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Safety and Efficacy of Oral Feeding in Infants with BPD on nasal CPAP

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Abstract

Objective—Safety and efficacy of oral feeding was examined in infants with bronchopulmonary dysplasia (BPD) on nasal continuous positive airway pressure (NCPAP). We hypothesized that repetitive oral feeding enhances aerodigestive outcomes and reduces resource utilization.

Methods—Data from infants with BPD (37–42 weeks post menstrual age) that were orally fed while on NCPAP (n=26) were compared with those that were exclusively gavage fed on NCPAP (n=27). Subject assignment was random and physician practice based. Specifically, we compared the differences in aero-digestive milestones, resource utilization and safety metrics.

Results—Demographic characteristics such as gender distribution, gestational age and birth weight, clinical characteristics such as frequency of intraventricular hemorrhage and patent ductus arteriosus needing surgical ligation were similar in both groups ($p > 0.05$). Characteristics of respiratory support and airway milestones were similar in both groups ($p > 0.05$). However, infants in NCPAP-oral fed group had earlier acquisition of full oral feeding milestone by 17 days (median) vs. infants who were not orally fed during NCPAP ($p < 0.05$). Discharge weights and the frequency of gastrostomy tube placement were also similar in both groups ($p > 0.05$). There were no tracheostomies in either group. There was no incidence of clinically significant aspiration pneumonia in infants during the period of the oral feeding while on NCPAP.

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Conclusion—Controlled introduction of oral feedings in infants with BPD during NCPAP is safe and may accelerate the acquisition of oral feeding milestones.

Keywords

oral feeding; CPAP; aero-digestive milestones; deglutition; deglutition disorders

Background

Infant with Bronchopulmonary dysplasia (BPD) have delayed attainment of aero-digestive milestones which includes attainment of full oral feeding [1–3]. Maturation and oral feeding experiences modify infant's abilities to achieve full oral feeds in a timely manner [4, 5]. However for infants with severe BPD, feeding opportunities may be limited due to respiratory distress and prolonged need for positive pressure support. As a result, the practice of oral feeding in infants on NCPAP is currently not a standard care in most nurseries.

NCPAP is increasingly considered as a non-invasive form of respiratory therapy and is necessary to prevent pharyngeal collapse and facilitate maintenance of functional residual capacity [1]. Although NCPAP is necessary to reduce respiratory distress, it can also affect interventions known to support feeding [3, 6]. For example, oro-motor stimulation, holding and touch can be limited due to equipment strapped to nares and face. Furthermore, nutritional needs for the infant on NCPAP are typically met through an orogastric tube which is also needed to vent the stomach between the feedings intervals for prevention of gaseous distention of bowel [7]; chronic presence of this tube can impact the infant's feeding and sensory motor aspects of aerodigestive reflexes [3, 8]. Also, the opportunities to consistently practice functional swallow/breathe coordination can be minimal while on pressure support during critical periods of oro-rhythmic development in late gestation and early infancy [9]. Absence of experienced skilled personnel (trained neonatal occupational therapists) in such nurseries is another limiting factor to advance oral feeding.

In our unit, an all referral NICU, we have a very diverse group of clinicians, some favoring oral nutritive stimulation during NCPAP and some not. Thus we had a convenient and unique opportunity as 2 different oral feeding approaches were practiced within the same time period and NICU using a retrospective design. This offered the advantage of having comparable subjects and overall clinical practices, except for the differing feeding approaches. The aim of this retrospective study was to assess the safety and efficacy of oral feeding while on NCPAP. We tested the hypothesis that an individualized oral feeding approach in infants on NCPAP is safe and efficacious.

Methods

Subjects & Study Design

This is a comparison of two clinical practices using a retrospective study design. The medical records of infants admitted between July 2009 and October 2011 at Nationwide Children's Hospital NICU were reviewed to describe and compare the clinical characteristics, safety metrics and discharge outcomes. The patient population of our NICU

is an entirely outborn patient population from a large referral area of Central Ohio with approximately 38,000 deliveries per year. The center also receives referrals due to severe BPD from areas outside the typical referral area.

In general, the inclusion criteria to feed infants orally while on NCPAP typically were (a) infants with 37 to 42 weeks PMA and (b) on 40% FiO₂. Exclusions were those infants with congenital anomalies, enterostomies and severe intra-ventricular hemorrhage (grade 3 and 4). During the above periods, there were 26 infants that were orally fed on NCPAP. Due to variability in feeding practices among the providers, infants (n =27) who met the inclusion criteria but did not receive the oral feeding therapy during NCPAP qualified as comparison group. The hospital Institutional Review Board approved the medical record review for this study.

