Care of the Critically Ill Pregnant Patient

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No conflict of interest related to this topic

May describe “off-label” use considering limited data in pregnancy
Case Presentation

- 26 year old woman, 27 weeks gestation
- Admitted with:
  - hypoxic respiratory failure
  - bilateral pulmonary infiltrates

- FiO2 0.60
- pH 7.29
- pCO2 46
- pO2 52
- HCO3 22
- Sat 79%
Overview

• Physiological changes in pregnancy
• Risks to the fetus of maternal ICU stay
• Causes of critical illness during pregnancy
• Management
Anatomic effects

- airway edema, friability
- widened AP and transverse diam.
- elevated diaphragm
- widened subcostal angle
- enlarging uterus

Functional effects
Anatomic effects:
- airway edema
- friability
- widened AP and transverse diam.
- elevated diaphragm
- widened subcostal angle
- enlarging uterus

Functional effects:
- increased respiratory drive
- minimal change in TLC
- increased Vt
- reduced FRC
- normal diaphragmatic function
- increased $O_2$ consumption and $CO_2$ production
Anatomic effects

- Airway edema, friability
- Widened AP and transverse diam.
- Elevated diaphragm
- Widened subcostal angle
- Enlarging uterus

Functional effects

- Increased respiratory drive
- Minimal change in TLC
- Increased Vt
- Reduced FRC
- Normal diaphragmatic function
- Increased $O_2$ consumption and $CO_2$ production
Blood gases in late pregnancy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.43</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>30 mmHg</td>
</tr>
<tr>
<td>PaO₂</td>
<td>105 mmHg</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>20 mEq/L</td>
</tr>
</tbody>
</table>

- hyperventilation
- normal a-A gradient
- renal compensation

Decreased oxygen reserve

- reduced FRC
- increase O₂ consumption
Cardiovascular Changes

- increased blood volume (up 40% by third trimester)
- increased cardiac output
  - 30 – 50% by 25 – 32 weeks
- decrease in blood pressure
  - 10 – 20%, nadir 28 weeks
- decreased SVR
- increased LV mass and LV ED dimension
Cardiovascular Changes

Supine hypotensive syndrome

Kinsella SM, Lohmann G. Obstet Gynecol 1994;83:774-788
<table>
<thead>
<tr>
<th></th>
<th>Mean value</th>
<th>Change from non-pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP</td>
<td>90±6</td>
<td>minimal change</td>
</tr>
<tr>
<td>PCWP</td>
<td>4±2.5</td>
<td>no change</td>
</tr>
<tr>
<td>SVR</td>
<td>1200±260</td>
<td>20 - 30% decrease</td>
</tr>
<tr>
<td>PVR</td>
<td>75 ±22</td>
<td>20 - 30% decrease</td>
</tr>
<tr>
<td>CO</td>
<td>6.2 ±1.0</td>
<td>20 - 50% increase</td>
</tr>
</tbody>
</table>

Risks to the fetus

- Fetal hypoxia
- Radiological investigations
- Drug therapy
Risks to the fetus

- Fetal hypoxia
- Radiological investigations
- Drug therapy
Fetal Oxygenation

- **Determinants**
  - placental function
  - uterine oxygen delivery
Fetal Oxygenation

Determinants

- placental function
- uterine oxygen delivery
  - Maternal oxygen content
  - Uterine blood flow
Fetal Oxygenation

- Determinants
  - placental function
  - uterine oxygen delivery
    - Maternal oxygen content
    - Uterine blood flow
      - normally maximally dilated
      - decreased by catecholamines
      - alkalosis
      - hypotension
      - contractions
Fetal Oxygenation
Risks to the fetus

- Fetal hypoxia
- Radiological investigations
- Drug therapy
Radiological Procedures

Fetal risk

- **oncogenicity**
  - increased incidence of childhood leukemia (RR 1.5 – 2.0)
  - associated with 2 – 5 rads

- **teratogenicity**
  - fetal exposure 10 to 50 rads
  - 10 – 20 in first 6 weeks gestation

- **other**
  - Neuro development (5-30 rad at 8-15 weeks)

Fetal exposure (rad)

- chest XR: 0.001
- V/Q: 0.060 – 0.5
- CT angio: 0.100 – 0.5
- CT pelvis/abdo: 0.6 – 5.0

