Disclosures

I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider of commercial services discussed in this CME activity.

I do not intent to discuss an unapproved/investigative use of a commercial product/device in my presentation.
Learning Objectives

After this activity, participants will be able to:

- Provide neonatal resuscitation using current guidelines
- Evaluate the newborn with respiratory distress and manage appropriately
- Participate in the initial management of a VLBW infant
- Assess and manage infants with neonatal depression
- Evaluate infant presenting with signs of GI obstruction
Content Specifications

** indicates material specifically matched to content specifications
## Outline

1. Neonatal resuscitation
2. Respiratory distress
3. VLBW infant
4. Neonatal depression
5. Intestinal obstruction
1. Neonatal resuscitation
2. Respiratory distress
3. VLBW infant
4. Neonatal depression
5. Intestinal obstruction
Case 1: Neonatal Resuscitation

You are called to attend a cesarean section at 39 weeks for a category II fetal heart rate tracing and failure to progress. The amniotic fluid is meconium-stained. At delivery, infant is brought to warmer and you note the baby to be term, floppy, and apneic.
Case 1: Neonatal Resuscitation

When should the cord be clamped? What are potential risks/benefits of delaying cord clamping? What factors influence the timing of cord clamping? (recent)

- For most vigorous deliveries, cord clamp at least 30 to 60 seconds after birth
- Benefits for preterm: ↓ mortality, ↑ higher BP, ↓ transfusion, ↓ IVH, ↓ NEC
- Benefits for term: ↓ iron-deficiency anemia, ↑ neurodevelopment
- Risks: delayed resuscitation, ↑ polycythemia, ↑ jaundice
- When not to delay cord clamping:
  - Should not delay: abruption, bleeding previa, cord injury
  - Unclear / not enough data: multiple gestation, fetal concerns, non-vigorous
- For non-vigorous infants: begin initial NRP steps, clamp cord if no response
  (Note: most centers do TCC for preterm infants, still very new for term infants)
Case 1: Neonatal Resuscitation

When is intubation and tracheal suctioning recommended for meconium-stained amniotic fluid?  (new)

- No routine intubation and tracheal suctioning for meconium-stained amniotic fluid, whether vigorous or non-vigorous

- Meconium-stained amniotic fluid still considered risk factor for need for resuscitation, should have providers for newborn (i.e., pediatrics) at delivery
Case 1: Neonatal Resuscitation

At delivery, the OB holds and gently stimulates the newborn. The infant remains limp and apneic, so the cord is clamped and infant is brought to warmer.

You provide warmth, dry and stimulate the infant, and position the airway.

When and how should nasopharyngeal suctioning be performed? **

- Clear secretions from airway if needed
  - Mostly: secretions obstructing airway, infant not clearing secretions
  - Others: apnea/gasping, poor tone, meconium-stained fluid, anticipating PPV
- No need for routine suctioning for vigorous infants
- Suction mouth, then nose (“M” before “N”)
- Suction with bulb syringe, turn head to side to help
- Avoid vigorous and deep suctioning – can cause vagal response, bradycardia
Case 1: Neonatal Resuscitation

Despite your initial steps of care, infant continues to be apneic. A team member listens for heart rate, which is less than 60. What is the next step?

Positive pressure ventilation (PPV) is indicated after initial steps of resuscitation if infant is **apneic or gasping**, **OR** if **heart rate is less than 100 bpm**.

- PPV should be started **within 1 minute of birth** when indicated
- First few breaths may need higher pressures to clear fetal lung fluid
  - Typical PIP 20-25 cm H₂O, may need 30-40 cm H₂O initially (in term infants)
  - In general, use just enough PIP to inflate lungs and increase heart rate
- Rate for PPV: **40-60 breaths per minute**
  - (we’re usually go too fast, particularly with T-piece resuscitator)
- Tip: always do two-person PPV when possible
Case 1: Neonatal Resuscitation

You prepare for PPV. How much oxygen should you use? (newish)

