Pulmonary Hypertension:
Follow-up in adolescence and adults

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Prevalence reported in ACHD up to 28%, defined by sPAP>40

ESC Guidelines for diagnosis and treatment of pulmonary hypertension 2009

Table 1. Updated clinical classification of pulmonary hypertension (D. Fontaine, 1998)

<table>
<thead>
<tr>
<th>1</th>
<th>Primary pulmonary hypertension (PPP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Hypoxia</td>
</tr>
<tr>
<td>12</td>
<td>Connective tissue disease</td>
</tr>
<tr>
<td>13</td>
<td>Drugs and toxins</td>
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<tr>
<td>14</td>
<td>Chronic lung disease</td>
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<tr>
<td>15</td>
<td>Severe anemia</td>
</tr>
<tr>
<td>16</td>
<td>Intracardiac shunts</td>
</tr>
<tr>
<td>17</td>
<td>Chronic thromboembolic disease</td>
</tr>
<tr>
<td>18</td>
<td>Pulmonary hypertension due to left heart disease</td>
</tr>
</tbody>
</table>

Table 2. Haemodynamic definition of pulmonary hypertension

<table>
<thead>
<tr>
<th>Group</th>
<th>Characteristic</th>
<th>Clinical presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mean PAP &gt;25mmHg</td>
<td>Progressive exertional dyspnoea</td>
</tr>
<tr>
<td>B</td>
<td>Mean PAP &gt;30mmHg</td>
<td>Progressive exertional dyspnoea</td>
</tr>
<tr>
<td>C</td>
<td>Mean PAP &gt;40mmHg</td>
<td>Progressive exertional dyspnoea</td>
</tr>
<tr>
<td>D</td>
<td>Mean PAP &gt;50mmHg</td>
<td>Progressive exertional dyspnoea</td>
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</tbody>
</table>

Table 3. Pulmonary hypertension due to left heart disease

<table>
<thead>
<tr>
<th>Category</th>
<th>Characteristic</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Mitral valve disease</td>
</tr>
<tr>
<td>2</td>
<td>Aortic valve disease</td>
</tr>
<tr>
<td>3</td>
<td>Left atrial myxoma</td>
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</tbody>
</table>

3 Chronic thromboembolic pulmonary hypertension

1. Preserved cardiac function or right heart disease that is reversible
2. Severe hypoxia due to decreased lung perfusion or right ventricular failure
3. Improvement in symptoms and exercise capacity with anticoagulation
Tricuspid Regurgitation: Estimation of Pulmonary Artery Pressure

- CW Doppler measurement of peak TR velocity

\[ \Delta p = 4v^2 \]

\[ 4V_{\text{max}} = RVP_{\text{syst}} - RAP \]

\[ 4V_{\text{max}} = RAP + RVP_{\text{syst}} \]

\[ RVP_{\text{syst}} = PAP_{\text{syst}} \]

If no obstruction between RV and PA (DCRV, subv. PS, valv. PS, periph. PS)

Pulmonary hypertension - Echocardiography Following adolescence and adults with CHD

- Detection of elevated PAP or progression of PH:
  - unoperated shunt lesions
  - newly diagnosed ASD
  - VSD considered too small for closure
  - „left” (systemic) heart disease
  - systemic AV valve regurgitation (surgery in asympt. pts with PAP>50)
  - severe systemic ventricle dysfunction (eligibility for transplantation)

- Follow-up after repair: recognition of PH

- Follow-up of pts. with severe PAH and Eisenmenger syndrome
  - prognostic parameters for treatment decisions (targeted therapy, transplant)
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Female 39 yrs          TGA, Mustard

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Pulmonary hypertension: Follow-up in adolescence and adults

<table>
<thead>
<tr>
<th>Table 16</th>
<th>Suggested assessment and timing for the follow-up of patients with PH</th>
<th>A baseline (prior to therapy)</th>
<th>Every 3-6 months</th>
<th>2-4 months after inclusion or change in therapy</th>
<th>In case of clinical worsening</th>
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<tbody>
<tr>
<td>Clinical assessment</td>
<td>PVR-PC</td>
<td>ESC</td>
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<tr>
<td>Lung function test</td>
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<td>Cardiorespiratory exercise testing</td>
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<tr>
<td>Echocardiography</td>
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<td>MRI</td>
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Following adolescence and adults with CHD

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- Follow-up after repair: recognition of PH
- Follow-up of pts. with severe PAH and Eisenmenger syndrome
  prognostic parameters for treatment decisions
  (targeted therapy, transplant)
Echo findings reported with best prognostic value:
- pericardial effusion, indexed RA area, LV eccentricity index,
- RV Doppler index, tricuspid annular plane systolic excursion (TAPSE)

PAH – RVF and TAPSE

Pulmonary hypertension:
Follow-up in adolescence and adults
- When to start targeted therapy?
- When to change targeted therapy?
- When to consider HLTX?

