Early Nutrition and Weight Gain in Preterm Infants with Bronchopulmonary Dysplasia

A Senior Honors Thesis Presented in Partial Fulfillment of the Requirements for the

Degree of Bachelor of Science in Nursing with Distinction

College of Nursing of The Ohio State University

By

Cara Marie Karn

* * * * *

The Ohio State University

2004

Approved by

Advisor

College of Nursing

Abstract

Purpose of the Study: Preterm infants born at or before 28 weeks gestation are at high-risk for the development of respiratory distress due to their underdeveloped lungs. One of the complications that arises as a result of the management strategies used for respiratory distress is bronchopulmonary dysplasia (BPD). BPD is a chronic lung disease of prematurity that requires supplemental oxygen until at least 36 weeks post-conceptional age. The numbers of preterm infants developing BPD is on the increase due to the improved survival rates of these infants. Providing adequate nutrition and promoting the growth of preterm infants is a significant challenge. Little evidence exists related to the nutritional intake of preterm infants with BPD. The purpose of this study was to compare actual nutritional intake and weight gain in preterm infants with BPD with the recommendations for nutrition and growth in preterm infants during the first 28 days of life.

Research Method: The sample was comprised of 30 preterm infants who developed BPD. All the infants were on the ventilator during the first 72 hours of life for respiratory distress. Data related to nutritional intake and weight gain for the first 28 days of life were abstracted from the infant's medical record. Daily nutritional intake and weights were analyzed using the nutritional software NEONOVA®. This software is specifically designed to analyze the nutrition and growth of newborn infants in the neonatal intensive care unit.

Findings: The average birthweight was 946 grams. The infants received significantly less kcal/kg/day than the recommended 120 kcal/kg/day. During the first week of life, the infants were receiving 68.35 kcal/kg/day. By 28 days of life, the infants were receiving 98.63 kcal/kg/day. The infants did not achieve 120 kcal/kg/day until day of life 27. The result of receiving less than the recommended caloric intake is that the infants had accumulated an energy

deficit of 598.23 kcal/kg by the end of 28 days of life. Further, these infants accumulated a protein deficit of 7.56 grams/kg. The goal for preterm infants is to gain weight at a minimum rate of 15 grams/kg/day. The rate of weight gain for the infants in this study was 11.55 grams/kg/day.

Implications: Preterm infants with BPD are undernourished during the first 28 days of life and, thus gain weight at a slower rate. The slow introduction and advancement of nutrition contributes to this clinical problem. Undernutrition very well may be contributing to the development of BPD. BPD develops because of damage to the immature lungs. Subsequent healing and continued growth and development of the lungs are most likely altered due to the preterm infant being undernourished. If the infant is not gaining weight at an appropriate rate, it could be hypothesized that the lungs also are not growing. The results from this study provide the basis for closely examining current nutritional practices in the neonatal intensive care unit.

Introduction

Bronchopulmonary dysplasia (BPD), defined as the requirement for mechanical ventilation and/or oxygen at 36 weeks postconceptional age, is becoming a more prevalent problem as increasing numbers of extremely immature preterm infants are surviving (Jobe, 2003). An inverse relationship exists between birthweight and the development of BPD. BPD is most common in the most immature infants. Although the incidence of BPD varies across neonatal centers, BPD occurs in approximately 43% of preterm infants with birthweights less than 1000 g (Lemons et al., 2001). The annual cost of caring for preterm infants with BPD in the United States is estimated to be $2.4 billion, second only to the costs of treating asthma in children (NHLBI, 1998).

The pathophysiology of BPD has changed over time. Originally BPD was viewed primarily as a disease of injury to the developing airways. Currently, the pathophysiology of BPD centers around interference with alveolar and vascular development (Jobe, 2003). BPD develops in preterm infants as a consequence of the use of mechanical ventilation and oxygen to manage respiratory distress during the first few days of life (Jobe & Ikegami, 1998). A critical step in the management of BPD is the development of strategies to prevent or minimize the alterations in alveolar development. One strategy receiving attention as a research priority is the evaluation of nutritional interventions in the prevention of BPD (Jobe & Bancalari, 2001). The discussion of nutritional intake in relation to BPD has been focused on the need for specific nutrients to prevent BPD such as vitamins A and E, inositol, and intravenous fatty acids or the need for nutrient-dense formula to promote growth in preterm infants with BPD (Atkinson, 2001; Cole & Fiascone, 2000). An important first step in designing nutritional interventions to prevent BPD is to describe the nutritional intake of preterm infants prior to the diagnosis of BPD.