Goal is to mimic saturations of normal term infants, which start around 60% and increased gradually over 5-10 minutes to above 90%

- Should use **oximeter** as soon as PPV or oxygen is needed to monitor/adjust
- Excessive oxygen associated with adverse outcomes including mortality

Recommended starting oxygen levels:

- ≥ 35 weeks gestation: 21%
- < 35 weeks gestation: 21-30%

(Note: oximeters are now routine in delivery rooms; NRP now also recommends cardiac ECG monitors for resuscitations)
Case 1: Neonatal Resuscitation

You have been giving PPV for 15-30 seconds. It does not appear the chest is moving, and HR remains under 60. What is the next step?

The next step is to adjust your technique. The most important step to correct bradycardia is effective PPV, defined as heart rate increasing and chest moving.

- Steps to correct mask ventilation: MR. SOPA (or MRS. OPA)
  - Mask adjustment (two-person PPV!)
  - Reposition airway (critical!)
  - Suction mouth and nose
  - Open mouth
  - Pressure increase
  - Alternative airway (i.e., intubate or laryngeal mask)
Case 1: Neonatal Resuscitation

You have undertaken the MR. SOPA steps, including intubation. HR remains < 60 despite 30 seconds of ventilation through the ETT. What is the next step? **

Chest compressions should be started.

- Chest compressions are indicated when HR remains < 60 bpm despite effective PPV, usually through an ETT or laryngeal mask with chest movement (new)
- Technique: two-thumbs, lower sternum, hands encircling chest, 1/3 depth
  - Two finger technique not recommended (newish)
- 90 compressions with 30 breaths per minute: 3:1 cycle every 2 seconds
- Increase O₂ to 100% if starting compressions
- Reassess after 60 seconds, stop if HR > 60. PPV continues until HR > 100.

(1. Chest compressions rare - focus on PPV! 2. ECG monitor super helpful. )
Case 1: Neonatal Resuscitation

HR remains less than 60 despite effective PPV through an ETT and 60 seconds of chest compressions. How would you give epinephrine, and at what dose?

- Epinephrine is indicated for persistent HR < 60 after at least 30 seconds of effective PPV and 60 seconds of chest compressions with PPV and 100% O₂

- **Preferred route: intravenous** (newish)
  - Place umbilical venous line
  - Dose 0.1 to 0.3 mL/kg of 1:10,000 (0.1 mg/mL) epinephrine

- Can give intraosseous (same dose as IV) (newish)

- Can give one dose via ETT: dose 0.5 to 1.0 mL/kg

- Can repeat epinephrine every 3 to 5 minutes (feels like forever)

- Consider volume resuscitation if signs of shock or blood loss
Case 1: Neonatal Resuscitation

After 2 doses of epinephrine and continued PPV, heart rate increases to above 100. Infant is brought to NICU. What types of medical complications can result from prolonged resuscitation and poor perfusion?**

- Pneumothorax, pneumonia
- Persistent pulmonary hypertension, hypotension
- Metabolic acidosis, hypoglycemia, hypocalcemia, renal dysfunction (ATN)
- Liver injury, feeding intolerance, ileus, intestinal injury
- Coagulopathy
- Temperature instability
- Seizures, encephalopathy

(If term/late preterm infant: need to consider therapeutic hypothermia!)
1. Neonatal resuscitation
2. Respiratory distress
3. VLBW infant
4. Neonatal depression
5. Intestinal obstruction
Case 2: Respiratory Distress

You are admitting a newborn infant born at 37 weeks for respiratory distress. Intrapartum course was notable for spontaneous labor, concerns for chorioamnionitis, meconium-stained amniotic fluid, and cesarean delivery for failure to progress. Infant emerged vigorous but had persistent work of breathing and desaturations requiring oxygen and then CPAP in the delivery room.
Case 2: Respiratory Distress

What is your differential diagnosis?

- Respiratory distress syndrome (RDS)
- Pneumonia / sepsis
- Meconium aspiration
- Pneumothorax
- Transient tachypnea of the newborn (TTN)
- Congenital lung malformations

What would be your next steps in evaluation?

