TIPQC

Quality Improvement Tool Kit: Improving Neonatal Nutrition

Adapted for TIPQC from the Illinois Perinatal Quality Collaborative (IL-PQC), with permission.

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BACKGROUND

Growth failure is well documented in the preterm infant. As many as 50% of all Very Low Birth Weight (VLBW) infants will have growth failure, defined as a discharge weight of less than the 10^{th} percentile for postmenstrual age, and as many as 36% may have severe growth failure, defined as a discharge weight of less than the 3^{rd} percentile for postmenstrual age (Horbar, et al 2015). Growth restriction tends to be worse with decreasing gestation age at birth. Neonatology has long recognized that this growth restriction can have neurodevelopmental and growth consequences long term (Horbar, et al 2015 and Vinall, et al 2013).

Multiple potentially better practices including early and aggressive parenteral nutrition, the use of human milk, and trophic feeding have been demonstrated to improve infant growth (Lunde, 2014).

There is also evidence to suggest that quality improvement techniques can be used to decrease variability in practice and improve nutritional outcomes (Grazianom et al 2015 and Lunde, 2014).

Preliminary Data From Tennessee and Evidence of a Performance Gap

The Vermont Oxford Network runs a data base that many of the NICUs in Tennessee use for benchmarking outcomes. In 2014, Tennessee NICUs that reported to the VON database, had more infants than the mean with head circumferences < 3% and less than 10% when compared to other hospitals in the database at discharge.

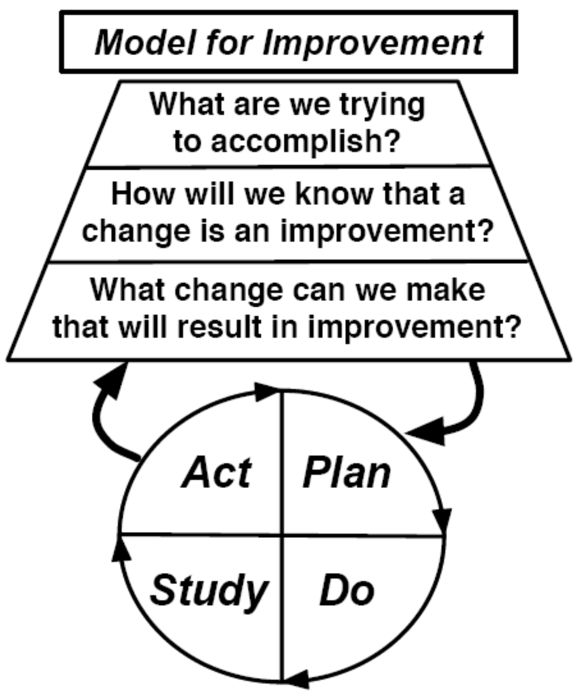
OVERVIEW

This Quality Improvement Tool Kit is based on a set of clinical practices that have the potential to improve the outcomes of neonatal care, known as **Potentially Better Practices (PBP's).**

They are labeled 'potentially better' rather than 'better' or 'best' because until the practices are evaluated, customized, and tested in your own NICU, you will not know whether are truly 'better' or 'best' (or 'worse'). Depending on the circumstances in your unit, you may have to implement other practices or modify existing ones to successfully improve neonatal outcomes.

The PBP's in this collection are not necessarily the only ones required to achieve the improved outcomes targeted. Thus, this list of PBP's is not exhaustive, exclusive, or all-inclusive. Changes in practice, guided by these PBPs, will require testing and adaptation to your circumstances and context to achieve measured improvements in outcomes

As you test and implement these PBP's you should monitor the results closely to ensure that you are obtaining the desired results, that no harm is being done, and that no unanticipated results are seen. In addition to the suggested measures, you should track balancing measures.



Your team can implement as many of the PBP's in this Tool Kit as you wish, based on an assessment of your unit's priorities, and based on availability of resources, time, and individuals with quality improvement skills.

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PBP #1: Consistent, comprehensive, multidisciplinary monitoring of nutritional status, outcomes and practice is an integral component of improving nutrition outcomes in the neonatal population.

Rationale: Nutritional management of the VLBW is marked by a lack of uniformity. This heterogeneity of practice applies to every aspect of nutritional management and persists from the first few hours of life all the way to the time of hospital discharge and beyond. Although the diversity of practice is greatest between nurseries, for instance see reports from Boston, (Olson 2002) and North Carolina (Porcelli 2004), it often exists between individual neonatologists within the same institution (Ziegler 2002). "Diversity of practice thrives where there is uncertainty" (Ziegler 2002). Although there is general agreement regarding the concept that nutrition should support" postnatal growth that approximates the in-utero growth of a normal fetus" (AAP 1985, AAP Committee on Nutrition 1998), and estimates of amounts of nutrients needed to achieve that model of growth, there is far less agreement, and much more uncertainty, about the details of how to provide those nutrients.

We urge a decrease in practice diversity for three reasons, not withstanding the current state of uncertainty surrounding so many current practices. First, consistent practice makes for perfectible practice. This notion is at the heart of the randomized control trial (RCT) technique, an exercise in which trialists attempt to control as many practice process variables as possible. Indeed there is even evidence that control groups do better than those not enrolled in RCTs (Schmidt 1999, Braunholtz 2001). Second, more intense process control, such as experienced by patients being treated with "algorithms" or "guidelines," is consistently associated with significant improvements in adherence to care guidelines and often with better disease control (Ofman 2004). Third, the quality improvement (QI) literature demonstrates the effectiveness of continuing cycles of planning a process, implementing it consistently, studying its use and effectiveness and then acting on ones' conclusions (Horbar 2003). The efficacy of the QI approach is illustrated by reports on improving neonatal nutritional practices in particular (Kuzma-OReilly 2003, Bloom 2003) and practices in general (Galvin 2003). The "measure to improve" paradigm is buttressed by both data and theory and leads to pragmatic steps that improve performance (Galvin 2003)

Implementation Strategies:

- Infant weight should be monitored at least daily while on parenteral nutrition or advancing enteral feedings. After full enteral feedings have been established and the infant is otherwise stable, weight can be monitored less frequently, but plotted at least weekly, and plotted against standard preterm growth curves (Anderson 2002, Kuzma-O'Reilly 2003, Schanler, 2003). Standard growth curves are Ehrenkranz, and the website version of it (http://neonatal.rti.org/) (Ehrenkranz 1999, Pauls 1998, Wright 1993)
  Infant length and head circumference should be measured weekly (Anderson 2002, Kuzma-O'Reilly 2003, Schanler 2003, Ehrenkranz 1999)
  Infant biochemical parameters should be monitored frequently in infants on parenteral nutrition. Expert opinion suggests that once full enteral feeding is

achieved, biochemical monitoring should be done weekly for 2 weeks, then every other week. TIPQC project will use the Fenton Growth Chart and Z scores will be calculated using Fenton values. This will allow us to calculate delta z scores and monitor for decreasing delta Z over time. The Z score calculator can be found at http://www.peditools.org/ .

- Mothers' milk production should be monitored. Mothers should be assisted in maintaining a full milk supply, even though the infant may be consuming only a small amount of the milk produced. Adequacy of milk supply is a key factor in transitioning to breastfeeding. RN and LC to check with mom periodically and assist her to keep a breastmilk log (Furman 2002, Wooldridge 2003, Meier 2003).

- Every NICU that cares for VLBW infants should have a Neonatal Nutritionist as part of the team to monitor infant growth and outcomes, calculate and relate parenteral nutrition and enteral intakes to current growth and medical conditions, suggest improvements in nutritional management, manage the formulary of premature infant feedings and supplements, and make nutritional plans with goals and resource referral information at discharge (Kuzma-O'Reilly 2003, Valentine1993, Elsaesser 1988, Rubin 1997, Anderson 2002, Olsen 2004).

