Breastfeeding Infants Who Were Extremely Low Birth Weight

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ABSTRACT. *Objective.* **To compare the clinical effect of breastfeedings and bottle feedings in extremely low birth weight (ELBW) infants (birth weight 800 g).**

Methods. **A total of 12 ELBW infants (mean birth weight, 672 ± 95 g; mean gestation, 26 ± 2 weeks) served as their own controls in this prospective study comparing physiologic parameters during bottle and breastfeeding. The infants were put to breast the same week they began on bottle feedings of human milk or premature infant formula (mean gestation, 35 weeks). One breastfeeding and one bottle feeding were observed each day for 10 days. Pre- and postfeeding weights were measured, and oxygen saturation, respiratory rate, heart rate, and axillary temperature were monitored continuously and recorded every minute during feedings.**

Results. **The infants demonstrated a higher oxygen saturation and a higher temperature during breastfeeding than during bottle feeding, and were less likely to desaturate to <90% oxygen during breastfeeding. Mean weight gain was greater during bottle feeding than during breastfeeding (31 vs 9 g).**

Conclusions. **Breastfeeding the ELBW infant is desirable from a standpoint of improved physiologic responses, but such practice requires breastfeeding support and possible supplementation to optimize weight gain.** ***Pediatrics*** **1997;100(6). URL: http://www.pediatrics.org/cgi/content/full/100/6/e3;** ***breastfeeding, extremely low birth weight infants.***

ABBREVIATIONS. ELBW, extremely low birth weight; SES, socioeconomic status; SCN, special care nursery; NEC, necrotizing enterocolitis; IVH, intraventricular hemorrhage.

Breastfeeding infants with birth weights <1500 g has been shown to have certain physiologic benefits.[1–4] Specifically, during breastfeeding, compared with bottle feeding, there is less oxygen desaturation to <90%. In addition, in infants with bronchopulmonary dysplasia, oxygen saturation remains higher throughout breast versus bottle feeding.[1] Studies done by Meier and colleagues demonstrated better sucking ability, less ventilatory disruption, and warmer skin temperature in healthy premature infants (birth weights <2000 g) during breastfeeding compared with bottle feeding.[2–4] Other studies have suggested that healthy low birth weight infants have the ability to be breastfed exclusively and maintain a reasonable weight gain.[5–7] However, in a previous study of 20 premature infants with birth weights <1500 g, several of whom had medical and neurologic morbidities associated with prematurity, we found significantly less intake, as reflected in weight gain, during breastfeeding versus bottle feeding.[1] Therefore, despite the known beneficial effects of breastfeeding for infants with birth weights <2000 g, it is unknown whether it is physiologically safe for the micropremie, ie, infants with birth weights ≤800 g.

The purpose of this study was to examine the ability of extremely low birth weight (ELBW) infants (birth weights ≤800 g) to breastfeed at the same postnatal age at which bottle feeding is initiated. We hypothesized that ELBW infants would be physiologically more stable during breastfeeding and that intake, as reflected in weight gain during the feeding, would be less during breastfeeding than during bottle feeding, as found in our results in larger premature infants.

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METHODS

Twelve ELBW singleton infants were enrolled in this study as soon as it was known that their mothers were interested in breastfeeding their infants. Included were infants whose birth weights were ≤800 g and whose mothers expressed the desire to breastfeed and were willing to express milk until their infants were able to start bottle feeding. Exclusion criteria included maternal human immune deficiency virus infection, a history of illicit drug use, medication use that contraindicates breastfeeding, and mental illness. Infants served as their own controls in this study comparing bottle and breastfeeding.

Maternal and neonatal characteristics, neonatal complications, feeding data, and growth data were prospectively recorded. Maternal data included family and social characteristics, marital status, and previous experience in breastfeeding. Socioeconomic status (SES) was calculated using the Hollingshead Four Factor Scoring System.[8] The Hollingshead SES score is derived from maternal and paternal education and occupations. Scores that are derived describe familial social strata as follows: unskilled laborers, menial service workers, scores: 8 to 19; machine operators, semiskilled workers, scores: 20 to 29; skilled craftsmen, clerical and sales workers, scores: 30 to 39; medium business professionals, minor professionals, technical professionals, scores: 40 to 54; and major business professionals, scores: 55 to 66.

