Transthoracic echocardiography in maternal critical illness
Preeclampsia, pulmonary oedema, maternal haemodynamics and the ROSE scan

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Disclosures

Nil
Institutional ethics approval and participant written consent

Yes
Overview

1. Maternal critical illness

2. Preeclampsia
   Hypertension and Haemodynamics
   Acute pulmonary oedema

3. ROSE scan
Maternal critical illness

“severe organ system derangement in a pregnant or recently pregnant woman, resulting, or likely to result, in severe morbidity or mortality”

Causes of maternal death
- Severe bleeding (haemorrhage) 25%
- Infections 15%
- Eclampsia 12%
- Obstructed labour 8%
- Unsafe abortion 13%
- Other direct causes 8%
- Indirect causes 20%

Maternal critical illness

“severe organ system derangement in a pregnant or recently pregnant woman, resulting, or likely to result, in severe morbidity or mortality”

Dennis AT. Transthoracic echocardiography in obstetric anaesthesia and obstetric critical illness. IJOA 2011;20:160-8
Maternal critical illness

Almost uniformly in both developed and developing countries, the two most common causes of admission to ICU were the obstetric diagnoses, hypertensive disorders of pregnancy and obstetric haemorrhage, with the majority of all ICU admissions occurring during the postpartum period.
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Maternal critical illness

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1 ICU admission for every 370 deliveries
Preeclampsia

A woman presented to an Emergency Department during her second trimester with abdominal pain and vomiting. Previously normotensive at the antenatal clinic, her blood pressure rose from 191/110 to 210/130 mmHg while in the Emergency Department. She had proteinuria ++++. She developed a severe headache and pain on breathing and was transferred to the labour ward where she was given a calcium channel blocker and opiate analgesia. Following an eclamptic seizure, treatment with magnesium sulphate and hydralazine infusion was started. First hands-on consultant involvement occurred around 8–10 hours after admission, at which time her blood pressure was still extremely high (systolic pressure still >200 mmHg) and she was unrousable. She died shortly after from a large intracranial bleed.
Healthy term pregnant woman

Woman with term preeclampsia
Definition

1. Hypertension occurring in pregnant women
2. Multi-organ system involvement
3. 5 – 8% of pregnant women
4. > 20 weeks gestation, resolves by 3/12 postpartum
Mortality

Figure 1 Contributory causes of maternal deaths due to hypertension in pregnancy: South Africa 2002–2004

Number of maternal deaths

- Cerebral complications
- Cardiorespiratory failure
- Multiple organ failure
- DIC
- Renal failure
- Unknown
- Hypovolaemic shock
- Hepatic failure
- Retroviral disease
- Septic shock
- Metabolic complications

Causes of maternal death
- Severe bleeding (haemorrhage) 25%
- Infections 16%
- Eclampsia 12%
- Obstructed labour 9%
- Unsafe abortion 13%
- Other direct causes 8%
- Indirect causes 20%


Peripartum complications- Suboptimal care

Pre-eclampsia and eclampsia: specific recommendations

- Pregnant women with a headache of sufficient severity to seek medical advice, or with new epigastric pain, should have their blood pressure measured and urine tested for protein, as a minimum. Epigastric pain in the second half of pregnancy should be considered to be the result of pre-eclampsia until proven otherwise.
- Any discussion between clinical staff about a woman with pre-eclampsia should include explicit mention of the systolic pressure.
- Severe, life-threatening, hypertension must be treated effectively. Management protocols should recognise the need to avoid very high systolic blood pressures which are associated with an increased risk of intracerebral haemorrhage.
- Systolic blood pressures of 150 mmHg, or above, require effective antihypertensive treatment. If the systolic pressure is very high, >180 mmHg, this is a medical emergency that requires urgent as well as effective antihypertensive treatment.
- Intramuscular oxytocin, not Syntometrine, should be the routine drug for active management of the third stage of labour.
- Women with severe pre-eclampsia need effective team care, based on clear communication and common understanding. There should be early engagement of intensive care specialists where appropriate. Efforts must be made to re-engage and re-skill GPs who see women with complications during pregnancy. Women who elect to pay for private obstetric care are entitled to as good a standard of care as they would receive in the NHS.

Pre-eclampsia/eclampsia: learning points

Eclampsia is important because it is a marker for severe disease, but seizures also carry additional intrinsic risks. Some automated blood pressure monitoring systems systematically underestimate systolic pressure in pre-eclampsia.
Classification - Mild versus severe preeclampsia

- Symptomatic disease is severe disease
- Abnormal biochemistry or haematology is usually severe disease

Table 3 Characteristics of severe pre-eclampsia.

