A Standardized Feeding Regimen and an Exclusively Human Milk-Based Diet Reduce Necrotizing Enterocolitis in VLBW Infants
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Aim:
For two sequential years (2009-2010), our rates of necrotizing enterocolitis (NEC) in very low birth weight (VLBW) infants climbed to 12-13%. This was significantly above our baseline rate of 5-6% and above the third quartile for VON NICU Type C. The goal of this quality improvement initiative was to reduce the rate of NEC back to our baseline rate of 5-6%, which approximates the VON mean.

Setting:
The neonatal intensive care unit (NICU) at Mayo Clinic is a 26 bed, level IV regional NICU with ~350 admissions annually. Pre-intervention, enteral feed volume and rate of advancement were at the discretion of the neonatologist and care team. VLBW infants were fed mother’s breast milk fortified with a bovine-based human milk fortifier or a preterm infant formula. Donor human milk was used sporadically.

Mechanisms:
In November of 2011, a multidisciplinary quality improvement team that included key stakeholders was assembled to review the literature and recommend potentially better practices for the reduction of NEC to our division-level Quality and Safety committee and Multidisciplinary Neonatal Practice committee. The DMAIC format for quality improvement was utilized.

Methods:
The QI initiative focused on two primary areas of improvement:
1. Creating a standardized feeding regimen (SFR). The SFR included three distinct birth weight categories. It recommended trophic feeds for a specified duration and prescribed the rate of feeding advancement and the timing of fortification, Figure 1. The SFR was built into the computerized, physician order entry system. A flowchart was also drafted to guide management of gastric residuals, Figure 2.

2. Offering an exclusively human milk-based diet (EHM). After parental consent was obtained, infants with birthweight ≤1250 grams were fed an exclusively human milk-based diet of mother’s own breast milk and/or donor human milk and a human milk-based human milk fortifier.

Measures:
Our primary outcome was the rate of necrotizing enterocolitis. Our secondary outcomes included: day of first enteral feed, number of days to reach goal enteral feeds, and episodes of feeding intolerance. Our counterbalance measures were largely focused on growth and included the number of days to reach birth weight and the calculated growth velocity (birth to 2 kg).

Data/Results:
The SFR and EHM diet were implemented in December of 2012. In 2013, our rate of NEC was 3.5%, the lowest in 5 years, Figure 3. Year to date for 2014, our NEC rate continues to be near the VON mean at 6.3%. Post-intervention, the time to first enteral feed and episodes of feeding intolerance were also improved, Figures 4 and 5. The number of days needed to reach goal enteral feeds was essentially unchanged. While the number of days needed to reach birth weight was not significantly different, we did observe slower growth velocity post-intervention, Figure 6.

Discussion:
Implementation of a standardized feeding regimen and an exclusively human milk-based diet reduced the incidence of NEC in our unit. We also saw improvement in feeding tolerance. However, postnatal growth should be monitored closely as infants may be at risk for extrauterine growth restriction.
Figure 1. Standardized feeding regimen for infants with birth weight ≤1250 grams.

### Feeding Advancement Schedule for Neonates with Birthweight ≤1250 grams

<table>
<thead>
<tr>
<th>Feeding Day</th>
<th>BW ≤750 grams</th>
<th>751-1000 grams</th>
<th>1001-1250 grams</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feeding</td>
<td>mL/kg/day</td>
<td>Check residuals?</td>
</tr>
<tr>
<td>1</td>
<td>Human milk (HM)</td>
<td>10</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>HM</td>
<td>10</td>
<td>N</td>
</tr>
<tr>
<td>3</td>
<td>HM</td>
<td>10</td>
<td>N</td>
</tr>
<tr>
<td>4</td>
<td>HM</td>
<td>10</td>
<td>N</td>
</tr>
<tr>
<td>5</td>
<td>HM</td>
<td>10</td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>HM</td>
<td>20</td>
<td>Y</td>
</tr>
<tr>
<td>7</td>
<td>HM</td>
<td>40</td>
<td>Y</td>
</tr>
<tr>
<td>8</td>
<td>HM</td>
<td>60</td>
<td>Y</td>
</tr>
<tr>
<td>9</td>
<td>HM</td>
<td>80</td>
<td>Y</td>
</tr>
<tr>
<td>10</td>
<td>HM/Prolact+4</td>
<td>100</td>
<td>Y</td>
</tr>
<tr>
<td>11</td>
<td>HM/Prolact+4</td>
<td>100</td>
<td>Y</td>
</tr>
<tr>
<td>12</td>
<td>HM/Prolact+4</td>
<td>120*</td>
<td>Y</td>
</tr>
<tr>
<td>13</td>
<td>HM/Prolact+4</td>
<td>140</td>
<td>Y</td>
</tr>
<tr>
<td>14</td>
<td>HM/Prolact+4</td>
<td>150 (goal)</td>
<td>Y**</td>
</tr>
</tbody>
</table>

*Discontinue parenteral nutrition or IVF when enteral feeds have reached at least 120 mL/kg/day.

