)
- Dynamic LVOT obstruction
Hypertrophic Cardiomyopathy
Distribution of LVH (600 Patients)

- Anterior and inferior septum (31%)
- Anterior septum only (25%)
- Septum & ant lat freewall (17%)
- Septum & all freewalls (17%)
- Lateral freewall (1%)
- Anterior septum & ant lat freewall (7%)
- Apex only (2%)

Klues HG, JACC 1995; 26: 1699
Left Ventricular Morphology in HCM

- Sigmoid Septum: 181 (47%) Gene + (8%)
- Reverse Septum: 132 (35%) Gene + (79%)
- Neutral Septum: 32 (8%) Gene + (41%)
- Apical Variant: 37 (10%) Gene + (32%)

Genetic testing for HCM
Mayo Clinic Database (389 Patients)

- Echocardiographic anatomic phenotypes are not specific for individual gene mutations
- Specific gene mutations not predictive of prognosis or need for myectomy

LVH in HCM: Sigmoid Septum
LVH in HCM: Neutral Septum
LVH in HCM: Reversed Septum
Systolic Anterior Motion (SAM)
HOCM: Systolic Anterior Motion (SAM)

- Drag effect >>> Venturi effect
- Anterior displacement of mitral valve and support apparatus; small LV cavity
- Septal encroachment into LVOT
- Mitral valve characteristics
  - Anterior displacement of papillary muscles
  - Unusual chordal attachments
  - Elongated anterior leaflet
  - Aberrant muscle bundles
Normal Anatomy of the LV Outflow Tract
Hypertrophic Cardiomyopathy
Systolic Anterior Motion (SAM)
Systolic Anterior Motion (SAM): LV Ejection ➔ Obstruction ➔ Regurgitation
Systolic Anterior Motion (SAM): LV Ejection
Systolic Anterior Motion (SAM): LV Ejection ➔ Obstruction
Systolic Anterior Motion (SAM):
LV Ejection ➔ Obstruction ➔ Regurgitation
Systolic Anterior Motion (SAM): LV Ejection → Obstruction → Regurgitation
Basal LVOT Obstruction
Basal LVOT Obstruction
Dynamic LVOT Obstruction vs. MR

CW Doppler \((\Delta P \approx 4V^2)\)
HCM Morphology and LVOT Obstruction
Mayo Clinic HCM Database (2,856 Patients)

- Resting Gradient <30 mmHg (41%)
- Provocable Gradient > 30 mmHg (27%)
- Mid-Cavity Obstruction (2%)
- Nonobstructive (23%)
- Apical HCM (7%)

Ommen SR, et al. 2006
39 y/o Executive: New DOE during workouts
Focal Anteroseptal Basal LVH = 17 mm
39 y/o Executive: New DOE during workouts

Rest
39 y/o Executive: New DOE during workouts

Rest
39 y/o Executive: New DOE During Workouts

Resting LVOT gradient = 12 mmHg
39 y/o Executive: New DOE During Workouts

Valsalva Maneuver
39 y/o Executive: New DOE During Workouts

Valsalva Maneuver
39 y/o Executive: New DOE During Workouts

Valsalva: LVOT gradient = 34 mmHg
39 y/o Executive: New DOE During Workouts

Amyl Nitrite
39 y/o Executive: New DOE During Workouts

Amyl Nitrite
39 y/o Executive: New DOE During Workouts

Amyl Nitrite: LVOT gradient = 77 - 100 mmHg

6.9 m/sec

5.0 m/sec

4.4 m/sec

LVOT

MR
Estimating LVOT Gradient Using MR Peak Velocity

MR Velocity = 6.9 m/sec         Systolic BP = 100 mmHg

\[ \Delta P \approx 4 \times (6.9)^2 = 190 \]

LV Pressure \( \approx 205 \)

LVOT gradient \( \approx 105 \)

LAP \( \approx 15 \)

Aortic \( \approx \) Systolic BP \( = 100 \)
Mid-Cavitary LVOT Obstruction
Mid-Cavitary LVOT Obstruction
Mid-Cavitary LVOT Obstruction
Asymmetric Inferior & Inferoseptal LVH
Mid-Cavitary LVOT Obstruction
Asymmetric Inferior & Inferoseptal LVH
Mid-cavitary LVOT Gradient: 56 mmHg
LVOT Obstruction in HCM: More than SAM Alone
Abnormal Mitral Support and Muscle Bundles
LVOT Obstruction in HCM: More than SAM Alone
Abnormal Mitral Support and Muscle Bundles
LVOT Obstruction in HCM: More than SAM Alone
Abnormal Mitral Support and Muscle Bundles
Apical HCM
Apical HCM
Apical HCM
Apical HCM
Apical HCM
Apical HCM with Apical Aneurysm
Apical HCM with Apical Aneurysm
Apical HCM with Apical Aneurysm
Apical HCM with Apical Aneurysm
Early and Late Systolic Outflow Obstruction ~ 60 mmHg

