Pulmonary Disease in Pregnancy

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• No financial interests to disclose.
Objectives

• Physiologic changes in pregnancy –
  – Pulmonary
  – ABGs, etc

• Asthma overview
  – Diagnosis
  – Classification
  – Management
Physiologic Changes

• Uterus enlarges, viscera are pushed up

• Chest wall
  – Diaphragm is elevated (4cm)
  – Increase in circumference (6cm)
  – Widening of costal angles (70 to 104 degrees)
  – Increase in diaphragmatic excursion (1.5cm)

• Occur before increases of uterine size, maternal body weight, or intraabdominal pressure

• Respire for the fetus
Respiratory physiology in pregnancy

- Upper airways
  - Mucosal edema
  - Capillary engorgement
  - Edema in preeclamptics, patients that have been aggressively hydrated
Why Pregnant Women Breathe More

• Progesterone induced hyperventilation
  – Serum levels increase in pregnancy
    • 25ng/mL at 6 weeks; term - 150ng/mL
  – Stimulates central respiratory center
    • Increased sensitivity to CO2
    • Estrogen increases central expression of progesterone receptors
  – Net = increased ventilatory drive

• Acute asthma ‘superimposes’ extra hyperventilation
  • More severe compromise during pregnancy vs nonpregnant state
Oxygen dissociation

- Right shift causes decreased maternal affinity for O2 (increased levels of 2,3-DPG)
- HbF is unable to react to 2,3-DPG, and so maintains high affinity for O2 despite relative acidemia
Respiratory Musculature

• Respiratory muscle function is unchanged
  – Maximal inspiratory and expiratory pressures are unchanged
Lung Volumes
Lung Volumes

• Respiratory rate (# breaths/minute) – no change
• Total lung capacity – total amount of volume you can breathe in after max inspiration
  – decreased
• Vital capacity – expired vol with maximal exhalation - NC
• Residual volume – what is left after maximal exhalation
  – volume in lungs after VC; decreased by 20%
• FRC – functional residual capacity – volume remaining after normal expiration (take normal breath out – how much vol is left in lungs)
  – Decreased 20%, by 300-500 mL – due to elevation of diaphragm
  – Changing from sitting to supine at term causes another 25% decrease in FRC
  • may increase closure of small airways especially in obese patients in the supine or lithotomy position
• ERV – expiratory reserve volume – (FRC – RV)
  – (Vol left after normal breath) – (Vol left after maximal breath)
Other variables

- **Airway function** – unchanged
- **Diffusing capacity** – unchanged
- **Oxygen delivery** – dependent on Hb
  - $O_2$ delivery $= CO \times CaO2 \times 10$
  - $CaO2 = (Hgb \times 1.34 \times SaO2) + (PaO2 \times 0.0031)$
  - $CaO2$ is thus much more dependant on Hgb function than diffusion of $O_2$ into serum
  - $O_2$ delivery can be significantly affected by maternal anemia or CO poisoning
  - Physiologic anemia of pregnancy is compensated by a 50% increase in CO (increases in both HR and SV)
Minute Ventilation is Increased

- Minute ventilation – RR x TV
  - Increases 40% to 100-200cc during early pregnancy and remains constant

- More ventilation at the expense of reserves
  - Increased AP diameter expansion
    - Chest circumference increases 2cm
    - Diaphragm excursion not impaired, rather increases
  - Use up FRC, VC
Respiratory physiology in pregnancy

- Residual volume
  - volume of air remaining in the lungs after maximal expiration
  - decreases 20% due to elevation of diaphragm

- Functional residual capacity (volume of air in lungs at resting expiratory level)
  - decreases 20% due to elevation of diaphragm
  - decreases 300-500mL
  - changing from sitting to supine at term causes another 25% decrease in FRC
    - may increase closure of small airways especially in obese patients in the supine or lithotomy position
Pathophysiologic Implications

- Mom is able to hold her breath less
  - 1 vs 2 lung example

- Decreased FRC
  - Closing capacity – amount of volume that has to be behind to keep small airways open
    - diminished

- Develop hypoxemia quicker than when not pregnant (at greater risk of hypoxemia)

