Fetus and Newborn

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Learning Objectives

After this activity, participants will be able to:
- Interpret and respond to measures of fetal assessment
- Provide comprehensive care of the normal newborn
- Identify and respond to certain maternal conditions that may impact the fetus and newborn
- Assess and manage term infants at risk for sepsis
- Evaluate and manage major types of birth injury

Content Specifications

All the topics presented are matched to content specifications. Therefore, "**" is not used to indicate content specifications in this presentation.

Outline

1. Fetus
2. Normal Newborn – Assessment
3. Normal Newborn – Routine Care
4. Abnormal Newborn

Outline

1. Fetus
2. Normal Newborn – Assessment
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1. Fetus

- Antepartum fetal surveillance
  - Some slides in supplemental section at end
  - Intrapartum fetal heart rate monitoring

Antepartum Fetal Surveillance

- Goal: identify fetus at risk of asphyxia or death
- Attempts to assess fetal hypoxia and acidosis (although other factors such as GA, maternal meds can interfere)
- Indicated in pregnancies with increased risk (e.g., diabetes, HTN, IUGR, twins, post-term, many others)
- Evidence is mostly from observational studies

Fetal Surveillance: Techniques

- Non-stress test (NST): FHR monitoring for 40 minutes
- Biophysical profile: 5 components – NST, fetal breathing, fetal tone, amniotic fluid volume, fetal movements
- Contraction stress test: FHR during contractions
- Amniotic fluid volume: normal, oligo, or poly
- Doppler velocimetry: reduction of diastolic flows

More details in supplemental slides

Fetal Surveillance: Use in Practice

- Indicated in pregnancies with risk for fetal demise
- Typically started after delivery for perinatal benefit would be considered (thus, after 24 weeks)
- No single test preferred: based on GA, availability, cost
  - generally NST and BPP most commonly used
  - Dopplers for growth-restriction, ? fetal anemia
- Generally repeated weekly (variable)

Intrapartum Fetal Heart Rate Monitoring

- Fetal monitoring during labor to detect fetal compromise
- Limited data on value, but general consensus on use
- Intermittent for low-risk, continuous for high-risk
- Baseline FHR (average over 10 mins): normal 110-160
- Variability: irregular fluctuations in baseline, 6-25 bpm
- Accelerations: abrupt increase in FHR, usually with fetal movements, >15 seconds, > 15 bpm (after 32 weeks)

Decelerations:
- Early: gradual, with contraction, likely caused by compression of fetal head, unrelated to oxygenation
- Late: gradual, longer, follows contraction, associated with fetal hypoxia during contraction
- Variable: abrupt decrease, varies with contractions, due to cord compression, hypoxia
- Prolonged: > 15 bpm, > 2 minutes (and < 10 min)
Intrapartum Fetal Heart Rate Monitoring

- Sinusoidal pattern: fluctuations in baseline FHR with regular amplitude and frequency
  - typically 3-5 cycles/min
  - amplitude 5-15 bpm above and below baseline
  - associated with severe fetal anemia (? other causes)

- Category I: predicts GOOD fetal acid-base status
  - All of the following:
    - normal baseline (FHR 110-160)
    - moderate variability (6-25 bpm)
    - no late or variable decelerations
    - early decelerations present or absent
    - accelerations present or absent

- Category II: neither I or III → indeterminate
  - In general, persistent category II is worrisome
  - Moderate variability reassuring
  - Accelerations with fetal scalp stimulation reassuring

- Category III: predicts BAD fetal acid-base status
  - One of the following
    - absent variability with recurrent late decelerations
    - absent variability with recurrent variable decelerations
    - absent variability with fetal bradycardia
    - sinusoidal pattern

Intrapartum Fetal Heart Rate Management

- Category III: prepare for delivery while resuscitating
- Category II: resuscitative measures, monitor closely
  - lateral position
  - oxygen
  - IV fluid bolus
  - reduce contraction frequency
  - amnioinfusion

Outline

1. Fetus
2. Normal Newborn – Assessment
3. Normal Newborn – Routine Care
4. Abnormal Newborn
2. Normal Newborn - Assessment

- Apgar scores
- Initial assessment
- Anthropometric measurements
- Blood pressure

Newborn Infant: Apgar Scores

<table>
<thead>
<tr>
<th>Sign</th>
<th>0</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>Activity (muscle tone)</td>
<td>Limp</td>
<td>Some flexion</td>
<td>Active motion</td>
</tr>
<tr>
<td>Pulse (heart rate)</td>
<td>Absent</td>
<td>&lt;100 bpm</td>
<td>≥ 100 bpm</td>
</tr>
<tr>
<td>Grimace (reflex irritability)</td>
<td>No response</td>
<td>Grimace</td>
<td>Cry, withdrawal</td>
</tr>
<tr>
<td>Appearance (color)</td>
<td>Blue or pale</td>
<td>Acrocyanotic</td>
<td>Pink</td>
</tr>
<tr>
<td>Respiration</td>
<td>Absent</td>
<td>Weak cry</td>
<td>Good cry</td>
</tr>
</tbody>
</table>

- 1 minute and 5 minutes
- If score < 7, repeat every 5 minutes up to 20 minutes

Newborn Infant: Initial Assessment

- Gender, deformations, malformations
- Qualitative assessment of fetal growth
- Respiratory effort, tone and activity, color
  - Acrocyanosis normal and common for first few days
  - Central cyanosis not normal after first couple minutes
- Physical examination
- Neurologic examination
Newborn Infant: Anthropometric Measurements
- Measure birth weight, length, and head circumference
- Plot on growth curves by gestational age and sex
- Implications for extremes across a baby
- Implications for discrepancies within a baby

Newborn Infant: Blood Pressure
- BP proportional to GA, PMA, and birth weight, and increases after birth (faster in preterm than term)
- Measurement considerations:
  - Ideally measure while infant is sleeping/resting
  - Arterial catheter most accurate
  - Non-invasive: right-size cuff; 1-2 hours after feed; prone/supine; right upper arm; measure several minutes after cuff placed and infant has settled/calm

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1. Fetus
2. Normal Newborn – Assessment
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3. Normal Newborn – Routine Care
- Vitamin K and eye prophylaxis
- Umbilical cord care
- Newborn screening – blood spot, CCHD, hearing
- Unconjugated hyperbilirubinemia
- Neonatal hypoglycemia

Newborn Infant: Anthropometric Measurements
- Low birth weight (LBW): BW < 2500 gm
- Very low birth weight (VLBW): BW < 1500 gm
- Extremely low birth weight (ELBW): BW < 1000 gm
- Small for gestational age (SGA): < 10th %ile for GA
- Large for gestational age (LGA): > 90th %ile for GA
- Different growth charts! Fenton/Olsen/WHO/CDC

3. Normal Newborn – Routine Care
   NOT COVERED DURING TALK (slides at end)
- Temperature support in delivery room
- Discharge planning, early discharge, home birth
**Vitamin K**

