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# Considerations Regarding the Digestive Development of the Premature Neonate

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For most parents, adjusting to life with a typical newborn revolves around two main priorities: getting the baby sufficiently fed and watching for tell-tale signs of adequate digestion. Usually this does not involve much consideration for what is going on between the two ends of the digestive system. However, if the infant is born prematurely or needs to spend the start of life in the Neonatal Intensive Care Unit (NICU), they find themselves thrust into a foreign world where life revolves around the baby's fluid intake & output, oxygen saturations and heart rate. At this point, a conversation about the physiological maturation of the digestive system may need to take place between parents and health care providers.

After general health status is stabilized in the NICU, the digestive system will eventually take center stage as success as a “feeder and grower” will determine discharge timeline for most babies. For



*Image credit Clavey 1*

many parents the foreign world of the NICU can become a place of endless waiting and wondering when the baby will finally get to come home. The feeling of powerlessness and wanting life to return to normal can become overwhelming for any parent in this situation. Practically speaking, infant feedings are one key way for parents and other family members to engage in the care of the neonate and possibly feel empowered help the child get closer to discharge. More than just a means of helping parents cope, this involvement can potentially provide vital care for the newborn despite the fact that they are under the watchful eye of the bedside nurse 24 hours a day. But the pressure to get the baby to achieve a defined caloric intake goal can sometimes lead to new problems. This may inadvertently slow down the process of discharge or possibly lead to more frustration by parents who don't see the goals being met fast enough. All involved need to maintain a perspective that long-term oral feeding success, as opposed to the pressure to achieve short term goals for discharge, should continuously inform decisions about care of the infant. Maturation of the digestive system cannot be rushed. The NICU nurse is in a position to keep

this perspective reiterated as time passes as well as to be vigilant about using proper feeding technique and minimizing negative stimulus that the infant could come to associate with eating. Ultimately this could lead to feeding intolerances or interrupt development of this basic skill long after NICU discharge.

Several issues stand out as key for NICU caregiver education. These include: 1) understanding the dynamic process of infant gut maturation after birth; 2) motivation to begin or continue providing breastmilk for their neonate as a means to help achieve gut maturity; and 3) the importance of supporting the physiologic and neurodevelopment of digestion and oral feeding skills by minimizing noxious stimulus (especially during feeding), by utilizing cue-based feeding as well as non-nutritive suckling.

#### Dynamic process of infant gut maturation

At birth, the typical neonate transitions reasonably well to eating orally after having relied on the umbilical cord for sustenance. However, full-term infants without health issues can still struggle with oral coordination or may exhibit latching issues which benefit from the help of a lactation professional. Premature infants are at great risk for feeding difficulties due to the immaturity of their digestive system and will need to complete a large part of the maturation process before discharge from the NICU is possible.

In an online publication by the Hospital for Sick Children, the point is emphasized that problems related to feeding and digestion in the neonate are not necessarily pathological conditions (such as malformations of the GI tract or intestinal infections) but could simply be that the digestive system (beginning with the mouth), has not had



*Image credit Clavey 2*

enough time before birth to mature (Sick Kids Hospital Staff, 2009). And while maturation takes place over time it's important to be mindful that it is a dynamic process which is influenced by outside variables such as composition of first feeds, method of feeding or external stimulus.

Dr. Morais, a pediatric gastroenterologist, contends that understanding normal development of the GI tract is beneficial for understanding how these babies, especially those born prematurely, transition to a normally functioning gut. He states that,

“the intestine undergoes a rapid morphological growth process in terms of length and absorptive surface...the intestinal length grows from 50 cm in the middle of pregnancy...approximately 100cm in the weeks before birth and 200 cm in the first weeks of life” (2016).

Interestingly, he also mentions that “colostrum is an important stimulus for this process (2016). So while there is a natural progression of intestinal development, the outside variable of mother’s colostrum can positively influence the course of the development.

Another example that illustrates the dynamic nature of digestive system development is the influence of microbes on gut development. Cong et al. stated that “the body of research in animal models suggests that the gut microbiota can affect physiological programming and that there is a “window of vulnerability” within which the gut microbiota can affect physiological function, with potentially lifelong consequences” (2016). These same authors state that “the development of the gut microbiome is influenced by multiple factors, such as delivery mode, feeding, medication use, hospital environment, early life stress and genetics. The dysbiosis of gut microbiota persists in during infancy, especially in high-risk preterm infants who experience lengthy stays in the NICU.” (2016). With this in mind, variables that may disrupt the maturation process should be carefully assessed and addressed in the care received at birth. Making good use of this insight necessitates understanding key details of digestive system’s prenatal development.