The approach to oral feeding session on NCPAP

All the oral feeding sessions on NCPAP were done by trained neonatal occupational therapists. A thorough clinical assessment was completed by the occupational therapist prior to the initiation of the feeding therapy. This assessment included determining physiologic stability defined as absence of bradycardia and desaturation events, cardiorespiratory stability during routine cares, demonstration of appropriate neurobehavior for the maturational age, self-regulatory behaviors and postural control [10]. Sustained alertness defined as the infant's ability to maintain alertness during and following routine cares was also a necessary skill [11]. Evaluation of oromotor apparatus and oral reflexes, coordination of functional skills involving palate, tongue and jaw movements were assessed [12]. Non-nutritive sucking strength, rhythm and coordination with breathing were also observed as per clinical practice. Infants who demonstrated appropriate readiness received the oral feeds, which included an oral feeding session for no more than 30 minutes per session, one session per day, 3–5 times per week for a minimum of 10 sessions until the infant was weaned off NCPAP. On an average, infants accepted 59% of their total feed by bottle with volumes varying from few milliliters to entire volume of feeds. Remaining feeding sessions were gavage fed sessions every 3–4 hours and were provided by the nurses. Also, the oral feeding sessions during post-NCPAP period for both the group of infants were done by nurses.

Cardiorespiratory rates, rhythms and coordination were monitored during the feeding intervention. Clinical observations and assessments of the infants' behavioral and physiologic responses before, during and after each feeding attempt were directly observed and documented by the occupational therapists. Heart rate, respiratory rate, oxygen saturation, coughing, gagging or work of breathing was also monitored. The oral feeding on NCPAP was discontinued when infants exhibited increase in respiratory rate, decrease in oxygen saturation, bradycardia, coughing, gagging or other behavioral signs of distress such as tongue thrusting and arching.

Feeding strategy of NCPAP-gavage fed group

This group of infants received all feedings (6–8 feedings per day every 3–4 hours) via an orogastric tube exclusively while on NCPAP. For this group of infants, the first oral feed was provided when infants were off of NCPAP and on either nasal cannula or room air.

Standard feeding practices

Developmentally supportive feeding techniques were encouraged for all infants in the NICU based the framework of Supporting Oral Feeding in Fragile Infants (SOFFI) method per education and intervention from the neonatal occupational therapists [13]. Techniques include use of a slow flow nipple, swaddling to promote flexion, side lying, modified flow rate and external pacing by lowering the bottle to facilitate breaths and promote efficient bolus clearance throughout the feed [13]. Parents and caregivers were encouraged to be present and participate in oral feeding, kangaroo care and routine infant care.

Safety metrics during oral feeding on NCPAP

To seek evidence for pulmonary infiltrates suggestive of clinically significant aspiration pneumonia, x-rays of chest were done during the period of oral feeding through 48 hours after discontinuation of NCPAP were reviewed. The x-rays were subjectively ordered by physicians if there was a concern for either assessment of intra-gastric tube placement or distended abdomen on CPAP or feeding intolerance or respiratory distress (increased work of breathing and increased oxygen requirements or oxygen desaturations). Comparisons were made with baseline x-rays of chest performed prior to starting of oral feedings. Usage of any antibiotic during the period of NCPAP oral feeding was also scrutinized to assess whether clinical suspicion of aspiration pneumonia warranted treatment with antibiotics.

Aerodigestive milestones & Statistical analysis

Data were collected from the medical records of the infants in comparison group (NCPAP-gavage fed group) and NCPAP-oral fed group and patient information was de-identified. Demographics and disease characteristics including gender, birth weight, discharge weight, gestational age, patent ductus arteriosus (PDA) needing surgical ligation, intraventricular hemorrhage (IVH) and oxygen therapy were compared. Airway milestones analyzed were oxygen requirement at discharge and duration of NCPAP. Feeding and digestive milestones analyzed were: chronological age and post menstrual age at full oral feeding, as well as discharge feeding methods, i.e., either oral feeding or gastrostomy tube feeding methods. Data on resource utilization was also collected including length of hospital stay and rate of readmissions (%) within 30 days of discharge. Oxygen requirement at discharge or need for tracheostomy were also evaluated.

Statistical analyses were performed using unpaired t-test, Fisher's Exact, and Wilcoxon-Mann-Whitney tests. Data are presented as mean $\pm$ SD, median (range) and $p < 0.05$ was considered significant. The analysis was done using Graphpad Prism Version 6.03.

Results

Demographic, clinical and outcome characteristics

Demographic and clinical characteristics are summarized (Table 1). Airway and digestive outcomes are summarized (Table 2). Among these infants who achieved full oral feeding milestone, NCPAP-oral fed group acquired full oral feeding milestone at 120.5 (105.3–132) days of life compared to NCPAP-gavage fed group who achieved it at 137(113.0–158.5) days of life (Figure 1A). As shown in figure 1B, though GA at birth was similar in two

groups, NCPAP-oral fed group achieved full oral feeding milestone at 41.6(40.0–43.1) weeks of PMA compared to NCPAP-gavage fed group who achieved the same at 45.5(40.9–46.9) weeks of PMA ($p=0.03$).

