Diastology: What the Radiologist Needs to Know.

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Objectives

• To review the physiology and clinical importance of diastolic function.
• To briefly overview the physiology and echocardiographic patterns of diastolic dysfunction.
• To review the current literature on assessment of diastolic function using MRI.

LV Diastolic Function: Introduction

• The ability of the ventricle to fill at low (normal) left atrial pressure.
  – At rest and with exercise.
• Of equal importance to systolic function.
• Energy-dependent process
  – Susceptible to disruption by various pathologies.
  – More energy-dependent than contraction, therefore:
    • More likely to precede systolic dysfunction.

• Frequency increases with age
  – Up to 50% of patients over 70

LV Diastolic Function: Introduction

• Clinically indistinguishable from systolic heart failure.
• ACC/AHA Guidelines (2001):
  – The diagnosis of diastolic HF is generally based on the finding of typical symptoms and signs of HF in a patient who is shown to have a normal left ventricular ejection fraction and no valvular abnormalities on echocardiography.
LV Diastolic Function: Introduction

- Patients with diastolic heart failure:
  - Not capable of distending a stiff LV.
  - Capable of distending a poorly compliant LV with elevated filling pressures.

- Congestive symptoms result from:
  - Pulmonary congestion
  - Left atrial enlargement and arrhythmia
  - Reduced cardiac capacity for exercise

LV Diastolic Function: Introduction

- Patients with diastolic dysfunction are also at increased risk of future cardiac events.
- When present in combination of systolic failure, it is a predictor of mortality.
- Additionally, the degree of diastolic dysfunction may explain the clinical difference in patients with similar EF.

LV Diastolic Function: Hemodynamics

- LV compliance
  - Myocardial compliance (intrinsic factor)
  - External factors
    - Pericardium
    - Right Ventricle
    - Blood volume
    - Intra-thoracic pressure

LV Diastolic Function: Hemodynamics

- The effect of impaired diastolic function is reflected on the LV pressure-volume loop.

Ventricular relaxation is divided in four phases:

- Isovolumic relaxation
  - From aortic closure to LV pressure falling below LA pressure
- Early LV filling
  - From mitral valve opening to LV equaling LA pressure
- Diastasis
  - Equal pressures, no LV filling occurs
- Atrial contraction
  - Transmirtal pressure gradient is re-established
LV Diastolic Function: Hemodynamics

• Early LV filling
  - The predominant factors that affect early filling are
    • Rate of LV relaxation
    • Elastic Recoil
    • LA pressure

• Abnormal relaxation will result in prolongation of the isovolumic relaxation time, a slower rate of decline in LV pressure, and a consequent reduction in early filling.
  - Due to a smaller pressure difference between the LA and LV.

LV Diastolic Function Assessment

• For a given LA pressure, slower LV relaxation results in a later MV opening, reduced early diastolic transmitral gradient, and a compensatory increase in the proportion of filling at atrial contraction.

• Direct measurements of LV volume or pressure are impractical and usually only used for experimental studies.
• A more practical way of assessing LV relaxation is by measuring the transmitral pressure gradients.

LV Diastolic Function Assessment

• In recent years, non-invasive assessment of diastolic function by transthoracic Doppler echocardiography has become the most practical and clinically reliable modality used in the evaluation of diastolic function.

• A sample volume is placed between the mitral leaflets and Doppler tracings are obtained.
LV Diastolic Function Assessment

- Several parameters which reflect the diastolic function may be obtained by analyzing the Doppler velocity tracing of blood flow through the mitral valve:
  - early and late (E and A) diastolic flow velocities
  - the ratio between them (E/A)
  - the deceleration time
  - the isovolumic relaxation time

Filling Patterns

- Three patterns of diastolic filling (transmitral flow) are usually recognized:
  - Normal
  - Delayed Relaxation
  - Restrictive

- Additionally, in patients with a normal appearing mitral flow but underlying abnormal diastolic function, a 'Pseudonormal' pattern is described.

Filling Patterns

- However, even in normal patients, ventricular compliance will change over time with age, therefore changing this normal pattern with the proportion of LV filling in early diastole (E) decreasing as age advances.

- The opposite occurs to the atrial contraction (A).
Filling Patterns

• Patients with a pseudonormal pattern have:
  – Apparently normal transmural flow
  – Moderate decrease in LV compliance with compensatory increase in LA pressure

Filling Patterns

• A restrictive LV filling pattern:
  – Severe decrease in LV compliance
  – Significantly elevated LA pressures

Filling Patterns

• To differentiate between the normal and pseudonormal patterns, the mitral annulus velocity (E') is a useful parameter.

Diastology for the Radiologist

• What is the relevance?
  – MRI is considered the gold standard in the evaluation of left ventricular volumes and systolic function.
  – Commonly used and fairly available nowadays.
  – Newer sequences make it a robust modality for measuring flow.

What can we find in the literature

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Type of Disease</th>
<th>Number of Patients</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Netolitzki, et al.</td>
<td>1991</td>
<td>Normal and mitral MR</td>
<td>19</td>
<td>Found the technique to have good correlation with echo.</td>
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<tr>
<td>Tartaglia, et al.</td>
<td>1994</td>
<td>Echocardiogram and Doppler</td>
<td>32</td>
<td>Volumetric mitral flow correlates with Doppler.</td>
</tr>
<tr>
<td>Kousoulakos, et al.</td>
<td>1999</td>
<td>MRI and Tissue Doppler</td>
<td>19</td>
<td>Early diastolic filling velocities correlate with Doppler.</td>
</tr>
<tr>
<td>Kousoulakos, et al.</td>
<td>1999</td>
<td>MRI and Tissue Doppler</td>
<td>25</td>
<td>Early diastolic filling velocities have a significant effect on left ventricular filling patterns.</td>
</tr>
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<td>Relling, et al.</td>
<td>1995</td>
<td>MRI and Tissue Doppler</td>
<td>19</td>
<td>Found the technique to have good correlation with echo.</td>
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<tr>
<td>Patrick, et al.</td>
<td>1995</td>
<td>MI and Tissue Doppler</td>
<td>19</td>
<td>Found the technique to have good correlation with echo.</td>
</tr>
<tr>
<td>Rats, et al.</td>
<td>2008</td>
<td>MRI and Tissue Doppler</td>
<td>31</td>
<td>Good agreement between MRI and TTE evaluation of diastolic function.</td>
</tr>
<tr>
<td>Kousoulakos, et al.</td>
<td>2009</td>
<td>MRI and Tissue Doppler</td>
<td>19</td>
<td>Moderate good correlation with echo and identified most patients with restrictive patterns.</td>
</tr>
</tbody>
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