In the interest of providing accurate information to the parent about the child’s physical condition, it is important for the bedside nurse to have a solid understanding of relevant physiological stages of pre- and post-natal development and obstacles that may impede this process. It is of great benefit to condense this information to its most relevant understandable points for caregiver education and

relay strategies to help support the child’s maturation process. Assessing caregiver readiness for this education and communicating this to other appropriate NICU team members can greatly benefit the collaborative effort to care for the child. This team approach can benefit the infant greatly and provide the framework for the infant to make a smoother transition out of the NICU and into life at home.

Highlights of gastrointestinal (GI) system development before birth:

The process begins with cell differentiation after the gastrulation phase of early embryological development. Fifteen days after fertilization the germ layers (ectoderm, mesoderm and endoderm) are differentiated in the newly implanted embryo. The innermost layer, the endoderm, will become the greater portion of the digestive tract including smooth muscle tissue (Martini, 2017) eventually giving rise to the foregut, midgut and hindgut.

<b>Table 1</b>		
<b>Digestive structures arising from different gut regions</b>		
Foregut:	Midgut:	Hindgut:
Cranial: <u>pharynx (nasopharynx, oropharynx, laryngopharynx)</u> ; <u>Esophagus, stomach, duodenum</u> (cranial half), liver*, gallbladder*, pancreas*	Remainder of <u>duodenum</u> (caudal half), <u>Jejunum, ileum,</u> <u>cecum, appendix, ascending</u> <u>colon, hepatic flexure of colon,</u> <u>transverse colon</u> (proximal 2/3rds)	<u>transverse colon</u> (distal third), <u>splenic flexure, descending</u> <u>colon, sigmoid colon, rectum</u>
(Duke University Medical School, 2015)		
Underlined: <u>major organs of digestive tract</u> ; *accessory organs of digestive system (Martini, 2017)		

Portions of the system will also include ectoderm derivatives that generate components of the enteric nervous system (ENS) and mesoderm layers which give rise to intestinal stem cells (Morais, 2016).

Intrinsic innervation of the digestive tract is provided by the (ENS) which is established between the 4<sup>th</sup>

and 7<sup>th</sup> week of gestation (Perin, 2017). The ENS is influenced by both the primary divisions of the autonomic nervous system (Martini, 2017). Intestinal segmentation develops during the 10<sup>th</sup> week of gestation (Morais, 2016). Motility continues to be “disorganized after the 24<sup>th</sup> week of gestation” and continues to improve until around the 36<sup>th</sup> week (Morais, 2016). Recycling of amniotic fluid by the fetus begins after the first trimester. This occurs as the fluid is swallowed and urinated continuously (Delisle, 2017). Although the ability to do this is possible around 28 weeks, the process does not reach maturity until around 33-34<sup>th</sup> week (Foster, 2016) when the oropharyngeal coordination needed to safely ingest liquid after birth is typically developed. For this reason, babies born before this timeframe are typically given gavage feeding via nasogastric tube (NG). In the case of an immature neonate too young to properly digest enteral nutrition, intravenous or total parenteral nutrition (TPN) may be needed until the necessary motility and adequate digestive enzymes are produced.

The intestines have been noted by Morais as being “of the most complex organs in the body” (2016). Not only does this part need to be functional but it must also work in conjunction with the other body systems to sustain life and harmonize properly before and after birth. Morais mentions two variables involved in this dynamic process:

“In addition to the digestive and absorptive functions, there are also the intestinal endocrine system (involved in the regulation of systemic levels of nutrients and feeding behavior) and the so-called intestinal barrier, which prevents the passage of the intestinal contents, including microorganisms, into the body (2016).

If a part of the process is affected by immaturity or in some other way kept from functioning, the ingestion-digestion-absorption-elimination process of the digestion system will be impaired to some degree. Signs of feeding intolerance will be observed.

Readiness of the digestive system for enteral nutrition:

In addition to the development of the GI system along with the successful integration of pertinent body systems, there is also a progression of increased exocrine function that continues postnatally. This correlates with the digestive system's readiness for processing nutrients. Lee and Lebenthal state that "overall digestion of lipid, protein and carbohydrates in infants depends to a large extent on the state of the maturation of the exocrine pancreatic function" and they also caution that, "neonates are amylase and lipase deficient in the first few months of life has to be taken into consideration when triglycerides and complex carbohydrates are fed to very young infants" (Lee, 1993). Therefore, if the neonate is able to ingest nutrients enterally it is ideal to provide the most appropriate form of nutrition for their developmental state.