<table>
<thead>
<tr>
<th>Severe pre-eclampsia threshold level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
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<tr>
<td>Systolic blood pressure</td>
</tr>
<tr>
<td>≥ 140 mmHg</td>
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<tr>
<td>≥ 160 mmHg – severe hypertension</td>
</tr>
<tr>
<td>≥ 180 mmHg – hypertensive crisis</td>
</tr>
<tr>
<td>And/or diastolic blood pressure</td>
</tr>
<tr>
<td>≥ 90 mmHg</td>
</tr>
<tr>
<td>≥ 110 mmHg – hypertensive crisis</td>
</tr>
<tr>
<td>And one or more of:</td>
</tr>
<tr>
<td>Central nervous system</td>
</tr>
<tr>
<td>Seizures/eclampsia</td>
</tr>
<tr>
<td>Headache</td>
</tr>
<tr>
<td>Visual disturbances</td>
</tr>
<tr>
<td>Papilloedema</td>
</tr>
<tr>
<td>Clonus/hyperreflexia</td>
</tr>
<tr>
<td>Pulmonary oedema</td>
</tr>
<tr>
<td>Cardiorespiratory system</td>
</tr>
<tr>
<td>Gastrointestinal system</td>
</tr>
<tr>
<td>Elevated liver transaminase enzymes</td>
</tr>
<tr>
<td>≥ 70 IU.L⁻¹</td>
</tr>
<tr>
<td>Liver tenderness</td>
</tr>
<tr>
<td>Nausea and vomiting</td>
</tr>
<tr>
<td>Epigastric pain</td>
</tr>
<tr>
<td>Haemoatological system</td>
</tr>
<tr>
<td>Haemolysis</td>
</tr>
<tr>
<td>Thrombocytopenia &lt; 100 × 10⁹.L⁻¹</td>
</tr>
<tr>
<td>Disseminated intravascular coagulation</td>
</tr>
<tr>
<td>Renal system</td>
</tr>
<tr>
<td>Proteinuria &gt; 5 g excreted in 24 h,</td>
</tr>
<tr>
<td>3 + protein dipstick</td>
</tr>
<tr>
<td>Protein/creatinine &gt; 0.5 g.mmol⁻¹</td>
</tr>
<tr>
<td>Urine output &lt; 500 ml in 24 h</td>
</tr>
<tr>
<td>Renal failure</td>
</tr>
<tr>
<td>Uteroplacental/fetal circulation</td>
</tr>
<tr>
<td>Placental abruption</td>
</tr>
<tr>
<td>Intrauterine growth restriction</td>
</tr>
<tr>
<td>Umbilical artery/uterine artery</td>
</tr>
<tr>
<td>blood flow abnormalities – absent</td>
</tr>
<tr>
<td>or reversed end-diastolic flow</td>
</tr>
</tbody>
</table>

General principles - severe preeclampsia

1. Early senior and multidisciplinary involvement
   Obstetrician, Midwife
   Anaesthetist – optimise, avoid intubation response, no ergometrine
   Haematologist, Intensive care team, Paediatrician

2. Standardised guidelines

3. Regular review and awareness of complications

4. Control of hypertension with antihypertensives
   SBP > 180 mmHg constitutes a medical emergency and should trigger and emergency response
   Do not use ergometrine

5. Prevention and treatment of seizures with MgSO₄

6. Meticulous fluid balance
Hypertension and haemodynamics

\[ \text{pressure} = \text{flow} \times \text{resistance} \]

- Blood pressure
- Cardiac output
- Systemic vascular resistance
- Stroke volume
- Heart rate

Diastolic function
Cardiac filling
Amount of fluid and the rate of filling

Systolic function
Cardiac emptying
Amount of fluid and rate of emptying
Transthoracic echocardiography

Structural information
Functional information
  Real time
  Non-invasive
  At the bedside
Haemodynamics in healthy pregnancy

Determined haemodynamics using this method in

- Healthy term pregnant women
- Healthy pre-term pregnant women
- Obese pregnant women – body mass index > 30 kg.m\(^{-2}\)
- Morbidly obese pregnant women – body mass index > 35 kg.m\(^{-2}\)

Conclusions:

1. Systolic function is reduced at term
2. Diastolic function is reduced at term
3. Pericardial effusions and left ventricular hypertrophy are common findings
4. Echocardiography is acceptable and applicable in healthy obese and non-obese pregnant women
Haemodynamics in women with untreated preeclampsia

Compared with healthy pregnant women:

1. What is the systolic function in women with preeclampsia?
2. What is the diastolic function in women with preeclampsia?
3. What is the cardiac structure in women with preeclampsia?
4. What is the haemodynamic reason for the hypertension in women with preeclampsia?