- Vitamin K: fat-soluble, cofactor for factors II, VII, IX, X (and protein C and protein S)
- Newborns are at risk for Vitamin K deficiency:
  - Limited placental transfer
  - Low levels in breast milk
  - Lack of intestinal flora which produce vitamin K
  - Inefficient use of vitamin K by immature liver

**Vitamin K: Vitamin K Deficiency Bleeding**

- Vitamin K Deficiency Bleeding (VKDB)
  - “Hemorrhagic disease of the newborn” (old name)
  - Cutaneous bruising
  - Bleeding from mucosal surfaces, GI tract
  - Bleeding from umbilicus, circumcision
  - Intracranial hemorrhage
  - Prolonged PT in excess of PTT (can be both if severe)

<table>
<thead>
<tr>
<th>Type</th>
<th>Timing</th>
<th>Causes</th>
<th>Clinical</th>
</tr>
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<tbody>
<tr>
<td>Early</td>
<td>&lt; 24 hours</td>
<td>Maternal meds: anticonvulsants, warfarin, rifampin, INH, abx</td>
<td>Intracranial hemorrhage (25%) Severe bleeding</td>
</tr>
<tr>
<td>Classic</td>
<td>1-7 days</td>
<td>Typically breastfed infants without birth prophylaxis (formula is supplemented)</td>
<td>GI, mucosal, umbilical bleeding Bleeding after circumcision Intracranial hemorrhage rare</td>
</tr>
<tr>
<td>Late</td>
<td>1-8 weeks</td>
<td>Classically fat malabsorption (biliary atresia, CF, alpha-1-antitrypsin deficiency) Rarely antibiotics, poor intake Also exclusive breast-feeding without birth prophylaxis</td>
<td>Intracranial hemorrhage (50%) GI, mucosal bleeding Recent reports of increase late-onset VKDB in U.S.</td>
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**Vitamin K: Prophylaxis**

- Prophylaxis: 0.5 - 1 mg Vitamin K1 IM shortly after birth - can do after first breastfeeding, no later than 6 hours - for preterm infants < 1000 gm: can do 0.3 to 0.5 mg IM - virtually eliminates classic and late-onset VKDB

**Vitamin K: “Controversies”**

- IM preferred over oral - some late-onset VKDB still seen with oral regimens - need multiple doses for oral versus one for IM - oral dosing not available routinely in U.S.
- IM NOT associated with cancer (leukemia) - two reports (same author), not seen in larger studies - Prior concerns for preservatives: mercury, benzyl alcohol - mostly preservative-free, one brand with benzyl alcohol

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**Notes from the Field**

*Late Vitamin K Deficiency Bleeding in Infants Whose Parents Declined Vitamin K Prophylaxis* — Tennessee, 2013

Vitamin K deficiency bleeding (VKDB) is a complication that develops in infants who do not have sufficient vitamin K stores to support production of clotting factors. In adults, vitamin K deficiency is usually secondary to liver disease, malnutrition, or use of medications that interfere with vitamin K metabolism. However, millions of infants in the United States are at risk for VKDB. The incidence of VKDB is generally low, but in recent years, there has been an increase in the number of cases reported. This increase may be due to improvements in detection and reporting, as well as changes in hospital practices. Identifying and addressing the factors that contribute to this increase is crucial for improving outcomes for affected infants.
### Ophthalmia Neonatorum
- Newborn conjunctivitis in first 4 weeks of life
- Gonococcus, Chlamydia (others, including HSV)
  - Gonococcus: typically 1-5 days after birth
  - Chlamydia, others: typically 5-14 days after birth
  - 30-50% infection rate when born to infected mothers

### Eye Prophylaxis
- Prophylaxis against Ophthalmia Neonatorum:
  - 0.5% erythromycin
  - 1 cm ribbon to lower conjunctival sac, each eye
  - Shortly after birth (within 2 hours, can be after 1st BF)
  - Can wipe away excess after 1 minute
  - NOT effective against Chlamydia
  - Other agents (tetracycline, silver nitrate) not in U.S.
  - Some other countries have stopped prophylaxis

### Umbilical Cord Care
- Goal: reduce risk of omphalitis
- In past: alcohol, triple dye, chlorhexidine
- Currently: aseptic and dry cord care
  - Clamp and cut with sterile scissors and gloves
  - Maintain cord clean and dry
  - Topical antiseptics may have value in low-resource areas

### Newborn Screening
- Criteria for mass screening test:
  - Serious disorder that can lead to long-term morbidity
  - Treatment available
  - Treatment early (pre-symptomatic) better
  - Sensitive, cheap, and timely screening test available
  - Definitive specific follow-up test available

### Newborn Screening
- 1960s, PKU: bacterial inhibition assay, “Guthrie card”
- Has expanded with numerous new technologies, particularly tandem mass spectrometry
- Recommended Uniform Screening Panel (RUSP) - HHS
  - 34 core conditions
  - Additional 26 secondary conditions
  - Process for considering new conditions

### Newborn Screening
- Three components:
  - Heel stick blood sample
  - Pulse oximetry for congenital heart disease
  - Hearing screen for congenital hearing loss
  - Screening policies vary state to state
  - Mandatory other than religious exemptions
Newborn Screening

- Need rapid follow-up of positive screening tests
- False positives expected, need rapid confirmatory tests
- Need close collaboration between public health agency, primary care providers, and specialists

Newborn Screening

- About 1 in 4000 infants identified with a disorder
- Most common disorders:
  - hearing loss
  - congenital hypothyroidism
  - cystic fibrosis
  - sickle cell disease
  - medium-chain acyl-CoA dehydrogenase deficiency

Newborn Screening: CCHD Screening

- Critical congenital heart disease (CCHD)
  - congenital heart disease (CHD): 1% of newborns
  - CCHD is about 25% of CHD
  - up to 30% of CCHD not detected prenatally or clinically
- CCHD: requires intervention within 1st year of life
  - cyanotic lesions and ductal-dependent lesions
  - HLHS, PA, TOF, TGA, TA, Truncus, TAPVR, others
- CCHD screening added to RUSP in 2011

Newborn Screening: Blood Spot Screening

- Blood spot screening:
  - Generally obtained 24 to 48 hours after birth
  - Guidelines for follow-up screens for premature and other NICU infants
  - Laboratory processing at state (or regional) level
  - Need reliable communication systems between state lab, providers, and parents

Newborn Screening: CCHD Screening

- Most states use AAP algorithm
  - Screen after 24 hours of age
  - O2 sat in right hand (pre-ductal) and foot (post-ductal)
  - can repeat three times, each separated by 1 hour
- Positive screen (needs eval):
  - O2 sat < 90% in either extremity on any screen
  - O2 sat 90-94% in both extremities on three screens
  - Difference > 3% between extremities on three screens
**Newborn Screening: CCHD Screening**

- Positive screens require evaluation before discharge
  - many (? 50%) will have non-cardiac conditions
  - not all will require ECHO if other condition identified
  - need protocols for evaluation (telemedicine, transport)
- Special considerations:
  - out-of-hospital births, early discharges
  - high-altitude centers (above 2643 feet)
  - NICU infants