Table 13: Definition of inadequate response to PAH treatments (see also sections 7.3.5 and 7.36)

Inadequate clinical response for patients who were initially in
WHO-FC III or IV

1. No rapid improvement to WHO-FC II or better
2. No rapid improvement to WHO-FC II or better
3. No rapid improvement to WHO-FC II or better
4. No rapid improvement to WHO-FC II or better
Recommendations for Targeted Pulmonary Arterial Hypertension Therapy in Congenital Heart Disease

- Targeted PAH therapy in CHD should only be performed in specialized centres
- The ERA bosentan should be initiated in WHO-FC III* patients with Eisenmenger syndrome
- Other ERAs, phosphodiesterase type-5 inhibitors and prostanoids should be considered in WHO-FC II* patients with Eisenmenger syndrome
- Combination therapy may be considered in WHO-FC II patients with Eisenmenger syndrome
- The use of calcium channel blockers should be avoided in patients with Eisenmenger syndrome

a = class of recommendation. b = level of evidence.

*Although recent data support the use of ERA such as bosentan also in WHO-FC II, in pts with idiopathic PAH and PAH associated with connective tissue diseases such data are currently not available for Eisenmenger pts. Because of marked differences in the natural history between these groups, the results cannot simply be applied to GUCH and further studies are required before recommendations.

ESC Guidelines for the management of grown-up congenital heart disease 2010

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iPAH vs. Eisenmenger

- Outcome of Eisenmenger patients vs. iPAH

Hopkins WE et al J Heart Lung Transplant 1996;15:100-105
Survival of Adult Eisenmenger Patients
N = 109 (>18 yrs at entry)
Simple anatomy: 66    complex anatomy: 43
9 transplants (4 deaths), 33 additional deaths
median survival 52.6 yrs (age at death 37±13 yrs)
Cantor WJ et al Am J Cardiol 1999;84:677-81

Natural history of Eisenmenger vs. transplantation in Eisenmenger / iPAH
* Nagaya OH et al Am Heart J 2002;143:739-44
** Stoica SC et al Ann Thorac Surg 2001;72:1887-91

Eisenmenger: Causes of Death

Eisenmenger: Predictors of outcome

- NYHA functional class, early presentation, complex anatomy
- RV dysfunction, elevated RAP, decreased systemic flow
- SV arrhythmias, RVH ECG index
- Noncardiac surgery, pregnancy
- Renal dysfunction
- But not: Syncope, haemoptysis, cerebral events

Cantor WJ et al Am J Cardiol 1999;84:677-81 (N=109)
Nagaya OH et al Am Heart J 2002;143:739-44 (N=106)

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Table 15 Parameters with established importance for assessing disease severity, stability and prognosis in PAH (adapted from McLaughlin and McGoon®)

<table>
<thead>
<tr>
<th>Worse prognosis</th>
<th>Better prognosis</th>
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<tr>
<td>No</td>
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Parameters with best prognostic value: Clinical status of RV failure, systolic pulmonary pressure, tricuspid annular plane excursion (TAPSE), right ventricular area, right ventricular ejection fraction.

Echo findings reported with best prognostic value: pericardial effusion, indexed RA area, LV eccentricity index, RV Doppler index, tricuspid annular plane systolic excursion (TAPSE)

Eisenmenger: FU of RVF
RV Function, normal

**systolic**

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<thead>
<tr>
<th>Subject</th>
<th>Baseline</th>
<th>Follow-up</th>
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<tbody>
<tr>
<td>Index 1</td>
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<td></td>
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<tr>
<td>Index 2</td>
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**summary**

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**diastolic**

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**Speckle Tracking – RV Longitudinal Strain**

- NORMAL
- Eisenmenger 2
- Eisenmenger 3

**BNP in PPH (iPAH)**

N = 60, Measurements repeated after 3mo (mean FU) in 53
49 pts. received i.v. or oral prostacyclin; mean clinical FU 2yrs

**Baseline BNP**

- BNP < 150 pg/mL
- BNP ≥ 150 pg/mL

**Follow-up BNP**

- BNP < 150 pg/mL
- BNP ≥ 150 pg/mL

_Nagaya N et al Circulation 2000;102:865-870_
BNP in Pediatric Patients with Pulmonary Arterial Hypertension

N=78 No strong correlation of BNP with echo and hemodynamics, but of change in BNP and change in hemodynamics

Bernus A et al Chest 2009;135:745-751

N=78 No strong correlation of BNP with echo and hemodynamics, but of change in BNP and change in hemodynamics

All Patients

iPAH only

BNP < 180 pg/ml

BNP ≥ 180 pg/ml

Time from last BNP measurement (years)

Survival Distribution Function

BNP - Predictor of Outcome in CHD

RESULTS: Pts. with PHT

Event-Free Survival: BNP <150 vs BNP ≥150

Gabriel H et al Circulation 2002 (Suppl) / AHA

BNP < 150 pg/ml

BNP ≥ 150 pg/ml

Days

Event-Free Survival

48 pts.

CHD, PAP >50mmHg

FU 15±11 yrs

Events:

Death

Hosp. for CHF

Transplantion

Pulmonary hypertension - Echocardiography

Following adolescence and adults with CHD

- Careful noninvasive assessment of PAP in all adults with CHD at FU visit
  - detect elevation of PAP and progression

- In pts. with severe PAH / Eisenmenger
  3 – 6 months evaluation:
  - signs of right heart failure
  - functional status
  - 6MWT (CPET)
  - Echo (RVF, pericardial effusion)
  - BNP / NT-proBNP plasma levels
Thank you for your attention!