Barriers:

- Large current variation in practice
- Cost associated with registered dietician and lactation consultation
- Systems to support daily calculation and trending

Measurement:

- Growth charts on every VLBW infant chart
- Documented assessments by registered dieticians
- Health care provider variation
- Use of established monitoring protocols with nutritional goals
- Consistent appraisal of mother's milk supply (pumping log, discussion on rounds)
- Rate of conversion of AGA infants at birth to SGA infants at discharge (i.e. B Wt/EGA vs Discharge Wt/CGA)

II. PARENTERAL NUTRITION

OVERVIEW

The development of sophisticated techniques for providing short- and long-term parenteral nutrition to critically ill infants has been one of the major advances in neonatology of the last several decades. However, there is still a wide variation in practice between nurseries, and even within nurseries, in how and when parenteral nutrition is started in VLBW infants. This document will review the current literature on initiation of parenteral nutrition in VLBW infants, recommend evidence-based best practices in this area, and discuss some of the barriers (as well as ways to overcome them) to implementing these best practices. There are several recent excellent reviews of neonatal nutrition, including information on early parenteral nutrition (Perreira 1995, Hay 1999, Thureen 2000, Thureen 2001, Pinchasik 2001, Ziegler 2002, Yeung 2003, ASPEN 2002). In addition, the latest version of Polin and Fox's Fetal and Neonatal Physiology contains several very detailed chapters on protein requirements for the fetus and preterm newborn (Matthews 2004, Hay 2004, Heird 2004).

At birth, a VLBW infant is abruptly disconnected from the ideal source of parenteral nutrition - the placenta. If the goal of post-natal nutrition in the VLBW infant is to mimic in utero nutrition, as recommended by the AAP, then the VLBW infant should be immediately placed on balanced parenteral nutrition, including sugar, protein, lipids, trace elements, and vitamins. It is clear that current parenteral nutrition does not entirely mimic in utero nutrition and is not without some undesired side effects. It is also clear that the preterm infant is in many ways a fundamentally different organism than an infant of the same gestation who is still in utero. Thus, decisions about how and when to implement parenteral nutrition in the VLBW infant are really best estimates, based on incomplete information and utilizing a still-evolving technology. Despite these limitations, there is no reason to believe there are advantages to under-nourishing the VLBW infant.

Parenteral nutrition previously was delayed for several days; however, by the late 1980s it was clear that earlier institution of parenteral nutrition was associated with improved growth and outcome (Georgieff 1989). Since the late 1980s, there has been a gradual shift in most US nurseries toward beginning total parenteral nutrition within the first day or two.

There is considerable evidence that nutritional status early in gestation and in post-natal life effect health status throughout life. The fact that infants who are small at birth appear to be more at risk for subsequent diabetes and cardiovascular disease suggests that the fetal adaptation to limited nutrition has long term end-organ consequences (Barker 1993). Presumably, post-natal under-nutrition (or over-nutrition) could cause similar significant long-lasting effects.

PBP #1: Begin amino acids as part of balanced parenteral nutrition, within the first 24 hours of life. The amount of amino acids administered can be as high as 3.5 g/kg/d on the first day of life. Adequate non-protein calories (80-100 kcal/kg/d) and amino acids (3.0-4.0 g/kg/d) should be administered as soon as possible, preferably no later than 5-7 days of age.

Rationale: Despite what most clinicians consider "aggressive" nutritional support, postnatal growth of VLBW infants is usually significantly less than in-utero growth rates.

While 60-80 kcal/kg/d is probably adequate to support the basal metabolic needs of the VLBW infant, a minimum of 90 non-protein kcal/kg/d is a more realistic estimate of what is required to achieve growth (Dusick 2003). Similarly, approximately 3.0-4.0 g/kg/d of protein is required to achieve adequate growth in the VLBW infant. Other reviewers have concluded that even higher caloric intake (125-130 kcal/kg/d and 3.5-4 g/kg/d of protein) is required to achieve normal growth (Denne 2001).

In a recent review of the growth pattern of all surviving infants with birth weight less than 1300 g, Carlson showed that despite an average of 75 kcal/kg/d and 1.9 g/kg/d protein in the first two weeks of life, with subsequent increases in both total calories and protein, growth was less than the in utero rate (Carlson 1998). In a similar study from th
e UK, 105 infants less than 1750 g at birth developed a significant calorie and protein deficit, despite aggressive attempts to meet recommended nutritional intake (Embleton 2001). It appears that most VLBW infants in ICNs are not achieving desired growth (Olsen 2002). Unfortunately, for many VLBW infants the initial calorie and protein deficit is never entirely corrected, and infants remain below their ideal growth curves long after hospital discharge (Ernst 2003). Data from the NICHD Neonatal Research Network suggests that by 36 weeks corrected age, nearly 90% of VLBW infants have growth failure, and that this growth failure persists into early childhood in a significant proportion of these infants (Dusick 2003).

Berry analyzed the course of 109 AGA infants who weighed less than 1000 g at birth to determine the factors that influenced their growth. Not surprisingly, better caloric and protein intake early in their course were associated with better growth (Berry 1997). Pauls recently published growth curves for infants born at less than 1000 g who were started on combined enteral and parenteral nutrition on day one, and rapidly advanced to 92 kcal/kg/d within the first week of life, and suggested that these are more appropriate growth curves to use for VLBW infants than the older published growth curves (Pauls 1998). Increasing the early nutritional status of infants can improve their growth curves without any adverse effects on their clinical course (Wilson 1997).

It is clear that early and “aggressive” use of parenteral nutrition containing amino acids is well tolerated and improves growth. Fifteen years ago, Saini showed that sick infants who were started on parenteral amino acids in the first day of life had better protein intake, energy intake, and nitrogen retention than infants who were not started on amino acids until 72 hours of age (Saini 1989). In a recent study, Thureen randomized 28 infants with a mean birth weight 946 g to either 1 or 3 g/kg/d of amino acids, starting at approximately 48 hrs of age. She was able to show a difference in protein balance after only 12 hours of amino acid administration, with more protein synthesis occurring in the 3 g/kg/d group. There was no evidence of toxicity in the high amino acid group (Thureen 2003). Ibrahim recently published a randomized trial in which ventilator dependent preterm infants were randomized to begin early total parenteral nutrition, including 3.5 g/kg/d of amino acids and 3 g/kg/d of 20% Intralipid® within one hour of birth, vs later parenteral nutrition. Infants in the early parenteral nutrition group had better energy and nitrogen balance with no adverse clinical or laboratory effects (Ibrahim 2004). Looking at even higher amino acid doses, Porcelli randomized VLBW infants to receive a maximum of 3 vs 4 g/kg/d amino acids. The high amino acid group reached a mean of 3.3 g/kg/d by the end of week one, and a mean of 3.8 g/kg/d by the end of week two. They tolerated the high dose amino acids well, with no evidence of acidosis and only a minimal increase in BUN. The high dose amino acid group had better growth from week one (Porcelli 2002). Amino acid intake is not correlated with BUN concentration in the first days of life (Ridout 2005).

Ideally, the total non-protein calories and the amount of amino acid infused will be matched, so that the amino acids can be used for protein deposition, rather than as an energy source. The ideal ratio has been estimated as 24-32 non-protein calories per g of protein infused (Kerner 2003). However, there is evidence that the fetus can effectively utilize amino acids as an energy source, so there is probably little downside in administering maximum amino acid amounts, even to the infant who is receiving slightly sub-optimal calories (Ziegler 2002).