- History and physical examination
- Chest x-ray, blood gas, CBC and culture, transillumination
Case 2: Respiratory Distress - RDS

A super-wise neonatologist is walking by and casually remarks, this is clearly RDS. What are the typical findings of RDS, and how would you manage it?**

Presents at or shortly after birth, worsens over first 48 hours if untreated:
- Tachypnea, retractions, grunting, flaring, cyanosis, diminished breath sounds
- Hypoxia responsive to oxygen, hypercarbia
- CXR (diagnostic): low lung volumes, diffuse granular pattern, air bronchograms

Management:
- Antenatal corticosteroids for threatened delivery 23-34 weeks (? to 36 weeks)
- CPAP/PEEP, mechanical ventilation if necessary, surfactant if intubated
- Permissive hypercarbia, O₂ sat targeting, avoid volutrauma/barotrauma
- Caffeine, vitamin A; iNO NOT effective
Case 2: Respiratory Distress - Pneumonia

An ID fellow walks by, and says this must be neonatal pneumonia. Can you tell?**

Not necessarily! Early onset neonatal pneumonia and RDS can look similar.

- Early-onset neonatal pneumonia: within 1st three days, perinatal acquired
- GBS, E. coli, Klebsiella, Staph aureus, Strep pneumoniae, ? Ureaplasma
- Typically will see risk factors for pneumonia: PROM, fever, chorioamnionitis
- Can present like RDS with respiratory distress soon after birth; can be more ill-appearing, with lethargy, hypotension, shock, pulmonary hypertension
- CBC may be shifted, blood culture important
- CXR can be diffuse granular like RDS (particularly GBS), can also be more coarse or more patchy and irregular, can see pleural effusions
- Treatment: supportive care and antibiotics
Case 2: Respiratory Distress - Pneumothorax

A surgery resident walks by and wonders if this could be a pneumothorax. What are the typical findings and management for pneumothorax?**

- Air leak more common in neonatal period than any other time in life
- Risk factors: RDS, meconium aspiration, pneumonia, ventilation, PPV, CPAP, pulmonary hypoplasia -- but good portion spontaneous without risk factor
- Clinical findings: respiratory distress (can be acute change), distension of affected side of chest, diminished breath sounds on affected side, displaced cardiac sounds away from affected side, shock if tension pneumothorax
- Diagnosis: trans-illumination, chest x-ray (two views can be helpful)
- Management: observe, lower pressures, thoracentesis, chest tube
- Other types of air leak: PIE, pneumomediastinum, pneumopericardium
Case 2: Respiratory Distress - TTN

A NICU nurse says “You’re all ridiculous, just leave this infant alone. He clearly has TTN”. What are the findings of TTN, and how do you manage it?**

- TTN: pulmonary edema from delayed clearance of fetal lung fluid
- Risk factors: cesarean section, prematurity, IDM, maternal asthma
- Clinical: classically tachypnea within first few hours of life, can also have increased work of breathing and cyanosis
- CXR: increased lung volumes, mild cardiomegaly, prominent vascular markings with perihilar streaking, fluid in fissures, +/- effusions, can rapidly resolve
- CBC typically normal
- Management: supportive care, oxygen, rarely CPAP, typically lasts 12-24 hours, can linger for several day
Case 2: Respiratory Distress - MAS

The pediatrics intern finally speaks up and says, “folks, this baby looks sick, and there’s mec-staining everywhere. Is this meconium aspiration syndrome?” Is it?