**Newborn Screening: Hearing Screening**

- Neonatal bilateral hearing loss: 1 to 3 per 1000 infants
- Types of neonatal hearing loss:
  - Conductive: abnormalities of outer or middle ear
  - Sensorineural: abnormalities of inner ear
- Most neonatal hearing loss is sensorineural
  - About 50% of these are genetic; others are acquired

**Unconjugated Hyperbilirubinemia**

- Physiologic hyperbilirubinemia (all newborns):
  - Increased production (higher Hct, shorter RBC half-life)
  - Decreased conjugation (lower UGT activity in liver)
  - Decreased clearance (more enterohepatic circulation)
- Peaks around day 2 to 5 of life, resolved by 1-2 weeks
  - later in East Asians, preterm infants
- Concern: Bilirubin-induced neurologic dysfunction (BIND)
  - Acute bilirubin encephalopathy (ABE), kernicterus

**Unconjugated Hyperbilirubinemia – “Pathologic”**

- Increased production:
  - Hemolysis: immune (ABO, Rh), membrane defects (spherocytosis), enzyme defects (G6PD), sepsis
  - Polycythemia, cephalohematoma
- Decreased clearance or excretion:
  - Crigler-Najjar, Gilbert, hypothyroidism, galactosemia
  - Intestinal obstruction
- Direct hyperbilirubinemia – almost always pathologic
### Unconjugated Hyperbilirubinemia - Breast Milk

- Breast-feeding jaundice:
  - inadequate intake, weight loss, hypovolemia
  - presents in first week of life
  - significant risk factor for severe hyperbilirubinemia
- Prevention: lactation support, education, follow-up
- Breast-milk jaundice:
  - mild persistent physiologic jaundice, peaks 1-2 weeks
  - presumed due to substance in milk, ? polymorphism

### Unconjugated Hyperbilirubinemia - Screenig

- Blood type and antibody screen on all mothers;
  - Type and Coombs on infants for Rh- mothers (+/- if O+);
- Early bilirubin if antibody positive (maternal or infant), or if early or excessive infant jaundice
- Universal assessment for hyperbilirubinemia risk:
  - pre-discharge measurement of bilirubin in all infants
  - assessment of risk factors
- Follow-up within 3 days, depending on timing/risk

### Unconjugated Hyperbilirubinemia - Screening

- Major risk factors: early jaundice, positive antibody screen, GA 35-36 weeks, sibling needing phototherapy, bruising, exclusive breast-feeding, East Asian race, others
- Minor risk factors: GA 37-38 weeks, jaundice before discharge, sibling with jaundice, macrosomia/IDM, maternal age > 25, male gender, others

### Hour-specific nomograms for designating risk level and phototherapy threshold

AAP Clinical Practice Guideline, Pediatrics, July 2004

### Unconjugated Hyperbilirubinemia - Treatment

- Phototherapy
- Hydration
- IVIG
- Exchange transfusion

### Unconjugated Hyperbilirubinemia - Preterms

- More prevalent, severe, and protracted than in term:
  - increased immaturity of RBCs, increased immaturity of liver and GI tract, decreased enteral feeds
- Limited data on risk of injury, and therefore thresholds for phototherapy and exchange transfusion
- Most will use GA or BW-based thresholds for treatment
  -- e.g., BW (kg) x 5 for phototherapy
- Neurologic findings of BIND not as apparent
Neonatal Hypoglycemia

- Inadequate glucose supply
  - Inadequate glycogen stores: prematurity, FGR
  - Impaired glucose production: metabolic disorders, cortisol deficiency, growth hormone deficiency,
- Increased glucose utilization
  - Hyperinsulinism: IDM, FGR, Beckwith-Wiedemann, genetic causes, asphyxia
  - FGR, sepsis, asphyxia, polycythemia

Neonatal Hypoglycemia - Screening

- Risk groups for neonatal hypoglycemia:
  - Preterm infants < 37 weeks
  - Infants that are LGA or SGA
  - Infants of diabetic mothers
  - ? Post-term infants > 41-42 weeks
  - ? Perinatal stress
  - ? Family history of genetic form of hypoglycemia
  - ? Congenital syndromes, midline defects
  - Any infant with symptoms of hypoglycemia

Neonatal Hypoglycemia - Measuring Glucose

- Gold standard: plasma glucose in clinical laboratory
- Point-of-care meters:
  - Whole blood glucose, which is ~15% lower than plasma (most now have built-in conversion factor)
  - Less accurate at low glucose levels (±10-15 mg/dL)
- Glucose values in specimens decrease by up to 6 mg/dL/hour if processing is delayed

Neonatal Hypoglycemia - IDM

- Maternal diabetes → Intermittent maternal hyperglycemia → Fetal hyperglycemia
- Fetal pancreatic upregulation → Fetal hyperinsulinemia → Neonatal hyperinsulinemia
- Loss of maternal glucose supply → Neonatal hypoglycemia after birth

Neonatal Hypoglycemia - Additional Evaluation

- For persistent or unusual hypoglycemia:
  - Endocrinology evaluation
  - Critical labs, including insulin, free fatty acids, ketones, growth hormone, cortisol, metabolic profiles
  - Fasting challenge
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### 4. Abnormal Newborn

- Small for gestational age infant
- Sepsis risk in term infants, GBS sepsis
- Maternal conditions: IDM, thrombocytopenia
- Maternal substance use: opioids, tobacco, alcohol
- Birth injuries
- Tracheoesophageal fistula, abdominal wall defects
- Ill-appearing infant

### 4. Abnormal Newborn

**NOT COVERED DURING TALK (slides at end)**
- Abnormal maternal screening: Hepatitis B, HIV, Syphilis
- Maternal conditions: PKU, oligohydramnios
- Polycythemia
- Delayed passage of urine or meconium
- Neonatal cholestasis
- Infant botulism

### 4. Abnormal Newborn

**TOPICS COVERED IN CASES (separate slide set)**
- Neonatal resuscitation
- Very low birth weight infants
- Respiratory distress in a newborn
- Intestinal obstruction in a newborn
- Hypoxic-ischemic encephalopathy

### Small for Gestational Age

- Small for gestational age (SGA): birth weight < 10th %ile
- Fetal growth restriction (FGR): < expected fetal growth (typically defined as estimated fetal weight < 10th %ile)
- SGA and FGR closely related, not quite the same
- SGA can include constitutionally small infants (normal)
- FGR typically reflects poor in-utero nutritional supply
- Exam can help: thin, loose skin, decreased fat

### Small for Gestational Age: Causes

- Causes SGA/FGR:
  - Fetal: genetic, infection (CMV), anomalies
  - Maternal: genetic, hypertension, medical conditions, uterine anomalies, poor nutrition
  - Placental: ischemia, abruption, ? cord problems
  - Some others (multiple gestation, alcohol, others)
  - Unknown (about 40%)
### Small for Gestational Age

- **Symmetric:** weight, HC, and length proportional
  - begins early in gestation
  - intrinsic causes: chromosomal, congenital infection
- **Asymmetric:** HC relatively preserved, length somewhat
  - begins later, late second or third trimesters
  - reduced nutrition, placental problems, hypertension

