Necrotizing Enterocolitis in the Neonatal Intensive Care Unit (NICU): Case Control Review

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4-14-13
Background

Necrotizing enterocolitis (NEC) is the leading cause of morbidity and mortality among premature infants in the neonatal intensive care unit (Lin, Nasr, & Stoll, 2008). The infants most susceptible to developing NEC are those who are of premature gestation (32 weeks or less), (Morgan, Young, & McGuire, 2011), and/or of very low birth weight (VLBW, 1500 grams or less), (Morgan et al., 2011; Gephart, McGrath, Effken, & Halpern, 2012; Adamkin, 2012). Full term infants can also be affected by NEC but typically have a specific causative factor such as sepsis, cardiac anomaly, or hypotension (Berman & Moss, 2011; Gephart et al., 2012). Mortality rates of infants with NEC are 30 to 40% of all reported cases of NEC that require a surgical intervention (Gephart, McGrath, Effken, & Halpern, 2012). The high mortality rates are seen in the earlier gestation and lower birth weight infants (Berman & Moss, 2011). There are many risk factors that may contribute to NEC, but prematurity is a common risk factor that has been identified (Horton, 2005). Factors that often coincide with the treatment of preterm infants which may also be causative risk factors for NEC include the use of antibiotics, the presence of a patent ductus arteriosus (PDA), and the placement of umbilical lines. Another accepted epidemiologic precursor for NEC along with prematurity is gastrointestinal feedings (Kamitsuka, Horton, & Williams, 2000). The Vermont Oxford Database reported that the incidence of NEC ranges overall from 5.6 to 7.2% and 7% was reported by the National institute of Child Health and Development (Schurr & Perkins, 2008).

Families of infants with NEC face both financial and emotion burdens. Infants diagnosed with NEC whom are managed medically, incur on average, an additional 22 hospital days and $73,700 in hospitalization costs more than other premature infants (Gephart et al., 2012). If
surgical intervention is necessary, an additional 60 hospital days and approximately $186,200 more in costs are incurred on average (Gephart et al., 2012).

**Significance**

NEC is the most common and serious acquired intestinal illness in premature infants, which places a stressful burden on the infant, family, and medical institution. Given the significant morbidity, mortality, cost, and hospital stays that are associated with the incidence of NEC and the above average rates of NEC in the institution for which this research was proposed, the need for quality improvement is affirmed. With so many confounding variables found in the premature infants who develop NEC, further investigation proved to be important to identify those variables that have statistically significant influence on the development of NEC in the study population.

An additional risk factor is related to gastric feedings and feeding schedules. Patole and Klerk (2005) found that 90% of verified cases of NEC occur in infants that had received gastric feedings. This also suggests that NEC has an iatrogenic component related to feeding regimens and strategies (Patole & Klerk, 2005). Schurr and Perkins (2008) stated that the key to NEC prevention is to follow a standardized feeding regimen and to use human expressed breast milk exclusively. Within the Midwestern medical center where the research was conducted, the rates of NEC reported to the Vermont Oxford Network Database were between 9% and 13.2% in 2008 to 2010. Similar institutions during that same time reported an average of 8.1 and 9.9% (Vermont Oxford Network, 2011).

**PURPOSE STATEMENT:** The purpose of this scholarly research project was to conduct a retrospective chart review on infants less than 32 weeks gestation and diagnosed with NEC who were admitted to the selected NICU from January 1, 2006 to November 1, 2012. The key
common contributing factors described coinciding with prematurity, enteral feedings, product fed including timing and rate of feeding, antibiotic use, presence of a PDA and the use of umbilical lines.

**Middle Range Theory**

**Description**

A theory of health promotion for preterm infants based on Levine’s conservation model of nursing (Mefford, 2004) has a focus on total wellness of the preterm infant. Mefford (2004) explains that any type of disruption between the internal environment and external environment equals a disruption in health. Therapeutic and supportive interventions by the nurse aim to restore a state of wholeness or health of the patient (Mefford, 2004).

The premature birth of an infant is a disruption of normal intrauterine growth and fetal development. The premature infant was fully capable of survival in utero, but is not quite ready for extrauterine life, requiring the facilities offered by the neonatal intensive care unit. This is classified as disruption of wholeness. Disruption of wholeness is characterized by threat to the balance of energy, threat to structural integrity, threat to personal integrity, and/or threat to social integrity (Mefford, 2004). The premature infant and his/her family will respond to the disruption of wholeness with adaptive change. The nurse’s responsibility is to implement interventions that support the adaptive efforts of the infant and family. Along with the interventions, the nurse will also support the overall goal of wholeness with the conservation of energy, structural integrity, personal integrity, and social integrity (Mefford, 2004).