Literature Review

Because preterm infants are born before the formation of alveoli and the alveolar capillary bed, the development of the extremely immature lungs must occur in the extrauterine environment (Eber & Zach, 2001). Between 26 and 36 weeks gestation, the lungs of a fetus would normally grow in size, volume, and surface area at a faster rate than any other point in life (Langston, Kida, Reed, & Thurlbeck, 1984). Interference with the development during this crucial period could have a lasting affect on the structure and function of the lungs (Frank, Sosenko, & Gerdes, 1998). Typically, the lungs grow in proportion to the rest of the body, so, accordingly, poor general growth severely limits the growth and development of immature lungs (Hodson, 1998; Massaro & Massaro, 1996). It has been hypothesized that undernutrition could contribute to BPD by altering the growth velocity and overall development of the infant and, thus, it's lungs (Frank, Sosenko, & Gerdes, 1998). Providing adequate nutrition often is overlooked while preterm infants are acutely ill during the first few weeks of life. Very little is actually known about the nutritional intake of preterm infants with BPD during this early period. Much of the reported research findings describe nutritional practices after BPD has developed. While researchers have examined growth in preterm infants with BPD, there is a lack of empirical evidence related to growth during the first few weeks of life. Further, little attention has been given to both growth and nutritional intake during the early weeks of life.

Growth

Promoting the growth of preterm infants especially the extremely immature infant is receiving increasing attention. Experts hypothesize that the first weeks of life appear to be a critical time for establishing adequate growth patterns in preterm infants (Bloom et al., 2003; Clark et al., 2003; Radmacher, Looney, Rafail, & Adamkin, 2003). The goal for weight gain in preterm infants is to gain weight at a rate that approximates 15 g/kg/day, the expected intrauterine rate of growth for a fetus (Ziegler, Thureen, & Carlson, 2002). Few researchers have examined the rate of growth of preterm infants with BPD during the first few weeks of life. Most of what is known about the growth of preterm infants with BPD is based on research conducted after the diagnosis of BPD. Researchers who have reported on growth during the first few weeks of life for preterm infants with BPD have demonstrated that these infants exhibit growth faltering within the first two to four weeks of life when compared to comparable preterm infants without BPD (de Regnier, Guilbert, Mills, & Georgieff, 1996; Ehrenkranz et al., 1999). Further, these researchers demonstrated that these infants deposited less fat and lean tissue during this time period. In the only study to report the actual rate of growth during the first four weeks of life, preterm infants with BPD grew at a rate of 8.2 g/kg/day, well below the recommended 15 g/kg/day (Boehm, Bierbach, Moro, & Minoli, 1996).

Because a significant number of preterm infants with BPD are born with birthweights less than 1000 grams, examining the growth trajectories of preterm infants with birthweights less than 1000 grams provides further evidence of the potential for growth faltering that accompanies BPD. Significant numbers of this specific group of preterm infants develop extrauterine growth retardation, weight < 10^{th} percentile, by discharge (Clark, Thomas, & Peabody, 2003). Researchers compared the growth rate of extremely preterm infants to fetuses of comparable gestational age and demonstrated that, after birthweight was regained, the infants' growth rates approximated intrauterine growth rates (Ehrenkranz et al, 1999). Importantly, the researchers also demonstrated that the growth trajectory of these infants had fallen below the 10^{th} percentile by discharge despite approximating the intrauterine rate of growth. These findings were further supported by Steward and Pridham (2002) who compared the growth patterns of extremely preterm infants to fetuses of comparable gestational ages. Researchers have also demonstrated that it is difficult for these infants to maintain an adequate rate of growth (Guzmán et al., 2001; Radmacher et al., 2003). In the above studies, preterm infants with BPD were included in the samples. Based on the reported research, one can hypothesize that preterm infants destined to develop BPD begin to develop growth faltering and altered body composition during the early weeks of life that worsens over the duration of the hospital stay. In recognition of early growth faltering, researchers suggest undernutrition as a contributing factor to this growth deficit (Clark et al., 2003; deRegnier et al., 1996).