### Small for Gestational Age: Outcomes

- **Short-term:** increased risk of complications including prematurity, asphyxia, temp instability, hypoglycemia, hypocalcemia, polycythemia, PPHN
- **Increased risk of perinatal mortality**
- **Long-term:** risk of altered growth patterns, some data on risk for neurodevelopmental delays, some data on association with adult heart disease, hypertension, and kidney disease

### Sepsis Risk in Term Neonates

- **Neonatal sepsis:** sepsis in first month of life
  - Early onset: < 3-7 days, usually vertical transmission
  - Late onset: > 3-7 days, vertical or horizontal
- **Overall incidence 1-2 per 1000 births**
  - higher in preterm births
  - early-onset sepsis is decreasing, late-onset is stable
- **Most common:** Group B Strep, E. coli
  - others: Listeria, Staph aureus, Enterococcus, gram neg

### Sepsis Risk in Term Neonates: GBS

- **Universal screening at 35-37 weeks (10-40% colonized)**
- **Positive GBS:**
  - positive screening culture
  - GBS bacteriuria anytime in pregnancy
  - early-onset GBS disease in previous infant
- **Intrapartum antibiotic prophylaxis:**
  - Penicillin, ampicillin, or cefazolin at least 4 hours PTD
  - All other agents (clinda, vanco) considered inadequate

### Sepsis Risk in Term Neonates: Chorioamnionitis

- **Associated with neonatal sepsis as well as other adverse outcomes, including long-term neurologic impairment**
- **Diagnosis is clinical and difficult:**
  - Maternal fever (required)
- **Other supporting findings:** maternal leukocytosis, maternal tachycardia, fetal tachycardia, uterine tenderness, purulent or malodorous amniotic fluid
Sepsis Risk in Term Neonates: Chorioamnionitis

Terminology Features

| Isolated fever | Oral temp ≥ 102.2 on one occasion  
|                | Oral temp 100.4-102.2 on two occasions 30 minutes apart |
| Suspected Triple I | Fever plus any of the following:  
|                    | - Fetal tachycardia > 160 for 10 minutes  
|                    | - Maternal WBC > 15,000  
|                    | - Purulent fluid from cervical os |
| Confirmed Triple I | Suspected Triple I plus:  
|                   | - Positive amniotic fluid analysis  
|                   | - Positive placental pathology |

Sepsis Risk in Term Neonates: Evaluation

- Limited evaluation (CBC and blood culture):  
  - GBS+, inadequate antibiotic prophylaxis, AND either:  
    - Gestational age < 37 weeks, or  
    - Rupture of membranes > 18 hours  
  - Maternal chorioamnionitis (or maternal fever)  
  - Empiric neonatal antibiotic therapy (typically amp/gent):  
    - Maternal chorioamnionitis (or maternal fever)

Sepsis Risk in Term Neonates: Evaluation

- Considerations:  
  - ONLY risk factor GBS+ without antibiotic prophylaxis?  
    Can monitor without laboratory evaluation or abx  
  - Abnormal CBC findings (limited predictive value):  
    WBC < 5000, ANC < 1000, immature to total PMN ≥ 0.3  
  - CBC may have more value at 6-12 hours of age  
  - Diagnosis of chorioamnionitis extremely variable  
    - Some centers rely primarily on maternal fever

GBS Sepsis

- Early-onset (birth to day 6, usually within 24 hours):  
  sepsis, pneumonia or meningitis; can see profound shock  
- Late-onset (1 week to 3 months, usually 4-5 weeks):  
  sepsis, meningitis, focal infection including osteomyelitis, septic arthritis, and cellulitis adenitis  
- Late, late-onset (> 3 months): bacteremia in preterm infants < 28 weeks or immunocompromised  
- Treatment: penicillin, length depending on site

Maternal Conditions: Infant of Diabetic Mother

- “Diabetic embryopathy” – first trimester effects  
- Typically pregnancies with pregestational diabetes  
- Can lead to major birth defects, spontaneous abortions  
- “Diabetic fetopathy” – second and third trimesters  
- Maternal hyperglycemia leading to fetal hyperglycemia and fetal hyperinsulinism  
- Fetal hyperinsulinism leads to increased fetal metabolism, oxidative stress, and hypoxia

Maternal Conditions: Infant of Diabetic Mother

- Most common neonatal effects:  
  - Macrosomia/LGA, hypoglycemia  
  - Prematurity  
  - Respiratory distress  
  - Hyperbilirubinemia  
  - Polycythemia  
  - Congenital anomalies  
- Increased risk of NICU admission, ? increased mortality
### Maternal Conditions: Infant of Diabetic Mother

**Specific neonatal effects:**
- Anomalies: congenital heart disease, neural tube defects, small left colon, caudal regression syndrome
- Cardiomyopathy: hypertrophic intraventricular septum
- Perinatal asphyxia, from macrosomia, cardiomyopathy
- Birth injuries, from shoulder dystocia
- Respiratory distress, particularly RDS
- Hypocalcemia, hyperbilirubinemia, polycythemia

**Long-term outcomes:**
- Some increased risk of diabetes (may be genetic)
- Some increased risk of obesity, impaired metabolism
- Possible associations with neurodevelopmental outcomes (conflicting and limited data)

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### Maternal Conditions: Thrombocytopenia

**Gestational thrombocytopenia (GT):**
- Most common thrombocytopenia in pregnancy, usually around delivery, usually >100K (rarely to 80K), no risks to mom or baby
- Immune thrombocytopenia (ITP): 10X increased incidence in pregnancy; antiplatelet autoantibodies; can occur any trimester; severity variable; no diagnostic testing; if mild, difficult to distinguish from GT
- Others: preeclampsia, HELLP, DIC, fatty liver, TTP

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### Maternal Conditions: ITP

**ITP in pregnancy and neonatal thrombocytopenia:**
- Risk of neonatal thrombocytopenia: 10-25%
- Low but present risk of intracranial hemorrhage
- Usual nadir day 2-5 of life
- If thrombocytopenia occurs, can last weeks to months
- Different than neonatal alloimmune thrombocytopenia

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### Maternal Conditions: Opioids

**Neonatal autoimmune thrombocytopenia: management**
- Platelet count at birth and day 2-5 (at least)
- Platelets < 50K: consider head ultrasound
- Platelets < 20-30K: IVIG, platelet transfusion or both
- If bleeding: platelet transfusion +/- IVIG
- Platelet transfusions may have less efficacy than usual
- Sometimes need second dose of IVIG at 4-6 weeks
- ? Steroids for persistent thrombocytopenia (no data)

**Clinical:**
- Neonatal withdrawal syndrome
- State control: irritability, poor sleep, poor feeding
- Motor control: increased tone, tremors
- Autonomic: fever, sweating, sneezing, loose stools

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**Opioids:** methadone, buprenorphine, heroin, morphine, codeine, hydromorphone, fentanyl
- Goal: maternal abuse → medication-assisted therapy
Maternal Substance Use: Opioids