National Radiological Protection Board, 1998
Ratnapalan et al, CMAJ 2008; 179:1293
Radiological Procedures

Management

- Consider risk-benefit
  - Don’t avoid necessary studies, eg. CT angio
  - Don’t do unnecessary, eg. daily CXR, lateral
  - Remember contrast for CT angio may carry risk

- Screen abdomen
  - Reduce exposure by 50%
  - Still internal scatter

- Discuss with mother and father
  - Perceived risk very high (parents and family doc)
  - Can be a major source of concern

National Radiological Protection Board, 1998
Ratnapalan et al, CMAJ 2008; 179:1293
Risks to the fetus

- Fetal hypoxia
- Radiological investigations
- Drug therapy
Drug therapy

- altered clearance
- increased volume of distribution
- effects on placental perfusion & fetus
- teratogenic effects
Drugs in Pregnancy

- **Inotropic therapy:**
  - All inotropes potentially reduce placental perfusion
  - Use what is best for the mother
    - Fluid first
    - **Remember left lateral positioning**
  - Specific drugs:
    - Ephedrine – suggested drug of choice for hypotension
    - Dopamine – variable effects on uterine blood flow
    - Dobutamine – variable effects on uterine blood flow
    - Norepinephrine – reduced uterine blood flow
    - Epinephrine – reduces blood flow, data supporting use
    - Phenylephrine – used for hypotension 2° to spinal
Drugs in Pregnancy

➢ DO NOT avoid drugs needed by the mother!

   e.g.

   STEROIDS
   INOTROPES
   ANTIBIOTICS
   EPINEPHRINE in CODES
Risks of an ICU stay to the fetus


- Fetal loss
  - 1\textsuperscript{st} trimester: 65% spontaneous abortion
  - 2\textsuperscript{nd} trimester: 43% fetal loss
  - 3\textsuperscript{rd} trimester: 5% fetal loss

- Risk factors for fetal loss:
  - Maternal shock
  - Lower gestational age
  - Maternal transfusion
## Risks of an ICU stay to the fetus

- Secondary analysis of 30 pregnant women in ICU

<table>
<thead>
<tr>
<th>Variables</th>
<th>Fetus survived, median (IQR) (N = 24)</th>
<th>Fetus died, median (IQR) (N = 6)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25.5 (19.5-33.0)</td>
<td>24.0 (19.0-28.0)</td>
<td>0.46</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>30.5 (25.5-35.5)</td>
<td>20.5 (18.0-29.0)</td>
<td>0.05</td>
</tr>
<tr>
<td>Gravity</td>
<td>1 (0–1.5)</td>
<td>0 (0–1)</td>
<td>0.31</td>
</tr>
<tr>
<td>APACHE II</td>
<td>12.5 (7.5-14.0)</td>
<td>15.5 (13.0-21.0)</td>
<td>0.08</td>
</tr>
<tr>
<td>GCS</td>
<td>15 (14–15)</td>
<td>12 (7–15)</td>
<td>0.13</td>
</tr>
<tr>
<td>Maximum temperature (celsius)</td>
<td>37.5 (36.8-38.1)</td>
<td>38.6 (37.6-39.5)</td>
<td>0.07</td>
</tr>
<tr>
<td>Minimum systolic blood pressure (mmHg)</td>
<td>107 (103–118)</td>
<td>108 (88–110)</td>
<td>0.80</td>
</tr>
<tr>
<td>Minimum diastolic blood pressure (mmHg)</td>
<td>58 (55–68)</td>
<td>69 (61–70)</td>
<td>0.41</td>
</tr>
<tr>
<td>P/F ratio</td>
<td>238 (178–375)</td>
<td>190 (177–292)</td>
<td>0.44</td>
</tr>
<tr>
<td>A-a DO2</td>
<td>164 (62–236)</td>
<td>172 (127–374)</td>
<td>0.27</td>
</tr>
<tr>
<td>Alkaline phosphatase (U/L)</td>
<td>160 (99–251)</td>
<td>57.5 (44.5–91.5)</td>
<td>0.05</td>
</tr>
<tr>
<td>Hgb (g/dL)</td>
<td>96.5 (85–105.5)</td>
<td>91 (74–97)</td>
<td>0.28</td>
</tr>
<tr>
<td>Bicarbonate (mmol/L)</td>
<td>22 (18.0-23.6)</td>
<td>18.5 (15.5-20.1)</td>
<td>0.06</td>
</tr>
<tr>
<td>PTT (seconds)</td>
<td>28.7 (25.9-32.4)</td>
<td>20.6 (16.6-24.5)</td>
<td>0.03</td>
</tr>
<tr>
<td>Hospital LOS (days)</td>
<td>7.5 (7–11)</td>
<td>11 (9–31)</td>
<td>0.25</td>
</tr>
<tr>
<td>ICU LOS (days)</td>
<td>2 (2–4)</td>
<td>7.5 (5–9)</td>
<td>&lt;0.002</td>
</tr>
</tbody>
</table>

