Management of the Pregnant Patient in a Critical Care Setting

Joseph Fitzwater, MD
Maternal-Fetal Medicine

Objectives

1) Recognize physiologic changes of pregnancy
2) Review pregnancy-specific considerations to advanced cardiac life support
3) Attain a basic comprehension of teratogens
4) Discuss imaging safety pregnancy
5) Define appropriate management of obstetrical hemorrhage
6) Attain basic knowledge of common obstetrical critical scenarios
7) Recognize the role of the maternal-fetal medicine provider in the critical care patient

NO FINANCIAL DISCLOSURES
Effects of Pregnancy on Maternal Physiology

- Pregnancy impacts a variety of organ systems
  - Cardiovascular
  - Respiratory
  - Renal
  - Endocrine
  - Hematopoietic
- Changes begin in 1st trimester but continue throughout the pregnancy
- Important to take these into consideration as they adjust the definition of "normal"

Cardiovascular Changes

- Blood volume increases by 50%, red blood cell mass by up to 30%
  - Prepares patient for blood loss associated with delivery
  - Adjusts for perfusion of the placenta (up to 800 mL/min or 17% of CO) and vasodilation from progesterone
  - Causes physiologic hemodilution
- Physiologic dilation of the heart as well as lateral displacement (may affect EKG/chest x-ray interpretation)
- Systolic flow murmur evident in 95% of pregnant women
- Increased dependent edema due to venous compression and decrease in colloid osmotic pressure

Williams Obstetrics, 23rd ed
Cardiovascular Changes

- Increased cardiac output by up to 50%
  - Increased stroke volume
  - Increased heart rate (up to 20 bpm)

Creasy & Resnik, 7th ed

Cardiovascular Changes

- Blood pressure reaches its nadir in the 2nd trimester and returns toward nonpregnant values
- Similar pattern with systemic vascular resistance

Creasy & Resnik, 7th ed

Pulmonary Changes

- No change in respiratory rate but up to 50% increase in minute ventilation due to increased tidal volume
  - Hyperventilation
  - Hypocapnia
  - Stimulated by progesterone and increased metabolic rate
- Decrease in functional residual capacity due to drop in expiratory reserve and residual volume
- Up to 75% of women report dyspnea by the 3rd trimester
  - Effect of progesterone on respiratory drive
  - Displacement of the diaphragm by the gravid uterus
Pulmonary Changes

- PaCO₂ decreases from 39 mmHg to 28 mmHg
- Arterial pH increases to 7.44 from 7.40
- Facilitates transfer of CO₂ from fetus to mother
- Normalization of lab values is an early warning of maternal respiratory failure (i.e., acute asthma exacerbation)

Renal Changes

- Physiologic dilation of the genitourinary tract
- Greater dilation on the right than left due to the gravid uterus and displacement from the sigmoid colon on the left
- Increased susceptibility to urinary tract infections and pyelonephritis
- Stress urinary incontinence present in up to 40% of women at term
Renal Changes

- Increased renal plasma flow and creatinine clearance
- Decreased serum creatinine (0.8 to 0.5 mg/dL)
- Increased glucosuria from impaired reabsorption (cannot reliably predict maternal glucose values)

Endocrine Changes

- Pregnancy hormones increase
  - Prolactin (lactation)
  - Progesterone (uterine quiescence)
  - Estrogen (placental perfusion, labor)
- Insulin production increases
- Overall increase in total hormone levels but tight control of active forms

Sample Lab Changes

- Decreased hemoglobin and hematocrit levels
- Decreased white blood cell count
- Decreased protein S levels
- Decreased coagulation factors II, V, VII, IX, and X levels
- Decreased fibrinogen levels
- Increased D-dimer levels
- Increased erythrocyte sedimentation rate
- Decreased serum creatinine levels
- Decreased blood urea nitrogen level (BUN)
- Decreased uric acid level
- Increased alkaline phosphatase level
- Increased serum cortisol, free cortisol, cortisol-binding globulin, and adrenocorticotropic hormone level
- Increased insulin level
- Decreased fasting blood glucose level
- Increased triglyceride level
- Increased cholesterol, low-density lipoprotein, and high-density lipoprotein levels
Pregnancy Effects on Advanced Cardiac Life Support

- Compression from the gravid uterus
- Increased maternal cardiac output requirements
- Increased risk of aspiration
- Decreased chest wall compliance
- Consideration of the fetus