The concept of total nutritional deficit is a useful one which has not yet made its way into most US nurseries, but is a simple and powerful tool for evaluating how far behind nutritional goals an infant has fallen. To calculate nutritional debt for calories or protein, total the amount of calories or protein the infant has received, and subtract that from the amount of calories or protein the infant would have received under ideal circumstances. (Embleton 2001, Dusick 2003). However, the “gold standard” of adequate protein and calorie nutrition is appropriate growth, rather than arbitrary amounts of protein and/or calorie amounts delivered. A simple way to think of this is that VLBW infants, once growing, increase their body weight by 2% a day (Ziegler 2002).

Implementation Strategies:

- Standardized policies and admission order sets which include balanced parenteral nutrition as the “maintenance” fluid
- Availability of “pre-mixed” amino-acid (Beecroft 1999) containing parenteral nutrition solutions in hospital pharmacy

Barriers:

- Perception that early amino acid administration is of no benefit
- Perception that early amino acid administration is potentially toxic
- Perception that early amino acid administration is more expensive than glucose and electrolyte-containing fluids
- Lack of pharmacy resources
- Pharmacy policies regarding limited timeframe of ordering parenteral nutrition

Measurement:

- Measure provider consistency in implementation
- % of VLBW infants started on amino acids at admission
- % of VLBW infants on amino acids by 24 hours of age
- % of VLBW infants receiving 3-4 g/kg/d parenteral protein by 72 hours of age
- % of VLBW infants receiving 80-100 non-protein kcal/kg/d by 5 days of age

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PBP #2: Start Intralipid® at 0.5 –1.0 g/kg/day within the first 24 hours of life (adequate to avoid fatty acid deficiency) and advance over the first week. Achievement of optimal Intralipid® administration, 3.0 - 3.5 g/kg/day, may be limited by hyperglycemia and hypertriglyceridemia.

Rationale: The role of lipids in early nutrition is particularly complex, largely because of the complex interactions of lipids and disease states. However, there is fairly convincing evidence that early lipids are well tolerated, and that delaying the introduction of lipids has adverse consequences. Specifically, the Aspen study showed that administering .0.5 gms/kg/day Intralipid® is necessary to prevent essential fatty acid deficiency (ASPEN 2002, Lee 1993). Lipid administration should advance to 3.0 - 3.5 gm/kg/day (ASPEN 2002, Kerner 2003, Putet 2000, AAP 2004).

Lipids and brain development: Both arachadonic acid and docosahexaenoic acid are essential components of brain structure, and animal studies have shown that early essential fatty acid deficiency has long term adverse effects on brain development (Crawford 1993). The ability to synthesize arachadonic acid and docosahexaenoic acid from linoleic acid is decreased in preterm infants (Decsi 1994). Given the high rate of long-term CNS abnormalities in the smallest of preterm infants, one wonders about the advisability of delaying the introduction of lipids in these infants.

Lipids and glucose: Infants receiving lipids in addition to parenteral glucose, with or without amino acids, have higher serum glucose levels than infants who are not receiving lipids (Savich 1988). This suggests there may be advantages to delaying the introduction of lipids in infants where hyperglycemia is a significant problem. In contrast, there are data that suggest parenteral lipids play an important role in supporting neonatal gluconeogenesis (Sunehag 2003).

Lipids and bilirubin displacement: A recent Cochrane database review failed to find any relationship between early parenteral nutrition and jaundice (Farber 2003).

Lipids and free-radical issues: The lipids which make up Intralipid® can easily undergo peroxidation to form hydroperoxides, potentially damaging substances which might alter arachidonic acid metabolism and/or form free radicals (Helbock 1993). However, whether these hypdroperoxides are of any clinical consequence is unknown. In contrast, Tomsits' data suggests that VLBW infants who are not given lipids during the first week of life develop essential fatty acid deficiency, a condition which when combined with Vitamin E deficiency, leads to increased free radical formation (Tomsits 2000). Multivitamins given together with Intralipid® (3-in-1) prevent lipid peroxidation and vitamin loss in the infusate (Silvers 2001). Light exposure has been associated with the formation of malondialdehyde (MDA) in light exposed lipids (Picaud 2004), but there is insufficient evidence to recommend for or against light shielding for parenteral nutrition or lipid during preparation or delivery to the patient.

Lipids and Nosocomial Infection: Of particular concern for protracted use of parenteral nutrition are the data which link Intralipid® administration to a significantly increased risk of coagulase negative *Staphylococcus* sepsis (Freeman 1990, Avila-Figueroa 1998).

Lipids and Chronic Lung Disease(CLD): Although there is some concern that early administration of lipids might increase the risk of CLD, clinical trials have not supported this. In a trial, which randomized 129 infants who weighed less than 1750 g to early vs late parenteral nutrition with lipids, there was no difference in the incidence of BPD (Brownlee 1993). Another small trial randomized VLBW infants to initiation of Intralipid® at 5 vs 14 days of age and failed to show any difference in the risk of CLD (Alwaidh 1996).
The most concerning data about the potential adverse side effects of early lipids comes from a study designed to determine whether early administration of Intralipid® decreased the incidence of CLD. In this study, 133 infants weighing between 600 and 1000 g at birth were randomized to receive lipids starting within the first 12 hours of life vs no lipids for the first 7 days. Overall, there was no difference in the mortality rate or incidence of BPD between the two groups. However, sub-group analysis showed that for infants with birth weight 600-800 g, infants receiving early lipids were more likely to have pulmonary hemorrhage and had a higher mortality rate than the control infants. Whether this was related to lipid administration, or was a statistical anomaly in this group is unclear. Somewhat reassuring is the fact that there were no differences in the 800-1000 g sub-group (Sosenko 1993).

In contrast to the theoretical concerns about the possibility of lipids contributing to CLD, there is good evidence that under-nutrition can worsen the condition of the infant with CLD (Frank 1988). There is also intriguing animal evidence that maternal undernutirition decreases lung surfactant lipid content in the early neonatal period. Whether this indicates that early post-natal lipid deprivation could interfere with surfactant lipid formation is unknown (Chen 2004).

Lipids and pulmonary hypertension: When intravenous lipids were first introduced into adult critical care units, there were a number of publications showing an association between lipid administration and hypoxia. Similar results were also reported in neonates (Pereira 1980). Based primarily on animal data, it appears that the rapid administration of a large dose of lipid led to a significant increase in pulmonary vascular resistance. Presumably, the prostinoid precursors in the Intralipid® led to a thromboxane-mediated constriction of the pulmonary vascular bed. However, this effect has been seen only with rapid administration of large doses of lipid (Hammerman 1988). It is probably not a clinically significant problem in neonates who are given the usual dose of Intralipid® over 24 hours. In a clinical trial in which critically ill VLBW infants were randomized to receive 1 g/kg/d of Intralipid® on day one and increasing to 3 g/kg/d by day four, or to receive no lipid until day eight, there were no differences in oxygenation or in any other marker of lipid toxicity (Gilbertson 1991).
Recent clinical trials: In their recent study of very early parenteral nutrition (3.5 g/kg/d amino acids and 3 g/kg/d of Intralipid® starting in the first hour of life) Ibrahim found no evidence of hyperlipidemia or other adverse effect of the early aggressive lipid administration (Ibrahim 2004). Similarly, in Thureen's study of early aggressive amino acid administration, infants were started on Intralipid® at 1 g/kg/d within 48 hrs of life and appeared to tolerate this dose well (Thureen 2003).

Implementation Strategies:

- Standardized policies and admission order sets which include Intralipid®administration starting within the first 24 hours of life
- Consideration of a combined amino acid and lipid solution, also known as “3-in-1” or “Total Nutrition Admixture (TNA) solutions to simplify administration issues

Barriers:

- Perception that early lipid administration is of no benefit
- Perception that early lipid administration is potentially toxic

Measurement:

- Measure provider consistency in implementation
- % of VLBW infants receiving lipids by 24 hours of age

PBP #3: Nutritional assessment of all VLBW infants should include daily calculations of energy and nutrient intake. In addition, weight should be followed frequently enough to monitor growth.