Aoyama et al, Crit Care 2014; 18:307
Critical illness in pregnancy

- Pregnancy-specific
- Aggravated by pregnancy
- Non-specific
Critical illness in pregnancy

- Pregnancy - specific
  - Preeclampsia
  - Amniotic fluid embolism
  - HELLP syndrome
  - Acute fatty liver of pregnancy
  - Obstetric sepsis (eg. chorioamnionitis)

- Aggravated by pregnancy

- Non - specific
Critical illness in pregnancy

- Pregnancy-specific
- Aggravated by pregnancy
- Non-specific
  - Gastric acid aspiration
  - Venous thromboembolism
  - Pyelonephritis (producing ARDS)
  - Pneumonia (varicella, fungal)
  - Connective tissue disease
  - Cardiac disease
  - Diabetes
Critical illness in pregnancy

- Pregnancy-specific
- Aggravated by pregnancy
- Non-specific
  - Trauma
  - Non-obstetric infections
  - Chronic respiratory failure
  - and others
Preeclampsia

 Syndrome of

- hypertension
- proteinuria
- after 20 weeks gestation

 Complications:

- pulmonary edema
- cerebral edema
- hypertensive crises
- renal failure
- eclampsia (seizures)
- hepatic: HELLP
Preeclampsia & pulmonary edema

- affects 3% of preeclamptics
- more common in obese, chronically hypertensive women
- mechanisms:
  - diastolic LV dysfunction
  - volume increases
  - increased afterload
  - reduced colloid osmotic pressure

*Obstet Gynecol* 72:553
Preeclampsia - Management

Well-timed delivery

- **Hypertension:**
  - ONLY to avoid maternal hypertensive complications
  
  *Von Dadelszen, Lancet 2000; 355:87*

- **Seizures:**
  - Rx and prophylaxis with Magnesium sulfate

  *Lancet 2002, 359:1877*

- **Fluid Management:**
  - usually volume depleted - careful fluid administration
  - PA-line – if oliguric
  - avoid overdiuresis
Preeclampsia - Management

Well-timed delivery

- Hypertension:
  - ONLY to avoid maternal hypertensive complications
    
- Seizures:

**Magnesium sulfate**

**Dose:** 2-4 g followed by 1-3 g/hr infusion

**Level:** usually 2.0 – 3.0 mmol/L

**Complications:** Toxic >3.5 mmol/L (NB renal F)
  - respiratory muscle weakness
  - cardiac conduction defects

**Antidote:** Calcium IV

Von Dadelszen, Lancet 2000; 355:87

Lancet 2002, 359:1877
Preeclampsia - Management

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HELLP syndrome
HELLP syndrome

- Hemolytic anemia
- Elevated liver enzymes
- Thrombocytopenia

4 to 12% of preeclampsia
Occasionally presents post-partum

Differential diagnosis
- TTP
- HUS
- AFLP
- SLE
- APLAS
HELLP syndrome

- **Hepatic:**
  - Abdominal pain, nausea, vomiting
  - Elevated AST, ALT
  - Intrahepatic hemorrhage

- **Coagulopathy:**
  - Thrombocytopenia
  - DIC: 38%
  - Hemorrhage

- **Hemolysis:**
  - Microangiopathic anemia

- **Other:**
  - Renal failure
  - ARDS
HELLP - Management

- Treat Preeclampsia
- Blood products
- Monitor liver

Delivery!

Plasmapheresis if > 72 hr postpartum
TTP?