- Pulmonary insults are tolerated less well
### ABG Changes in Pregnancy

- *compensatory increase in renal bicarbonate excretion*
- **decreased in supine position and 3rd trimester**
- ***increased by 6 in supine position and 3rd trimester***

<table>
<thead>
<tr>
<th>Variable</th>
<th>Nonpregnant</th>
<th>Pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.35-7.43</td>
<td>7.4-7.47</td>
</tr>
<tr>
<td>pCO2 (mmHg)*</td>
<td>37-40</td>
<td>27-31</td>
</tr>
<tr>
<td>pO2 (mmHg)**</td>
<td>103</td>
<td>101-104</td>
</tr>
<tr>
<td>P(A-a)O2 (mmHg)***</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>HCO3- (mEq/L)</td>
<td>22-26</td>
<td>18-22</td>
</tr>
<tr>
<td>Base deficit (mEq/L)</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
# Blood Gas Interpretation – Pregnant Women

<table>
<thead>
<tr>
<th>pO₂</th>
<th>pCO₂</th>
<th>pH</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Decreased</td>
<td>Increased</td>
<td>Mild distress, compensated</td>
</tr>
<tr>
<td>Decreased</td>
<td>Decreased</td>
<td>Increased</td>
<td>Moderate distress, compensated</td>
</tr>
<tr>
<td>Decreased</td>
<td>Normal (~27-31)</td>
<td>Normal</td>
<td>Danger – Impaired Ventilation</td>
</tr>
<tr>
<td>Decreased</td>
<td>Increased (&gt;40)</td>
<td>Decreased</td>
<td>Respiratory Failure</td>
</tr>
</tbody>
</table>
CXR changes in pregnancy

- Apparent cardiomegaly (enlarged transverse diameter)
- Enlarged left atrium (lateral views)
- Increased vascular markings
- Straightening of left heart border
- Postpartum pleural effusion (right sided)
Asthma

- 4-8% of all pregnancies
- Prevalence and morbidity increasing
- Mortality decreasing

- Classification
- Step therapy
Pathophysiology

- Inflammation
- Bronchoconstriction
Diagnosis

• Symptoms (cough, dyspnea, wheezing)

• Demonstration of airway obstruction on spirometry that is partially reversible with a bronchodilator (>12% increase of FEV1 after bronchodilator)

• DDX – Dyspnea of pregnancy, GERD, bronchitis, postnasal drip (allergies)
Pulmonary function testing

• Peak expiratory flow rate (PEFR)
  – L/min

• Forced expiratory volume in the first second of expiration (FEV1) – L in 1st sec
Individualized PEFR zones

- Establish ‘personal best’ PEFR then determine zone based on the following:
  - Green - >80% of personal best PEFR
  - Yellow – 50-80% of personal best PEFR
  - Red - <50% of personal best PEFR

- Typical PEFR = 380-550 L/min
Table 1. Classification of Asthma Severity and Control in Pregnant Patients

<table>
<thead>
<tr>
<th>Asthma Severity* (Control†)</th>
<th>Symptom Frequency</th>
<th>Nighttime Awakening</th>
<th>Interference With Normal Activity</th>
<th>FEV₁ or Peak Flow (Predicted Percentage of Personal Best)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent (well controlled)</td>
<td>2 days per week or less</td>
<td>Twice per month or less</td>
<td>None</td>
<td>More than 80%</td>
</tr>
<tr>
<td>Mild persistent (not well controlled)</td>
<td>More than 2 days per week, but not daily</td>
<td>More than twice per month</td>
<td>Minor limitation</td>
<td>More than 80%</td>
</tr>
<tr>
<td>Moderate persistent (not well controlled)</td>
<td>Daily symptoms</td>
<td>More than once per week</td>
<td>Some limitation</td>
<td>60–80%</td>
</tr>
<tr>
<td>Severe persistent (very poorly controlled)</td>
<td>Throughout the day</td>
<td>Four times per week or more</td>
<td>Extremely limited</td>
<td>Less than 60%</td>
</tr>
</tbody>
</table>

Abbreviation: FEV₁, forced expiratory volume in the first second of expiration

*Assess severity for patients who are not taking long-term-control medications.