Rationale: Multiple studies have shown that, in most centers, VLBW infants receive significantly less protein and fewer calories than ideal. Monitoring of intake should be structured so that day-by-day evaluation of nutritional adequacy is possible. Given the high risk of post-natal growth failure among VLBW infants, maintaining adequate growth should take precedence over merely reaching some theoretical target of protein or energy intake.

Implementation:

- Readily accessible growth curves, including both weight and head circumference
- Readily accessible flow charts which display fluid intake, glucose intake (g/kg/d), protein intake (g/kg/d), fat intake (g/kg/d), and caloric intake (kcal/kg/d)
- Encourage parents to become involved in charting growth parameters

Barriers:

- Perception that nutritional status can be adequately managed on a day-by-day basis without looking at trending data
- Lack of standardized flow-sheets or charting tools
- Lack of personnel for doing accurate daily calculations

Measurement:

- % of charts that contain routine nutritional assessment

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PBP #4: VLBW infants on parenteral nutrition should have routine monitoring of serum chemistries. This includes sodium, potassium, chloride, calcium, phosphorus, magnesium, direct bilirubin, BUN, creatinine, alkaline phosphatase, and triglycerides, at least weekly but more frequently with parenteral nutrition changes. Measurement of albumin and/or pre-albumin may also be useful.

Rationale: Infants on parenteral nutrition are usually premature and/or moderately ill, and are at risk of abnormalities in electrolyte and mineral balance. Prolonged parenteral nutrition predisposes infants to both cholestasis and osteopenia. While there are little data to support choices of the most cost efficient way to monitor the VLBW infant receiving parenteral nutrition, it seems prudent to follow electrolytes, hepatic function, renal function, triglyceride levels, bone metabolism, and a marker of protein synthesis on a regular basis (Kerner 2003, Schanler 2003, Valentine 2003). Serum albumin has a half-life of 18-20 days and can reflect the severity of malnutrition. Prealbumin has a shorter half-life (2 days) and is often used to monitor acute nutritional changes (Benjamin 1989).

Implementation Strategies:
- Standing orders for monitoring of patients on parenteral

Barriers:
- Perception that “ad hoc” monitoring is adequate

Measurement:
- % of infants receiving routine monitoring
- % of infants with “unacceptable” values

III. ESTABLISHING ENTERAL NUTRITION

PBP #1: Human milk should be used whenever possible as the enteral feeding of choice for VLBW infants.

Rationale: There are benefits of utilizing human milk for the VLBW infant and corresponding risks of not using human milk. Human milk is associated with a reduction in the incidence of NEC, sepsis, BPD, infection and severe retinopathy of prematurity in preterm infants. The objective of feeding during the early days of life is to stimulate gut hormone maturation and release and support immune functions. Human milk not only supports, but complements the preterm infant’s immune system (Koletzko, Poindexter, & Uauy, 2014). Because of the numerous protective effects, human milk is the feeding of choice for the premature infant. (Ziegler 2002, AAP 2005, Schanler 2003, Koletzko, Poindexter, & Uauy, 2014).

A frequently encountered practical limitation is that lactogenesis (milk “coming in”) does not occur for 2-5 days after birth. During that time, only small quantities of mother’s first milk, colostrum, is available. Though the volume of colostrum is small, it is especially beneficial to the infant and should be utilized. Colostrum contains high concentrations of antimicrobial, anti- inflammatory and immunomodulating factors, and prepares the gut for mature milk. (Goldman AS 1993; Akers 2002). As milk protein decreases over time, human milk should be used in the order it is pumped for the first 2-3 weeks and then fresh milk as available (Ziegler 2002). Feedings should be started with undiluted human milk (Berseth 1992a, Koenig 1995). Routine culturing or heat treatment of mothers’ own milk has not been demonstrated to be necessary or cost-effective (AAP 2003). If mother’s own milk is not immediately available, the clinician should consider the use of pasteurized donor human milk. Donor milk has most of the properties of fresh human milk (immunoglobulins, growth and developmental hormones, enzymes, anti- inflammatory factors, etc.). Evidence suggests that donor milk reduces incidence of NEC while improving feeding tolerance as compared to formula (Lucas 1990, Arnold 2004, Ziegler 2002).

The mother of a VLBW infant is initially pump dependent for the establishment of lactogenesis. Evidence suggests that the hours immediately post-birth are critical for the stimulation and programing of milk production. Milk output in the first two weeks can predict milk production throughout the NICU stay. (Meier, 2013). It is critical that the mother of a VLBW infant receive early and consistent lactation education and support.

When infant formulas must be used, premature formulas should be used, as they are formulated specifically for the VLBW infant as compared to term or elemental formulas.

Implementation Strategies:

- Create a supportive environment to maximize milk production in the early postpartum period. This should include early and consistent lactation support.
- Teach every mother hand expression and collection techniques to maximize colostrum availability
- Establish a relationship with the nearest milk bank and define procedures for obtaining milk as needed.

Barriers:

- Maternal disappointment over small expressed volumes
- Because other issues are perceived as higher priority, there may be a lack of appreciation of the importance of small volumes of colostrum
- Difficulty with collection and labeling of small expressed volumes

- Mother's own milk not always available
- Lack of recognition of the role of pumping in the mothers' recovery process
- Lack of knowledge regarding use of pasteurized donor human milk
- Lack of knowledge regarding use of premature formulas
- Resistance to changing current practices
- The desire to initiate trophic feeds regardless of breastmilk availability

Measurement:

- Documentation of utilization of colostrum or breastmilk for the initial feeding
- Maternal education on importance of providing breast milk for premature infants
- Availability of maternal early and consistent lactation support
- Documentation of post-partum provider's competency in helping mothers collect colostrum
- If colostrum or breastmilk is not available in the NICU, are there documented efforts to contact the mother before providing alternatives?
- Survey of NICU staff attitudes and knowledge regarding human milk and breastfeeding
- Documentation of milk supply maintenance by DOL #14

PBP #2: Enteral feeds, in the form of minimal enteral feeds (also called GI priming), should be initiated within 1-2 days after birth, except when there are clear contraindications such as a congenital anomaly precluding feeding (e.g. omphalocele or gastroschisis), or evidence of GI dysfunction (as with hypoxic-ischemic compromise or shock).

Rationale: There is not a standard definition for trophic or minimal feeds. In general, it refers to enteral feedings of 5-25 ml/kg/day (Thureen and Hay, 2012). The objective of feeding during the early days of life is to stimulate gut maturation, hormone release and motility. During the 70's and 80's, withholding feeds as a strategy to prevent necrotizing enterocolitis (NEC) was widely practiced without evidence of efficacy. Delaying enteral feedings can lead to atrophy of the gut (La Gamma 1994) which may make initiation of feeds more risky (Ziegler 2002). Beneficial effects of minimal enteral feedings include shorter time to full feeds, faster weight gain, less feeding intolerance, less need for phototherapy, enhanced maturation of small intestine function and decreased length of stay (Thureen and Hay, 2012). A randomized, controlled, prospective study involving 100 LBW infants (McClure 2000) confirmed these findings and found a significant reduction in serious infections with "early" (from day 3) introduction of feedings. A review of nutrition practices in New York State NICUs demonstrated that the incidence of extrauterine growth failure varied greatly by center, but was lowest in those NICUs that initiated feedings earlier and achieved full feedings earlier (Stevens, et al, 2016).