Steroids

HELLP - Management

- Treat Preeclampsia
- Delivery!
- Blood products
- Monitor liver
- Plasmapheresis if > 72 hr postpartum TTP?
- Steroids

References:
Acute Fatty Liver of Pregnancy
Acute Fatty Liver of Pregnancy

uncommon 1 in 15,000 pregnancies

Clinical Features
- onset usually late third trimester
- anorexia, vomiting, jaundice
- abdominal pain
- coagulopathy, encephalopathy, renal failure

Early reports: fulminant hepatic failure, high mortality
More recently: early recognition, improved outcome
Acute Fatty Liver of Pregnancy

Management

DELIVERY

- no reversal without delivery
- improvement occurs within 2 to 3 days
- gestation usually near term
- high incidence of placental damage
Acute Fatty Liver of Pregnancy

Management

- **DELIIVERY**
  - no reversal without delivery
  - improvement occurs within 2 to 3 days
  - gestation usually near term
  - high incidence of placental damage

- **supportive**
  - as for hepatic failure

- **specific**
  - none effective plasmapheresis?

- **transplant**
  - if deteriorate after delivery
Liver disease in pregnancy - Etiology

- 79% of mothers carrying a fetus homozygous for a specific mutation of long chain 3-hydroxyacyl-CoA dehydrogenase had AFLP

Amniotic Fluid Embolism
Amniotic Fluid Embolism

- Rare: 1/8,000 to 1/80,000
- Catastrophic: mortality 10 - 86%
- Presentation: cardiorespiratory collapse, fetal distress, cardiac arrest, seizures
- Late effects: ARDS & DIC
Amniotic Fluid Embolism

- **Pathophysiology:**
  - Amniotic fluid enters venous circulation
  - Cellular contents and humoral factors
  - Abnormal maternal immune response
  - Pulmonary hypertension & myocardial dysfunction

- **Management:**
  - Supportive - ventilation, inotropes
  - Steroids?
  - Anticipate ARDS & DIC
Amniotic Fluid Embolism

Testing for AFE

- Usually diagnosis of exclusion
- Not yet adequately validated:
  - Tryptase (ie. anaphylaxis)
  - Fetal squames and debris in pulmonary capillaries
  - Complement levels
  - Zinc coproporphyrin
  - Sialyl Tn antigen
  - C1 esterase inhibitor

ICU Management
Intubation:

- difficult – desaturate, aspirate
- most experienced person available

Non-invasive ventilation

- role in short term support, eg
  - pulmonary edema
  - tiring neuromuscular disease
- benefit: avoid sedation, risks of intubation
- risks: aspiration
**Mechanical Ventilation in Pregnancy**

**Conventional Ventilation**

- **Oxygenation**
  - optimize: \( \text{PaO}_2 > 90 \text{ mmHg} \) if possible

- **Ventilation**
  - normal \( \text{PaCO}_2 \) 30 mmHg
  - permissive hypercapnia?
  - avoid alkalosis

- **Pressure**
  - respiratory system compliance
  - adequate PEEP
Mechanical Ventilation in Pregnancy

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  - adequate PEEP
Conventional Ventilation

- **Hypocapnia**
  - Maternal PaCO$_2$ < 25 mmHg:
    - decreased UBF -> fetal hypoxia and acidosis

- **Hypercapnia**
  - Fetal acidemia 2$^o$ to maternal acidemia: not 2$^o$ to fetal hypoxemia
  - Maternal PaCO$_2$ of 50-60 mmHg seems well tolerated
  - Small studies: mild hypoventilation (pH 7.36) better tolerated by fetus than mild hyperventilation (pH 7.5)

*Peng et al, Br J Anaesth 1972, 44:1173
Buss Am J Physiol 1975; 228:1497
Clark Anesth Analg 1971; 50:713
Hollemen, Acta Anaesth Scan 1972, 221
Ivankovic et al, Am J Obstet Gynecol 1970*
Mechanical Ventilation in Pregnancy

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  - adequate PEEP
Cardiac Arrest in Pregnancy

- 1 in 12,000 admissions for delivery (US data)
- 58.9% survive to hospital discharge

