Diastolic function
Flow, function and haemodynamics
## Table 1 Diagnosis of heart failure

The diagnosis of HF-REF requires three conditions to be satisfied:

1. Symptoms typical of HF
2. Signs typical of HF<sup>a</sup>
3. Reduced LVEF

The diagnosis of HF-PEF requires four conditions to be satisfied:

1. Symptoms typical of HF
2. Signs typical of HF<sup>a</sup>
3. Normal or only mildly reduced LVEF and LV not dilated
4. Relevant structural heart disease (LV hypertrophy/LA enlargement) and/or diastolic dysfunction (see Section 4.1.2)
RVH (Rob), ° 1933

- abdominal obesity
- COPD, GOLD stage II
- 1985: hypertension
- 2003: NSTEMI inferior. BMS stent RCA and CX. Moderately reduced EF (0.47)
- 2005: ulcerative colitis
2011: edema of the legs, which I attributed to venous insufficiency and/or nifedipine treatment

Edema persists. Cannot tolerate compression stockings because of latex hypersensitivity. Rob had to adapt his shoes to swollen feet.

Complaints about shortness of breath when he walks swiftly or when he walks upstairs. NYHA II

No angina

Colitis is stable under medication
Drug therapy

- **Cardiovascular drugs**
  - Aspirin 80 mg QD
  - Simvastatine 40 mg QD
- **Hypertensive therapy**
  - Perindopril 5 mg and HCT 12.5 mg QD
  - Bisoprolol 10 mg QD
  - Nifedipine (SR) 30mg QD
- **Furosemide 40 mg 0.5 QD**

- **Other drugs**
  - Omeprazole 20mg, Azathioprine 100mg, tamsulosine 4mg
Clinical examination

- 181 cm 96 kg; BMI 29; waist 109 cm
- BP = 137/71 mmHg, PP=66mmHg, HR 56pm
- No elevated jugular vein pulsations
- Moderate edema of both legs and feet
- No abdominal organomegaly
- Clear lungs, normal heart sounds, no heart murmur
Born: 30.03.1933
Age: 79 Y
Sex: Male
Height: 180.0 cm
Weight: 95.0 kg
BP: / - mmHg
Med: 
Rem: 

HR  72 /min
Axis
P  37°
QRS -5°
T  69°

Intervl
RR  830 ms
P  134 ms
PQ  184 ms
QRS  86 ms
QT  400 ms
QTc  439 ms

Interpretation
SINUS RHYTHM
LEFTWARD AXIS
LOW LIMB LEAD VOLTAGE
T ABNORMALITY IN HIGH LATERAL LEADS

Validated by
Exercise ECG

- Protocol 25/10/1
- Peak work\(\text{watt} \quad 105 \text{ watt (74\% of the prediction)}\)
- Peak HR 105 pm; peak BP 160/100 mmHg
- The test was interrupted because of exhaustion
  - No angina
  - No dyspnea
  - No repolarisation disturbances
I. What is the tentative diagnosis?

1. Edema of the legs attributed to venous insufficiency and/or nifedipine treatment. Dyspnea is not objectivated.

2. We need additional investigations to sort out if edema and dyspnea are symptoms and signs of HF

3. This definitely is heart failure and has to be treated as such
Suspected heart failure

Acute onset

ECG 
Chest x-ray

- Echocardiography
  - ECG normal and NT-proBNP <300 pg/mL or BNP <100 pg/mL
    - Heart failure unlikely

- BNP/NT-pro BNP
  - ECG abnormal or NT-proBNP ≥300 pg/mL or BNP ≥100 pg/mL

Non-acute onset

ECG 
Possibly chest x-ray

- Echocardiography
  - ECG normal and NT-proBNP <125 pg/mL or BNP <35 pg/mL
    - Heart failure unlikely

- BNP/NT-pro BNP
  - ECG abnormal or NT-proBNP ≥125 pg/mL or BNP ≥35 pg/mL

If heart failure confirmed, determine aetiology and start appropriate treatment
Laboratory data

- Hb = 14,8 gr/dl
- FG = 0,097 g/l and Hba1c 6,0% or 42 mmol/mol
- TC=169; HDL-C=76; LDL-C=80; TG=61 (mg/dl)
- Normal liver tests including gamma-GT
- Ureum 52 mg%; creatinine 1,23 mg%; UA 8,3 mg%
  - GFR 57 ml/min (CKD stage 3A)
- Sodium 143 meq/l and potassium 4,8 meq/l
Laboratory data (1)

- CRP = 0.10 mg% or 10 mg/l
- TSH = 0.345 mcU/ml
Laboratory data (2)

- CRP = 0,10 mg% or 10 mg/l
- TSH = 0,345 mcU/ml
- NT-pro-BNP = 465 pg/ml
Apical 4C view

Biplane EF = 0.47
General measurements relevant for diastolic function: key points

- LV mass, optimally with three dimensional echocardiography. Scale LV mass for BSA \((m^2)\) or for body height \((g/m^{1.7})\) depending on the clinical question.
- LA volume. Scale LA volume accordingly.
- Pulmonary artery systolic pressure and venous pressures.
Echocardiography

- LV mass index (<115 gr/m$^2$) = 168.74 gr/m$^2$
- RWT (0.32-0.42) = 0.45
- LAV index (<34 ml/m$^2$) = 58 ml/m$^2$
- No tricuspid regurgitation recorded
- Vena cava (<1.5 cm): max 1.8 cm with respiratory variation
Measurements of diastolic function: key points