Implementation Strategies:

- Enteral feeding protocols should be available in each NICU and specify:
  - ❖ Early (day 1-2) initiation of feedings for most infants
  - ❖ Initiation of feedings with undiluted human milk (mother's own milk is the first choice, human donor milk if mother's own milk is not available) or formula
  - ❖ Consider providing trophic feeds but extending time prior to advancement in the presence of cardiorespiratory instability
  - ❖ Progressive advancement of feeding is dependent on clinical status and should be standardized as much as possible within each NICU
  - ❖ Create a standard definition of feeding intolerance and a consistent approach to management
- Reasons for withholding feedings should be documented in the hospital chart/progress notes and discussed on rounds.

Barriers:

- Lack of staff information about the hazards of delayed feedings in VLBW infants
- Current practices/beliefs regarding contraindications surrounding umbilical artery catheters
- Lack of consensus about physiology and definition of feeding intolerance
- Lack of consensus about whether to continue feedings in the presence of potentially vascularly reactive medications (e.g. indomethacin, dopamine, etc.)
- Lack of consistency across studies about content and advancement of feeds and relationship to outcomes

Measurement:

- Hour or day of life when trophic feeds initiated
- Day of life when feeding advancement begun
- Day of life when full enteral feeds achieved
- Day of life when birthweight regained
- Days of parenteral nutrition

PBP #3: NICU's should standardize their definition of feeding intolerance, with specific reference to acceptable residual volumes and changes in abdominal girth.

Rationale: Feeding intolerance in the VLBW infant is a common occurrence in the NICU. This may lead to the enteral feedings being held or the feeding volume not being advanced due to concerns of "feeding intolerance". The definition of intolerance may include the presence and quality of gastric residuals (normal, yellow, green, blood-tinged), emesis, an increase in abdominal girth or abdominal tenderness, abnormal-appearing stool, the presence, absence or quality of bowel sounds, or any combination thereof (Jadcherla 2002, Mihatsch 2002). These clinical signs may also occur in a healthy premature infant tolerating feedings (Moody 2000); therefore, it is important to put these findings into a clinical context that is understood by nursing and physician staff. The ability to advance enteral feedings will improve growth and nutritional status, decrease the need for parenteral nutrition, and potentially decrease length of stay (Oh, Kim & Neu, 2012). In one study, when feeding intolerance was more clearly defined, nutritional outcomes were dramatically improved (Patole 2003). Kamitsuka et al. (2000) showed that implementation of a consistent feeding schedule and standardized feeding evaluation alone reduced NEC and improved weight gain. Given the variability of residuals upon initiation of feedings, it may be more appropriate to use the presence of a large volume residual only as one part of the decision to limit feeding advancement (Li, 2014) (Torrazza et al, 2015). One should be cautious about using residuals as the sole reason to completely stop enteral feedings, as many factors may contribute toward the production of a residual at any one feeding (e.g. impaired gut motility in premature infant, exposure to gut-slowing medications like magnesium, etc.).

Implementation Strategies:

- Key NICU team members should discuss and develop a working definition of feeding intolerance
- Establish a protocol delineating unit-specific definition of feeding intolerance and how to address it
- Education for staff regarding the new definition and protocol

Barriers:

- Difficulty in coming to a consensus on the definition of feeding intolerance among members of the medical team and staff
- Difficulty in understanding clinical context of phenomena in healthy vs sick infants

Measurement:

- Chart review of VLBW infants at risk for feeding intolerance:
    - ❖ Feeding stops and starts
    - ❖ Documentation of protein and calorie deficits associated with the interruption in enteral nutrition
    - ❖ Any complications associated with extended parental nutrition therapy

PBP #4. Enteral feeds should usually be given by intermittent bolus, rather than continuously, and by gastric, rather than transpyloric administration.

Rationale: VLBW infants are usually started on feedings before they can suck and swallow. Tube feedings are an essential component of enteral nutrition. There are various methods of tube feeding including continuous, semi-continuous or intermittent bolus, and several approaches such as orogastric, nasogastric, transpyloric or gastrostomy.

Milk feedings given by intermittent bolus gavage method are thought to be more physiologic because they promote the cyclical surges of gut hormones seen in normal term infants and adults (Aynsley, 1982) (Ors, 2013). Bolus feeds may optimize the nutrition delivered to the infant and minimize nutrient loss to tubings (Brooks, 2013). Occasionally, intolerance is seen in the bolus-fed preterm infant, with duodenal motility decreasing following the bolus feeding (DeVille 1993). A bolus feeding given over a longer time interval, such as 30-120 minutes, results in a return of motility and improved tolerance (Schanler 2003, Schanler 1999). Premature infants experienced more feeding intolerance (Scanler 1999, Dollberg 2000) and a slower rate of weight gain with continuous infusion when compared to the bolus technique (Schanler 1999). In infants with gastrointestinal disease (for example, diarrhea and feeding intolerance that results in stopping feedings), continuous infusion has been associated with better nutrient absorption (Parker 1981) (McGuire 2004, updated in 2013).

Delivery of tube feedings into the stomach elicits the associated physiologic stimulation and digestive processes. Transpyloric feedings have the potential benefit of delivering feeds past the pylorus and gastroesophageal junction. Transpyloric (e.g. NJ) feeds must be continuous, which may account for decreased gastroesophageal reflux symptomatology. Transpyloric feedings are not recommended for routine use in preterm infants, as no benefit was found in a meta-analysis, and they are associated with a greater incidence of gastrointestinal disturbance and possibly death (McGuire 2004, updated 2013).

Implementation Strategies:

- NICU feeding policy specifying bolus, intra-gastric feeds
- Documentation of reason for variance in medical record and discussed on rounds

Barriers:

- Staff resistance to change in current practice
- Controversy surrounding gastroesophageal reflux

Measurement:

- Chart audit of enteral feeding practices on 10 VLBW infants

TIPQC

PBP #5: Efforts should be made to limit nutrient loss (primarily fats) to tubing and feedings systems. Depending on feeding systems used this may include:

A. Orienting Pumps delivering breastmilk so that the syringe is vertically upright

B. Using tubing of the smallest caliber and shortest possible length

C. Choosing a feeding delivery system designed to optimize fat delivery
D. Using intermittent bolus feeding techniques

Rationale: Multiple research studies have shown when human milk is exposed to feeding tubings that fat and caloric content can be lost to those tubings. In addition, fats in breastmilk are of lower density than other components, and will therefore rise within the syringe and separate. If a syringe is horizontal, fat may float to the top and therefore will be the last fluid emptied into the tubing, resulting in variable fat administration rates and causing some of the highest caloric feed to never reach the baby (Spencer 1981, Greer 1984, Narayanan 1984, Stocks 1985, Mehta 1988, Jajour 2015). As fortifiers may fall to the bottom of the feeding, the feeding syringe may need to be gently manipulated several times during a continuous or prolonged "bolus" feed to ensure all nutrients are administered to the neonate.

Implementation strategies:
- Education for MDs and RNs regarding the rationale and importance of syringe position and tubing characteristics that will minimize loss of nutrients during breastmilk administration
- Policy and procedure regarding pump positioning

Barriers:
- Lack of equipment for pumps and syringes to be positioned on
- Resistance to change in practice
- Bedside staffing ratios to implement these measures

Measurement:
- Survey pump positioning after education/implementation

PBP #6: Enteral feeds should be advanced until they are providing adequate nutrition to sustain optimal growth (2% of body weight/day). For infants fed human milk this could mean as much as 170 - 200+ mL/kg/day, to provide an overall weight gain of 10-20 grams/kg/day.