- MAS: intrauterine aspiration of meconium with resulting lung disease from: obstruction; pneumonitis; +/- infection; and +/- surfactant deficiency
- Occurs in 2-10% of deliveries with meconium stained amniotic fluid (MSAF)
- Highest risk: post-term, SGA infants; incidence has decreased thanks to OBs
- Clinical: hx of MSAF, mec-staining; +/- neonatal depression; respiratory distress soon after birth, barrel-shaped chest, coarse breath sounds, often sick
- CXR: can be streaky and linear like TTN, typically more coarse, hyperinflated, can have patchy infiltrates, can be complicated by air leak
- Management: O₂ (generous), ventilation, sedation, surfactant (variable)
Case 2: Respiratory Distress - Persistent Hypoxia

As usual, the intern is correct. Infant appears ill and is needing a LOT of oxygen. What else does the infant have? Could this be cyanotic heart disease?**

- Persistent pulmonary hypertension (PPHN): persistent R→L shunting through PFO and/or PDA, severe hypoxemia, may see pre-/post-ductal sat gradient
- Vs. cyanotic congenital heart disease (CCHD):
  - Typically more lung disease on CXR with PPHN vs CCHD (not always, though)
  - Often have cardiomegaly or classic cardiac silhouettes with CCHD
  - Pre/post-ductal gradient with PPHN, not with CCHD
  - Hyperoxia test: some increase in pO₂ with PPHN, no increase with CCHD
  - PPHN will respond to PPHN treatments, CCHD will not
- Can treat empirically, but do need ECHO for definitive diagnosis
Case 2: Respiratory Distress - PPHN

What strategies do you use to avoid and treat PPHN?

- Avoid factors that increase pulmonary vascular resistance:
  - Generous oxygen support targeting high saturations
  - Target normal pCO₂
  - Correct acidosis
  - Sedation, +/- muscle relaxation
- Assisted ventilation - HFOV
- Increase systemic vascular resistance, blood pressure – volume, pressors
- Severe cases: Oxygenation index: \( OI = \left[ \frac{\text{MAP} \times \text{FiO}_2}{\text{PaO}_2} \right] \times 100 \)
  - \( OI > 25: \) inhaled nitric oxide (iNO) \( \rightarrow \) reduces need for ECMO
  - \( OI > 40: \) ECMO
Outline

1. Neonatal resuscitation
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Case 3: Very Low Birth Weight Infant

You are covering the NICU and are told of an impending delivery at 25 weeks. Mother presented with preterm labor that is progressing. It is a singleton male infant.
Case 3: Very Low Birth Weight Infant

What would you tell the family about overall chances of survival for this extremely preterm infant? What are the most common morbidities he might experience?