**Causes:**
- A anesthetic complications, accidents
- B bleeding
- C cardiovascular (MI, cardiomyopathy, dissection)
- D drugs (e.g. magnesium, narcotics, oxytocin bolus)
- E embolic (amniotic fluid, thromboembolism)
- F fever (sepsis)
- G general (usual differential for cardiac arrest)
- H hypertension (preeclampsia, HELLP)

*Circulation. 2015 Nov 3;132(18):1747-73*
Cardiac Arrest in Pregnancy

Management differences:
Cardiac Arrest in Pregnancy

Management differences:

- Manually displace uterus to left
- No change in defibrillation
- No change in drug therapy
- Attention to oxygenation
- Place IV access above the diaphragm
- Perimortem Cesarean section
Cardiac Arrest in Pregnancy

Perimortem Cesarean section:

- Who? Potentially viable fetus
- Don’t move patient
- Benefit to both mother and fetus
- Initiate if no ROSC at 4 minutes
  - Immediately, if timing unclear
  - Still beneficial if much later
Cardiac Arrest in Pregnancy

Perimortem Cesarean section:

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Benson et al, EBIOM 2016. 6:253-7
Other Management Issues

- Sedation & NM blockade
- Fetal monitoring
- Delivery
Other Management Issues

- Sedation & NM blockade
- Fetal monitoring
- Delivery

Remember fetus may be sedated/paralysed
Other Management Issues

- Sedation & NM blockade
- Fetal monitoring
- Delivery
  - fetus acts as end-organ:
    - not protected by maternal homeostasis
    - indicator of maternal oxygen delivery
    - need to interpret & respond
Other Management Issues

- Sedation & NM blockade
- Fetal monitoring
- Delivery
Delivery of the fetus

- Given the physiological changes, it may be considered that delivery of the pregnant women with respiratory failure is beneficial to the mother.
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**NOT always the case:**
- Small oxygenation improvement
- Little change in compliance or PEEP requirement

Delivery of the fetus

- Given the physiological changes, it may be considered that delivery of the pregnant women with respiratory failure is beneficial to the mother.

- NOT always the case:
  - Small oxygenation improvement
  - Little change in compliance or PEEP requirement

- Delivery:
  - If fetus is viable and at risk due to maternal hypoxia
  - NOT purely to improved maternal condition

Prepare the ICU for Emergencies in Pregnancy
Labour & Delivery Equipment (Checklist #1)

On Trolley:
1. Charting-
   i. this will require paper documentation
   ii. post c/s order sets (in the event that a c/s is done post procedure)
2. Ceserean Section Tray/Vaginal Delivery Tray
3. Sterile C-section pack
4. Package of sterile gowns
5. Sterile gloves - 2 of each size
6. single examining sterile glove
7. Vaginal delivery basin set
8. Medication Tray - take an extra 10 vials of Oxytocin
9. Sponges – 4 packs of 5 sponges
10. Sutures
11. Scalpel blades
12. Kiwi Vacuum
13. Baby blankets 2 sterile, 3 non-sterile

In Fridge: (take from L&D fridge, check dates and put in med fridge on off service unit, with patient’s identification on it)
1. Hen sobate
2. Ergot
3. Misoprostol

Infant Support Required Equipment (Checklist #2)

- 1x amp of Epinephrine 1:10,000
- 1x amp of Naloxone 0.4mg
- Omnibed/Overhead warmer/Isolette
- Temperature Probe
- 3x Silver Dots
- Intubation Kit, including 2x #2.5 ETT, 2x #3.0 ETT, 2x #3.5 ETT, stylet, magills, blades, oral airways (size 5 and 6), ECO2 detector, scissors, 1 roll pink tape
- Flow-inflating Bag w/ size 00 and 0 masks
- Pressure Manometer for Flow-inflating Bag
- Oxygen tank (Grab and Go)
- SpO2 monitor (for SpO2 and HR)
- Sterile gown and gloves, hat and surgical mask
- Multi-purpose tray
- Umbilical catheters (2x 3.5Fr, 2x5Fr)
- #15 Scalpel blade
- 3x Chlorhexidine prep sticks
- 3x 10cc syringes
- 2x Blunt Filling Needles
- 2x amps of Normal Saline
- 1x amp of Sterile Water
- 3x 4x4 Sterile Gauze
- 1x amp of Vitamin K
- 1x Tuberculin Syringe w/ needle
- 2x IV Pumps
- 1x 500cc bag of D5W