The Pregnant Patient

ANESTHETIC CONSIDERATIONS:

- Anatomic and physiologic changes associated with pregnancy.
- Possible difficult airway, increased risk of aspiration and rapid desaturation.
- Risk of aortocaval compression requiring LLD position.
- 2 patients.
- Possibility for urgent/emergent obstetrical intervention with little/no time for optimization and possible need for NICU care.

ANESTHETIC GOALS:

- Maintain maternal oxygenation and ventilation
- Maintain maternal hemodynamic stability
- Provide optimal maternal analgesia
- Maintain uteroplacental perfusion
- Avoid fetal compromise
- Communication and coordination with Obstetrics and NICU

HISTORY

- Obstetrical
  - GPTAL
  - Current pregnancy
    - Single vs multiple gestation
    - EtOH and street drug use
    - Complications (see below)
  - Previous pregnancies – mode of delivery, complications
- PMHx
  - Neuro
  - Cardiac
  - Pulmonary
  - GI
  - Renal
  - Hematologic
- PSHx/Anesthesia Hx
  - Uterine surgery – C-sections, other
  - Other
- Medications – including OTC and herbal
- Allergies
- Last meal
- Informed consent

PHYSICAL

- Vital signs
  - Mother
  - Fetus
- Airway
- CVS – flow murmur, S3, S4, displaced PMI are normal in pregnancy
- Respiratory
- MSK – examine back

INVESTIGATIONS

- **Labs**
  - Hb
  - Plts, INR, PTT
  - Consider need for – WBC, blood glucose
- **Imaging**
  - Prenatal U/S
- **FHR monitoring**
  - Normal (term): HR 110-160, accelerations (↑HR by 15bpm x 15sec) 15-40/hr, variability 5-25 bpm, no decelerations
  - Tachycardia
    - Causes: prematurity, mild fetal hypoxia, chorioamionitis, maternal fever, drugs (catecholamines, atropine), hyperthyroidism
  - Bradycardia
    - Causes: post-term, congenital heart block, fetal asphyxia, maternal drugs
  - Reduced variability (sympathetic-parasympathetic responsiveness)
    - Causes: prematurity, fetal dysrhythmias, fetal asphyxia, anencephaly, CNS depressants, anticholinergic drugs
  - Decelerations
    - Prolonged if lasting 2-10 min
    - Early decelerations (Type I): mirror uterine contractions, vagal response to fetal head compression
    - Variable decelerations (Type III): vary in shape and timing of uterine contractions, due to umbilical cord compression
    - Late decelerations (Type II): onset after peak uterine contractions, due to impaired uteroplacental perfusion
  - Uterine contractions

        - Normal: frequency every 2-3 min during active phase labour, resting pressures 5-20 mmHg, peak pressures 50-80 mmHg
        - Decreased contractility: uterine overdistention, aortocaval compression
- **Fetal pulse oximetry**
    - Normal: 30-70% (<30% suggests acidemia)

OPTIMIZATION

- **Maternal**
    - Fluids
    - Reduce gastric acidity and volume
        - Sodium citrate, metoclopramide, H2 blocker
- **Fetal**
    - Intrauterine resuscitation
        - D/C oxytocin infusion
        - Positioning: LLD, knee-chest
        - Maternal O2, fluid bolus, vasopressors
        - Tocolysis: terbutaline, nitroglycerine
        - Amnioinfusion