To evaluate the effectiveness of the theory there are four criteria used to evaluate the outcome of the nursing care. The infant is evaluated by the physiologic stability and growth,
minimal structural injury, neurodevelopmental competence, and the stability of the family with
the inclusion of the infant into the family (Mefford, 2004).

Application

In relation to the conceptual model of health promotion for the preterm infant, the
diagnosis of NEC is an example of a disruption of wholeness. Within the disruption of
wholeness a threat to the balance of energy translates to the lack of physiologic maturity of the
infant. Threat to structural integrity is the potential for injury during the NICU stay. Threat to
personal integrity is the lack of neurologic and sensory maturity. Additionally, this disruption
has a negative impact on the family dynamic is a threat to social integrity.

Supportive care interventions that support the adaptive infant in the NICU include
standardizing a feeding regimen for the advancement of feedings and monitoring for sign of
feeding intolerance with gastric feedings. The evaluation of feeding intolerance fits in the
intervention of conserving structural integrity. Interventions to conserve energy of the infant
include the monitoring of the pulmonary and cardiovascular systems during the transition from
intrauterine life to extrauterine life. Ensuring the infant is adequately oxygenated will promote
proper cellular function. Adequate oxygenation to the gut is important to the prevention of NEC.
Nursing attempts to conserve the personal integrity of the premature infants are confounded by
the infants’ immature nervous system. The only way an infant can communicate is with
behavior; the nurse’s ability to interpret the behavior of the infant helps to evaluate
neurodevelopmental actions.

Social integrity is related to the family and their ability to cope. They have to deal with
many crisis situations: the premature birth of their child, disruption in bonding and attachment,
and the illness of a family member. The family should be part of the multidisciplinary team to
reinforce their ability to help make decisions regarding the care of their child. These interventions are intended to conserve the wholeness of the infant and their family during this disruption of wholeness.

Literature Review

Pathophysiology

The pathophysiology of NEC is unclear and not well-defined within the literature. The evidence is related to the prematurity of the intestinal tract resulting in reduced gastrointestinal motility, digestive ability, circulatory regulation, barrier function, and immune defense. NEC occurs when there is inflammation of the bowel from some insult, which then creates an immune response (Berman & Moss, 2011). Ischemia and potential necrosis of the gut wall is caused by the inflammation and immune response that causes a release of cytokines that attack the wall of the gut (Berman & Moss, 2011). Gastrointestinal motility begins in the second trimester but is not fully mature until the third trimester (Lin, Nasr, & Stoll, 2008). Most likely NEC is multifactorial in the setting of a stressed gut with immature protective mechanisms (Gregory, 2008). Berman and Moss (2011) also agree that immaturity of the neonate gastrointestinal system and an immature immune system make the premature infant susceptible to NEC. There are many hypothetical factors that may contribute to NEC. Circulatory alteration, infection, enteral feeding, feeding regimen, hypoxia, and vascular compromise are all implicated as potential causes of the initial insult that trigger the development of NEC (Gephart, McGrath, Effken, & Halpern, 2012), but the true cause is unknown.

Stages

There are three stages of NEC according to Bell’s staging criteria. Stage one is suspected NEC. Systemic signs of stage one NEC include body temperature instability, apnea, and
bradycardia. Intestinal signs may include an increase in gastric residuals, mild abdominal distention, and occult blood in stool. Abdominal radiograph of stage one NEC may be normal or show some distention with mild ileus. Systemic signs of stage two would be the same as stage one with the addition of mild metabolic acidosis and some mild thrombocytopenia. The intestinal findings of the neonate with stage two NEC include the findings of stage one plus the absence of bowel sounds, abdominal tenderness, abdominal cellulitis, and right lower quadrant mass. Abdominal radiograph reveals significant intestinal distention with ileus, edema in the bowel wall, pneumatosis intestinalis, and portal vein gas. Stage three NEC may have the previously listed symptoms, plus hypotension, respiratory acidosis, disseminated intravascular coagulation, and neutropenia. Overall the neonate with stage three NEC would present with signs and symptoms of deterioration and evidence of septic shock. Abdominal radiograph may show pneumoperitoneum in addition to the other findings in stages one and two (Bell et al., 1978).