Nutrition

There is concern that all preterm infants are undernourished during the first few weeks of life (Clark et al., 2003; Embleton, Pang, & Cooke, 2001). This may be even more pronounced in preterm infants destined to develop BPD. Very little empirical evidence is available describing their nutritional intake prior to the diagnosis of BPD. Anecdotally, clinicians report that preterm infants who are at risk for developing BPD are often the sickest and thus, the most difficult to provide nutrition to. Infants with BPD face problems of undernutrition that may result in poor growth. They may also have special nutrient requirements due to the inability to utilize some nutrients, the need for catch up growth, and the need to use some energy for epithelial cell repair (Atkinson, 2001). It is extremely difficult to provide infants with BPD optimal nutrition as they are often fluid restricted due to their lung disease (Fewtrell et al., 1997; Ryan, 1998; Wilson et al., 1991; Yeh et al., 1989). Studies have found that BPD babies had lower energy intakes from day 7-56 than those of comparable gestational age (Dodge, Halliday, McClure, Reid, Wilson, 1991). The actual nutritional intake of all categories of preterm infants rarely meets the recommended values (Cooke & Embleton, 2000). These major deficits in energy and protein are not recovered by time of discharge. Undernutrition of preterm low birth-weight infants may contribute to their development of BPD as they have decreased natural defenses and ability to repair damaged lung tissue (Cox, Groh-Wargo, Hartline, &Thompson, 2000). Calorically dense formula is often provided to these infants in attempts to stimulate growth despite fluid restrictions (Fewtrell et al., 1997; Puangco & Schanler, 2000). However, using high nutrient formulas for infants with BPD has not yet shown any significantly improved growth or respiratory outcomes when compared with normal preterm formula despite small increases in energy and protein intake (Adams et al, 1997). The current recommendation for energy intake in preterm infants is 120 kcal/kg/day and the daily protein requirement is 3.5-4 grams/kg/day (Cooke & Embleton, 2000). It is hypothesized that preterm infants with BPD require higher energy and protein intakes to sustain growth.

Purpose of Study

Altogether, it is evident that preterm infants with BPD are not receiving adequate nutrition and are experiencing lags in growth. But, not much is known about what nutritional interventions may help to diminish these trends and possibly prevent the development of BPD in at risk infants. No recent conclusive research has been performed that simultaneously explores the nutritional intake and the growth of preterm infants who develop BPD in the first month of life. This first month of life is critical as infants begin the progression towards chronic lung disease during this time period. The purpose of this research study is to examine the nutritional practices in preterm infants that go on to develop BPD in their first month of life in comparison to the recommended requirements.

Hypotheses

Preterm infants with a diagnosis of BPD would:

1). Not achieve 120 kcal/kg/day by 28 days of life.

2). Develop a significant energy deficit by 28 days of life.

3). Not achieve 3 grams of protein/kg/day by 28 days of life.

4). Not achieve growth velocity of 15 grams/kg/day.

Research Questions

1). How does their weight gain trajectory compare to the ideal weight gain trajectory?

2). What is the average caloric intake for each of the first four weeks of life?

3). What type of cumulative energy deficit do these infants develop?

Methods

This study was performed retrospectively and the data were obtained from a review of the medical chart. The subjects were classified as having BPD based on their diagnosis during their stay in the Neonatal Intensive Care Unit (NICU).

Sample

The subjects were recruited from a convenience sample of infants from a midwestern state. The sample included both male and female preterm infants who were hospitalized at the NICU at Columbus Children's Hospital. Preterm is defined as gestational age at or under 34 weeks at the time of birth (Cooke & Embleton, 2000).