- Management:
  - Adequate observation: minimum 4-7 days
  - Standardized symptom assessment: Finnegan score
  - Non-pharm care: rooming in, breast-feeding, holding
  - Pharmacologic care: morphine, phenobarb, clonidine
  - Social supports, coordination of care, child protection
  - Incidence increasing dramatically

Maternal Substance Use: Tobacco

- Adverse pregnancy outcomes: spontaneous loss, abruptio, preterm labor, PPROM, placenta previa, growth restriction
- Adverse fetal/neonatal outcomes: congenital anomalies (cleft lip, gastroschisis, others), irritability, hypertonicity, SIDS, ? long-term neurologic impacts
- Smoking cessation at any time helpful

Maternal Substance Use: Alcohol

- Fetal alcohol spectrum disorder (FASD): umbrella term, broad array of impacts of prenatal alcohol exposure
- Incidence: up to 10/1000 when all types are included
- Clinical:
  - Classic facial features: short palpebral fissure length, thin upper lip, smooth philtrum
  - CNS: microcephaly, abnormal neurologic exam, cognitive, functional, and behavioral abnormalities

Birth Injuries

- Incidence: 1-2%, ? lower for cesarean section
- Risk factors:
  - Macrosomia (> 4000 gm, proportional to weight)
  - Maternal obesity (? may be due to ↑ risk of LGA)
  - Abnormal presentation (particularly breech)
  - Operative vaginal delivery with forceps or vacuum
  - Small maternal stature, maternal pelvic anomalies

Birth Injuries: Extracranial Scalp/Skull

<table>
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<tr>
<th>Injury</th>
<th>Location/Etiology</th>
<th>Exam</th>
<th>Course</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caput succedaneum</td>
<td>Edema above parietoeum, after prolonged fetal head engagement or vacuum</td>
<td>Soft swelling, extends across suture lines</td>
<td>Benign, largest at birth, resolves within few days</td>
<td>Skin necrosis, infection, occasionally hemorrhagic</td>
</tr>
<tr>
<td>Cephalohematoma</td>
<td>Subperiosteal hemorrhage, much more common with forces of vacuum</td>
<td>Firm then fluctuant, not discolored, distinct margins, does not cross suture lines</td>
<td>Can increase for 12-24 hours, resolves over 2-3 weeks</td>
<td>Fracture, infection, hyperbilirubinemia, leptomeningeal cysts (rare)</td>
</tr>
<tr>
<td>Subgaleal hemorrhage</td>
<td>Before aponeurosis, above periosteum, shearing of veins, more common after vacuum</td>
<td>Diffuse, fluctuant, fluid waves, unconfined, can extend from orbital ridges to upper neck</td>
<td>Can increase steadily after birth, resolves over 2-3 weeks</td>
<td>Blood loss, coagulopathy, shock, 12-14% mortality!</td>
</tr>
</tbody>
</table>

Birth Injuries: Shoulder Dystocia

- Need for more than gentle traction to deliver shoulders
- Risk factors: macrosomia > 4Kg, IDM, operative vaginal delivery, previous dystocia, precipitous and prolonged labor, post-term, maternal obesity → but 50% of cases have no identifiable risk factors
- Complications: brachial plexus injury, clavicular fracture, humerus fracture, hypoxic-ischemic encephalopathy, death (5-15% complication rate)

Birth Injuries: Brachial Plexus Injury

- Major risk factor: shoulder dystocia, but can be seen in non-complicated deliveries
- Almost always from stretching/traction of nerves, with different degrees of nerve injury
- Most cases are unilateral (5% bilateral)
- Can see associated clavicle or humerus fracture

<table>
<thead>
<tr>
<th>Injury</th>
<th>Nerve Roots</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper (Erb Palsy)</td>
<td>C5, C6, +/- C7</td>
<td>• Upper arm adducted and internally rotated, forearm extended, hands and wrists flexed (waiter’s tip)</td>
</tr>
<tr>
<td>Lower (Klumpke Palsy)</td>
<td>C8 and T1</td>
<td>• Hand paralysis, inability to flex wrist or grasp</td>
</tr>
<tr>
<td>Total</td>
<td>C5 to T1</td>
<td>• Arm and hand paralysis, possible sparing of finger flexion</td>
</tr>
</tbody>
</table>

Birth Injuries: Other Neurologic Injuries

- **Facial nerve palsy**: compression of nerve by forceps or pelvic bone; diminished movement of side of face – loss of nasolabial fold, partial closing of eye, drooping mouth, asymmetric cry (mouth drawn to unaffected side); protect cornea, spontaneous resolution within two weeks (unless non-traumatic/syndromic)
- **Recurrent laryngeal nerve injury**: vocal cord paralysis with stridor, respiratory distress, hoarse/absent cry, dysphagia
- **Spinal cord injury**: rare, some association with forceps and breech vaginal delivery, varying presentation but severe

Birth Injuries: Brachial Plexus Injury

- Diagnosis clinical; rarely EMG/nerve conduction, imaging
- Management:
  - Physical therapy after several days
  - Unclear roles for surgery, botulinum toxin
- Prognosis: recovery over 1-3 months in most, persistent impairment in 20-50%; isolated upper lesions favorable; early recovery good sign, but long-term hard to predict

Tracheoesophageal Fistula (TEF)

- TEF: 1 in 3500 live births, usually with esophageal atresia
- Most common: EA with distal TEF (type C)
  - H-type (without EA) uncommon
- Clinical: polyhydramnios, excessive secretions, cough, respiratory distress, gastric distension, ? VACTERL
  - H-type can have subtle presentation
- Dx: inability to pass NG tube, dilated tracheal pouch
  - Contrast study sometimes helpful
Abdominal Wall Defects

<table>
<thead>
<tr>
<th></th>
<th>Omphalocele</th>
<th>Gastrochisis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Midline, at umbilicus, covered by protective sac</td>
<td>Just lateral to umbilicus, almost always to right, exposed abdominal contents</td>
</tr>
<tr>
<td><strong>Associations</strong></td>
<td>Advanced maternal age, karyotype abnormalities (trisomies, others), Beckwith-Wiedemann syndrome</td>
<td>Young maternal age, smoking, illicit substance use, medications</td>
</tr>
<tr>
<td><strong>Incidence</strong></td>
<td>1-3 per 10,000</td>
<td>Increasing, now 1-3 per 10,000</td>
</tr>
<tr>
<td><strong>Intestinal injury</strong></td>
<td>Uncommon</td>
<td>Common</td>
</tr>
<tr>
<td><strong>Other anomalies</strong></td>
<td>Common</td>
<td>Uncommon</td>
</tr>
</tbody>
</table>

**Initial Management**
- Airway protection as needed, avoid non-invasive positive pressure if possible, early gastric decompression, protection of defect with saline-soaked dressings or bowel bag, fluid resuscitation, temperature support, antibiotics