†Assess control in patients taking long-term-control medications to determine whether step-up therapy, step-down therapy, or no change in therapy is indicated.
Evaluation & Treatment

• H&P, EKG, Echocardiogram if severe, uncontrolled disease, PFTs

• Avoid triggers
• Reflux – H2 blocker, PPI
• Immunoprophylaxis (Allergy shots) – OK in pregnancy if on maintenance dosing
• Step therapy
Limiting Exposure to Asthma Triggers

- Plastic mattress, pillow covers
- Weekly washing of bedding in hot water
- Animal dander control (baths, pets out of bedroom, keep outside)
- Cockroach control
- Avoid tobacco smoke
- Inhibit mite and mold growth by reducing humidity
- Leave when home is vacuumed
- Immuno therapy OK to continue in pregnancy
Risk Factors Of Death From Asthma

- History of sudden severe exacerbations
- Prior intubations
- Prior admission to ICU due to asthma
- >2 hospitalizations per year
- >3 ER visits for asthma
- Hospitalization or ER visit within last 30 days
- Use of > 2 cannisters of beta agonist per month
- Current use of steroids or recent withdrawl from them
- Comorbidity (cardiovascular or COPD)
- Serious psychiatric illness
- Illicit drug use
- Poor perception of air flow or severity
- Low socioeconomic status
- Sensitivity to mold
Pregnancy Outcomes

- Mild and well-controlled moderate asthma
  - Good outcomes
- Severe and poorly controlled asthma
  - PTB
  - CD
  - Preeclampsia
  - Growth restriction
  - Perinatal complications
  - Maternal morbidity and mortality
The Relationship Of Asthma Medication Use To Perinatal Outcomes

Schatz, et al MFMU Network, 2004

• Study relationship of asthma and asthma medications and adverse perinatal outcomes (risk of preeclampsia, preterm deliveries, and lower-birth-weight infants)
• 16 centers, 1994-2000; N = 2123 asthmatic participants
• No relationship between inhaled beta agonists, inhaled corticosteroids, theophylline and adverse perinatal outcomes
• Oral corticosteroid use associated with preterm birth, LBW
  – Related to asthma severity
  – Mechanism unknown
National Asthma Ed and Prevention Program

• ‘Safer for pregnant women to be on asthma medications to control the disease than it is for them to have asthma symptoms and exacerbations…’
Mild Intermittent

• Pregnancy
  – 13% exacerbation rate
  – 2.3% hospitalization rate

• Symptoms <2d/week or <2nights/month

• PEFR ≥80%

• Management –
  – Avoid triggers
  – Albuterol inhaler, prn
  – No maintenance medication needed
  – Severe exacerbations may occur; long asymptomatic periods are common
  – Course of systemic steroids with exacerbation if needed
Mild Persistent

- Pregnancy
  - 13% exacerbation rate
  - 2.3% hospitalization rate

- Symptoms >2d/wk but not daily; Nighttime awakening >2x/month

- PEFR >80%

- Preferred treatment
  - Low dose inhaled corticosteroid

- Alternative
  - Cromolyn sodium inhaler
  - Montelukast sodium - Leukotriene receptor antagonist – 10mg orally daily
Moderate Persistent

- Pregnancy
  - 26% exacerbation rate
  - 7% hospitalization rate
- Symptoms daily or nighttime awakening >1 night/week
- PEFR 60-80%
- Preferred treatment
  - Medium dose inhaled corticosteroid
  - Long acting beta2 agonist
- Alternative
  - Low dose inhaled corticosteroid
  - Leukotriene receptor antagonist
Severe persistent

- Pregnancy
  - 52% exacerbation rate
  - 27% hospitalization rate
- Symptoms continually, daily; >4 nights/week
- PEFR <60%
- Preferred treatment
  - High dose inhaled corticosteroid steroid
  - Long acting beta2 agonist
  - Oral corticosteroids
    - Prednisone 1-2mg/kg/day
    - Vit D/calcium
- Alternative
  - High dose inhaled steroid
Step Therapy Medical Management of Asthma During Pregnancy

Mild Intermittent Asthma
• No daily medications, albuterol as needed

Mild Persistent Asthma
• Preferred—Low-dose inhaled corticosteroid
• Alternative—Cromolyn, leukotriene receptor antagonist, or theophylline (serum level 5–12 mcg/mL)