- LBW: < 2500 gm; VLBW: < 1500 gm; ELBW: < 1000 gm
- Very preterm: ≤ 32 weeks; Extremely preterm: ≤ 28 weeks
- Overall survival at 25 weeks: around 60-70%  
  - Slightly less at 24 weeks
  - Significantly less at 23 weeks
  - Worse for males, multiples, growth-restriction, and lack of antenatal steroids
- Most common morbidities:
  - Bronchopulmonary dysplasia, late-onset sepsis, retinopathy of prematurity
<table>
<thead>
<tr>
<th>Study</th>
<th>Region/country</th>
<th>Study years</th>
<th>Survival [n/N (percent)] by gestational age (week)</th>
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<tbody>
<tr>
<td>---</td>
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<tr>
<td>EPICure*</td>
<td>UK; Ireland</td>
<td>1995</td>
<td>2/22 (0.22%)&lt;br&gt;26/131 (20%)&lt;br&gt;100/296 (34%)&lt;br&gt;186/357 (52%)&lt;br&gt;314/611 (51%)</td>
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<tr>
<td>Epiage*[2]</td>
<td>9 regions in France</td>
<td>1997</td>
<td>0/16 (0%)&lt;br&gt;0/30 (0%)&lt;br&gt;13/42 (31%)&lt;br&gt;36/119 (30%)&lt;br&gt;72/207 (35%)</td>
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<tr>
<td>Epiage*[3]</td>
<td>26 regions in France</td>
<td>2011</td>
<td>0/58 (0%)&lt;br&gt;0/1/9 (1%)&lt;br&gt;18/196 (31%)&lt;br&gt;102/300 (34%)&lt;br&gt;241/641 (38%)</td>
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<td>Epibel*[4]</td>
<td>19 perinatal centers in Belgium</td>
<td>1999 to 2000</td>
<td>0/2 (0%)&lt;br&gt;1/18 (6%)&lt;br&gt;19/9 (29%)&lt;br&gt;50/60 (83%)&lt;br&gt;175/322 (54%)</td>
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<tr>
<td>Field*[5,6]</td>
<td>Trent, UK</td>
<td>1994 to 1999</td>
<td>0/15 (0%)&lt;br&gt;15/16 (9%)&lt;br&gt;1/16 (6%)&lt;br&gt;10/16 (62%)&lt;br&gt;174/490 (36%)</td>
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<td>Field*[7]</td>
<td>23 NNH sites, USA</td>
<td>2000 to 2003</td>
<td>0/9 (0%)&lt;br&gt;12/16 (75%)&lt;br&gt;2/16 (12%)&lt;br&gt;142/229 (62%)&lt;br&gt;236/497 (47%)</td>
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<tr>
<td>Field*[8]</td>
<td>20 NNH sites, USA</td>
<td>2006 to 2010</td>
<td>0/1 (0%)&lt;br&gt;16/16 (100%)&lt;br&gt;16/16 (100%)&lt;br&gt;137/204 (67%)&lt;br&gt;215/436 (50%)</td>
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<td>Carlo*[6]</td>
<td>ANS 32/118 (27%)&lt;br&gt;No ANS 50/283 (18%)&lt;br&gt;ANS 405/1147 (42%)&lt;br&gt;No ANS 396/814 (49%)&lt;br&gt;ANS 1798/2975 (57%)&lt;br&gt;No ANS 528/804 (66%)&lt;br&gt;ANS 2721/3555 (77%)&lt;br&gt;No ANS 1202/2732 (44%)</td>
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<td>Markstad*[6]</td>
<td>Norway</td>
<td>1999 to 2000</td>
<td>0/2 (0%)&lt;br&gt;9/23 (39%)&lt;br&gt;35/38 (92%)&lt;br&gt;55/99 (56%)&lt;br&gt;90/152 (59%)</td>
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<td>Tyson*[7]</td>
<td>19 NNH sites, USA</td>
<td>1998 to 2003</td>
<td>0/2 (0%)&lt;br&gt;1/23 (50%)&lt;br&gt;1/23 (50%)&lt;br&gt;1/23 (50%)&lt;br&gt;1/23 (50%)</td>
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<td>Ishii*[10]</td>
<td>20 NNH sites, Japan</td>
<td>2003 to 2005</td>
<td>28/75 (37%)&lt;br&gt;158/245 (64%)&lt;br&gt;238/322 (74%)&lt;br&gt;348/503 (69%)&lt;br&gt;791/1057 (75%)</td>
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<td>Hoshii*[11]</td>
<td>Japan</td>
<td>2005</td>
<td>33/97 (34%)&lt;br&gt;153/282 (54%)&lt;br&gt;324/423 (77%)&lt;br&gt;428/501 (85%)&lt;br&gt;938/1303 (72%)</td>
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<tr>
<td>EXPRESS*</td>
<td>Sweden</td>
<td>2004 to 2007</td>
<td>5/51 (10%)&lt;br&gt;33/101 (33%)&lt;br&gt;96/141 (68%)&lt;br&gt;167/205 (81%)&lt;br&gt;321/501 (64%)</td>
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<td>Stoll*[12]</td>
<td>20 NNH sites, USA</td>
<td>2003 to 2007</td>
<td>25/421 (6%)&lt;br&gt;226/871 (26%)&lt;br&gt;754/1370 (55%)&lt;br&gt;1079/1498 (72%)&lt;br&gt;2084/4160 (50%)</td>
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<td>Stoll*[13]</td>
<td>26 NNH sites, USA</td>
<td>2012</td>
<td>7/75 (9%)&lt;br&gt;50/150 (33%)&lt;br&gt;174/269 (65%)&lt;br&gt;249/308 (81%)&lt;br&gt;480/602 (80%)</td>
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<td>Andersson*[5]</td>
<td>State of California</td>
<td>2007 to 2011</td>
<td>25/450 (6%)&lt;br&gt;162/602 (27%)&lt;br&gt;458/786 (60%)&lt;br&gt;621/796 (78%)&lt;br&gt;1270/2614 (49%)</td>
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Case 3: Very Low Birth Weight Infant