TIPQC

Rationale: The goal of enteral feedings is to provide optimal nutrition and growth; therefore, eliminating the need for parenteral nutrition. The historic target for premature infants of 150 mL/kg/day of enteral feedings may be inadequate to overcome prior nitrogen deficits and establish optimal growth. A randomized trial of enteral feeding volumes (150 and 200 mL/kg/day) of infants born less than 30 weeks' gestation, once they reached full enteral feeds, found that individual milk volume requirements for adequate weight gain without significant adverse effects varied between 150-200 mL/kg/day (Kusechel 2000). Increased milk intakes were associated with increased daily weight gains and a greater weight at 35 weeks, but no difference in any growth parameter at 1 year or difference in morbidity (Kuschel 2000). Ziegler suggests that feeding volume should be increased until the infant shows signs that GI capacity has been reached, then kept at that volume through daily adjustment of the feeding volume (Ziegler 2002). Restricting feeding volume until the weight plateau has been identified as the most common cause of growth delay (Hay 1999).

It has been suggested that fortified human milk must be fed at approximately 180 mL/kg/day if ELBW infants are to achieve adequate growth, nutrient retention, and biochemical indices of nutritional status (Hay 1999). Vitamin and mineral supplementation may be required to meet nutritional goals, especially if feeding volume must be restricted for some reason (e.g. pulmonary disease). Total feeding volume should be individualized to each baby to achieve optimal growth.

Implementation Strategies:

- Daily monitoring of feeding volumes
- Automate calculations of feeding volumes and calories
- Consider crematocrtis or using premature donor milk

Barriers:

- Reluctance to go above previous recommendations of 150 mL/kg/d
- Effort to calculate feeding volumes
- Reliance on feedings by the clock rather than relying on early infant clues (i.e., fussiness or excessive pacifier)
- Cost of donor breast milk and human milk-derived fortifiers

Measurement:

- Chart review for serial recording of feeding volume

IV. SUSTAINING ENTERAL NUTRITION AND BREASTFEEDING THROUGH DISCHARGE AND BEYOND

PBP #1: **Mothers' milk supply should be maintained and the milk handled safely and appropriately.**

Rationale: The single most important factor determining the exclusivity and duration of breastfeeding for the mother-infant dyad is the volume of milk produced which typically plateaus by 1-2 weeks postpartum (Neville, 2001).

The average baseline milk production on days 6-7 postpartum is highly predictive of adequacy of milk volume (defined as ε 500 mL/d) at 6 weeks post-partum (Hill, 2005). Mothers of preterm infants were 2.8 times more at risk of not producing adequate milk than term mothers who were fully breastfeeding. Although a better comparison group would have been mothers of full-term infants who were exclusively pumping and not breastfeeding, it is not clear to what extent, if any, preterm birth contributes to limitation of milk supply in mothers of VLBW infants. Lactogenesis I (the hormonal preparation and growth of breast tissue) starts during pregnancy (Neville, 2001). Some experts suggest that the mother of an extremely preterm infant may be at a disadvantage regarding milk production as she has not had the full time for breast growth and development. Also, lactogenesis II may be delayed in mothers with diabetes and in mothers who delivery very preterm infants (Cregan 2002, Henderson 2004).

Early, frequent, and effective breastfeeding, manually expressing, or pumping appears to be the most important factor in establishing normal lactation (Furman 2002, Smith 2003, Wooldridge 2003). Prolactin bursts associated with the infant suckling or the mother pumping support the continued growth of secretory tissue in the maternal breast for several weeks or months after birth (Cox 1999). Initiating early pumping within the first day, ideally within the first hour is associated with higher levels of milk production (Wooldridge 2003, Hill 1999, Flacking 2003, Smith 2003, Furman 2002, Bier 2002).

Mothers of VLBW infants typically must express milk for several weeks before the infant can be put to breast, and for several weeks after discharge, before full exclusive breastfeeding is achieved, if ever (Wooldridge 2003, Furman 2002). The initiation (See CPQCC Toolkit Part 1 –The First 100 Hours) and maintenance of lactation for mothers of VLBW infants is best accomplished with a hospital grade, automatic-cycling electric "double" pump (Hill 1996, Slusher 2004).

It is very common for a mother of a VLBW infant to have her milk supply decrease after 4-6 weeks of pumping, as she resumes her normal daily routine or returns to work (Hill 1999, Ehrenkrantz 1986). Even if a full milk supply was never established, every effort should be made to help mothers of VLBW infants to maintain the supply they have. Returning to an increased pumping schedule (including night-time expression) and galactogogues may be useful after evaluation of the mother's situation (ABM 2004a).

Fenugreek is often used as a first line galactogogue (ABM 2004a, Wight 2001). The use of metoclopramide 10 mg tid for 14 days, followed by a tapering dose for mothers who respond favorably, has been demonstrated to be an effective way to increase milk production in some women (Budd 1993, Emery 1996).

Although human milk has remarkable antibacterial properties, it is not sterile and should be handled and stored properly to maintain its nutritional, developmental and immunological potential, and prevent transmission of infection (AAP 2003, HMBANA 1999, Tully 2000). Appropriate steps should be taken to ensure an individual mother's milk is given only to her own child, unless the milk has been heat-treated under standardized conditions (AAP 2003).

Mastitis is a complication for pump-dependent mammals and has been associated with irreversible compromise of milk production. In addition to increasing the frequency of emptying, prompt antibiotic treatment may protect milk production. Mothers need to exercise vigilance in examining themselves for areas in the breast which have not been well drained (Thomsen, 1984).

Implementation Strategies:

- Each mother's milk supply should be monitored continuously
  - ❖ Use a pumping log – need this is in the language appropriate for that patient
  - ❖ Participation of the lactation consultant for daily needs and for work helping with discharge planning
  - ❖ Milk supply as a "vital sign" to be monitored by the RN
- Every NICU should have a policy regarding safe storage, handling and administration of human milk (HMBANA 1999, Tully 2000)
- Every NICU should have a policy regarding misadministration of human milk, i.e. a mother's milk given to the wrong infant (Warner 2004).
- NICU staff members should be familiar with galactogogues which may be used or requested by NICU mothers, and have information sheets for mothers'
- Mothers should be appropriately treated for mastitis should it occur. Discarding the milk from the affected breast is not recommended, except in unusual circumstances (AAP Red Book 2003). Although, it might be helpful if the milk coming from the affected breast is labeled accordingly.
- Establishment of communication and education with the mother's obstetrician or primary care provider around issues of lactation and the use of galactogogues.
- Facilitation of evaluation after discharge by a lactation consultant

Challenges to Success:

- Lack of appreciation that mothers' milk supply is a priority in the normal care of a VLBW infant
  - ❖ No mention of milk supply on rounds
  - ❖ Not encouraging the use of a pumping log
- Lack of policies regarding
  - ❖ Misadministration of human milk
  - ❖ Safe storage, handling and administration of human milk
- Lack of knowledge regarding treatment of maternal mastitis
  - ❖ Reluctance of NICU staff to get involved in maternal medical issues
  - ❖ Lack of ready referral sources for maternal treatment

Measurement:

- Review all policies regarding human milk in the NICU to identify what might be missing
- Monitor cases of EBM being misadministered and evaluate each case to determine root cause
- Periodic assessment of number (%) of mothers with inadequate milk supply after day 14 (< 350 mL/24 hours)
- One person on rounds designated to monitor discussion of milk supply
- Monitor cases of maternal mastitis and staff's awareness of treatment of mastitis

PBP #2: VLBW infants fed human milk should be supplemented with protein, calcium, phosphorus and micronutrients. Multinutrient fortifiers are a preferred method for providing these nutrients in infants receiving human milk. Formula fed infants may also require specific caloric and micronutrient supplementation.