Neonatal data included birth weight, gestational age, history of sepsis, necrotizing enterocolitis (NEC), grade III–IV intraventricular hemorrhage (IVH), periventricular leukomalacia, number of days of tracheal intubation, number of days of oxygen use, and postnatal and gestational ages in weeks when bottle and breastfeedings were begun. Assessment of maturity was determined using the Ballard Assessment of gestational age and plotting the weight on the Lubchenco intrauterine growth curve.[9]

Criteria for initiation of nipple feeding according to the special care nursery (SCN) protocol included signs of a sucking reflex and absence of congenital anomaly that would interfere with sucking or swallowing. Each mother arranged to meet with a member of the study staff twice a day for 10 days. In our nursery, infants are initially nipple fed once a day for the first few days and increased to once per shift, followed by more than once each shift as tolerated. Therefore, the feedings observed in this study were initially the only bottle and breastfeedings that the infant received each day. Infants were offered 10 mL of human milk or standard premature infant formula for their first bottle feeding. In our nursery, one packet of human milk fortifier (4 kcal) is added to each 25 mL of human milk. Bottle feedings of premature infant formula are begun using 20 kcal per oz of formula, gradually increasing to 22 or 24 kcal per ounce. Human milk was used for 69% of the bottle feeding sessions, but because of a limited supply, premature infant formula was used in 31% of the bottle feedings. One breastfeeding and one bottle feeding were observed daily for 10 days, for a total of 20 observations per infant over a 10-day period. The method used for the remaining infant feedings (ie, bottle, breast, or gavage) was determined by the nursery staff. Consultation with a lactation consultant was available for mothers; one mother in the study requested and used this service.

The infant's body weight, determined with a pediatric scale (Scale-Tronix Inc, White Plains, NY), was recorded before and after each feeding. Infants were weighed fully clothed before and after each feeding and their clothes were not changed even if voiding or spitting occurred. The variability on this scale with repeated measures was ±5 g. Oxygen saturation (measured by Ohmeda Biox 3700 Pulse Oximeter, Ohmeda, Louisville, CO), respiratory rate, heart rate (Corometrics Neonatal Monitor, Corometrics Medical Systems Inc, Wallingford, CT), and axillary temperature (Mon-a-Therm Temperature System, Mallinckrodt Medical Inc, Earth City, MO) were monitored continuously and recorded every minute during the feedings. If intake during the breastfeeding (estimated by weight change before and after feeding) was less than the amount of the infant's expected intake, supplementation with the appropriate amount of human milk or premature infant formula either by bottle feeding or gavage feeding was provided.

A total of 97 mother/infant breastfeeding sessions and 97 bottle feeding sessions were observed. Bottle feedings ended once the desired amount of intake (physician orders) was completed or the infant appeared medically compromised (eg, oxygen saturation continuously <90%). Ending of the breastfeeding sessions was determined by the mothers when they thought the infant was done or when a predetermined time limit set by the mother was completed (for example, 5 minutes on each breast during the first session, 7 minutes on each breast during the second session). Of the scheduled 240 feeding sessions, 46 were missed for the following reasons: two infants were discharged after four bottle and four breastfeedings (therefore, 12 bottle and 12 breastfeeding sessions were not completed), one infant was discharged after seven bottle and seven breastfeedings (three bottle and three breastfeeding sessions not completed), a fourth infant was discharged after nine bottle and nine breastfeedings (one bottle and and one breastfeeding session not completed), and one infant became ill and was not permitted enteral feedings after three bottle and three breastfeeding sessions (seven bottle and seven breastfeeding sessions not completed). Hence, these infants did not complete the 10-day observation period. A total of 669 nonstudy feedings (280 bottle feedings, 11 breastfeedings, and 378 gavage feedings) were given to the infants in addition to the 194 study feedings during the study period.

Statistical analysis consisted of two-way repeated-measures analysis of variance for analyzing oxygen saturation, respiratory rate, heart rate, and temperature over time, and the paired *t* test for analyzing weight change and feeding time.

RESULTS

Mean maternal age was 31 ± 4 years (range, 23 to 37 years). Of the 12 mothers, 11 were married, and mean Hollingshead SES score was 52 ± 13 (range, 27 to 66). Five (42%) mothers were multiparous: four (33%) mothers gravida II, and one (9%) mother gravida III (and all but one of the gravida II mothers had previous experience in breastfeeding). Seven mothers (58%) were primiparae.

Infant characteristics are shown in Table 1. There were an equal number of males and females. All infants were ELBW (≤800 g) with a mean prolonged oxygen requirement. The infants began the study at a mean chronologic age of 62 ± 15 days (range, 24 to 82 days), a mean gestational age of 35 ± 2 weeks (range, 32 to 39 weeks), and a mean weight of 1450 ± 210 g (range, 1060 to 1720 g).

Three infants had one or more morbidities associated with prematurity, including one with sepsis, NEC, and grade III IVH; one infant with NEC; and a third infant with grade IV IVH and periventricular leukomalacia. Five infants were small for gestational age. All these morbidities were diagnosed before the initiation of bottle and breastfeedings. Of the 12 infants, 2 required oxygen supplementation by nasal cannula at the time of the study. Mean number of days of oxygen requirement was 47 ± 33 (range, 0 to 121). Three breastfeedings and three bottle feedings were observed in which oxygen supplementation was required.