Moderate Persistent Asthma
• Preferred—Low-dose inhaled corticosteroid and salmeterol or medium-dose inhaled corticosteroid or (if needed) medium-dose inhaled corticosteroid and salmeterol
• Alternative—Low-dose or (if needed) medium-dose inhaled corticosteroid and either leukotriene receptor antagonist or theophylline (serum level 5–12 mcg/mL)

Severe Persistent Asthma
• Preferred—High-dose inhaled corticosteroid and salmeterol and (if needed) oral corticosteroid
• Alternative—High-dose inhaled corticosteroid and theophylline (serum level 5–12 mcg/mL) and oral corticosteroid if needed
# Treatment

<table>
<thead>
<tr>
<th>Corticosteroid</th>
<th>Amount</th>
<th>Low Dose</th>
<th>Medium Dose</th>
<th>High Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beclomethasone HFA</td>
<td>40 mcg per puff</td>
<td>2–6 puffs</td>
<td>More than 6–12 puffs</td>
<td>More than 12 puffs</td>
</tr>
<tr>
<td></td>
<td>80 mcg per puff</td>
<td>1–3 puffs</td>
<td>More than 3–6 puffs</td>
<td>More than 6 puffs</td>
</tr>
<tr>
<td>Budesonide</td>
<td>200 mcg per inhalation</td>
<td>1–3 puffs</td>
<td>More than 3–6 puffs</td>
<td>More than 6 puffs</td>
</tr>
<tr>
<td>Flunisolide</td>
<td>250 mcg per puff</td>
<td>2–4 puffs</td>
<td>4–8 puffs</td>
<td>More than 8 puffs</td>
</tr>
<tr>
<td>Fluticasone HFA</td>
<td>44 mcg per puff</td>
<td>2–6 puffs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>110 mcg per puff</td>
<td>2 puffs</td>
<td>2–4 puffs</td>
<td>More than 4 puffs</td>
</tr>
<tr>
<td></td>
<td>220 mcg per puff</td>
<td>1–2 puffs</td>
<td></td>
<td>More than 2 puffs</td>
</tr>
<tr>
<td>Fluticasone DPI</td>
<td>50 mcg per inhalation</td>
<td>2–6 puffs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100 mcg per inhalation</td>
<td>1–3 puffs</td>
<td>3–5 puffs</td>
<td>More than 5 puffs</td>
</tr>
<tr>
<td></td>
<td>250 mcg per inhalation</td>
<td>1 puff</td>
<td>2 puffs</td>
<td>More than 2 puffs</td>
</tr>
<tr>
<td>Mometasone</td>
<td>200 mcg per inhalation</td>
<td>1 puff</td>
<td>2 puffs</td>
<td>More than 2 puffs</td>
</tr>
<tr>
<td>Triamcinolone</td>
<td>75 mcg per puff</td>
<td>4–10 puffs</td>
<td>10–20 puffs</td>
<td>More than 20 puffs</td>
</tr>
</tbody>
</table>

*Total daily puffs is usually divided into a twice-per-day regimen.

Abbreviations: DPI, dry powder inhaler; HFA, hydrofluoralkane

Home Management Of Acute Asthma Exacerbations

• Inhaled albuterol 2-4 puffs, check PEFR in 20 minutes
  - PEFR <80% predicted despite therapy or <60% without therapy
    • Report to ER/LDR
    • OR, Repeat albuterol treatment, check PEFR in 20 minutes
    • If still 50-80% of predicted, report to ER
  - PEFR > 80% predicted
    • Continue inhaled albuterol (2-4 puffs q3-4hr for 6-12hr prn)
  - If decreased FM
    • ER/LDR
ER/LDR Care