Prevention

The etiology of NEC is unclear, so the prevention is related to the risk factors identified that potentially contribute to NEC. The patient population identified to be at greatest risk is those infants weighing between 500 and 1500 grams and born prior to 28 weeks gestation (Gregory, 2008).

Another prevention strategy could focus on feeding strategies and infectious characteristics of the gastrointestinal tract (Henry & Moss, 2008). Studies of feeding strategies, including supportive data of the benefits of a standardized feeding protocol, and further investigation in the use of arginine supplements are warranted. Henry and Moss (2008) investigated the effectiveness in arginine supplements preventing NEC. The outcome of the small study was
optimistic, but the sample size was small. Further research in to the effectiveness of arginine supplementation is needed.

**Treatment**

NEC can also be classified as surgical or medical. Regardless of the classification, once the signs of NEC are identified treatment should begin immediately. Surgical NEC, focal perforation noted on radiograph, is managed depending on the weight and stability of the patient. For infants less than 1000 grams or those that are too unstable to go to the operating room, a peritoneal drain is placed to remove the air and stool to allow the affected area to heal (Morgan et al., 2011). For infants that are able to go to the operating room, the standard of care is a laparotomy with resection and creation of an enterostomy (Horton, 2005). Without the presence of an intestinal perforation, the treatment of medical NEC includes NPO, antibiotics, and supportive care.

**Feeding Regimen**

When examining feeding regimens of the premature infant there is not a standard recommendation. Gephart et al. (2012) reported a decrease in the risk for NEC by 87% by utilizing a standardized feeding regimen. This apparent association of lower NEC rates and a standardized feeding protocol reveals a need to explore the literature to provide further recommendations to initiate a well-defined feeding guideline. Currently, there are too many variables to make clear assumptions on the best feeding plan for the premature infant.

The timing of the introduction of milk feedings, the rate of their advancement, and concentration of the feeds are key areas for further study in developing a feeding guideline to prevent NEC (Henderson, Craig, Brocklehurst, & McGuire, 2009). Patole and Klerk (2005) looked at six different studies to compare different feeding guidelines to their own and found no
common themes present that produced a concrete recommendation. Within the results of one benchmark study Uauy et al. (1991) suggest that NICUs that introduce enteral feedings earlier and advance feeding volumes more quickly tend to have higher incidence of NEC.

One possible variation to the feeding regimen includes initiating trophic feedings, small volume feedings, for some number of days before advancing to a goal of larger volume feedings. The idea behind this is to prime the gastrointestinal tract.

There is a higher incidence of NEC with infants that were increased to goal feedings by 20 milliliters per kilogram per day from the first day of feeding versus maintaining 20 milliliters per kilogram per day for 10 days (Berseth, Bisquera, & Paje, 2003). Of those infants with rapid advancement, 10 percent were diagnosed with NEC, versus 1.4 percent of the infants with 10 days of gut priming trophic feedings. Enteral fasting has not shown to decrease the incidence of NEC when compared with early trophic feedings (Bombell & McGuire, 2008). The review done by Bombell and McGuire also found that it is recommended that the feeding volume be advanced by 15-35 milliliters per kilogram per day when an infant is judged ready by the provider to tolerate feeding advancements. Gephart et al. (2012) indicated that by standardizing a feeding regimen the provider is able to closely watch for signs of feeding intolerance along with the feeding advancement since it is well detailed in the guideline. This attention to detail is part of the successful prevention in NEC.

**Human Milk**

The National Association of Neonatal Nurses released a position statement regarding the use of human breast milk and breastfeeding, stating that the use is essential for providing optimal health in the most critically ill neonates (National Association Of Neonatal Nurses, 2009). Human milk contains immunologic and anti-infective properties that have been identified to
protect infants against NEC (Sisk, Lovelady, Dillard, Gruber, & O'Shea, 2007). Sisk et al. (2007) indicates that breast milk has a number of healthy organisms, that when introduced to the infants gut, can prevent the overgrowth of pathologic bacteria that can cause NEC. These same protective qualities found in mothers expressed breast milk are not found in donated human milk from a bank (Henderson, Craig, Brocklehurst, & McGuire, 2009). This can conclude that mother’s expressed breast milk does not compare to donor-banked milk. Many institutions use formula versus donor breast milk due to the cost of donor breast milk. Donor breast milk costs three to four dollars per ounce (Ganapathy et al., 2012). Although the cost is far more than formula, for every dollar spent on donor breast milk the state can save up to $11 on medical bills (National Association Of Neonatal Nurses, 2012). Medicare and some private insurance companies have recently chosen to cover the cost of the donor breast milk.