**Once baby has been on goal volume feeds for 24 hours and stable, no longer need to check residuals routinely.

Important points:
- Goal is to start trophic feeds by 48-72 hours of life. Recommend patient to NPO for 48-72 hours if significant CPR, asphyxia, hemodynamic instability, IUGR, total body cooling, etc.
- Feeding should be given over 20-30 minutes via gastric tube every 2 hours.
- Use birthweight for calculations until baby returns to birthweight at which time daily weight should be used.
- Feeding volume can be rounded to the nearest 0.5 mL for feeds ≤2.5 mLs or to the nearest 1 mL for feeds ≥2.5 mLs.
- When infant reaches 1500 grams, advance bolus feeds to every 3 hours.
- When infant reaches both 1500 grams and at least 34-37 weeks CGA, transition to either maternal breastmilk with bovine-based HMF or Similac Special Care over five days (see order set).
- See accompanying “Assessment and Management of Feeding Intolerance During Feeding Advancement” for guidance regarding residuals.

Figure 2. Algorithm for the management of gastric residuals.

**This is feeding intolerance.**
1. Stop feeding and notify provider for clinical evaluation.
2. Resume feeds based on provider evaluation and decision.
   - If no concerns are present, the recommendation is to refeed the residual only and do not give additional volume.
   - Recheck residuals at the next scheduled feeding time.
   - Resume feeding advancement when conditions no longer meet criteria for feeding intolerance.

**Signs and Symptoms Concerning for NEC**
- Dark bile or blood-stained gastric residual (light green or yellow gastric output is normal and not a concern)
- Emesis > 50% of previous feeding volume
- Abdominal distension, discoloration or tenderness
- Bloody stool
- Abdominal x-ray indicating signs of distended loops of bowel
- Other signs that baby is not well (including but not limited to: new or worsening apnea, increased respiratory distress, lethargy, poor perfusion, temperature instability, etc.)

Infant has a gastric residual. **Are there other signs or symptoms concerning for NEC?**

- Yes
- No

Is the residual volume >50% of the previous feed volume?

- Yes
- No

**This is NOT feeding intolerance.**
1. Re-feed the residual as a part of the total volume of the next feeding and continue feeding advancement per orders.
2. Consider these interventions to improve residual volume:
   a. Check feeding tube placement.
   b. Position baby prone or right side down.
   c. Consider glycerin suppository if no stool in the past 18-24 hours.
   d. If recurrent episodes occur after a recent feeding advancement or fortification, consider returning to previously tolerated volume or concentration.
Figure 3. Primary outcome: Rate of NEC for inborn VLBWs at our center compared to VON NICU Type C.

Figure 4. Secondary outcome: Median day of first enteral feed.
**Figure 5.** Secondary outcome: Mean number of episodes of feeding intolerance.

*Episodes of Feeding Intolerance*  

- **≤25 6/7 weeks**: 0.8, 0.7, 0.7  
- **26 0/7 to 27 6/7 weeks**: 0.9, 0.5, 0.3  
- **≥28 0/7 weeks**: 0.1, 0.7, 0.1  
- **All infants**: 0.6, 0.6, 0.4

*Defined as times when feedings were stopped due to feeding issues with subsequent sepsis evaluation and determined not to be NEC.*

**Figure 6.** Counterbalance measure: Mean calculated growth velocity.

*Mean Growth Velocity*  

- **≤25 6/7 weeks**: 14.3, 11.6, 13.3  
- **26 0/7 to 27 6/7 weeks**: 14.9, 11.8, 13.8  
- **≥28 0/7 weeks**: 16.5, 12.1, 15.8  
- **All infants**: 15.1, 14.8, 11.8  

*2011, n=43  
2012, n=49  
2013, n=30*