The Ill-Appearing Infant (Lethargy, Coma)
- Infection: bacterial sepsis (E. coli, GBS, others), UTI, HSV, enterovirus, pertussis, botulism, bronchiolitis, influenza
- Critical congenital heart disease, arrhythmia
- Congenital adrenal hyperplasia
- Inborn errors of metabolism
- NEC, Hirschprung, malrotation, pyloric stenosis
- Glucose/electrolyte abnormalities, toxins, bilirubin

Outline
1. Fetus
2. Normal Newborn – Assessment
3. Normal Newborn – Routine Care
4. Abnormal Newborn

4. Abnormal Newborn

**TOPICS COVERED IN CASES (separate slide set)**
- Neonatal resuscitation
- Very low birth weight infants
- Respiratory distress in a newborn
- Intestinal obstruction in a newborn
- Hypoxic-ischemic encephalopathy

Changes in Practice
**Changes you may wish to make in practice:**
- Provide comprehensive care to all normal newborns, including appropriate prophylaxis and newborn screening
- Assure all newborns are appropriately evaluated for jaundice
- Assure all newborns at risk for sepsis are appropriately evaluated
- Assure all newborns at risk for hypoglycemia are screened
- Adequately monitor infants impacted by perinatal opioid use, and provide compassionate and supportive care to their families
References
Broad references covering newborn care:
- Guidelines for Perinatal Care (7th edition), AAP and ACOG
- Textbook of Neonatal Resuscitation (7th edition), AAP and AHA
- www.neoreviews.org
- www.uptodate.com

Supplemental Slides

Supplemental Slides Not Covered in Talk
- Fetal surveillance methods
- Gestational age assessment
- Temperature support in delivery room
- Discharge planning, early discharge, home birth
- Abnormal maternal screening: Hepatitis B, HIV, Syphilis
- Maternal conditions: PKU, oligohydramnios

Supplemental Slides Not Covered in Talk (cont.)
- Polycythemia
- Delayed passage of urine or meconium
- Neonatal cholestasis
- Infant botulism

Fetal Surveillance: Non-Stress Test
- Non-stress test (NST): fetal heart rate (FHR) monitoring for 40 minutes (not during labor)
- Reactive: at least 2 accelerations of at least 15 seconds peaking at least 15 bpm above baseline
- Non-reactive: does not meet acceleration criteria
- High false-positive rate (50-60%)
- Valid after 26-28 weeks (revised criteria < 32 weeks)

Fetal Surveillance: Stress Test
- Contraction stress test (CST): FHR monitoring during three contractions within 10 minute period (can stimulate contractions if needed)
  - Negative: no late or significant variable decelerations
  - Positive: late decelerations >50% of contractions
  - Equivocal: variables, intermittent late decelerations
- Not used much
**Fetal Surveillance: Biophysical Profile**

- 5 components, 2 points each:
  - NST: reactive
  - Fetal breathing: ≥1 episode of extension/flexion
  - Fetal tone: ≥1 episode of extension/flexion
  - Amniotic fluid volume: pocket ≥ 1 cm x 2 cm
  - Fetal movements: ≥3 discrete movements
- Monitor at least 30 minutes if needed
- Modifications: no NST, or only NST/AFV

**Fetal Surveillance: Biophysical Profile**

- Interpretation:
  - 10/10, 8/8 (no NST): normal
  - 8/10 with 2 for AFV: normal
  - 6/10 with 2 for AFV: equivocal \(\rightarrow\) repeat or ? deliver
  - 6/10 or 8/10 with 0 for AFV: abnormal \(\rightarrow\) ? deliver
  - 0 to 4/10: abnormal \(\rightarrow\) deliver
- Can be used as early as 24 weeks, generally used beginning at 32-34 weeks for most at-risk pregnancies

**Fetal Surveillance: Amniotic Fluid**

- Standard in 2\(^{nd}\) and 3\(^{rd}\) trimester ultrasounds
- Qualitative: normal, oligo, or poly
- Semi-quantitative:
  - Single deepest pocket (SDP): vertical dimension of largest pocket, normal 2 cm to 8 cm
  - Amniotic fluid index (AFI): sum of deepest pockets in each of four quadrants, normal 5 cm to 24 cm

**Fetal Surveillance: Doppler Flows**

- Umbilical artery diastolic flow
  - normal: low resistance, so high-velocity diastolic flow
  - abnormal: reduced, absent, or reversed diastolic flow
  - placental dysfunction \(\rightarrow\) ↑ resistance \(\rightarrow\) ↓ flow
  - used primarily for fetal growth restriction monitoring
- Middle cerebral artery peak systolic velocity
  - can monitor for fetal anemia in at-risk pregnancies
  - flow >1.5 MoM (multiple of median) \(\rightarrow\) fetal anemia

**Newborn Infant: Assessment - Gestational Age**

<table>
<thead>
<tr>
<th>Physical</th>
<th>Term</th>
<th>Post-Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin red, translucent, Visible veins, lanugo</td>
<td>Skin mostly bald to bald</td>
<td>Macrocornia</td>
</tr>
<tr>
<td>Faint or flat areola</td>
<td>Rare veins</td>
<td>Skin peeling</td>
</tr>
<tr>
<td>GVI less developed</td>
<td>GA fully developed</td>
<td>&quot;Dysmaturity&quot; (\rightarrow) SGA, thin, leathery wrinkled skin</td>
</tr>
<tr>
<td>Less creases</td>
<td>Creases over most of sole</td>
<td>Similar to term</td>
</tr>
</tbody>
</table>

| Neurologic | | |
| Hypotonic | Flushed limbs | Similar to term |
| Limbs more extended | Rooting/sucking | |
| Pupils 28-32 weeks | Mild head lag | |
| Grasp 28-36 weeks | Complete Mono | |
| Monotone 26-38 weeks | | |
| Sucking 33-36 weeks | | |

| Behavioral | | |
| Alertness with stimulus | Alert for long periods | "Dysmaturity" \(\rightarrow\) increased alertness, wide-eyed |
| Short sucking periods | | |

**Delivery Room: Hypothermia / Cold Stress**

- Normal newborn temp (goal): 36.5-37.5°C
- Hypothermia: temp < 36.0 or 36.5°C
- Cold stress: increased metabolism, 02 consumption, vasoconstriction, acidosis, PPHN, hypoxia
- Associated with significant adverse outcomes
  - Mortality! In preterm: IVH, NEC, sepsis, RDS
- Mainly preterm in U.S., all gestations in low-resourced
Delivery Room: Hypothermia / Cold Stress

- Mechanisms of heat loss:
  - Evaporation of fluids (most important)
  - Conduction of heat through contact with surfaces
  - Convection of heat to surrounding air
  - Radiation of heat to nearby environment
- Newborn factors: high surface to weight ratio, thin skin, less subcutaneous fat, wet skin, wet blankets

Delivery Room: Hypothermia / Cold Stress

- Management in healthy term infants:
  - dry, and then skin-to-skin!
- Management in other term infants, preterm infants:
  - maintain delivery room at suitable temp (74-77°F)
  - use pre-warmed blankets
  - pre-warm radiant warmer
  - pre-warm transport incubator if needed