How would you plan for the initial care of this extremely preterm infant, in the delivery room and over the first few hours of life?**

- Delivery room:
  - full NICU team in DR, attention to team work and communication
  - thermal support: warm room, preheat radiant warmer, warm blankets, chemical mattress, plastic wrap, pre-warmed transport incubator
  - non-invasive respiratory support if possible, T-piece resuscitator, O₂ targeting
  - use oximeter, consider cardiac ECG monitor
  - family presence and engagement
  - side note: Apgar scores have less validity in preterm infant: preterm infants often need resuscitation, tone and reflexes less developed
Case 3: Very Low Birth Weight Infant

How would you plan for the initial care of this extremely preterm infant, in the delivery room and over the first few hours of life?**

- NICU:
  - early surfactant if intubation needed, monitor tidal volumes, gases
  - umbilical lines
  - maintain normal blood pressure, minimize wide fluctuations
  - early initiation of IVF and starter PN, monitor glucose
  - early administration of antibiotics (if warranted)
  - rapid transition from warmer to incubator
  - plan for monitoring electrolytes, bilirubin
Case 3: Very Low Birth Weight Infant - Fluids

You are working on orders for fluids and nutrition. What are the fluid requirements of a preterm infant as compared to a term infant? What factors impact fluid requirements in preterm infants?**

- Fluid requirement: renal urine production + insensible losses
- Insensible losses: skin (1/2 to 2/3) and respiratory (1/3 to 1/2)
  - Insensible losses increase dramatically with lower gestational age
  - Skin evaporative losses can be extreme: up to 200 mL/kg/day at 24 weeks versus 20 L/kg/day at term
  - Radiant warmers increase evaporative fluid loss, up to 50%
  - Humidity (in incubator, and in respiratory support) reduces insensible loss
You are working on orders for fluids and nutrition. What are the fluid requirements of a preterm infant as compared to a term infant? What factors impact fluid requirements in preterm infants?

- Initial fluid requirements, in moderate humidity thermal neutral environment:
  - ELBW infants: 100 mL/kg/day
  - VLBW infants: 80 mL/kg/day
  - Term infants: 60 mL/kg/day
- No sodium or potassium usually needed in first day
- Early PN (particularly protein) critical in ELBW infants
- Fluid requirements for term and preterm infants gradually increase to approximately 150 mL/kg/day over first 3-5 days of life
Case 3: Very Low Birth Weight Infant - BPD

You discuss with the family that respiratory support will be the most active issue for him over the next few days. What are the risk factors for bronchopulmonary dysplasia (BPD), and how is it managed?**

- **BPD:** chronic lung disease, O₂ for at least 28 days, O₂ at 36 weeks
  - Physiologic definition? Positive pressure without oxygen?
- **Risk factors:**
  - Prematurity
  - Mechanical ventilation: volutrauma, biotrauma, atelectatrua, O₂ toxicity
  - Infection: postnatal, chorioamnionitis
  - ? Genetics
  - ? Patent ductus arteriosus
You discuss with the family that respiratory support will be the most active issue for him over the next few days. What are the risk factors for bronchopulmonary dysplasia (BPD), and how is it managed?

- **BPD management:**
  - Ventilation: low volume, high rate; long I-time; avoid atelectasis; O₂ targeting
  - Nutrition and growth
  - Monitor/avoid complications (infection, pulmonary hypertension)

- **Controversies/limited data:**
  - Appropriate role for steroid therapy
  - Fluid restriction, diuretics
  - Bronchodilators
Case 3: Very Low Birth Weight Infant

On day of life 2, the infant has an acute worsening, with hypotension, worsening respiratory status, and increased oxygen need. What is your differential diagnosis for this change in status?