- **Evaluation** – H&P, PEFR, oximetry, fetal monitoring, ABG
- **Treatment**
  - Albuterol – 3 puffs, repeat every 15-30 minutes
  - IV hydration
  - Oxygen to maintain saturation >95%
- **If no wheezing and PEFR or FEV1 >70% baseline, discharge with follow up; ± oral steroid course**
- **If PEFR or FEV1 >40% but <70% baseline after beta2 agonist**
  - ABG
  - IV corticosteroids
  - Admission to hospital
- **If oximetry <90%, FEV1 <1.0L, or PEFR <100 L/min on presentation**
  - ABG, ICU admission
  - Continuous nebulized albuterol
  - IV corticosteroids (methylprednisolone 1.5mg/kg OR hydrocortisone 100mg IV q8hr)
  - Magnesium sulfate 2gm IV
  - Intubation (CO2 >40)
Pregnancy Management

• Daily peak flow measurements – if able to get meter
  – If 20% drop from baseline, evaluate as risk of impending exacerbation is significant
• Maintenance therapy
• Serial growth scans/BPPs if moderate or severe
Vaccinations

- Influenza – recommended
- Pneumococcal vaccination
  - Immunocompromised
  - HIV +
  - Smoker
  - Diabetes mellitus
  - Cardiac disease
  - Pulmonary disease
  - Asthma
  - Renal disease
  - Asplenia, sickle cell disease patients
  - 2nd/3rd trimester – PPSV 23

CDC
Williams Obstetrics
Labor and Delivery

- O₂ saturation, Peak flows if moderate or severe on admission, q 12 hr
- Give asthma medications while in labor if due for dose
- IV hydration
- Adequate analgesia to reduce chance for bronchospasm
- Chronic steroid use – (intermittent, in last 4-6 weeks)
  - Hydrocortisone 100mg q 8hr during labor and for 24 hrs following delivery to prevent adrenal crisis (NAEP)
- Mode of delivery – vaginal
  - If asthmatic crisis, at term, refractory to medical intervention, expediting delivery could improve the respiratory status and ability to ventilate
- PGE1 and PGE2 – OK (ripening, induction, PPH)
- Carboprost and methylergonovine can cause bronchospasm
- Magnesium sulfate (can act as bronchodilator) is safe in PTL and seizure ppx
- Indomethacin can induce bronchospasm in aspirin sensitive pts
Breast Feeding

• In general only small amounts of meds enter breast milk
  – OK with prednisone, antihistamines, beclomethasone, beta agonists, and cromolyn
  – Theophylline sensitive individuals
    • Toxicity includes vomiting, feeding difficulties, jitteriness, cardiac arrhythmias
Pulmonary Insults are More Likely During Pregnancy and Pregnant Women are More Prone to Respiratory Problems and Failure
Tuberculosis

- Bacterium – Mycobacterium tuberculosis
- Respiratory spread (not by touching, sharing food/drink, touching bed linens or toilet seats, sharing toothbrushes, kissing
- Symptoms of TB disease – severe cough for 3+ weeks, pleuritic chest pain, hemoptysis, weakness/fatigue, weight loss, anorexia, F/C, night sweats
TB - Diagnosis

- Groups to test – exposure to person with TB disease, HIV infection, symptoms of TB disease, from country that TB disease is common (Latin America, the Caribbean, Africa, Asia, Eastern Europe, and Russia), live/work where TB disease is common (homeless shelters, prison or jails, or some nursing homes), illegal drugs)

- Testing – Valid and safe in pregnancy (CDC)
  - Skin testing - >5mm (CDC) → check CXR
  - Interferon-gamma release assay – pt with previous BCG vaccine, unable to do skin test
    - If +, check CXR
TB – Diagnosis/Tx (CDC)

• Latent TB infection (LTBI) - +skin/blood test, negative CXR
  – Incidence to active infection – 3%/year
    • INH 300mg/day x9months, pyridoxine 25mg/d (decrease hepatic toxicity) - CDC
  – HIV + - 8% incidence to active infection

• TB Disease - +skin/blood test, + CXR
  – 4 drug regimen – INH, rifampin, ethambutol, pyrazinamide x9months

• MDR, HIV pt etc – consult CDC website>ID

• Pregnancy – Tx AP to decrease risk of neonatal disease, separation of mother/baby in select cases of active disease
Conclusions

• FRC decreased by 20%
• PCO2 > 40, respiratory distress, impending failure in pregnant women
• Asthma classes
• Step therapy
• ER if FEV1 <80%, Admit if FEV1 <70%
• Avoid hemabate
End 9-8-15

• ??