Systolic

Diastolic
Hypertrophic Cardiomyopathy Complicated by Apical Aneurysm

- Apical abnormalities in apical HCM: Pouch: 15%; Aneurysm: 3%

- Adverse events associated with aneurysm (not apical pouch)
  - Progressive heart failure/death (18%)
  - SCD or revived cardiac arrest (14%)
  - Appropriate ICD discharge (11%)
  - Nonfatal embolic stroke (7%)

Binder J et al. JASE 2011;24:775
Hypertrophic Cardiomyopathy
Differential Diagnosis of Thickened LV Walls

Cardiovascular

Acquired
- Hypertension
- Aortic stenosis
- Athlete’s heart

Systemic Disease
82 y/o Man: Hypertension x 30 yrs; No Sxs
34 y/o Triathlete: LVH on ECG, No Symptoms
LV wall thickness 13 mm
## Athlete’s Heart versus HCM

<table>
<thead>
<tr>
<th></th>
<th>HCM</th>
<th>Athlete’s Heart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LV wall thickness</strong></td>
<td>≥ 15 mm</td>
<td>&lt; 15 mm (usually &lt; 13 mm)</td>
</tr>
<tr>
<td><strong>Morphology</strong></td>
<td>Asymmetric</td>
<td>Symmetric</td>
</tr>
<tr>
<td><strong>LVEDD</strong></td>
<td>&lt;45mm</td>
<td>&gt;55mm</td>
</tr>
<tr>
<td><strong>Diastolic filling</strong></td>
<td>Abnormal</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>LA volume</strong></td>
<td>Increased</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Response to</strong></td>
<td>None</td>
<td>Regression of LVH</td>
</tr>
<tr>
<td><strong>deconditioning</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strain Imaging</strong></td>
<td>Abnormal</td>
<td>Normal</td>
</tr>
</tbody>
</table>

-Maron BJ. Heart 2005; 91: 1380

Hypertrophic Cardiomyopathy
Differential Diagnosis of Thickened LV Walls

Cardiovascular

Acquired
- Hypertension
- Aortic stenosis
- Athlete’s heart

Congenital
- Subaortic stenosis
- LV noncompaction

Systemic Disease
71 y/o Woman: Murmur Since Childhood; Previously Treated as HOCM

Congenital Fibromuscular Subaortic Stenosis
68 y/o Woman: Abnormal ECG; Asymptomatic Left Ventricular Noncompaction Syndrome
68 y/o Woman: Abnormal ECG; Asymptomatic Left Ventricular Noncompaction Syndrome
Hypertrophic Cardiomyopathy
Differential Diagnosis of Thickened LV Walls

Cardiovascular

Acquired
- Hypertension
- Aortic stenosis
- Athlete’s heart

Congenital
- Subaortic stenosis
- LV noncompaction

Systemic Disease

- Fabry disease
- Cardiac amyloidosis
- Hypereosinophilic syndrome
70 y/o Man: Dyspnea on exertion

Fabry Disease (Alpha-Galactosidase A Deficiency)

Glycosphingolipid Accumulation

Hyper-refractile subendocardial border: 94% Sensitive 100% Specific

Pieroni M, et al. JACC 2006; 47: 1663
56 y/o Woman: Biventricular heart failure; SAM
Amyloid Infiltrative Cardiomyopathy
Amyloid Infiltrative Cardiomyopathy

- Low voltage QRS
- Anteroseptal Pseudoinfarction Pattern
Risk Stratification in HCM
Sudden Cardiac Death
Hypertrophic Cardiomyopathy (HCM)
Arrhythmogenic Myocardial Substrate

Myocyte Disarray
Coronary Arteriole Remodeling
Ischemia Micro-infarction Fibrosis

Maron BJ. Circulation 2010; 121: 445
Sudden Cardiac Death (SCD) in HCM

Primary Risk Factors

- SCD in 1º relative due to HCM
- Unexplained syncope (≥ 1 episode)
- Massive LVH (≥ 30 mm thickness)
- Nonsustained VT on ECG monitoring
- Exercise BP response: ↓ or →