When compared to bovine-based infant formula and fortifier, human milk has shown to have many benefits. Bovine-based milk includes infant and preterm formula, and human milk fortifiers. Often human milk is fortified with a bovine product to add more calories and nutritional supplements to a preterm infant to optimize growth. A limitation to using human milk is the inability for the mother to supply appropriate volumes of milk for the preterm infant. In a study done by Schanler, Lau, Hurst, and Smith (2005) only 30% of the mothers of premature infants were able to supply 100% of the infants needs.

Infants that were exclusively fed human milk had a reduction of 50% in medical NEC and 90% in surgical NEC compared to those infants that received bovine products (Sullivan et al., 2010). The infants that received breast milk fortified with a bovine product had a moderate drop in the incidence of NEC, but there were minimal studies done related to the fortification of breast milk and the correlation of NEC. One limitation of the research related to breast milk and bovine
products is the lack of complete blinding, which is often not possible. There are many types of fortifier used in the NICU and there are not many studies looking at each specific fortifier. Examples include human milk fortifier, medium-chain triglyceride oil, and protein powders. A donor human milk based fortifier is another option for use to prevent the exposure to bovine products (Sullivan et al., 2010). This fortifier is expensive, approximately $6.25 per milliliter, which can be a restrictive factor (Ganapathy et al., 2012).

Antibiotics

Antibiotics have also been implicated as a contributing factor for NEC. A multivariable analysis of 365 preterm infants <32 weeks gestation and 1500 grams or less found that prolonged early antibiotic therapy > 5 days was independently associated with the composite outcome of length of stay, NEC, or death (Kuppala, et al. 2011). For each day of initial empirical antibiotic therapy, the odds of increased length of stay, NEC, or death increased significantly. A part-blinded randomized control trial of 112 preterm infants conducted over nine months determined that routine antibiotic use in preterm infants did not have any protective effect. A secondary outcome of this study showed that infants receiving antibiotic therapy had a higher rate of NEC (Tagare et al, 2010). A retrospective review by Clark et al. (2012) found that broad spectrum antibiotics such as ampicillin and gentamicin at the time of diagnosis of NEC were associated with better survival rates versus clindamycin which was associated with an increased risk of death.

PDA

Normal transition of the neonate from fetal circulation to extrauterine life is a complex process that normal term newborns generally accomplish without complications. The patent ductus arteriosus (PDA) is needed for fetal circulation to shunt the blood flow away from the
lungs. At birth there are many contributing factors in the closure of the PDA, mostly oxygen and vasoactive substances, and it should begin to close immediately after birth then functionally close by 96 hours of life (Blackburn, 2007). The ductus arteriosus is less likely to close spontaneously in the premature infant.

The PDA may increase the risk for developing NEC because of the reduced blood flow to the mesenteric artery, which supplies the blood to the bowel (Dollberg, Lusky, & Reichman, 2005). The blood flow to the mesenteric artery is thought to be decreased due to reversal of the blood flow in the aorta due to the PDA. The blood is pulled from the mesenteric artery into the aorta and back through the PDA causing the lack of perfusion to the bowel. It is not clear whether the increased risk for NEC in an infant who has a PDA is due to the interruption of mesenteric blood flow or if the treatment for the PDA could be contributory. In either case the etiology is related to an altered blood flow in the bowel which is compounded by the enteral feeds that the infant receives.

**Umbilical Lines**

A study by Rand et al. (1996) suggested the impairment of mesenteric blood flow by an umbilical artery catheter (UAC) could be a potential cause for NEC. Concern for this may have attributed to the perception that UACs themselves contribute to NEC and if enteral feeds were started, this could have the potential to exacerbate the problem further. However, a small prospective randomized study by Davey et al. (1994) determined that premature infants who were fed with umbilical artery catheters in place had no increase in necrotizing enterocolitis or feeding intolerance compared to those who were not fed. This is one of the few studies that looked specifically at UAC placement and its relationship to NEC. Although the results did not show a correlation between umbilical arterial lines and NEC, intensive care units around the
country continue with protocols that involve not beginning enteral feeds with a baby who has a UAC.