*Image credit Clavey 3*

Recognizing breastmilk as the superior source of nutrition is, for the most part, standard clinical priority for neonate consumption whenever possible. Research has confirmed the unparalleled qualities of human colostrum and breastmilk compared to even newer hydrolyzed preemie formulas which do not require enzymes for initial digestion of the nutrients. Echoing numerous recommendations based on the research about superior nature of breastmilk compared to formula, a recent British Journal of Medicine editorial made the case that "formula feeding, whether the formula is hydrolyzed or not, cannot replicate the complex and adaptive constituents of breast milk and the benefits of breast feeding for mothers or babies" (Lodge, 2016). Additionally, the American Academy of Pediatrics (AAP) recommends human milk over formula for premature infants. The AAP connects human breast milk with decreased risk of "developing necrotizing enterocolitis (NEC), sepsis and mortality, improved tolerance of feeding, earlier

attainment of full enteral feeding, and improved long-term growth and neurodevelopment” (American Academy of Pediatrics, 2012).

In the interest of supporting the mother’s of NICU babies, the bedside nurse can offer encouragement and motivation to help the mother establish and maintain milk supply after birth. Even if the infant is not yet ready to safely eat orally, breastmilk can be pumped and either gavage or bottle-fed. The infant’s GI system will greatly benefit from this source of nutrition which is the main objective. Assessing the knowledge base of the mother and then providing appropriate information about the benefits of breastmilk can help mothers persevere in the arduous task of around-the-clock pumping. The nurse can also watch for signs of the mother having lactation issues and recommend the help of an expert in this field. Lactation consultants and NICU speech & language pathologists (SLPs) are excellent sources of information, training and support for women in all stages of the breastfeeding journey—even if bottle-feeding will become the ultimate goal for the infant. This is especially important during the time period where the infant remains in the NICU while the mother is discharged after delivery. This time frame is critical to have lactation support and consultation in order to maintain milk supply during this very stressful and unusual circumstance.

#### Effects of feeding techniques on long-term positive response to feeding

While the immature infant is receiving nutrition through the NG tube, oral feeding may begin when deemed appropriate. Regardless of whether a woman is able to breastfeed, is pumping breastmilk or choosing to use formula, the process of getting the infant to consume nutrition orally is a task that calls for a deliberate plan to make the experience a positive one for the infant. Parents and caregivers need to be prepared for a potentially lengthy process that requires patience.

Catherine Shaker, MS, CCC-SLP, BRS-S makes the point that “in the NICU, preemies are developing motor and sensory neuropathways (and that) stress during feeding...may alter sensory-motor



pathways in the brain that guide the infant away from feeding and affect the ability and desire to feed” (Shaker, Reading the Feeding, 2013).

Shaker is among a growing number of experts in swallowing and feeding who urge caregivers, especially NICU nurses, to understand and use cue-based strategy to guide decisions about feeding. By advocating for a change in the definition of successful feeding, from a volume-driven approach to one that assesses infant cues and respects physiological signs of readiness and tolerance to feeds, the infant stands a better chance of having a long-term positive response to feeding. With the NG tube able to deliver whatever amount of feed is remaining after an infant communicates that they are done eating, volume goals can be maintained but not forced at the expense of making the infant physiologically unstable. Shaker maintains that “increased intake will come with positive learning” (Shaker, Reading the Feeding, 2013).

Going back to the idea of the physiological maturity of the preterm infant when it comes to digestion, learning infant cues about readiness or resistance to oral feeds puts the NICU nurse in a prime position to determine where an infant may be on the continuum of digestive system maturation. Shaker proposes that we observe for signs of instability during feeds. Some of these signs include a change in state of alertness, change in cardio-respiratory behavior (such as slowed heart rate, rapid breathing, nasal flaring, or unstable

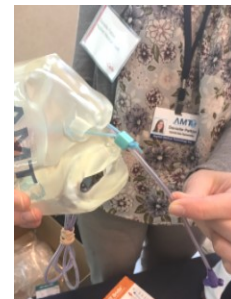
## The AMT BridlePro



Image credit AMT

An interesting note about potential discharge from the NICU earlier with an NG tube: The new AMT BridlePro NG tube is anchored to the vomer bone and not taped to the face.

Image credit Clavey



Time will tell if this device will be beneficial for babies who truly are just needing more time to develop oral coordination and not yet ready transition away from gavage feeding. Without the fear of pulling the tube out, some otherwise stable babies could potentially leave the NICU and continue the process of oral

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saturation), gulping, gurgling sounds on the pharynx (Shaker, Reading the Feeding, 2013). All of these signs should give caretakers pause when assessing readiness to eat.

Caring for a preterm infant in the NICU can be a long and unpredictable commitment for many parents. Depending on the level of physical development at birth, immaturity of the digestive system in particular can impact the length of time it takes to finally be discharged from the hospital. Health care providers can greatly impact those in their care by remaining mindful that infant gut maturation is a dynamic process which can benefit from appropriate nutrition and feeding technique. With a solid understanding on relevant physiological neonatal development, NICU nurses in particular are in a prime position to help parents learn ways they may support their babies continued development and long-term positive response to feeding.

*Image credit Clavey*



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