- Annular motion during rapid filling (e’) at the septal and lateral annulus.
  - Septal and lateral e’ values are averaged
  - In selected cases septal or lateral e’ is not a reliable marker of diastolic function
  - E’ is reduced in all degrees of diastolic dysfunction

- The mitral inflow signal
  The mitral inflow signal varies with varying filling pressures and is the best parameter of filling pressures when consecutive examinations are considered in a given patient
  Mitral inflow patterns include normal, impaired relaxation, pseudo-normal and restrictive signal
Septal annulus

\[ e' = 5.2 \text{ cm/s} \]
\[ a' = 6.1 \text{ cm/s} \]
Lateral annulus

$E' = 7.2\, \text{cm/s}$
Mitral inflow
Rob’s data

- Septal $e' = 5.2$ cm/s
- Lateral $e' = 7.2$ cm/s
- Mitral $E = 88$ cm/s
- Mitral $A = 78$ cm/s

Computations:
- $E/A = 1.3$
- $E/e'$ septal = 17
- $E/e'$ lateral = 12
- $E/e'$ mean = 14.6
Oh, JK, Park, SJ, Nagueh, SF.
<table>
<thead>
<tr>
<th>Normal subjects</th>
<th>Normal/athletes/constriction</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
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</thead>
<tbody>
<tr>
<td>Septal e’≥8</td>
<td>Septal e’≥8</td>
<td>Septal e’&lt;8</td>
<td>Septal e’&lt;8</td>
<td>Septal e’&lt;8</td>
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<tr>
<td>Lateral e’≥10</td>
<td>Lateral e’≥10</td>
<td>Lateral e’&lt;10</td>
<td>Lateral e’&lt;10</td>
<td>Lateral e’&lt;10</td>
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<tr>
<td>LA&lt;34 ml/m²</td>
<td>LA≥34 ml/m²</td>
<td>LA≥34 ml/m²</td>
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<td>E/A&lt;0.8</td>
<td>E/A 0.8–1.5</td>
<td>E/A≥1.5</td>
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<tr>
<td></td>
<td></td>
<td>DT&gt;200 ms</td>
<td>DT 160–200 ms</td>
<td>DT&lt;160 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average E/e’≤8</td>
<td>Average E/e’ 9–12</td>
<td>Average E/e’≥13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ar-A&lt;0 ms</td>
<td>Ar-A≥30 ms</td>
<td>Ar-A≥30 ms</td>
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<td>Valsalva ΔE/A&lt;0.5</td>
<td>Valsalva ΔE/A≥0.5</td>
<td>Valsalva ΔE/A≥0.5</td>
</tr>
</tbody>
</table>

Modified after Nagueh et al., with permission. DT, deceleration time; LA, left atrium; see text for explanation of other abbreviations.
Grading of diastolic dysfunction: key points

- The presence or absence of diastolic dysfunction relies on the annular velocity e’ and the size of the left atrium.
- Once diastolic dysfunction is deemed present, the mitral inflow and the ratio E/e’ allow the distinction between grade 1 (impaired relaxation), 2 (pseudo-normal filling) and 3 (restrictive filling).
- In case of uncertainty, the pulmonary vein signal or the mitral inflow signal during the Valsalva manoeuvre may help to classify.
Before Valsalva
During Valsalva manoeuvre
<table>
<thead>
<tr>
<th>Normal LA pressures</th>
<th>Elevated if...</th>
<th>Elevated LA pressures</th>
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</thead>
<tbody>
<tr>
<td>Septal E/e’ ≤8</td>
<td>Septal E/e’ 9–14</td>
<td>Septal E/e’ ≥15</td>
</tr>
<tr>
<td>Lateral E/e’ ≤8</td>
<td>Lateral E/e’ 9–11</td>
<td>Lateral E/e’ ≥12</td>
</tr>
<tr>
<td>Average E/e’ ≤8</td>
<td>Average E/e’ 9–12</td>
<td>Average E/e’ ≥13</td>
</tr>
<tr>
<td>Mitral E/A &lt;1</td>
<td>Mitral E/A 1–2</td>
<td>Mitral E/A &gt;2</td>
</tr>
<tr>
<td>E ≤50 cm/s</td>
<td>Mitral E/A &lt;1 and E &gt;50 cm/s</td>
<td></td>
</tr>
</tbody>
</table>

Elevated if LA volume ≥34 ml/m², E/Vp ≥2.5, pulmonary vein flow S/D <1, pulmonary Ar-A ≥30 ms, Valsalva Δ E/A ≥0.5, pulmonary artery pressure >35 mm Hg. Please note that this table is not applicable to normal subjects, as defined in table 1. Modified after Nagueh et al.,² with permission. LA, left atrium; see text for explanation of other abbreviations.
Evaluation of filling pressures with echocardiography and cardiac Doppler: key points

- Is feasible in most patient populations including severe systolic heart failure
- Is mainly based on the E/e’ ratio and the mitral inflow signal
- Requires additional measurements when values of E/e’ are in the intermediary range or when the mitral inflow is (pseudo)-normal
- In selected disease states E/e’ is not reliable as a predictor of filling pressures
HEART FAILURE

Echo-Doppler assessment of diastole: flow, function and haemodynamics

Thierry C Gillebert, Michel De Pauw, Frank Timmermans

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