Assessment and Management of Pulmonary Heart Disease in the Female Patient

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Deborah Women’s Heart Center

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Disclosure

None related to this presentation
RV is not the innocent bystander

- Ventriculo-arterial coupling
  - RV pumps as much blood at a rate that the pulmonary vasculature can accept
  - Contractility and compliance are balanced
Ventriculo-arterial coupling

- Uncoupling leads to Right heart failure and symptoms of pulmonary heart disease
- Primary RV failure
- Changes in pulmonary vascular compliance
WHO classification PHTN

• Group 1 – Pulm arterial HTN (PAH)
  – Familial
  – Toxins/Drugs
  – CTD – scleroderma
  – HIV, schistosomiasis
  – Portal HTN
  – Congenital Disease
WHO classification cont

- Group 2 – due to Left Heart Disease
- Group 3 – due to Lung disease, hypoxia
  - Includes COPD and ILD but also high altitude and OSA, hypoventilation
- Group 4 – CTEPH
- Group 5 – unclear mechanism
  - Chronic hemolytic anemia, sarcoidosis
From: **Relevant Issues in the Pathology and Pathobiology of Pulmonary Hypertension**


**Figure Legend:**

Proposed Multifactorial Factors Influencing Progression of Pulmonary Hypertension

In a suitable genetic background, the interplay of epigenetics and pathobiological injurious events may amplify the severity of the disease, often associated with more pronounced remodeling and worse clinical outcome.
Pathophysiology of RV Dysfunction in PAH

Increased right ventricular (RV) wall stress, neurohormonal activation, inflammation, and altered bioenergetics contribute to RV remodeling in pulmonary arterial hypertension (PAH). Adaptive remodeling is associated with minimally altered ventriculoarterial coupling. Progressive RV dilation with maladaptive remodeling further contributes to RV stress.
Figure Legend:

Describing Right Ventricular Function

(A) Pressure-volume relation, illustrating the concepts of ventricular elastance (Ees), arterial elastance (Ea), and the maximal isovolumic pressure used to estimate single-beat Ees. (B) Pump function graph, illustrating that when baseline pulmonary vascular resistance (PVR) is high, a decrease in PVR mainly causes an increase in stroke volume, while at lower baseline PVR, pressure is more affected.
Ventriculo-arterial coupling

RV keeping up

RV dysfunction
Assessment of Right Heart Function

- Size and wall thickness
  - Interventricular Dependence
- Contractility
  - Fractional area change
  - TAPSE and tissue Doppler
- PA systolic pressure
- Pulmonary vascular resistance
RV focused apical view

- Diameter
  - Basal 33 (>42 abnl)
  - Mid 27 (>35 abnl)
- Long axis
  - 71 (> 86 abnl)
- Indexing to BSA may be relevant but no standards
Other things can make the right heart look abnormal
RV contractility – fractional area change (<35% abnormal)
Other measures of contractility

Normal Systolic wave

Abnormal s’ (<9.5 abnl)
TAPSE

Incorrectly measured 1.4 cm

More correctly measured 0.8 cm (<1.7 abnormal)
PA systolic pressure

- PASP = \(4 v^2 + RAP\)
- RAP =
  - NI RA size, IVC complete collapse - 3 mm Hg
  - Either or = 8 mm Hg
  - RA large, IVC collapse < 50% - 15 mm Hg
  - No IVC collapse - 20 mm Hg
Pulmonary Artery Systolic Pressure

Measured incorrectly

Measured more correctly
IVC with sniff

RA pressure = 3 mm Hg

RA pressure = 15 mm Hg
RV Volume overload

- Young age, athletic training, pregnancy
- High output states - cirrhosis
- RV volume loads - ASD, TR, anomalous pulmonary venous return
  - Severe PR rare
- RV function normal or hyperdynamic
  - TAPSE may be > 2.5 cm
- Stroke volume high
  - PA velocity > 0.8 m/sec
PA diastolic pressure from PR jet