Keys to ACLS in a Gravid Patient

- Place at a left-lateral tilt (about 27 degrees)
- Consider early intubation
- May perform electrocardioversion
- Do not attempt to perform continuous fetal monitoring
- 4-minute rule for emergent cesarean (may be performed in the room)

Teratogens

- Agent that has the potential to interfere with embryonic structure/function
- Multiple sources (genetics, environmental, medications, physical conditions)
- Half of US pregnancies are unintended
- Drugs frequently used off-label with well-defined pregnancy risks absent in more than 90% of medications
- Effect of teratogen impacted by embryonic age, dose, duration of exposure, and maternal factors
Teratogens - Limitations

- Reliable information is limited
- Insufficient data to confirm or rule out teratogenicity in greater than 80% of prescription medications in the United States
- Difficult to get IRB approval for research on pregnant women (most trials don’t include them)
- Lack of standard surveillance system
- Animal studies are used in substitution

Medication Considerations in Critical Care

- Avoid (many are relative contraindications)
  - NSAIDs
  - ACE Inhibitors/ARBs
  - Methotrexate (folate antagonists)
  - Selected antiepileptic agents: Phenytoin, valproic acid, Lamictal
  - Selected antibiotics: tetracyclines, fluoroquinolones, chloramphenicol
  - Warfarin
  - Chemotherapeutic agents
Medication Considerations in Critical Care

- Could consider
  - Acetaminophen
  - Narcotics
  - Benzodiazepines
  - Corticosteroids
  - Unfractionated and low-molecular weight heparins
  - Beta blockers, calcium channel blockers
  - Furosemide, hydrochlorothiazide, chlorthalidone
  - Insulin (regular, NPH, aspart, lispro, glargine, detemir)

Clinical Imaging

- Modalities
  - Ultrasonography
  - Ionizing radiation (eg CT scan and X-Ray)
  - Magnetic resonance imaging

Ultrasonography

- Used most frequently
- Interpretation of sound waves reflecting off varying densities
- Theoretically can lead to cavitation and temperature elevation
- Obstetrical machines have energy limitations to reduce these effects
- Not proven to pose a risk to the fetus
Magnetic Resonance Imaging

- Evaluates energy released by protons in tissue when exposed to a strong external magnetic field
- Does not involve ionizing radiation
- Theoretical risks from tissue heating
- Better visualization for some soft tissue structures than ultrasound (eg appendix)
- Potential adverse effects on the fetus from gadolinium-based contrast (continually recycled in the fetus)

Ionizing Radiation

- Background radiation of 1 mGy during pregnancy
- Early lethal exposure – “all or nothing”
- Additional adverse effects
  - Microcephaly
  - Intellectual disability
  - Growth restriction
  - Childhood malignancies (eg leukemia)

- Shield the abdomen
- Review alternate imaging modalities
- Consider low-exposure protocol
- Oral contrast is safe
- Due to theoretical risks, withhold intravenous contrast, unless necessary
- Can breastfeed immediately after IV contrast exposure
Thresholds for Adverse Effects of Radiation

<table>
<thead>
<tr>
<th>Development Period</th>
<th>Effects</th>
<th>Estimated Necessity</th>
</tr>
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<tbody>
<tr>
<td>Birth complications</td>
<td>Birth weight less than 2,500 g</td>
<td>0.02-0.001 rad</td>
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<tr>
<td>Organ systems damage</td>
<td>Significant growth retardation</td>
<td>0.1-1 rad</td>
</tr>
<tr>
<td>Fetal death</td>
<td>Fetal death</td>
<td>1 rad</td>
</tr>
</tbody>
</table>

Sample Radiation Exposures

Obstetrical Hemorrhage

- One of the leading causes of maternal death
- Postpartum blood loss averages 500 mL with vaginal delivery and 1000 mL with cesarean
- Provider estimates are inaccurate
- Early recognition and intervention are important
Etiologies

• Place foley catheter
• Evaluate uterine fundus
• Perform bimanual exam to assess for uterine atony and apply pressure/massage
• Obtain adequate lighting and equipment to evaluate for lacerations and retained products
• Administer uterotonics
• Consider placement of uterine tamponade (e.g., Bakri balloon)
• Prepare for intraoperative evaluation/arterial embolization
• Low threshold for transfusion