ANESTHETIC OPTIONS

- **Non-obstetric surgery in pregnancy**
    - General principles – term-specific anatomic/physiologic changes of pregnancy, aspiration prophylaxis after 12 wks, LLD position after 16 wks, maintain uteroplacental blood flow, direct/indirect effects of drugs on fetus (including teratogenicity in T1, NSAIDs), monitor FHR after 16 wks, risk of PTL (T3), risk of fetal loss, ↑risk VTE, more complicated surgical management
    - Technique – order of preference: regional block > neuraxial > GA
- **Labor analgesia**
    - Non-pharmacologic – psychoprophylaxis (Lamaze), TENS (ineffective), acupuncture
    - Systemic medications – opioids (meperidine, fentanyl, remifentanil; nurse administered vs PCA), promethazine, ketamine, benzodiazepines; note that all cross placenta, risk of fetal depression and FHR abnormalities
        - Bolus meperidine 25-50 mg iv *or* 50-100 mg im
        - Bolus fentanyl 25-50 mcg iv
        - PCA remifentanil: bolus 0.4 mcg/kg (lockout 1 min) *or* infusion 0.05mcg/kg/min with bolus 25mcg (lockout 5 min)
        - Ketamine: for labor 0.2-0.5 mg/kg iv q 2-5 min (max 1mg/kg/30 min); to supplement incomplete neuraxial block 25-50 mcg iv; high doses (>2mg/kg) ↑uterine tone
        - Naloxone: to reverse neonatal depression administer to infant post-delivery, not to mother pre-delivery (withdrawal)
    - Inhalational techniques
        - Entonox (50:50 N2O:O2), isoflurane (0.2%), desflurane (0.2%), sevoflurane (0.8%)
            - All provide comparable (but incomplete) analgesia; sevo superior to Entonox
            - Disadvantages: lack of scavenging, drowsiness and risk of overdose with volatiles
    - Neuraxial techniques
        - Epidural (lumbar) – continuous infusion vs PCEA (lower total dose of anesthetic used)
            - May prolong 1st stage of labour in all parturients and 2nd stage in nulliparous (of no clinical consequence)
        - Spinal – single shot vs catheter (risk cauda-equina syndrome)
        - Combined spinal-epidural – ↑risk non-reassuring FHR but does not affect c-section rate
    - Regional blocks
        - Lumbar sympathetic block for 1st stage of labor
        - Paracervical block for 1st stage of labor (associated with poor neonatal outcome)
        - Pudendal block for vaginal delivery/forceps/episiotomy repair
- **Operative delivery**
    - Neuraxial techniques
        - Epidural, spinal, combined spinal-epidural, continuous spinal=
    - General anesthesia

ANESTHETIC SETUP

- GA backup equipment and drugs
- Emergency equipment
- IV, O2, monitors
- Blood product availability
- NICU availability

MANAGEMENT OF LABOUR ANALGESIA

- **Drugs**
    - LA – less motor block with dilute solutions bupivacaine/ropivacaine
    - Opioid – fentanyl, sufentanil
    - Adjuncts – epinephrine, clonidine, bicarbonate
- **Induction**
    - Epidural – aspiration, test dose, fractionated loading dose
    - Spinal – single-shot LA and/or opioid
    - CSE – single-shot spinal-dose LA and/or opioid, no test dose or loading dose for epidural
- **Maintenance**
    - Epidural – infusion low dose LA +/- opioid +/- epinephrine

- CSE – as for epidural

MANAGEMENT OF CESAREAN SECTION

- **Induction**
  - In general – LLD position, antibiotics
  - Regional-specific – fluid co-loading more effective than preloading to prevent hypotension
  - GA-specific – pre-oxygenation, RSI
- **Maintenance**
  - In general – oxytocin after delivery of infant
  - Regional-specific – catheter-based techniques more flexible, long-acting opioid after delivery of infant
  - GA-specific – O2/N2O/volatile, ventilate to PaCO2 30 mmHg (normal for pregnancy), opioid after delivery of infant
- **Emergence**
  - GA-specific – PONV prophylaxis, extubate awake

DISPOSITION & MONITORING

- **Analgesia**
- **Oxygenation**
- **Positioning**
- **Monitoring**

COMPLICATIONS

1. Complications of pregnancy
   - Hyperemesis gravidarum
   - Ectopic pregnancy
   - Molar pregnancy
   - Multiple gestation
   - GDM
   - Pre-eclampsia/Eclampsia
   - HELLP
   - 3rd trimester bleeding
     - Placenta previa
     - Placental abruption
     - Placenta accreta/percreta/increta
     - Vasa previa
     - Uterine rupture
   - PTL
   - Chorioamnionitis
   - Malpresentation
   - Umbilical cord prolapse
   - PPH
   - AFE
   - DVT/PE

2. Complications of obstetrical anesthesia
   - Complications of neuraxial techniques (back pain, PDPH, neuropathy, epidural hematoma, epidural abscess, meningitis, total spinal, incomplete/failed block, drug side-effects/toxicity)
   - Complications of general anesthesia (can't intubate/can't ventilate, aspiration, awareness, neonatal depression)
   - Complications of obstetrical management (neuropathy, bleeding, uterine inversion)