End PR velocity
2.5 m/sec
PAD = 25 + RAP
RA volumes

- Single plane measurement as opposed to LA biplane measurement
- 2D measurement underestimates compared to 3D
- Women – 21 ± 7 ml/m^2
- Men – 25 ± 7 ml/m^2
Clinical Characteristics, Management, and Outcomes of Patients Diagnosed With Acute Pulmonary Embolism in the Emergency Department: Initial Report of EMPEROR (Multicenter Emergency Medicine Pulmonary Embolism in the Real World Registry)


Flow Diagram of Enrolled Patients in the EMPEROR Trial

The flow diagram shows the outcome of all enrolled patients with respect to diagnosis of venous thromboembolism. DVT = deep venous thromboembolism; PE = pulmonary embolism.

Figure Legend:
Clinical Characteristics, Management, and Outcomes of Patients Diagnosed With Acute Pulmonary Embolism in the Emergency Department: Initial Report of EMPEROR (Multicenter Emergency Medicine Pulmonary Embolism in the Real World Registry)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Confirmed PE (n = 1,880)</th>
<th>PE Not Confirmed (n = 528)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause mortality in-hospital</td>
<td>63 (3.4)</td>
<td>22 (4.2)</td>
</tr>
<tr>
<td>Death from PE</td>
<td>20 (1.1)</td>
<td>6 (1.1)</td>
</tr>
<tr>
<td>Death from hemorrhage</td>
<td>3 (0.16)</td>
<td>1 (0.19)</td>
</tr>
<tr>
<td>Death from other</td>
<td>40 (2.1)</td>
<td>15 (2.8)</td>
</tr>
<tr>
<td>All-cause death within 30 days</td>
<td>102 (5.4)</td>
<td>37 (7.0)</td>
</tr>
<tr>
<td>Recurrent PE within 30 days</td>
<td>49 (2.6)</td>
<td>10 (1.9)</td>
</tr>
<tr>
<td>New DVT within 30 days</td>
<td>11 (0.58)</td>
<td>2 (0.38)</td>
</tr>
</tbody>
</table>