Bedside Assessment

Laboratory Assessment

• Complete blood count (may have delay in normalizing)
• PT/INR, PTT
• Fibrinogen
• Urine output may be leading indicator (“30/30 rule”)
Diabetic Ketoacidosis

- Diabetes (gestational or pregestational) is present in 7% of pregnancies
- Up to 3% of women with diabetes will experience an episode of DKA
- Most frequent in type I diabetics, arising from a relative deficit in insulin
- Triggers alternative pathways for metabolism

Maternal Findings

- Hypovolemia
- Reduced total body potassium
- Hyperglycemia
- Metabolic acidosis
- Pregnancy unique factors
  - Insulin resistance
  - Increased incidence of nausea/vomiting (dehydration)
  - Increased sensitivity to starvation (more rapid production of ketones)
Fetal Findings

- Glucose is actively transported across the placenta
- Ketoacids cross the placenta
- Maternal hypovolemia leads to underperfusion of the placental bed
- Fetal hypoxia
- Increased fetal insulin raises oxygen requirement

DKA Complications

- Maternal death <1% but up to 36% with fetal demise
- Additional consequences
  - Preterm delivery (indicated or spontaneous)
  - Cesarean delivery
  - Risk for developmental delay in the fetus

Fetal acidemia

DKA Management

- Replace what’s been lost
  - Aggressive IV fluids
  - Insulin drip
  - Potassium replacement
- Restrict administration of bicarbonate (may worsen fetal hypoxemia)
  - Maternal pH < 7.0
  - Cardiac dysfunction
  - Shock
- Treat the mother first
  - Expect the fetus to demonstrate evidence of acidaemia
  - Tracing may take 4-8 hours to improve
  - Emergent cesarean delivery upon diagnosis may worsen maternal morbidity/mortality without improving fetal outcomes.

Critical Care Scenarios: Trauma

- Incidence up to 7%
- Domestic violence is underreported
- Majority of cases are motor vehicle collisions and maternal falls
- Blunt trauma may lead to placental abruption

Initial Evaluation

- Begin with standard work-up (e.g., ABCs)
- Initial focus is stabilizing the mother
- Obtain the emergent imaging needed (most diagnostic studies are well below teratogenic thresholds)
- Consult OB/Gyn for fetal evaluation once patient is stabilized or if concern for emergent delivery
Pregnancy-specific Considerations

- If possible, displace the gravid uterus by placing the patient in a left lateral position
- Pregnant women may tolerate greater blood loss without manifesting changes in vital signs
- Remember: low-normal fibrinogen levels are too low for a pregnant woman
- A gravid uterus can protect the bowel from penetrating injury (at the detriment of the fetus)
- Mother may need Rhogam if Rh negative
- Corticosteroids if delivery anticipated

Placental abruption

- Premature separation of the placenta from the uterine wall
- Cannot be ruled out by ultrasound
- May be associated with:
  - Uterine contractions
  - Abnormal coagulation studies
  - Maternal-fetal hemorrhage (e.g., positive K-B)
Surgical Considerations

- Increased risk of miscarriage, preterm birth, though this may be related to the disease process
- Anesthetic agents not shown to be teratogenic in standard concentrations
- Usually fetal evaluation pre/postoperatively is acceptable
- Nonelective surgery should not be delayed
- Take care with entry with laparoscopic procedures

Critical Care Scenarios: Hypertensive Emergency

- Cardiovascular conditions are the leading cause of pregnancy-related mortality
- Acute-onset severe hypertension of ≥160 mmHg systolic or ≥110 diastolic may lead to maternal cerebral hemorrhage/infarction
- Goal 140-150/90-100 mmHg, avoid overcorrection if pregnant
- Monitor blood pressure every 10-20 minutes for response and need to escalate therapy

First-line Medications

- Labetalol
- Hydralazine
- Immediate-release oral nifedipine
Nonresponsive Hypertension

- Transfer to ICU setting for continuous infusion
- Second-line agents
  - Nicardipine
  - Esmolol
- Sodium nitroprusside associated with worsening cerebral edema and toxic fetal effects

Role of MFM Provider

- Assess fetal status (e.g., level II ultrasound, biophysical profile)
- Give insight into maternal physiologic changes
- Provide guidance for navigating the care of both patients
- Answer questions regarding medication safety
- Assist in identification and management of pregnancy-specific diseases

QUESTIONS?