Rationale: Studies have repeatedly demonstrated that protein and multinutrient fortification of human milk is associated with short-term growth advantages (weight, length and head circumference) for infants < 34 weeks' gestation or birthweight <1800g (Kuschel 2004, Schanler 1998, Schanler 2003). In addition, VLBW infants demonstrate greater growth velocity and have higher bone mineral content at 1 year of age if provided with additional nutrients, especially protein, calcium and phosphorus (Lucas 1992, Wheeler 1996; Friel 1993).

Fortification of breastmilk should be initiated well before a full feeding volume is reached (Ziegler, 2014). Studies of feeding types and their advancement have typically initiated fortifiers at enteral feeding volumes of 100 mL/kg/day, but no current research exists to suggest starting earlier (50-75 mL/kg/day) is harmful. While methods of fortification are discussed, one thing that is not discussed is whether to begin fortification at half-strength (1 packet of fortifier per 50 mL of EBM) or full strength (1 packet per 25 mL of

EBM. There is no research as to how fast to "advance" fortification, but multiple studies demonstrate no increase in feeding intolerance or NEC when human milk was fortified (Sullivan, Schanler, Kim et al, 2010). Sullivan et al (2010) also reported a significantly higher incidence of NEC in infants receiving a cow's milk-based fortifier compared with a human milk-based fortifier.

VLBW infants fed human milk can benefit from vitamin supplementation, most specifically vitamins A, C, E, and D. Most NICU's provide such supplementation in the form of a multivitamin solution, 1 mL/day, which may be divided into twice daily dosing for extremely premature infants and for those who do not tolerate full doses. Patients with or recovering from cholestasis may also require additional fat-soluble vitamins (A,D,E,K).

In preterm infants, inadequate levels of Vitamin E may result in oedema, thrombocytosis, and hemolytic anemia. This deficiency typically presents at approximately two months of age (Leaf and Lansdowne, 2014). In 2003, a Cochrane review identified that Vitamin E supplementation reduced the risk of severe retinopathy of prematurity and blindness, yet it significantly increased the risk of sepsis (Brion, 2003). The AAP currently recommends that preterm infants (<1000 gm birthweight) receive 6 –12 IU/kg/day, which may be supplied either by preterm formula or by supplementation of human milk (AAP 2004).

Vitamin A has an important role in vision, growth, healing, reproduction, cell differentiation, and immune function. A deficiency in Vitamin A may contribute to the development of chronic lung disease (Leaf and Lansdowne, 2014).

Iron supplementation should be given to VLBW infants fed human milk at a dose of 2 - 4 mg/kg/d starting at 2 weeks of age (Baker & Greer, 2010). Multivitamins with iron contain 10 mg/mL, which is adequate for supplementation. VLBW infants receiving most or all their feedings from infant formulas should not require additional iron supplementation when intake is 180 mL/kg/day. Preterm and term infants receiving recombinant erythropoietin require additional amounts of supplemental iron, up to 6 mg/kg/day.

VLBW infants are at significant risk for chemical and clinical osteopenia due to inadequate calcium and phosphorous intake, dysfunctional vitamin D metabolism and/or excessive renal losses of these minerals (which may be exacerbated by diuretics, especially furosemide). In one study, over half of infants with a birthweight < 1000 grams and nearly 25% of those with a birthweight < 1500 grams had radiographic evidence of rickets (Backstrom, 1996). Nutritional screening usually includes testing for these minerals. VLBW infants receiving breastmilk that is fortified with commercially available products receive additional calcium and phosphorus, in a quantity associated with improved growth (Kuschel 2004). Babies considered to be osteopenic may need to be supplemented with calcium and phosphorus, although the effect of such supplementation on bone density remains unproven (Faerk, 2000). Similarly, supplementation of a premature infant's diet with vitamin D beyond 200-400 IU/day has not been found to increase bone density later in life (Backstrom ,1999).

Despite studies to support multinutrient fortification of human milk for preterm infants it is unclear whether the rapid catch-up growth seen with aggressive supplementation is of benefit or harm for long term overall health, growth, and neurodevelopment (Hall 2001, Griffin 2002). Exclusively breastfed former preterm infants tend to "catch up" if given sufficient time (2-8 years) (Schanler, 1992; Morley, 2000; Backstrom, 1999). Further research is needed to evaluate long-term benefits of continued post-discharge fortification.

Implementation Strategies:

- Fortification should be used for all VLBW infants on breastmilk and may be started when enteral feeds reach 50-100 mL/kg/day
- Every NICU should have a set of guidelines for supplementation of human milk
- Supplemental iron should be provided to premature infants receiving breastmilk as well as all VLBW infants on erythropoietin
- Regular assessment of mineralization should be done for VLBW infants, with provision of appropriate supplementation when indicated

Barriers:

- Lack of research specific to various types of fortification and timing of their start and advancement
- Fear of NEC due to alteration of human milk with fortifiers or other supplements
- Lack of inpatient neonatal/pediatrics nutritional services and expertise
- Lack of consistent unit-based nutritional practices

Measurement Strategies:

- Documentation of guidelines for use of fortification in EBM
- Documentation of compliance with guidelines
- Documentation of a nutritional monitoring schema for stable preterm growing infants
- Documentation of supplemental nutrients being provided to VLBW infants

PBP #3: Infants should be transitioned from gavage to oral feedings when physiologically capable, not based on arbitrary weight or gestational age criteria.

Rationale: Kangaroo care (skin-to-skin care), non-nutritive breastfeeding (practicing breastfeeding on an "emptied" breast) and early introduction of the breast have been associated with increased breastmilk production and longer breastfeeding post-discharge (Furman 2002, Kirsten 2001, Hurst 1997, Blaymore-Bier 1996).

Infants can be introduced to oral feeds as soon as the infant is deemed stable. There are no minimum gestational age or weight requirements. Infants have been shown capable of breast or bottle-feeding much sooner than previously believed, with some breastfeeding as early as 28 weeks, and achievement of full nutritive breastfeeding at 36 weeks (Simpson 2002, McCain 2001, Nyqvist 2001, Nyqvist 1999). Many variables must be evaluated when determining if an infant is stable enough for the introduction of the breast or bottle. These variables include respiratory rate, work of breathing, ability to handle their own secretions, ability to coordinate sucking/swallowing/breathing and the demonstration of sucking behavior on a finger, pacifier or the emptied breast. Introducing the infant to breastfeeding before introducing a bottle may facilitate breastfeeding (Auer 2004). There is no reason to "test" a preterm infant on a bottle before offering the breast.

Transitioning directly from gavage to all PO breastfeeding is possible, and seems to prolong both exclusive and any breastfeeding (Kliethermes 1999), but requires the mother to be continuously present, which may not be possible because of physical limitations of many NICUs and the mothers' own outside commitments. Mothers of preterm infants in the USA, in contrast to other countries (e.g. Sweden) are not expected or facilitated to remain with their infants to encourage earlier development of breastfeeding competence, or enable use of at-the-breast supplementation methods such as a supplemental nursing system. Transported infants' mothers may not be available for frequent feeding practice. The increasing use of individual room NICU care, enabling parents to remain with their ill infants, may well facilitate earlier and increased direct breastfeeding.

It may be difficult to determine the true intake and ensure weight gain for a medically fragile or preterm infant, where consistent weight gain is crucial. Although research as to efficacy is limited, cup-feeding appears safe for preterm infants (Marinelli 2001, Howard 1999, Malhotra 1999, Howard 2003, Kramer 2001, Schubiger 1997, Lang 1994) and may facilitate longer breastfeeding post-discharge, although may necessitate a somewhat longer hospital stay (Collins 2004). Clinical experience suggests other methods of feeding may be appropriate for specific infants, e.g. finger-feeding for neurologically impaired, or supplemental nursing systems at the breast for mothers with insufficient milk supply (Oddy 2003, Wolfe 1992). Nipple shields can be used, when appropriate, to maximize milk transfer at the breast (Meier 2000).
In the absence of good research, every effort should be made to accommodate mothers' preferences if appropriate weight gain is maintained.