PATHOPHYSIOLOGY

A) AT TERM

1. CNS
   - ↑Sensitivity to volatile anesthetics → ↓MAC 32-40%
   - ↑Neuronal sensitivity to LA → ↓intrathecal dose 25%
   - Epidural venous engorgement
     - ↑Epidural pressure →↑epidural spread of LA
     - N CSF pressure
   - Dependence on SNS to maintain hemodynamic stability (esp. venous tone)

2. AIRWAY
   - Capillary engorgement of mucosa → friable, bleeding; avoid nasal instrumentation
   - Airway edema → smaller ETT size, avoid repeated laryngoscopy

3. CVS
   - ↑C.O. 30-50%
     - ↑HR 15-25%
     - ↑SV 20-30%
     - ↑Contractility
   - Unchanged CVP, PAP, PCWP
   - ↓SVR 20%
   - ↓PVR
   - ↓BP midtrimester then ↑ to baseline

- Blood flow to organs
  - ↑BF to kidneys, uterus, extremities
  - No change in BF to brain, liver
- Aortocaval compression (max at 36-38 wks)
  - Supine hypotensive syndrome
  - Collateral routes of venous return develop
- LVH (eccentric)
- EKG changes
  - LAD, PACs, tachyarrhythmias

4. RESP
- ↑O2 consumption 20% → rapid O2 desaturation
- ↑CO2 production 30%
- ↑Minute ventilation 45-50%
  - ↑Alveolar ventilation 45%
  - ↑Dead space 45%
  - RR unchanged
- ↓TLC 5%
  - VC unchanged
  - ↑Tidal volume 50%
  - ↑IRV
  - ↓ERV, RV
  - ↓FRC 20% → rapid O2 desaturation,↓equilibration time for volatile anesthetics
- FEV1, closing capacity, flow-volume loops unchanged
- Diaphragmatic breathing
  - Elevated diaphragm → ↑diaphragm excursion
  - ↑Thoracic cage circumference 5-7cm → ↓chest wall excursion
- ABGs
  - ↑PaO2 by 10mmHg
  - ↓PaCO2 to 30-32 mmHg
  - ↓HCO3 to 20 mEq
  - ↑pH to 7.44
- ↓Sleep

5. GI
- ↓LES tone
- ↓Esophageal motility → GERD
- ↓Intestinal motility → ileus
- ↓Gastric emptying or unchanged (controversial)
- Gastric volume and acidity unchanged
- Hepatobiliary
  - Liver size and morphology unchanged
  - Biliary stasis → gallstones
  - ↑ALT, AST, and bilirubin to ULN, ↑ALP 2x (placental source)

6. RENAL
- Enlarged kidneys
- ↑RPF 75%
- ↑GFR 50% → ↑Cr clearance
  - ↓Filtration fraction
- ↑Creatinine clearance → ↓Cr
- Glucosuria

7. ENDO
- Thyroid enlargement, ↑TBG → ↑T3 and T4; no change in fT3 or fT4, ↓TSH in T1 (N thereafter)
- Fasting hypoglycemia, insulin resistance with glucose load
- ↑CBG 200%, ↑total cortisol, ↑free cortisol 2.5x
- ↑Mineralocorticoid activity → Na/H2O retention → ↑plasma volume
- ↑Progesterone → accounts for many physiologic changes of pregnancy

8. HEME
- ↑Total blood volume (25-40%)
  - ↑Plasma volume (40-50%)
  - ↑RBC volume (20-30%)
- ↓Hb (physiologic anemia, avg Hb 116g/L)
- ↓Platelet count, although ↑platelet activity
- ↑WBC to 9-11 x 10^3
  - ↑PMNs but impaired function – ↑infection, ↓autoimmune disease
- Coagulation factors
  - ↑Fx I, VII, VIII, IX, X, XII
  - ↓Fx XI, XIII
  - No change – Fx II, V
- Anticoagulant factors