Delivery Room: Hypothermia / Cold Stress

- Management in preterm infants:
  - use chemical warming mattress
  - use plastic wrap or bag without drying
  - use heated humidified gases for resuscitation
- In all: avoid HYPERTHERMIA
- Also: excludes THERAPEUTIC HYPOTHERMIA

Delivery Room: Radiant Warmer Use

- Pre-warm: typically manual mode, 100% output
- Switch to servo-controlled mode as soon as possible
- skin probe on infant, set target temp around 36.5°C
- Concerns:
  - HYPERTHERMIA - prolonged use of manual mode
  - HYPERTHERMIA – misuse, dislodgement of temp probe
  - Continued evaporative (and convective) heat loss with ongoing insensible fluid loss, particularly if preterm

Routine Newborn Care: Discharge Planning

- Minimum criteria for discharge of well term newborn:
  - Stable vital signs at least 12 hours, including temp
  - Regular urine output, at least one spontaneous stool
  - At least two successful feedings
  - No excessive circumcision bleeding for at least 2 hours
  - Appropriate screening for hyperbilirubinemia
  - Appropriate evaluation and monitoring for sepsis risk

Routine Newborn Care: Discharge Planning

- Minimum criteria for discharge (cont):
  - Hepatitis B vaccine, review of maternal vaccinations
  - Newborn metabolic, hearing, and CCHD screening
  - Appropriate car seat available
  - Follow-up care identified
  - Maternal and family education provided
  - Risk factors for safe home environment assessed
**Routine Newborn Care: Early Discharge**

- Minimal criteria for discharge generally not met until 48 hours after birth
- Early discharge before 48 hours after delivery:
  - Generally limited to AGA singletons 38-42 weeks
  - Appointment with provider made within 48 hours (can be at clinic or at home)
  - Appropriate repeating or scheduling of screening studies if discharge before 24 hours

**Home Birth: General Concepts**

- AAP/ACOG: hospitals and birthing centers are safest settings for birth, but respect rights of women to make medically-informed decision about delivery
- AAP/ACOG: do not support care by lay midwives not certified by American Midwifery Certification Board
- Home birth in U.S. appears associated with higher risks of mortality, low Apgar scores, and seizures
- 10-40% may need transfer to hospital before birth

**Home Birth: Care of Newborn**

- Regular monitoring of vital signs until stable > 2 hours
- If appears < 37 weeks → transfer to hospital
- If chorio → transfer to hospital
- Routine IM vitamin K and eye prophylaxis
- Early hepatitis B vaccination
- Glucose screening if LGA/SGA

**Home Birth: General Concepts**

- Candidates for home delivery:
  - Absence of pre-existing maternal disease
  - Uncomplicated pregnancy
  - Singleton fetus, appropriate weight for gestation
  - Cephalic presentation
  - Gestational age 37 to 40 weeks
  - No previous c-section (ACOG)

- Systems needed to support planned home birth:
  - Availability of certified mid-wife or physician practicing within integrated health care system
  - One person with primary responsibility for newborn, with neonatal resuscitation training
  - Access to consultation and pre-existing arrangement for safe and timely transport when necessary
  - Appropriate communications between providers

- Cord blood testing when appropriate
- Bilirubin screening at 24-48 hours
- State newborn screen at 24 to 48 hours
- Hearing screening by 1 month of age
- Primary care evaluation in first 24 hours, and then again within 48 hours
Abnormal Maternal Screening: Hep B
- Neonatal management for mother HBsAg positive:
  - Bathe/clean infant to remove maternal blood
  - Hep B vaccine and HBIG within 12 hours of birth
  - Complete three dose series (four if BW < 2000 gm)
  - Test infant for HBsAb and HBsAg at 9 months of age
  - Breast-feeding ok
  - Can reduce risk of neonatal Hep B infection by 95%

- Neonatal management for mother HBsAg unknown:
  - Test mother for HBsAg immediately
  - Hep B vaccine within 12 hours of birth
  - If BW ≥ 2 kg: HBIG if maternal HBsAg positive, or if remains unknown at 7 days of life
  - If BW < 2 kg: HBIG if maternal HBsAg positive, or if remains unknown at 12 hours of life

Abnormal Maternal Screening: HIV
- ACOG: universal screening for HIV early in pregnancy
  - Screening should be voluntary
  - Written consent no longer required by any state
  - “Opt-out” strategy preferred over “opt-in”
- HIV+:
  - Start combination ART as early as possible
- HIV unknown at delivery:
  - Send rapid assay on mother as well as confirmatory test

- Perinatal/neonatal management based on risk:
  - High risk: viral load > 1000 copies/mL near delivery, HIV positive without antepartum ART, and mothers unknown at delivery with positive rapid assay
  - Low risk: viral load < 1000 copies/mL but detectable near delivery
  - Lowest risk: undetectable viral load near delivery

<table>
<thead>
<tr>
<th>Mode of delivery</th>
<th>Low Risk</th>
<th>Medium Risk</th>
<th>High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrapartum treatment</td>
<td>Continue ART</td>
<td>Continue ART</td>
<td>Continue ART with IV zidovudine</td>
</tr>
<tr>
<td>Neonatal treatment</td>
<td>Zidovudine 4-6 weeks</td>
<td>Zidovudine 4-6 weeks</td>
<td>Zidovudine 6 weeks, combination with nevirapine (two-drug) or nevirapine &amp; lamivudine (three-drug)</td>
</tr>
</tbody>
</table>

- Infant HIV DNA PCR testing at birth, 14-21 days, 1-2 months, and 4-6 months, ? HIV antibody testing at 12-18 months
- Breastfeeding not recommended

Abnormal Maternal Screening: Syphilis
- Maternal RPR/VDRL test confirmed with treponemal test
- RPR/VDRL (same as mother) on infant, physical exam
  - Clinical findings can include: hepatomegaly, jaundice, nasal discharge (“snuffles”), rash, lymphadenopathy, long-bone abnormalities, pneumonia, CNS disease
- Evaluation and treatment based on maternal titers, maternal treatment, neonatal titers, and neonatal exam
### Abnormal Maternal Screening: Syphilis

<table>
<thead>
<tr>
<th>Category</th>
<th>Findings</th>
<th>Evaluation¹</th>
<th>Treatment²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proven or highly probable disease</td>
<td>Titer &gt; 4x maternal or abnormal physical findings</td>
<td>Full evaluation</td>
<td>10 days penicillin</td>
</tr>
<tr>
<td>Possible disease</td>
<td>Titer &lt; 4x maternal, normal exam, inadequate maternal treatment or relapse</td>
<td>Full evaluation</td>
<td>10 days penicillin</td>
</tr>
<tr>
<td>Unlikely disease</td>
<td>Titer &lt; 4x maternal, normal exam, appropriate maternal treatment</td>
<td>No evaluation</td>
<td>1 dose IM penicillin</td>
</tr>
<tr>
<td>Negative titers</td>
<td>Non-reactive titers, inadequate maternal treatment or relapse</td>
<td>No evaluation</td>
<td>No treatment</td>
</tr>
<tr>
<td>Negative titers</td>
<td>Non-reactive titers, appropriate maternal treatment</td>
<td>No evaluation</td>
<td>No treatment</td>
</tr>
</tbody>
</table>

1. Evaluation: CBC, CSF with VDRL, and as indicated, UFTs, CXR, long bone films, HUS, eye exam, ABAs
2. Significant variability present in treatment recommendations -- some are more conservative.