Inclusion criteria for the sample consisted of:

- Gestational age = 34 weeks
- Need for ventilator support with oxygen supplementation during the first 72 hours of life
- Diagnosis of RDS in the first 72 hours of life
- Remained in the NICU for the first 28 days of life

Exclusion criteria for the sample consisted of:

- Major congenital anomalies of respiratory, cardiac, gastrointestinal, or oral structures
- Pulmonary hemorrhage
- Periventricular leukomalacia or intraventricular hemorrhage grades III-IV
- Anoxia at birth
- Necrotizing enterocolitis
- Malabsorption disorder
- Evidence of sepsis at 28 days of life
- Use of postnatal corticosteroids

- Major surgery performed during data collection period

Procedure

Human Subjects

The Institutional Review Board (IRB) of Children's Hospital approved this study. Informed consent is not necessary as the patients were already discharged at the time of data collection. Thus, the right to self-determination and full disclosure were not issues for this study. The principal investigator did sign a confidentiality statement in relation to HIPAA guidelines. Confidentiality was maintained by using a code system to distinguish between subject's rather than their names, social security numbers, or hospital identification numbers. Subject's charts were released in increments of 25 and all information was recorded at the hospital in the office of Medical Records. Therefore, there were no risks associated with this study and any benefits that may result from this study would greatly outweigh the risks.

Method of Data Collection

Potential infants were identified by diagnosis through a computer sort in the Medical Records Department. Medical records were then screened to identify infants who met the eligibility criteria. Data from the first 28 days of life was recorded directly from the charts of the first 30 infants who qualified for the study. Variables included were weight, enteral and parental nutritional intake, and amount of oxygen in use if applicable. All data recorded in the medical record was accepted as accurate.

Description of Research Variables and Instruments

Weight and growth velocity

The infants' weights were recorded daily at approximately the same time of day with the infant being nude on an electronic scale or with the use of isolette scales. Scales are the standard of measuring weight in NICUs as they are the most efficient of the valid and reliable instruments.

Growth velocity is defined as grams of weight gain per kilogram per day. To determine growth velocity for each week, the total weight gain in grams for the week were determined and divided by 7. Then, this value was divided by the infant's average weight in kilograms to determine the final value.

Nutritional intake

Nutritional intake is the amount of formula, given enterally or parentally that an infant receives. Nutritional intake was recorded onto the charts to represent the actual volume the infant received, whether it be more or less than the amount prescribed. The daily nutritional intake was calculated and then divided into weekly averages of kcal per day, grams of protein per kilogram per day, and percentage of the kcal that came from fat and carbohydrates each day.

NEONOVA® was used to determine the macronutrient components of the infant's nutritional intake. NEONOVA is a DOS-based program developed and distributed by the Ross Products division of Abbott Laboratories for the nutritional management of high-risk neonates (Ross Products Division of Abbott Laboratories, 2001). NEONOVA contains a database of more than 100 formulas, solutions, and supplements, in addition to charts onto which anthropometrical measurements can be automatically plotted. The NEONOVA database is a very stable source of information, thus resulting in NEONOVA being an overall reliable instrument.

Data Analysis

Descriptive statistics were used to examine the data. Means and standard deviations were used for the interval data and frequencies were used for ordinal data. A correlation matrix was done to see if there were any relationships among the study variables.

Results

The sample was comprised of 30 preterm infants with BPD who met the inclusion criteria. Descriptive data of the sample and nutritional intake are presented in the Table. 57% of the infants were white and 60% were boys. The mean birthweight was 996.2 grams (± 289. 97 grams) and the mean gestational age was 27.8 weeks (± 1.98 weeks). The growth velocity for the first 28 days of life was 11.55 grams/kg/day. This rate of weight gain was significantly less than the recommended 15 grams/kg/day, $t = -5.470$, $p < .000$. The average caloric intake was 68.35 kcal/kg/day during the first week of life, 83.23 kcal/kg/day (± 9.04) after the first two weeks, and 98.63 kcal/kg/day (± 9.39) for the entire first month. This caused an average caloric deficit of 514.7 kcal/kg (± 126.66) for the first two weeks and 598.23 kcal/kg (± 263.08) for the first month (See Figure). The infants also were not receiving as much protein as recommended and accrued an average protein deficit of 7.56 grams/kg (± 7.20) over the first month of life.