Of the breastfeedings and bottle feedings observed, 100% and 94%, respectively, were ≥6 minutes long. Mean weight change for each infant before and after feeding is shown in Fig 1. During breastfeedings, mean weight change was 9 ± 6 g (range, no weight change to 18 g); during bottle feedings, mean weight gain was 31 ± 6 g (range, 20 to 39 g; $P < .001$). The mean intake for the 97 bottle feedings was 35 ± 12 mL.

Mean axillary temperature, oxygen saturation, respiratory rate, and heart rate recorded every minute during the first 6 minutes of the feedings are shown in Fig 2. Oxygen saturation and axillary temperature were significantly higher during breastfeeding than during bottle feeding ($P < .05$ and $P < .001$, respectively). Oxygen saturation was identical at baseline for both groups. At 1 minute, the oxygen saturation of breastfed infants increased to 94% and remained elevated for the remainder of the study. Temperature for breastfeeding infants was higher at 2, 3, 4, 5, and 6 minutes of age, compared with bottle-feeding infants. There were no differences in respiratory rate or heart rate. Of the 510 oxygen saturation recordings during breastfeeding, 47 (9%) were <90%, whereas of the 506 recordings during bottle feedings, 101 (20%) were <90% ($P < .001$).

DISCUSSION

The results of this study support our hypothesis that premature infants with ELBW (≤800 g) who are at greatest risk for medical and neurologic morbidi-

TABLE 1. Infant Characteristics (N = 12)

Gender (male)	6 (50%)
Birth weight (g)	672 ± 95 (470–800)
Gestation (weeks)	26 ± 2 (24–30)
Days of oxygen use	45 ± 28 (0–91)
Days of intubation	13 ± 13 (median, 9.5) (0–42)
Age at onset of study	
Chronologic (days)	62 ± 15 (24–82)
Gestational (weeks)	35 ± 2 (32–39)
Weight at onset of study (g)	1460 ± 210 (1060–1720)

Mean ± SD; ( ) = range.

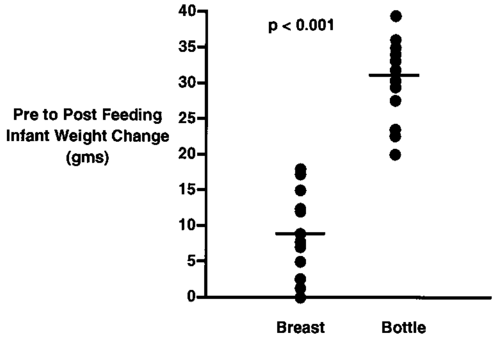

Fig 1. Weight changes that occurred during the feeds are shown for both breastfeedings and bottle feedings. The horizontal line indicates mean intake of 9 g for breastfeedings and 31 g for bottle feedings.

ties are able to tolerate breastfeeding physiologically. Although their low birth weight makes them a group not previously studied, the relatively high SES of this study population (mean Hollingshead Score, 52 ± 13) is similar to that found in other breastfeeding studies in the United States.

The higher oxygen saturation during breastfeeding is consistent with studies in larger premature infants demonstrating similar physiologic benefits of breastfeeding. We reported this difference in oxygen saturation in premature infants with compromised pulmonary status; that is, those with bronchopulmonary dysplasia.[1] Meier reported less ventilatory disruption during breastfeeding compared with that during bottle feeding,[2–4] and this may result in the higher oxygen saturation. The lower intake, as reflected in weight gain, as we have also shown previously, may have a secondary benefit of resulting in higher oxygen saturation. During breastfeeding, infants may have better control of their sucking and pausing rate and rhythm. Premature infants, however, may be less able to regulate their intake during bottle feeding (with the artificial nipples releasing milk even when sucking is not strong) resulting in lower oxygen saturation.

Heart rate dropped from baseline to 1 minute during both feeding methods, but did not differ significantly. Respiratory rate increased from baseline and then plateaued during both bottle and breastfeeding. Mean respiratory rate was 56 during breastfeeding and 51 during bottle feeding.

Meier reported a higher maximum temperature change during breastfeeding compared with that during bottle feeding in five clinically well preterm infants with mean birth weight of 1296 g and mean gestation of 30.5 weeks.[2] Similarly, our data also demonstrate a warming effect of breastfeeding specifically in the ELBW infant. This may reflect direct transfer of maternal heat from breast to infant face and body.