Implementation Strategies:

- Kangaroo care and non-nutritive breastfeeding policies and procedures should be available and followed
- Policies containing corrected age or weight criteria for initiation of breast- (or

- bottle-) feedings should be revised based on the information above and a current review of the literature
- Have at least 1 electronic scale (accurate to 1-2 g) and a protocol available for pre-post breastfeeding test weighing, in babies that this could benefit
- Nipple shields in various sizes should be available for use in the NICU as appropriate
- Policies and procedures, education, and competency verification, should be available for all feeding methods
- Routine assessment by skilled providers of oral readiness

Barriers:
- Outdated recommendations that infants must prove they can feed by bottle before being allowed to go to breast
- Over-reliance on a single feeding method for all infants
- Lack of maternal availability
- The pressure and desire to get preterm infants discharged home as soon as possible
- Varying expertise and comfort level of NICU nursing staff with alternate feeding methods
- Lack of substantive research on optimal feeding methods for preterm infants

Measurement Strategies:
- Survey of postnatal and corrected age at first kangaroo care, first non-nutritive breastfeeding, and first nutritive breastfeeding
- Protocol availability for test weighing, non-nutritive breastfeeding and kangaroo care

PBP #4: Nutritional discharge planning should be comprehensive, coordinated and initiated early in the hospital course. Planning should include appropriate nutrient fortification and nutritional follow-up.

Rationale: Discharge planning should be initiated upon admission to the NICU with an assessment of mother's breastfeeding goals and preferences (Morton 2003, Wight 2004). Prenatal intention to breastfeed is one of the strongest predictors of initiation and duration of breastfeeding (Coreil 1988, Donath 2003, Dennis 2001, de Oliveira 2001). Gestational age and early physical contact seem to be the strongest predictors of breastfeeding initiation and frequency for babies admitted to the NICU (Niela-Vilen, 2006). A prenatal visit from the Neonatologist makes a difference in the mother's choice whether to provide her own milk (Arnold, 2010).

Due to the physiology of breastfeeding, milk expression should begin within one hour after the infant's birth, if possible (Wambach, 2016). The breasts should be stimulated eight or more times every 24 hours (Wambach, 2016). A full milk supply at discharge is one of the best predictors of successful breastfeeding post-discharge (Wooldridge 2003, Furman 2002).

Many parents of VLBW infants perceive incorrectly that feeding problems are resolved pre-discharge, and that the infant will be able to breastfeed exclusively at discharge and thrive. If a rooming-in suite is available and parents are amenable, a 1 to 2 night stay before discharge can point out problems and maximize learning (Morton 2003, Wight 2004). At present, however, there are no randomized controlled trials that address whether rooming-in prior to discharge is associated with higher exclusive or any breastfeeding rates, or better long term outcomes for VLBW infants.

In the week prior to discharge an individualized nutritional plan should be prepared in coordination with the neonatologist/NNP, lactation consultant, NICU dietitian, and family. If possible, the plan should be reviewed with the post-discharge provider at the time of discharge. Post-discharge nutrition is a newly understood concern and many providers may not be aware of the need for special diets and frequent visits to monitor growth and biochemical status (ABM, 2004b). The plan should be based on the skills of the infant, the mother's milk production, and the infant's nutritional needs, and parenting skills and support, and should include provisions for making the transition to full breastfeeding (Morton, 2003). Included in this plan should be the "type" of feeding, (unfortified human milk, fortified human milk, formula, combination, etc.), frequency of feeding, "amount" of feeding (measurement, test weights if necessary), "method" of feeding (breast, bottle, cup, feeding device at breast, gastrostomy tube, etc.), "adequacy of growth" based on in hospital growth and expected growth and plotted on growth chart, "adequacy of nutrition" based on in-hospital biochemical nutritional status, when feasible (ABM, 2004b). All infants < 34 weeks or < 1800 grams at birth, and other larger infants with nutritional risk factors (CLD, short gut syndrome, neurologic impairment, etc.), should have a complete nutritional assessment prior to discharge.

Experts have suggested this assessment should include both growth parameters (weight, length, head circumference) and biochemical measurements (phosphorus, alkaline phosphatase, urea nitrogen, transthyretin (prealbumin), retinol binding protein) (Hall 2001, Griffin 2002, ABM 2004b). Additional specific laboratory studies may be necessary for the larger, high-risk infant. If the infant is taking 160-180 ml/kg/day and growth parameters have been normal or improving on human milk alone for a week or more prior to discharge, human milk alone should provide adequate nutrition post-discharge. A follow-up consultation with a Lactation Consultant should be scheduled prior to discharge.

If supplementation is necessary, the mother can directly breastfeed, but substitute post-discharge transitional formula for 1 to 4 feedings per 24 hours as needed, to reach growth and biochemical goals. Alternately, powdered transitional formula (e.g.

NeoSure or Enfacare) can be added as a fortifier to expressed breastmilk given in substitute for feedings at the breast. Human milk fortifier and powdered preterm formula are not usually recommended post-discharge because the nutrient content is far too great for the infant at the time of discharge, is expensive, and is difficult to prepare correctly (ABM, 2004b). Hindmilk (the fat-rich milk at the end of a breastfeed) may supply extra calories, but provides no extra protein or minerals (Valentine 1994). Multivitamins, dosed to deliver at least 1500 IU/day of Vitamin A, 20-70 mg/day of Vitamin C, and 400 IU/day of Vitamin D should be added at discharge. B vitamins are also necessary for the former premature infant receiving unfortified human milk. A multivitamin preparation dosed at 1 mL/day will usually supply all the above. If formula constitutes >50% of an infant's daily intake, the dose should be 0.5 mL per day. Multivitamin administration should be continued for at least 3 to 6 months, although the optimum length of use has yet to be determined (Hall 2001, Griffin 2002, Wight 2004).

At discharge, elemental iron should be continued/added at 2 mg/kg/day. If formula constitutes 50% of the diet, the dose should be reduced to 1 mg/kg/day (Hall 2001). When the multivitamin with iron preparation is stopped, the infant should be started on oral vitamin D drops or ACD vitamins to provide at least 200 IU per day until the child is drinking sufficient milk to provide that amount of vitamin D (AAP 2003).

Implementation Strategies:

- Standing order for lactation consultation and discharge planner to consult with mother upon admission to NICU
- Provide for rooming-in for a few nights prior to discharge, if appropriate
- Develop a discharge plan with the parents and follow-up provider and provide a copy to both
- A repeat biochemical assessment done at 1 month post-discharge may be helpful
- If the follow-up provider requests, then follow-up evaluation may be arranged with the dietician 2-4 weeks' post discharge to adjust caloric, protein, and other nutrient intake
- Ensure lactation follow-up visit after discharge

Barriers:

- Early discharge of the VLBW infant, before breastfeeding is completely established
- Assumption that breastfeeding needs to be addressed only immediately before discharge
- Lack of communication with the follow-up provider
- Lack of research to establish optimal growth patterns and feeding regimens for the post-discharge VLBW infant
- Inadequate diffusion of the emerging recommendations for nutritional surveillance post-discharge

- Fear of non-payment for outpatient nutritional services

Measurement:

- Investigate the frequency in which mothers access outpatient lactation services after discharge
- Presence of a discharge nutritional plan as developed in concert with the parents and follow-up provider
    - As part of the dictated or computerized discharge summary
    - As part of nursing discharge papers
    - As a separate document prepared by neonatology and/or the nutritionist
    - Documentation that nutritional assessments are completed prior to discharge on infants with nutritional risk factors

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