Dennis AT, Arhanghelschi I, Simmons SW, Royse CF. IJOA 2010;19:142-8
Systolic function

Diastole

Healthy pregnant

Preeclampsia

Systole

Diastolic function

Healthy pregnant woman

Woman with untreated preeclampsia

Left ventricular inflow velocities

Septal tissue Doppler waveform

\[ s' = 8.9 \text{ cm/s} \]
\[ \text{IVRT} = 40 \text{ ms} \]
\[ \text{baseline} \]
\[ a' = 6.7 \text{ cm/s} \]
\[ e' = 13.7 \text{ cm/s} \]

Dennis, A. T. (2010). "Cardiac function in women with preeclampsia. PhD thesis, Department of Pharmacology, Faculty of Medicine, Dentistry and Health Sciences, The University of Melbourne. [link]

Abnormal diastolic function

Healthy
MV E/e’ 6.3

Preeclampsia
MV E/e’ 10.6
Haemodynamics in women with untreated preeclampsia

- Preeclampsia is a state of
  - increased cardiac output
  - increased systemic vascular resistance
  - increased inotropy
  - markedly reduced diastolic function

- Hypertension is due to increased CO and mildly increased SVR
- Diastolic data consistent with Melchoirre 2011 and Rafik Hamad 2009
- Hypertensive cardiomyopathy due to diastolic failure causes acute pulmonary oedema

- Ongoing work.......
Review Article

Management of pre-eclampsia: issues for anaesthetists

A. T. Dennis

Review Article

Acute pulmonary oedema in pregnant women

A. T. Dennis¹ and C. B. Solnordal²
### Table 2. The Rapid Obstetric Screening Echocardiography Scan

<table>
<thead>
<tr>
<th>Transthoracic images</th>
<th>Modality</th>
<th>Measurements</th>
<th>Key findings sought</th>
<th>Structure</th>
<th>Size and function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasternal long axis</td>
<td>2D video, M-mode</td>
<td>Left ventricular outflow tract diameter, left atrial diameter, aortic root diameter, fractional shortening, left ventricular end-diastolic diameter, heart rate and rhythm</td>
<td>Presence of a pericardial effusion, presence of an intracardiac mass, aortic dissection</td>
<td>Left ventricular size and systolic function, right ventricular size and function</td>
<td></td>
</tr>
<tr>
<td>Parasternal short axis</td>
<td>2D video, M-mode</td>
<td>Fractional area change, movement of the interventricular septum, fractional shortening, left ventricular end-diastolic diameter, left ventricular end-diastolic area</td>
<td>Presence of regional wall motion abnormalities, presence of a pericardial effusion, presence of an intracardiac mass, position of the interventricular septum</td>
<td>Left ventricular size and systolic function</td>
<td></td>
</tr>
<tr>
<td>Apical 4-chamber</td>
<td>2D video, pulse wave Doppler, septal tissue Doppler</td>
<td>Left atrial volume, mitral valve E velocity, mitral valve A velocity, mitral valve deceleration time, mitral valve A wave duration, septal s’ velocity, septal e’ velocity, septal a’ velocity, isovolumetric relaxation time, mitral valve E/septal e’ ratio</td>
<td>Presence of increased right ventricular size compared with left ventricular size, presence of regional wall motion abnormalities, presence of a pericardial effusion, presence of an intracardiac mass, position of interventricular septum, position of interatrial septum</td>
<td>Left ventricular diastolic function, Left ventricular size and systolic function, right ventricular size and function</td>
<td></td>
</tr>
<tr>
<td>Apical 5-chamber</td>
<td>Pulse wave Doppler</td>
<td>Left ventricular outflow tract velocity time integral, cardiac output</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Systematic approach to examination

History/Examination
BP, HR, SpO₂, RR, Temperature, GCS, fluid balance
Respiratory and metabolic (ABGs), Renal, hepatic, haematological, TTE

• PLAX
• PSAX
• A4C
• A5C

– Observe
– Measure
– Calculate
– Verify
– Record
Parasternal Long Axis (PLAX)

Dennis AT: Transthoracic echocardiography in obstetric anaesthesia and obstetric critical illness. IJOA 2011; 20:160-168 doi:10.1016/j.iJOA.2010.11.007, Appendix A. Supplementary data
Parasternal Short Axis (PSAX)

Apical 4 and 5 Chamber (A4C, A5C)

Hypotension (heart failure)

Healthy

Hypotension (hypovolaemic shock due to haemorrhage)

Dennis AT, Stenson A. The use of transthoracic echocardiography in postpartum hypotension. Anesthesia and Analgesia 2012 115:1033-1037
Summary

- Maternal critical illness significant
- Transthoracic echocardiography can be used as a research and clinical tool
  - Reduced diagnostic uncertainty
  - Increases knowledge of physiology and pathophysiology
Thank you