Discussion

The purpose of this retrospective study was to compare nutritional intake and growth velocity in preterm infants with BPD to the recommendations for nutrition and growth. To our knowledge this is one of the first studies to closely examine nutritional intake and weight during the first few weeks of life. The recommendation is that preterm infants should receive 120 kcal/kg/day and gain weight at a rate of at least 15 gms/kg/day. The preterm infants with BPD in this study were undernourished during the first 28 days of life and were gaining weight at a rate that was significantly less than ideal. Further, preterm infants that were able to achieve an intake of 120 kcal/kg/day were unable to maintain this intake. Undernutrition during the first few weeks of life has ramifications for the development of the immature lungs. Undernutrition alters the ability of the lungs to heal and subsequently growth. Therefore, undernutrition may play a role in the development of BPD.

References

Atkinson, S. (2001). Special nutritional needs of infants for prevention of and recovery from bronchopulmonary dysplasia. *Symposium: Pediatric Pulmonary Insufficiency: Nutritional Strategies for Prevention and Treatment,* 943-946.

Bancalari, E. (2001). Changes in the pathogenesis and prevention of chronic lung disease of prematurity. *American Journal of Perinatology, 18*(1), 1-9.

Bloom, B.T., Mulligan, J., Arnold, C., Ellis, S., Moffitt, S., Rivera, A., Kunamneni, S., Thomas, R., Clark, R.H., & Peabody, J. (2003). Improving growth of very low birth weight infants in the first 28 days. *Pediatrics, 112,* 8-14.

Boehm, G., Bierbach, U., Moro, G., & Minoli, I. (1996). Limited fat digestion in infants with bronchopulmonary dysplasia. *Journal of Pediatric Gastroenterology and Nutrition, 22,* 161-166.

Clark, R.H., Thomas, P., & Peabody, J. (2003). Extrauterine growth restriction remains a serious problem in prematurely born neonates. *Pediatrics, 111,* 986-990.

Clark, R.H., Wagner, C.L., Merritt, R.J., Bloom, B.T., Neu, J., Young, T.E., & Clark, D.A. (2003). Nutrition in the neonatal intensive care unit: How do we reduce the incidence of extrauterine growth restriction? *Journal of Perinatology, 23,* 337-344.

Cooke, R. & Embleton, N. (2000). Feeding issues in preterm infants. *Archives of Diseases in Childhood (Neonatal ed.), 83,* 215-218.

deRegnier, R., Guilbert, T., Mills, M., & Georgieff, M. (1996). Growth failure and altered body composition are established by one month of age in infants with bronchopulmonary dysplasia. *Journal of Nutrition, 126,* 168-175.

Ehrenkranz, R., Younes, N., Lemons, J., Fanaroff, A., Donovan, E., Wright, L., Katsikiotis, V., Tyson, J., Oh, William, Shankaran, S., Bauer, C., Korones, S., Stoll, B., Stevenson, D., Papile, L. (1999). Longitudinal growth of hospitalized very low birth weight infants. *Pediatrics*, *104*, 280-289.

Embleton, N., Pang, N., & Cooke, R. (2001). Postnatal malnutrition and growth retardation: an inevitable consequence of current recommendations in preterm infants? *Pediatrics, 107* (2), 270-273.

Evans, R.& Thureen, P. (2001). Early feeding strategies in preterm and critically ill neonates. *Neonatal Network*, *20*(7), 7-18.

Fewtrell, M., Adams, C., Wilson, D., McClure, G., & Lucas, A. (1997). Randomized trial of high nutrient density formula versus standard formula in chronic lung disease. *Acta Paediatr*, *86*, 577-582.

Guzmán, J.M., Jaraba, M.P., De La Torre, M.J., Ruiz-González, M.D., Huertas, M.D., Alvarez, R., & Zapatero, M. (2001). Parenteral nutrition and immature neonates. Comparative study of neonates weighing under 1000 and 1000-1250 g at birth. *Early Human Development*, *65*, S133-S144.

Hay, W. (1995). Assessing the effect of disease on nutrition of the preterm infant. *Clinical Biochemistry*, *28*, 345.

Hay, W., Lucas, A., Heird, W., Ziegler, E., Levin, E., Grave, G., Catz, C., & Yaffe, S. (1999). Workshop summary: nutrition of the extremely low birth weight infant. *Pediatrics, 104*(6), 1360-1368.