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212  ACC/AHA Guidelines
HCM with massive (>30 mm) LV hypertrophy
Septum: 42 mm; LV mass index 548 gm/m²
HCM with massive (>30 mm) LV hypertrophy
Septum: 42 mm; LV mass index 548 gm/m²
Risk Stratification for Sudden Cardiac Death
LV Wall Thickness and Clinical Risk Factors

Sudden Cardiac Death (SCD) in HCM
Secondary Risk Factors

- Intramyocardial Fibrosis:
  Delayed gadolinium enhancement on MRI
- Apical LV aneurysm (Apical variant of HCM)
- Prior alcohol septal ablation
- Burning out phase of HCM (1-5% incidence)
- LVOT obstruction > 30 mmHg at rest
  (≤10% Positive Predictive Value)

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212  ACC/AHA Guidelines
Intramyocardial Fibrosis in HCM

Delayed Gadolinium Enhancement (DGE) on MRI

Focal: Low Risk

Confluent: Higher risk
Intramyocardial Fibrosis in HCM
Delayed Gadolinium Enhancement (DGE) on MRI

Predictors of DGE

- Reversed septal morphology
- Septal thickness > 20 mm
- LV Mass > 150 gm/m²
- LVEF < 50%

Nonsustained VT
(43±14 Months F/U)

Intramyocardial Fibrosis in HCM: Detection by Echocardiography?

Abnormal global and/or regional LV systolic function → Fibrosis likely where LV is dysfunctional

Apparent normal global and regional LV systolic function → Speckle Tracking Strain Imaging
Abnormalities in longitudinal strain correlate directly with degree of myocardial fibrosis by DGE on MRI and also LV wall thickness

Longitudinal Strain Imaging
Risk Stratification in HCM

The presence of strain values of $\geq -10\%$ in $> 3/18$ LV segments is an independent predictor of nonsustained VT (Sensitivity 81%, Specificity 97%)

31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3
31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3
31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3

Longitudinal Strain
31 y/o Electrician: Nonexertional presyncope, syncope, exercise induced hypotension, family history of SCD x 3
Sudden Cardiac Death (SCD) in HCM

Uncertain Risk Factors

- Gene mutation (>1,000 mutations; 11 genes)
- Atrial fibrillation
- Coronary artery bridging
- Diastolic dysfunction

Modifiable Risk Factors

- Highly competitive sports
- Coronary artery disease

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212  ACC/AHA Guidelines
Abnormal Relaxation
Mildly Elevated Filling Pressure (Grade Ia/IV)

MV Inflow

Medial TDI

E/e' = 0.6 / 0.03 = 20
Irreversible Restrictive
Severely Elevated Filling Pressure (Grade IV/IV)

MV Inflow

Medial TDI

\[ E/e' = 1.2 / 0.03 = 40 \]
Restrictive Diastolic Dysfunction
Prognosis in HCM (239 Patients)

Cumulative HCM-related death (%)

Log rank p < 0.001

Restrictive LV Filling at Initial Evaluation
HR: 3.54; 95% CI 1.91-6.57

Non-Restrictive LV Filling at Initial Evaluation

Indications for ICD in Hypertrophic Cardiomyopathy
- Prior cardiac arrest or Sustained VT
  => No
- Family Hx of SCD in first degree relative or Recent unexplained syncope or LV wall thickness ≥ 30 mm
  => No
- Nonsustained VT or Abnormal Stress BP response
  => No
- Yes
  Other SCD Risk Factors present?
    => Yes
    ICD Reasonable (Class IIa)
    => No
    ICD Not Recommended (Class III)
- Yes
  ICD Recommended (Class I)
- Yes
  ICD Reasonable (Class IIa)
- No
  ICD Role Uncertain (Class IIb)

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212  ACC/AHA Guidelines
Family Screening for HCM by Echo

- **< 12 Yrs Old**
  - Optional unless:
    - Malignant Family Hx
    - Cardiac symptoms
    - Competitive sports
    - Other signs of LVH

- **12 to 18-21 Yrs Old**
  - Every 12 to 18 Months

- **>18-21 Yrs Old**
  - Every 5 Yrs or as per clinical suspicion

Gersh, BJ, Maron BJ et al. JACC 2011; 58: e212  ACC/AHA Guidelines
Comprehensive echocardiography is indispensable for the diagnosis and hemodynamic assessment of HCM.

Echocardiography plays an important role in the clinical risk stratification and also the interventional management of the patient with HCM.