### Maternal Conditions: Phenylketonuria (PKU)
- Elevated maternal phenylalanine \(\rightarrow\) embryopathy
- Unrelated to fetal/neonatal PKU status
- Risk proportional to maternal phenylalanine levels
- Clinical effects: IUGR, microcephaly, cardiac malformations (coarct, HLHS), neurologic disability
- Prevention: dietary restriction of phenylalanine before and during pregnancy; monitor phenylalanine levels at least weekly (goal < 6 mg/dL); ± tyrosine supplements

### Maternal Conditions: Oligohydramnios
- ‘Oligohydramnios tetrad’ usually secondary to severe renal disease (renal agenesis, cystic kidney disease) or mid-trimester PPROM
- Outcomes can be poor
- Often leads to extreme preterm delivery
- Pulmonary hypoplasia common, severity depends on GA at onset and degree of oligohydramnios
- Severe pulmonary hypoplasia: high mortality rate

### Polycythemia
- Increased hematocrit leads to increased viscosity, decreased blood flow, and decreased oxygen delivery
- Hyperviscosity different but related to polycythemia
  - in neonates, hyperviscosity almost always due to Hct
  - not all neonates with high Hct will have hyperviscosity
- Clinical symptoms of polycythemia from hyperviscosity, increased metabolic needs, and increased red cell mass
  - most neonates with polycythemia are asymptomatic

### Polycythemia: Clinical Symptoms
- CNS: poor feeding, lethargy, hypotonia, apnea, tremors, seizures, cerebral venous thrombosis
- Cardiorespiratory: tachypnea, congestive heart failure, cyanosis, hypoxia
- Metabolic: hypoglycemia, hypocalcemia, jaundice
- Other: thrombosis, thrombocytopenia, ? NEC, ? DIC
- Possible association with long-term neurologic findings
**Polycythemia: Causes**

- Placental transfusion: delayed cord clamping (> 1 min), cord stripping, baby held below mother, maternal-fetal transfusion, twin-to-twin transfusion
- Placental insufficiency, increased fetal erythropoiesis: SGA, IUGR, preeclampsia, maternal chronic hypoxia, post-term infants, maternal smoking, high altitude
- Other conditions: IDM, LGA, Beckwith-Wiedemann, neonatal thyroid disorders, trisomy (21, 18, 13)

**Polycythemia: Diagnosis**

- Hematocrit > 65 on venous sample
- Ideally would measure viscosity, but not readily available
- No standard recommendations on screening
  - few suggest universal screening
  - some suggest screening only for symptoms
  - some suggest screening for high risk groups

**Polycythemia: Management (variable)**

- Hct 60-70 and asymptomatic: monitor, insure hydration
- Symptomatic with Hct > 65 or Hct > 70:
  - IV hydration
  - Partial exchange transfusion (threshold varies)
    - Volume = [(Hct - desired Hct) x blood volume] / Hct
    - ? risk of NEC with partial exchange
  - Exchange transfusion improves short term physiology; unclear if it impacts long-term outcomes

**Delayed Passage of Meconium (> 48 hours)**

- Causes:
  - Hirschsprung disease
  - Meconium ileus, meconium plug
  - Intestinal obstruction, small left colon
  - Hypothyroidism
- Evaluation:
  - Rectal exam, KUB, contrast enema, UGI

**Delayed Passage of Urine (> 24 hours)**

- Causes:
  - Renal agenesis, cystic kidney disease
  - Obstructive uropathy, posterior urethral valves (males)
  - Dehydration, asphyxia, shock, vascular thrombosis
  - Neuropathic bladder dysfunction
- Evaluation:
  - Exam, catheter, hydration, renal ultrasound, spine eval

**Neonatal Cholestasis (Direct Hyperbilirubinemia)**

- Definitions:
  - Cholestasis – conjugated hyperbilirubinemia
  - Conjugated bilirubin – direct bilirubin
  - Cholestasis: direct bilirubin > 1.0 and > 20% of total
  - Neonatal cholestasis: birth or first few months
- Early detection essential, particularly for biliary atresia
  - Outcomes much better for biliary atresia if surgery (Kasai) performed early (< 30-60 days)
### Neonatal Cholestasis: Causes

<table>
<thead>
<tr>
<th>Type</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstruction</td>
<td>Biliary atresia (extra-hepatic), choledochal cyst, biliary sludge, others</td>
</tr>
<tr>
<td>Infection</td>
<td>CMV, enterovirus, HSV, parvovirus B19, UTI, syphilis, toxoplasmosis, others</td>
</tr>
<tr>
<td>Metabolic</td>
<td>Carbohydrate disorders (galactosemia, fructosemia), amino acid disorders (tyrosinemia), lipid disorders (Niemann-Pick, Gaucher), bile acid synthesis disorders, alpha-1-antitrypsin deficiency, disorders of glycosylation</td>
</tr>
<tr>
<td>Genetic</td>
<td>Alagille syndrome, CF, progressive familial intrahepatic cholestasis (PFIC), others</td>
</tr>
<tr>
<td>Endocrine</td>
<td>Hypothyroidism, hypopituitarism</td>
</tr>
<tr>
<td>Toxic</td>
<td>Parenteral nutrition, drugs</td>
</tr>
<tr>
<td>Autoimmune</td>
<td>Gestational alloimmune liver disease (neonatal hemochromatosis)</td>
</tr>
<tr>
<td>Other</td>
<td>Paucity of intrahepatic bile ducts, idiopathic neonatal hepatitis</td>
</tr>
</tbody>
</table>

### Neonatal Cholestasis: Evaluation

- Screen any infant jaundiced at 2 weeks; most will have benign unconjugated hyperbilirubinemia, few will not
- If conjugated hyperbilirubinemia:
  - Abdominal ultrasound
  - If non-diagnostic, HIDA scan
  - If non-diagnostic, liver biopsy
  - Infection, endocrine, metabolic evaluation

### Clostridium Botulinum: Infant Botulism

- Onset at 1 week to 12 months, mostly at 2 to 8 months
- Mostly from environmental dust with spores → near construction or agriculture, more common in PA, UT, CA
- Type A more common in western U.S.
- Type B more common in eastern U.S.
- Some foodborne cases from wild honey, home canned foods, when transitioning from breast-feeding

### Clostridium Botulinum: Infant Botulism

- Clinical: progressive neuromuscular blockade
  - Cranial nerves, then trunk, extremities, diaphragm
  - Constipation, poor feeding, weakness, decreased gag/suck, less eye movement, ptosis, progressive hypotonia, respiratory failure; can be acute
  - Diagnosis: stool with spores and toxin (difficult), EMG
  - Treatment: botulism IG-IV (empiric), supportive care