**Methods**

**Design**

The purpose of this scholarly project was to perform a retrospective chart review to conduct a case-control study on infants less than 32 weeks gestation and diagnosed with NEC who were admitted to the selected NICU from January 1, 2006 to November 1, 2012. The infants in the case and control groups were matched for the following variables: birth weight, gestational age at birth, and gender. The variables which were collected from each patient chart included: the day of life when feeds were initiated, the day of life when full feeds were achieved, whether or not each patient received formula, breast milk, or human milk fortifier, if the infant received antibiotics, and the presence of PDA. This project was part of a non-experimental quality improvement analysis to examine infants less than 32 weeks gestation, less than 1500 grams diagnosed with NEC.

**Sample and Setting**

The sample population was comprised of infants less than 32 weeks gestation. The sample population was drawn from a Midwest neonatal intensive care unit in a large urban academic hospital. Upon initial review of the data, it became apparent performing a case-control study rather than a simple retrospective review could strengthen the study. Inclusion criteria were gestational age, weight, date of birth, and in the case group, those diagnosed with Stage II NEC or greater. With the help of a data abstractor, the cases of NEC were matched with a control group using their gestational age, birth weight, date of birth, and sex. Of the documented cases of NEC, we excluded those with Stage I NEC or suspected NEC, only including those with Stage II
or greater according to Bells Staging of NEC. Other exclusion criteria included any out born infant who initiated feeds or was diagnosed with NEC prior to admission to the facility. The sample size was 38 case and 38 control infants. Of note there were some infants who were included in the study due to random selection that were never fed. In the case group there were 4 infants and in the control group there were 6 infants who were never fed. This did have an impact on the variables that were feeding related.

Ethics

Permission to conduct this study was obtained by the Office of Research and Compliance at Creighton University and the Institutional Review Board (IRB) of the hospital in which the study was performed. As a quality improvement project, the study qualified for IRB exempt status. In addition, verbal approval was obtained from the Neonatal Intensive Care Unit managers and the primary physicians of the subjects. The benefit-risk ratio was assessed for this quality improvement project, indicating minimal risk secondary to the retrospective nature of the study and important benefits for noting statistically significant variables in those who develop NEC versus those that do not.

Measurement

No patient identifiers were used in this study. Each patient in the case and control groups was given a random number. Two data collection tools (Appendix A and B) were designed that included the variables for which the infants were matched as well as the variables that were identified as risk factors for the onset of NEC.

Some of the variables identified required further defining including; day of life when at full feedings, antibiotics, and PDA. The day of life at full feeds was determined when the infant reached full volume and full caloric feeds. Antibiotics were relevant if they had been started
within the first week of life and were administered for greater than five days. A PDA was relevant if diagnosis was confirmed with echocardiogram.

**Procedure**

Upon completion of the proposal and completion of the data collection tool, the data collector was contacted to extract the data relevant to the study. A control group and randomly selected case group were identified based on the inclusion criteria. The chart review was done to extract the necessary variables for each case and control patient. Upon completion of the chart review, the services of a statistician were utilized to identify the appropriate statistical measurements for the study.

**Results**

The initial study population was comprised of 66 patients with NEC. Four cases were eliminated based on the exclusion criteria of an out born infant who initiated feeds or was diagnosed with NEC prior to admission to the facility. Twenty-four additional cases were eliminated based on the exclusion criteria of Stage I NEC or suspected NEC. The final study sample contained 38 case infants who developed stage two or greater NEC and 38 control infants who were matched by gestational age, sex, and weight to their case counterparts.

When comparing the variables, for which the case and control groups were matched, a matched pairs statistical analysis was performed to determine the p value that was equal to the difference between these variables in each group. There was no statistically significant difference between the gestational age (p = 0.63), sex (p = 0.49), and birth weight (p = 0.28) between the case and control groups.

The first two variables studied were day of life when feeds were initiated and day of life when full feeds were reached. When considering the means, standard deviations, and calculating
a Wilcoxon signed rank test, both of these variables showed statistical significance between the case and control groups. The case group started feeds at a mean difference of 3.25 days later with a standard deviation of 2.06 days, and a p-value equal to 0.045, which represents the difference between the case and control group. The case group achieved goal feedings earlier, with a mean difference of 16.08 days and standard deviation of 6.49. This difference from the control group was significant at the p-value of 0.004.