ELBW infants are at high risk for long-term morbidities associated with prematurity, including failure to thrive.[10–12] The decreased intake during breastfeeding compared with during bottle feeding requires additional investigation. The infants in this study began breastfeeding at a mean gestational age 35 ± 2 weeks, with a range from 32 to 39 weeks. The

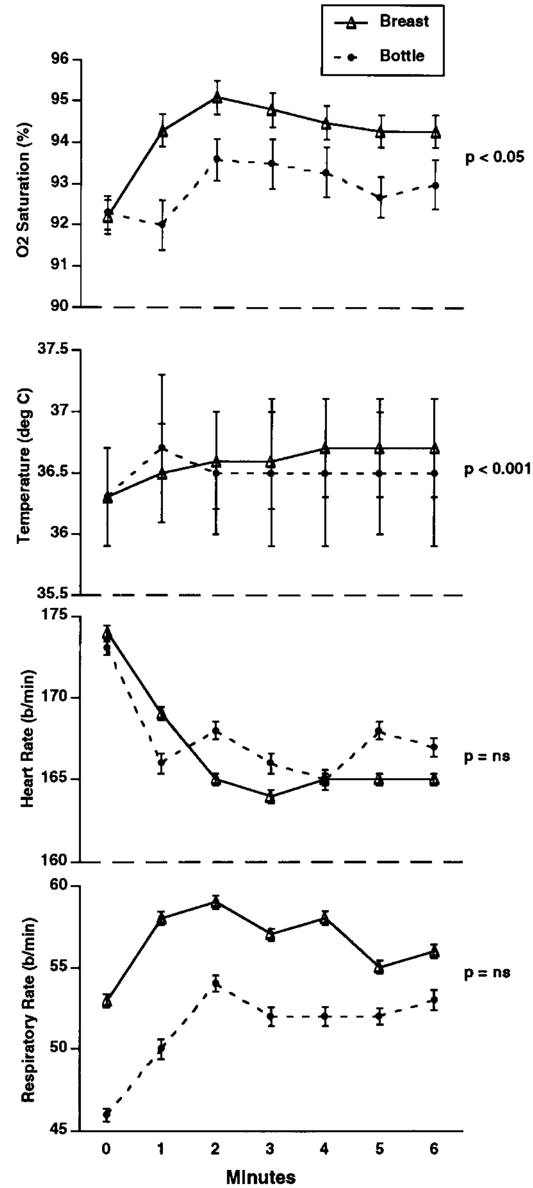

Fig 2. Oxygen saturation (top), axillary temperature (second from top), heart rate (third), and respiratory rate (bottom) at 1 minute intervals for a 6-minute period are shown comparing bottle feedings with breastfeedings. Data are expressed as mean ± SEM.

wide range was related to medical morbidities, with later initiation for infants requiring prolonged tracheal intubation and supplemental oxygen. Earlier initiation of breastfeeding in the healthier infants may have improved lactogenesis and success of breastfeeding, resulting in a better weight gain. In addition, the infants received many more bottle feedings than breastfeedings during the study period. Increasing the number of breastfeedings offered in place of bottle feedings may result in improved intake. By enabling mothers to breastfeed their infants more often, similar to protocols reported in other countries, infants would gain breastfeeding experience that may result in improved intake.[5–7] A third factor that may have affected intake is maternal milk supply. The fact that 31% of bottle feedings were with formula suggests a low maternal milk supply. Finally, infants demonstrated great variability in their ability to suck effectively from the breast. Although some infants were able to latch on to the breast early in their breastfeeding experience, some were only able to maintain effective sucking for short periods of time. This was the case in the four infants whose mean weight gain was ≤ 5 g during breastfeeding, as shown in Figure 1. Interestingly, these four infants did not show a greater difference in oxygen saturation during breastfeeding versus bottle feedings compared with the infants who demonstrated more effective sucking ability during breastfeeding. An increase in breastfeeding opportunity and support within the SCN is therefore needed.

The benefits of human milk for premature infants have been well studied. Previous investigators have found that premature infants who receive human milk have fewer infections during their initial hospitalization in the intensive care unit compared with those who are fed only formula.[13,14] These early protective effects of preterm human milk are thought to be related to its immunologic agents.[15–17] More recently, Lucas and colleagues reported improved developmental outcome of premature infants who received their mother's milk during their hospitalization in the SCN compared with premature infants who received only formula.[18] Given the immunologic and developmental benefits described in the literature, together with the physiologic benefits we are reporting, we feel it is important to investigate ways to improve these infants' breastfeeding skills and resulting intake.

We conclude that 1) it is physiologically safe for ELBW infants, including those with morbidities associated with prematurity, to breastfeed; 2) higher oxygen saturation during breastfeeding suggests that it is physiologically less stressful than bottle feeding; 3) higher temperature during breastfeeding indicates a warming effect; and 4) the lower weight gain after breastfeeding compared with that after bottle feeding suggests lower intake and requires monitoring, increased breastfeeding opportunities, and possibly supplementation to meet nutritional requirements.

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