Most likely etiologies for acute worsening in 2 day old very preterm infant:

- Pneumothorax
- Patent ductus arteriosus
- Sepsis
- Intraventricular hemorrhage
- Necrotizing enterocolitis
Case 3: Very Low Birth Weight Infant - IVH

Head ultrasound reveals bilateral intraventricular hemorrhage (IVH). Describe the different types of IVH in preterm infants, and the clinical presentation of IVH.**

Grading system:
- Grade I: hemorrhage only in germinal matrix (GMH)
- Grade II: IVH without ventricular dilation, < 50% of lateral ventricular volume
- Grade III: IVH with ventricular dilation, > 50% of lateral ventricular volume
- Grade IV: IVH with periventricular white matter hemorrhagic infarction

Clinical presentation:
- Ranges from silent (routine screening HUS) to gradual evolution over hours to days (decreased activity, tone) to acute decompensation over minutes to hours
- Virtually all IVH in preterm infants occurs in first 5 days of life, most in first 2
Case 3: Very Low Birth Weight Infant - IVH

What are management strategies to minimize risk of IVH? How would you manage IVH once it occurs?**

Decreasing risk of IVH:
- Maternal transport rather than neonatal (risk lower inborn vs. outborn)
- Antenatal corticosteroids pre-delivery, delayed cord clamping at delivery
- Avoid blood pressure swings, severe extremes of pCO₂ and pO₂
- Limit metabolic abnormalities, limit bicarbonate therapy
- Correct coagulation abnormalities, Treat PDA, Midline positioning

Management of IVH:
- Maintain hemodynamic, respiratory, hematologic, and metabolic stability
- Monitor for development of post-hemorrhagic hydrocephalus
Case 3: Very Low Birth Weight Infant - NEC

The infant is now 4 weeks old and is on CPAP and full enteral feedings. He develops abdominal distension and emesis. What are the clinical and laboratory features associated with necrotizing enterocolitis (NEC)?

- Typically develops in preterm infants who are on full enteral feeds
- Onset is inversely related to GA (later in the younger infants)
- Systemic signs: apnea, respiratory failure, lethargy, hypotension, hypothermia
- Abdominal signs: distension, residuals, emesis, bilious aspirates, abdominal tenderness, bloody stools
- Lab: neutropenia, thrombocytopenia, hyponatremia, hyperglycemia, acidosis
- Imaging: pneumatosis (air in bowel wall, hallmark of NEC), dilated or thickened loops, fixed loops, portal venous gas, pneumoperitoneum (two views can help)
Case 3: Very Low Birth Weight Infant - NEC

How is NEC managed? What are indications for surgery?**

- Medical management:
  - Bowel rest, gastric decompression, PN
  - Broad-spectrum antibiotics (amp/gent/clinda, amp/gent/flagyl, zosyn)
  - Support respiratory and hemodynamic status, fluid resuscitation
  - Correct metabolic and hematologic abnormalities

- Surgery:
  - Early surgical consultation
  - Surgery if intestinal perforation or unremitting clinical deterioration
  - ? Drain versus laparotomy - variable
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</table>
You are admitting an infant with neonatal depression. She was born at 39 weeks by urgent cesarean section for a non-reassuring fetal heart rate tracing. She required aggressive resuscitation in the delivery room including PPV, chest compressions, and epinephrine. Apgar scores were 1, 2, and 4.