Table Title: In-Hospital and 30-Day Outcomes

<table>
<thead>
<tr>
<th>Feature</th>
<th>Confirmed PE (n = 1,880)</th>
<th>PE Not Confirmed (n = 528)</th>
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</thead>
<tbody>
<tr>
<td>Vital signs at presentation in ED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate, beats/min</td>
<td>95.7 (20.5)</td>
<td>93.8 (21.8)</td>
</tr>
<tr>
<td>Respiratory rate, breaths/minute</td>
<td>20.5 (5.2)</td>
<td>21.2 (7.7)</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>132.3 (24.8)</td>
<td>137.1 (26.7)</td>
</tr>
<tr>
<td>Oxygen saturation, %</td>
<td>95.3 (5.4)</td>
<td>95.7 (5.6)</td>
</tr>
<tr>
<td>Symptoms reported by patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyspnea at rest</td>
<td>942 (50.1)</td>
<td>268 (50.8)</td>
</tr>
<tr>
<td>Pleuritic chest pain</td>
<td>740 (39.4)</td>
<td>150 (28.4)</td>
</tr>
<tr>
<td>Dyspnea with exertion</td>
<td>507 (27.0)</td>
<td>88 (16.7)</td>
</tr>
<tr>
<td>Cough without hemoptysis</td>
<td>430 (22.9)</td>
<td>121 (22.9)</td>
</tr>
<tr>
<td>Substernal chest pain</td>
<td>285 (15.2)</td>
<td>90 (17.0)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>230 (12.2)</td>
<td>51 (9.7)</td>
</tr>
<tr>
<td>Diaphoresis</td>
<td>220 (11.7)</td>
<td>70 (13.3)</td>
</tr>
<tr>
<td>Upper abdominal pain</td>
<td>202 (10.7)</td>
<td>39 (7.4)</td>
</tr>
<tr>
<td>Fever</td>
<td>182 (9.7)</td>
<td>52 (9.8)</td>
</tr>
<tr>
<td>Cough with hemoptysis</td>
<td>143 (7.6)</td>
<td>24 (4.5)</td>
</tr>
<tr>
<td>Unilateral extremity pain</td>
<td>110 (5.9)</td>
<td>28 (5.3)</td>
</tr>
<tr>
<td>Syncope</td>
<td>103 (5.5)</td>
<td>30 (5.7)</td>
</tr>
<tr>
<td>Altered mental status</td>
<td>90 (4.8)</td>
<td>29 (5.5)</td>
</tr>
<tr>
<td>Angina</td>
<td>74 (3.9)</td>
<td>20 (3.8)</td>
</tr>
<tr>
<td>Physical findings in ED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extremity swelling suggestive of DVT</td>
<td>442 (23.5)</td>
<td>97 (18.4)</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>309 (16.4)</td>
<td>71 (13.4)</td>
</tr>
<tr>
<td>Railes</td>
<td>158 (8.4)</td>
<td>32 (6.1)</td>
</tr>
<tr>
<td>Diaphoresis</td>
<td>133 (7.1)</td>
<td>28 (5.3)</td>
</tr>
<tr>
<td>Chest radiograph findings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>545 (40.1)</td>
<td>161 (40.7)</td>
</tr>
<tr>
<td>Westermark sign</td>
<td>5 (0.4)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Hampton hump</td>
<td>11 (0.8)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>290 (16.9)</td>
<td>61 (15.4)</td>
</tr>
<tr>
<td>Infiltrate</td>
<td>184 (13.5)</td>
<td>55 (13.9)</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>229 (16.2)</td>
<td>55 (13.9)</td>
</tr>
<tr>
<td>Elevated hemidiaphragm</td>
<td>34 (2.5)</td>
<td>7 (1.8)</td>
</tr>
<tr>
<td>Cardiomegaly</td>
<td>162 (11.9)</td>
<td>51 (12.9)</td>
</tr>
<tr>
<td>Stable non-PE pathology</td>
<td>197 (14.4)</td>
<td>59 (14.9)</td>
</tr>
</tbody>
</table>
72 yo man with HTN and diabetes and prostate cancer

- 2 week history of SOB and non-productive cough
- Unable to climb the stairs in his house
- At PMD his O2 sat – 84%
- Sent by ambulance to ED
- HR – 110; BP 110/70
<table>
<thead>
<tr>
<th></th>
<th>PESI</th>
<th>Simplified PESI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>age</td>
<td>1 point &gt;80</td>
</tr>
<tr>
<td>Male sex</td>
<td>10 points</td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>30 points</td>
<td>1 point</td>
</tr>
<tr>
<td>COPD or CHF</td>
<td>10 point each</td>
<td>1 point</td>
</tr>
<tr>
<td>Pulse ≥ 110</td>
<td>20 points</td>
<td>1 point</td>
</tr>
<tr>
<td>SBP &lt; 100</td>
<td>30 points</td>
<td>1 point</td>
</tr>
<tr>
<td>Resp rate ≥ 30</td>
<td>20 points</td>
<td></td>
</tr>
<tr>
<td>Temp &lt;36 C</td>
<td>20 points</td>
<td></td>
</tr>
<tr>
<td>Altered mental status</td>
<td>60 points</td>
<td></td>
</tr>
<tr>
<td>Oxygen sat &lt; 90%</td>
<td>20 points</td>
<td>1 point</td>
</tr>
</tbody>
</table>
Our Patient

PESI Score
- Class 1 ≤ 65 points
  - 30 day mortality 0-1.6%
- Class 2: 66-85 points
  - 1.7-3.5% mortality
- Class 3: 86-105
  - 3.2-7.1% mortality
- Class 4: 106-125
  - 4-11% mortality
- Class 5 ≥ 125 points
  - 10-24.5% mortality