Huysman, W., de Ridder, M., de Bruin, N., Helmond, G., Terpstra, N., Van Goudoever, J., & Sauer, P. (2003). Growth and body composition in preterm infants with bronchopulmonary dysplasia. *Archives of Disease in Childhood (Neonatal ed.), 88,* 46-51.

Jobe, A. & Bancalari, E. (2001). Bronchopulmonary dysplasia. *National Institute of Child Health and Human Development,National Heart, Lung, and Blood Instritute, Office of Rare Diseases Workshop on Bronchopulmonary Dysplasia Summary.*

Lemons, J., Bauer, C., Oh, W., Korones, S., Papile, L., Stoll, B., Verter, J., Temprosa, M., Wright, L., Ehrenkranz, R., Fanaroff, A., Stark, A., Waldemar, C., Tyson, J., Donovan, E., Shankaran, S., & Stevenson, D.**(**2000). Very low birth weight outcomes of the national Institute of Child Health and Human Development neonatal research network, January 1995 through 1996. *Pediatrics, 107*(1).1-8.

Munro, B. (2001). *Statistical Methods for Health Care Research*. 4th Ed.

Pauls, J., Bauer, K., Versmold, H. (1998). Postnatal body weight curves for infants below 1000 g birth weight receiving early enteral and parenteral nutrition. *Eur J Pediatr*, *157*, 416-421.

Pillitteri, A. (2003). *Maternal and Child Health Nursing: Care of the Childbearing and Childrearing Family.* (4th ed.). Philadelphia: Lippincott Williams & Wilkins.

Poindexter, B., Denne, S. (2003). Protein needs of the preterm infant. *NeoReviews*, *4*(2), 52-58.

Polit, D., & Hungler, B. (1995). *Nursing Research: Principles and Methods*. 6th Ed.

Radmacher, P.G., Looney, S.W., Rafail, S.T., & Adamkin, D.H. (2003). Prediction of extrauterine growth retardation (EUGR) in VLBW infants. *Journal of Perinatology, 23,* 392-395.

Steward, D.& Pridham, K. (2001). Growth patterns of extremely low-birth-weight hospitalized preterm infants. *JOGNN, 31*(1), 57-65.

Sunehag, A., & Haymond, M. (2002). Glucose extremes in newborn infants. *Clinics in Perinatology, 29,* 245-260.

Thureen, P. (1999). Early aggressive nutrition in the neonate. *NeoReviews,* 45-55.

Thureen, P. & Hay, W. (2000). Intravenous nutrition and postnatal growth of the micropremie. *Clinics in Perinatology, 27*(1), 197-215.

Wilson, D., Cairns, P., Halliday, H., Reid, M., McClure, G., & Dodge, J. (1997). Randomized controlled trial of an aggressive nutritional regimen in sick very low birthweight infants. *Archives of Diseases in Childhood, 77,* 4-11.

Wilson, D., McClure, G., Halliday, H., Reid, M., & Dodge, J. (1991). Nutrition and bronchopulmonary dysplasia. *Archives of Disease in Childhood, 66,* 37-38.

Ziegler, E., Thureen, P., & Carlson, S. (2002). Aggressive nutrition of the very low birthweight infant. *Clinics in Perinatology, 29,* 225-244.

Table *Description of Sample and Nutritional Variables*.

Variable	Mean (± sd) Range
Birthweight	996.2 (± 289.97) 449-1774 grams
Gestational Age	27.83 (± 1.98) 24-34 Weeks
Weight Gain	11.55 (± 3.45) 6.09-21.11 gms/kg/day
Kcal/kg/day@ 7days	68.35 (± 11.80) 31.14-86.14 kcal/kg
Kcal/kg/day @ 14 days	83.23 (± 9.04) 56.57-99.0 kcal/kg
Kcal/kg/day @ 28 days	98.63 (± 9.39) 78.07-115.75 kcal/kg
Caloric deficit @ 14 days	514.7 (± 126.66) 294-888 kcal/kg
Total Caloric Deficit	598.23 (± 263.08) 119-1174 kcal/kg
Day of Life achieving 120 kcal/kg/day	18.11 (± 5.55) 10-26 day of life
Protein Deficit @ 28 days	7.56 (± 7.20) -6.86-20.57 gms/kg/d

Figure. *Actual Caloric Intake Compared to Cumulative Deficit*