Diastolic Function

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What is that?

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Defining Systole

pressures [mmHg]
volume [ml]
phono
venous puls
ECG

systole

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Defining Diastole

pressures [mmHg]
volume [ml]
phono
venous puls
ECG

diastole

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Defining Diastole

ET
RF
diastasis
AC
IC
IR
AVO
AVC
MVC
MVO
valves
period
local change in muscle length (strain)
hemodynamic muscle
contr.
relaxation
compliance

systole
diastole

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Wall Stress vs. Cavity Pressure

law of Laplace

\[ \sigma = \frac{p \cdot r}{2d} \]

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Wall Stress vs. Cavity Pressure

law of Laplace

Diastolic Function

complex interaction of:
- compliance
- relaxation
- loading
- energy supply

... allowing adequate filling of the ventricle

Determinants of Diastolic Function

Model of LV Myocardium

active elements
- $p_a$ - actin / myosin

passive elements
- $p_e$ - elasticity
  - chamber restoring forces
  - torsion
- $p_{EDPVR}$ - unstrained volume equilibrium
- $p_{VE}$ - viscoelasticity
  - flow / heart rate dependent

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**Diastolic Function**

active: detachment of actin - myosin - bridges

5.3 pN / cross-bridge
100 cross-bridges / filament
5.7*10^10 filaments / cm²
30 N/cm² (≈ 3 kg/cm²)

**Diastole**

Model of LV Myocardium

active elements
- \( p_a \) - actin / myosin

passive elements
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- \( P_{EDPVR} \) - EDPVR (unstressed volume equilibrium)
- \( P_{VE} \) - viscoelasticity

flow / heart rate dependent

**Myocardial Fibre Architecture**

fibre / cross fibre shortening

adapted from: Rademakers et al., Circ '94

**Relaxation**

passive: restoring forces

- cross fibre shortening
- structural level
  - collagen between fibres and muscle layers
  - titin in myocytes
- external modulation
  - erectile function of coronary perfusion (?)
  - filling pressure (pathologic)
Diastolic Haemodynamics

Diastole

Model of LV Myocardium

active elements
- p_a - actin / myosin

passive elements
- p_r - elasticity chamber restoring forces

p_P - EDPVR

p_VE

viscoelasticity

flow / heart rate dependent

Definitions

Compliance

\[ C = \frac{\Delta \text{volume}}{\Delta \text{pressure}} \]

Stiffness

\[ E = \frac{\text{stress}}{\text{strain}} \]

synonyms:
- Young’s modulus
- modulus of elasticity
- elastic modulus

The Ventricle

pressure – volume - relation

Diastolic Function

How to Assess it?

traditional indices:
- mitral inflow
- pulmonary vein inflow
- morphology
- LV wall motion / EF
- LV size / wall thickness
- LA size
Diastolic Dysfunction

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitral inflow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary venous flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relaxation / Compliance</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Atrial pressure</td>
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</tbody>
</table>

Traditional Diastolic Parameters

- Biphasic response: IVRT: ↑↑ ↓↓ E:A: ↑↑ ↓↓ DecT*: ↑↑ ↓↓
  * E:A ↑↑ and DecT↓↓ may occur in young people with good function!

Mitral Inflow Profile

- Age dependence

Diastolic Dysfunction

- Dysfunction: none, mild "impaired relaxation", moderate "pseudo-normal", severe "restrictive"
- LV pressure: none
- LA pressure: none
- Mitral inflow: none
- Mitral ring velocity: none

Estimating Filling Pressure

- Filling pressure vs. E/e':

E/e' in Recommendations

- Special article

How to diagnose diastolic heart failure: a consensus statement on the diagnosis of heart failure with normal left ventricular ejection fraction from the Heart Failure and Echocardiography Associations of the European Society of Cardiology
**E/e’ and Diastolic Function**

- E/e’ vs. filling pressure
- Δ E/e’ vs. Δ filling pressure

**Diast. Lengthening Velocity**

- Depends on systolic function and preload!

**E/e’ and Diastolic Dysfunction**

- E/e’ is unreliable in:
  - normal healthy people
  - overfilling
  - mitral stenosis / ~insufficiency
  - hypertrophic cardiomyopathy
  - bad LV function / CAD
  - bundle branch blocks / CRT
  - constrictive pericarditis

**Estimation of Filling Pressures**

- ... with impaired LV function
- ... with normal LV function
Assessment of Diastolic Function

- Septal e’ > 8
- Lateral e’ > 10
- LA Vol. < 34ml/m²
  - E/A < 0.8
  - DT > 200ms
  - E/e’ < 8
  - Grade I

- Septal e’ < 8
- Lateral e’ < 10
- LA Vol. > 34ml/m²
  - E/A 0.8 - 1.5
  - DT 160 – 200ms
  - E/e’ 8 - 13
  - Grade II

- E/A > 2
- DT < 160
- E/e’ > 13
- Ar-A > 30ms
  - Grade III

Why measuring it?

- Diastolic Function

Summary

Diastolic function of the LV is complex and multifactorially determined.

- No Doppler-echocardiographic parameter alone allows a reliable diagnosis of elevated filling pressures in all cases.
- The assessment of diastolic dysfunction is often difficult and rarely influences clinical decision making.
- Diastolic function assessment should always consider all available echocardiographic parameters and clinical information.

Summary (Continued)

- EAE / EAHF criteria for diagnosing "HFNEF"
  - Diastolic Function and Diagnosis
  - Diastolic Function and Diagnosis

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Why measuring it?

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