Modified PESI
- 0 points – mortality risk
  - 1%
- ≥ 1 points – mortality risk
  - 10%
2014 ESC Guidelines on the diagnosis and management of acute pulmonary embolism

The Task Force for the Diagnosis and Management of Acute Pulmonary Embolism of the European Society of Cardiology (ESC)

Endorsed by the European Respiratory Society (ERS)

<table>
<thead>
<tr>
<th>Early mortality risk</th>
<th>Risk parameters and scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shock or hypotension</td>
</tr>
<tr>
<td>High</td>
<td>+</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Intermediate–high</td>
</tr>
<tr>
<td></td>
<td>Intermediate–low</td>
</tr>
<tr>
<td>Low</td>
<td>–</td>
</tr>
</tbody>
</table>
Troponin I – 0.66 (ULN 0.04)
60/60 sign
E = 44 cm/sec; e’ 6 cm/sec
E/e’ = 7.3
Ultrasound Assisted Catheter Directed Thrombolysis

## Table 3. Invasive Hemodynamic Measurements in Patients From the Ultrasound-Assisted Catheter-Directed Thrombolysis Group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Follow-Up*</th>
<th>Difference: Baseline vs Follow-Up</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary artery systolic pressure, mm Hg</td>
<td>52.0±11.5 (n=27)</td>
<td>39.7±10.3 (n=26)</td>
<td>12.3±10.0 (n=26)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulmonary artery diastolic pressure, mm Hg</td>
<td>19.6±8.1 (n=27)</td>
<td>16.2±5.4 (n=26)</td>
<td>3.2±7.8 (n=26)</td>
<td>0.049</td>
</tr>
<tr>
<td>Pulmonary artery mean pressure, mm Hg</td>
<td>30.2±9.1 (n=27)</td>
<td>24.1±6.7 (n=26)</td>
<td>5.7±7.6 (n=26)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Right atrial mean pressure, mm Hg</td>
<td>12.5±6.0 (n=24)</td>
<td>8.8±4.1 (n=21)</td>
<td>4.5±7.3 (n=19)</td>
<td>0.015</td>
</tr>
<tr>
<td>Cardiac index, L/min per m²</td>
<td>2.5±0.5 (n=16)</td>
<td>3.9±2.3 (n=15)</td>
<td>-0.7±0.6 (n=10)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

*Follow-up hemodynamic data were obtained at 18±3 h after initiation of therapy.

Seattle 2 trial – Late Breaking Clinical Trial ACC 2014

• 150 patients submassive or massive PE
• 21% patients with massive PE
• Successfully completed 98%
• Bilateral disease 86%
• Alteplase (25% of systemic dose) and ultrasound core catheter
• Reduced RV/LV ratio without bleeding
Echocardiography should not be used to “rule out” PE

- Indicated in hemodynamically unstable patients without diagnosis
- RV dysfunction may suggest acute PE but other causes must be ruled out
- Visualization of thrombus in transit is rare but should precipitate stat surgical consult

TEE if indicated should be done in OR
McConnell's sign
Acceleration time < 60 msec
Massive PE

- 59 yo morbidly obese woman with cardiopulmonary collapse at OSH
- Intubated, on pressors
- Hx Right leg injury, venous stasis ulcers, atrial fibrillation, seizure disorder
- BP – 90 palp, HR – 125, O2 sat – 85%
60/60 sign
OR TEE
Post op course

- Prolonged intubation
- Transient AKI with dialysis
- Discharged on day 18 with trach to rehab facility
Surgical Embolectomy

- US Nationwide Inpatient Sample – captures 20% inpatient data
- 1999-2008 – 2.1 M PE discharges
- 0.18% embolectomy with 28% in hospital mortality
- In-hospital mortality rate unstable pt with surgery 40%

No improvement in mortality over time
More aggressive support may reduce mortality with surgery

- Fukuda reported 19 patients with only 1 death
- 6 required CPR or percutaneous support prior to surgery
- Similar data from the Mayo but with higher mortality rate
Thank you for your attention