- ↓Protein S, AT-III
- Protein C resistance
- ↑Plasminogen, FDPs

- TEG – hypercoagulable
- ↓Serum cholinesterase activity 20% → no effect on duration of Sux
- ↓Albumin, ↓α1 acid glycoprotein, ↑globulins

9. MSK
- Low back pain (relaxin, biomechanical strain)
- Meralgia paresthetica, brachial plexopathy, carpal tunnel syndrome

10. OB
- Fetal blood flow 75 mL/kg/min
- Uterine blood flow
  - UBF = (UAP – UVP)/ UVR
  - Mean UBF 700 – 900 mL/min at term (12% of C.O.)
  - Limited autoregulation
  - Factors which↓uteroplacental perfusion (UPP): hypotension, uterine contractions,
  - Factors which ↑UPP: uterine relaxation
  - Phenylephrine associated with better fetal acid-base status compared to ephedrine
- Stages of labor
  - Stage I
    - Latent – from onset of contractions to onset of cervical dilation
    - Active – from onset of cervical dilation to full cervical dilation
  - Stage II – from full cervical dilation to delivery of infant
  - Stage III – from delivery of infant to delivery of placenta

11. REGIONAL
- Epidurals do *not* alter progress of labor or increase rate of c-section
- Stage I labor – pain from uterine contractions, epidural should cover T10 – L1 (sympathetic chain, visceral)
- Stage II labor – additional pain from stretching of perineum, extend epidural to cover S2-S4 (pudendal nerve, somatic)
- C-section – require T4 level of block, addition of opioid/epinephrine to LA improves visceral analgesia

12. PHARMACOLOGY
- Placental transfer of drugs
  - Easily cross placenta – small molecules (<500 D), ↑lipid solubility, non-ionized
- Drug disposition in fetus depends on:
  - Fetal pH – ion-trapping of local anesthetics in acidotic fetus
  - Fetal protein binding
  - Ductus venosus – 40% of umbilical venous blood bypasses liver
- Teratogenicity
  - General
    - Avoid antiepileptics, lithium, anti-throid meds, ACE-I, tetracyclines, warfarin, chemotherapeutic agents, EtOH, street drugs
  - Anesthetic drugs (controversial)
    - Benzodiazepines – diazepam: cleft palate with early exposure in utero
    - N2O – interference with DNA synthesis
- Maternal drug sensitivity
  - ↑Sensitivity to volatile agents, LA, thiopental, rocuronium
  - Sensitivity to propofol unaffected
  - ↓Sensitivity to vasopressors, ↓chronotropic effects of epinephrine (adrenergic receptor downregulation)

B) LABOUR AND PUERPERIUM

1. CNS
- Labour
  - ↑CSF pressure
- Postpartum
  - CSF pressure normalized by 6-12 hrs
  - SNS dependence normalized by 36-48 hrs

2. CVS
- Labour
  - ↑CO 25% 1st stage, 40% 2nd stage, 75% postpartum (compared to pre-labour)
  - Autotransfusion 300-500cc per contraction
- Postpartum
  - Anatomic and functional changes reverse within 2-24 wks

3. RESP
- Labour
  - ↑Minute ventilation 70-140% 1st stage, 120-200% 2nd stage (compared to non-pregnant)
  - ↑O2 consumption 40% 1st stage, 75% 2nd stage (compared to pre-labour)
  - ↓CO2 to 10-15mmHg
- Postpartum
  - FRC normalizes by 2 wks, minute ventilation and O2 consumption normalize by 6-8 wks

4. GI
- Labour

- ↓Gastric emptying (potentiated by opioids, unaffected by LAs)
- Postpartum
  - LES tone normalizes in 2 wks, gastric emptying normalizes in 18 hrs

5. RENAL
   - GFR normalizes by 12 wks

6. ENDO
   - Glucose regulation normalized within 24 hrs

7. HEME
   - EBL
     - Labour 500cc
     - C-section 1000cc
   - Postpartum
     - Hb ↓s x 3d, Hb normalizes by 6 wks
     - WBC takes >6 wks to normalize
     - Coagulation profile normalizes by 2 wks
     - Total protein normalizes by 6 wks
     - Pseudocholinesterase activity normalized by 2-6 wks

REFERENCES

- Barash Chpt 43, Miller Chpt 69, Chestnut (Chpt 2 Physiology)