When considering the product fed to infants in both the case and control groups, the means were analyzed and a McNemar’s test was performed to obtain a p value. Of those infants who received straight breast milk, there was an insignificant difference between the case (91%) and control (79%) groups with p-value of 0.20. Infants who were fed breast milk with fortifier showed a p-value of 0.25 with 76% of the control and 83% of the case infants receiving this form of food. The infants who were fed formula had a p-value of 0.083, which showed no statistical significance between the case and control groups. Formula feeding did initially seem to show significance with a p-value of 0.03 however when examining the data it was significant in that 21% of the infants in the case group were fed formula versus 42% of the control group. Of note, four infants in the control group and four infants in the case group died prior to the initiation of feeds.

No statistical significance was found with antibiotics administered in the first week of life for 5 days or more, with a p-value of 0.17 using McNemar’s statistical analysis. No statistical significance was found with the presence of a PDA using the McNemar’s test with a p-value of 0.317. Data was collected on umbilical lines, however no statistical analysis was performed as all infants in both the case and control groups had umbilical lines.
Discussion

Based on the review of literature, we expected to find a significant difference between case and control groups with most of the variables. However, the only statistically significant variables were the day of life at initiation of feedings and the day of life when full feedings were achieved. Using a larger sample might increase the power of the study and therefore show more significant values in some of the variables. For future studies, further defining the variables with time ranges might give more meaning to the significance of the variables.

It is important to note that all of the variables regarding feeding (i.e. product fed, day of life at start of feeds etc.) were affected by the fact that four of the case infants and six of the control infants never received feedings. This was due to death or development of NEC prior to the start of feedings. These infants were not eliminated, as it would have jeopardized the randomization of the sample.

The literature has proposed that there may be some correlation between umbilical lines and NEC. However, this study was unable to assess a correlation because umbilical lines were present in all the control and case groups. Further research is needed to determine if there is a correlation between patients that have umbilical lines and an increased risk for NEC.

The finding of a statistical significance in the day of life that feedings were started correlates with the literature. Upon discovery of this statistical significance additional literature was reviewed, which suggests minimal enteral nutrition (MEN) feedings in the first days of life is a good idea, in comparison to no feedings in the first days of life. This concept consists of administering 1 milliliter of feeding to the infant every 12 hours for 3 to 5 days before trophic feedings are started. According to Mishra et al, (2008) this type of enteral nutrition is found to be of value in helping the intestines mature and decreasing the risk of NEC.
The finding of a statistical significance in day of life when infant achieved full feedings, with the control group getting to goal later, may be interpreted to mean that going slower is better when advancing feeds. The statistical significance of these two variables would support change in when and how feedings are started, advanced and brought to goal in the institution.

Standardized feeding protocols, which include MEN feedings, might offer an alternative to the current feeding regimens.

**Limitations**

The study is limited by the unknown pathogenesis of NEC, and the variable acuity of the patient population that cannot be controlled. This is a non-experimental design, and a single center study that limits the number of infants involved. This also limits the variety of infants available for study during the timeframe specified. The infants were matched as closely as possible within the constraints of the population available. The design of this single center study limited our comparison for data with other centers, however results were compared to published studies. A power analysis was not performed prior to the scholarly project and the sample size was relatively small.

**Conclusion**

After reviewing the results of this case control study it can be concluded that the only statistically significant variables were the age when feedings are initiated and the length of time it took to reach full volume and full calorie feeds. This reiterates the need for a standardized feeding protocol for infants <32 weeks and less than 1500 grams. These findings may also support the concept found in recent literature, which suggests using MEN feedings for infants of this gestational age, however further studies are needed (Taylor et al, 2010).
With the many unknown variables related to necrotizing enterocolitis there is a need to identify markers of NEC to improve the prevention, early diagnosis, and treatment. Without further investigation, NEC will remain unpredictable and continue to be a devastating disease to infants and their families.


# Appendix A

## NEC Data Collection Tool

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<th>Birth Weight</th>
<th>GA at Birth</th>
<th>Sex</th>
<th>DOL at Start of Feeds</th>
<th>DOL at Full Feeds</th>
<th>Breastmilk</th>
<th>Breastmilk w/ fortifier</th>
<th>Formula</th>
<th>Abx Y/N</th>
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## Appendix B

### Control Group Data Collection Tool

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