*In addition to supportive care, what therapy would you consider for this infant?*
Case 4: Neonatal Depression - Hypothermia

*What is therapeutic hypothermia? What are indications for it? (newish)*

Therapeutic hypothermia (TH):
- Cool to 33.5°C, start within 6 hours of life, maintain for 72 hours
- Only neuroprotective strategy for neonatal hypoxic-ischemic encephalopathy
- Limits secondary phase of injury from reperfusion
- Eligibility criteria from trials (some variation):
  - GA > 35-36 weeks
  - Perinatal history or event concerning for hypoxic-ischemic injury
  - pH < 7.0, base deficit > 16, or Apgar score less than 5 at 10 minutes
  - Moderate to severe encephalopathy by exam or aEEG, or seizures

- Significant variation in use of TH – used much more widely in some centers
Case 4: Neonatal Depression - Asphyxia

What other systems can be affected by intrapartum asphyxia?**

- Cardiac: hypotension (myocardial ischemia), persistent pulmonary hypertension
- Respiratory: pulmonary edema, ARDS, MAS, PPHN
- Metabolic: hypoglycemia, hypocalcemia
- Renal: renal dysfunction, renal failure
- Hematologic: DIC, coagulopathy, thrombocytopenia
- GI: hepatic injury, feeding intolerance, NEC

All systems (other than neuro) tend to recover fully.
Big ones most often impacting management: cardiac, renal, liver
At 12 hours of age, the infant is noted to have repetitive focal clonic movements. **What is the differential diagnosis of neonatal seizures?**

- Non-seizure paroxysmal events: jitteriness, clonus, episodic chewing, sucking, or repetitive tongue thrusting, pedaling
- Normal newborn movements: benign sleep myoclonus, pronounced Moro, stretching/yawning
**Case 4: Neonatal Depression - Seizures**

*EEG confirmed seizure activity. Phenobarbital was begun. Other than hypoxic ischemic encephalopathy, what are other causes of neonatal seizures?*

- Ischemic stroke (arterial or venous)
- Intracranial hemorrhage
- CNS infection (meningitis, encephalitis, intrauterine infection)
- Electrolyte disorders (hypoglycemia, hypocalcemia, hypomagnesemia, hypernatremia, hyponatremia)
- Metabolic disorders (hyperammonemia, many others)
- Neonatal seizure syndromes
- Cerebral malformation or developmental defects
- Drug withdrawal
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Case 5: Intestinal Obstruction

You are on-call for general pediatrics, and the newborn nursery calls you. A two old term infant who has been exclusively breast-feeding has had several episodes of emesis that appear green in color. On exam, the abdomen feels distended.
Case 5: Intestinal Obstruction

What is your differential diagnosis for intestinal obstruction in a neonate?**

From proximal to distal (kind of):

- Pyloric stenosis – typically at 3-6 weeks, frequent non-bilious projectile emesis
- Duodenal atresia – distension, vomiting (bilious or non-bilious), can pass meconium
- Malrotation with volvulus – bilious emesis, +/- abdominal distension
- Jejunal atresia, ileal atresia – distension, bilious emesis, little meconium, can be associated with meconium ileus and cystic fibrosis
- Colonic atresia – distension, failure to pass meconium, emesis a bit later
- Small left colon syndrome – distal obstruction, associated with maternal DM
- Hirschsprung disease – failure to pass stool, abdominal distension, +/- emesis
- Meconium plug – failure to pass stool, abdominal distension, +/- emesis
How would you begin your evaluation??

Plain KUB is extremely helpful:

- Very proximal obstruction: paucity of intestinal gas, i.e., double bubble for duodenal atresia
- Proximal obstruction: few dilated loops
- Distal obstruction: multiple dilated loops

Next steps depend on KUB, exam, acuity of infant:

- Likely proximal obstruction → upper GI contrast study
- Distal obstruction → likely contrast enema
Case 5: Intestinal Obstruction

As you remember: bilious emesis in a newborn is an emergency, and requires rapid evaluation and almost certainly an upper GI study.
Changes in Practice

Changes you may wish to make in practice:

- Incorporate oximetry and cardiac monitoring into the DR
- Appropriately evaluate infants with respiratory distress
- Ensure attention to thermoregulatory support for VLBW infants
- Appropriate evaluate newborns with neonatal depression for therapeutic hypothermia
- Appropriately respond to newborns with bilious emesis
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](http://www.neoreviews.org)
- [www.uptodate.com](http://www.uptodate.com)