Resource utilization

Resource utilization metrics are summarized in figure 2. Though the length of hospital stay in NCPAP-oral fed group infants viz. 142.5 (116.5 – 153.3) days was shorter than that of in infants in NCPAP-gavage fed group viz. 160 (134 – 172) days, it was not statistically significant (figure 2A). Only 2 out of 26 (7.7%) infants in NCPAP-oral fed group were readmitted within 30 days of discharge compared to 6 out of 27 (22.2%) infants in NCPAP-gavage fed group ($p=0.25$) (figure 2B). The reasons for readmissions in NCPAP-gavage fed group were: respiratory distress due to upper respiratory tract infections (4 infants), gastroenteritis (1 infant), parental non-compliance with medications and supplemental oxygen (1 infant). The reasons for readmissions in NCPAP-oral fed group infants were: apnea alarms with home monitoring (1 infant) and respiratory distress due to upper respiratory tract infections (1 infant).

Safety metrics in NCPAP-oral fed infants

Safety measures of the NCPAP-oral fed group were also studied. Observations of physiologic and behavioral distress with feeds was summarized for all of the occupational therapy feeding sessions ($n=218$). The feeding sessions in which an apnea or bradycardia event occurred (2.7%, $n=6$), desaturation to less than target FiO_2 saturation (11%, $n=25$), respiratory rate increase 20 breaths per minute above baseline or increased accessory muscle use resulting in lower chest retractions, xiphoid retractions or nasal flaring (14%, $n=30$) [14], or more than one episode of coughing or gagging (0.4%, $n=1$) resulted in termination of the bottle feeding attempt. The desaturation events were identified as being lower than 90%, but none of the desaturations were less than 78%. All desaturation events resulted in self-recovery upon discontinuation of the feeding attempt with exception to 3 events that required increase in supplemental FiO_2 (1%). With any indications of behavioral or physiologic distress during the preparatory phase for the feeding therapy (17%, $n=38$), infants were not fed and standard of care interventions were provided such as non-nutritive sucking opportunities and holding during supplemental gavage feeds.

The infants' level of respiratory support upon initiation of oral feeding on NCPAP and two weeks following was recorded. All infants in the NCPAP-oral fed group were on a pressure of 6–8 cm H_2O and received between 21–38% FiO_2 on the date of the initial bottle feeding. Two weeks following the initial feeding session, 15 out of 26 infants (58%) had transitioned successfully to supplemental oxygen via nasal cannula. The other 11 infants (42%) remained on NCPAP on a lower percentage of FiO_2 .

Twenty-five out of 26 infants did not have any changes in x-rays of chest done during the period of NCPAP oral feeding through 48 hours after discontinuation of NCPAP compared to baseline films. In one patient the attempted transition of NCPAP to nasal cannula failed due to respiratory distress resulting in reinstatement of NCPAP support. Chest x-ray film done at that time revealed left upper lobe atelectasis but the atelectasis was attributed due to

loss of lung volumes due to BPD. Furthermore, in this infant antibiotics were not needed during this episode; thus this condition is unlikely to be due to clinically significant aspiration. None of the infants received any antibiotics during the period of NCPAP oral feeding for the purpose treatment of aspiration pneumonia or sepsis. However one infant did get low dose erythromycin for augmenting gastrointestinal motility

Discussion

In addition to decreased opportunity to develop oral motor and swallowing skills, infants with BPD do not follow predicted maturational patterns of suck-swallow integration similar to their peers without BPD [15]. Increased respiratory demands for infants with BPD may affect integration of suck and swallow with respiratory rhythms, feeding efficiency, endurance and energy expenditure, in addition to aero-digestive safety [16, 17]. Each of these concerns may contribute to delay in achieving aero-digestive milestones, thus prolonging transition from gavage feeding to full oral feeding. Therefore infants with BPD are at higher risk of prolonged hospital stays [18]. The stability of airway and breathing is essential for successful oral feeding. NCPAP overcomes proximal airway resistance minimizing pharyngeal collapsing forces and maintaining functional residual capacity. To date very little research exists to support or dispute the practice of initiating oral feeding infants on NCPAP [19] [20] and the consequences of positive pressure on the infant's ability to swallow remains unclear. Thus the dilemma to provide supportive oral feeding opportunities for infants on NCPAP persists, and acquisition of oral feeding milestones in a timely manner remains elusive. In our study, we have assessed the safety and efficacy of oral feeding while on NCPAP. Safety metrics including recorded physiologic response to oral feeding, amount of FiO₂ supplementation, chest x-rays and use of antibiotics were not however studied in the NCPAP-gavage fed group therefore comparisons in these areas were not provided.

The cardinal findings of our study were: 1) Infants fed orally on NCPAP achieved full oral feeding milestones at earlier chronologic and postmenstrual age than NCPAP gavage fed group. 2) There were no incidences of clinically significant aspiration pneumonia during the period when infant were fed orally on NCPAP. Safety measures were thoroughly investigated including chest x-rays, levels of respiratory support, readmission rates and clinical observations. These observations were noted despite the demographic and clinical characteristics being similar in both groups. All the infants included in both groups being on nasal CPAP at > 36 weeks PMA could be categorized as infants with severe BPD [21]. There were no significant differences in the IVH grades 2 in both groups indicating neurological morbidity was similar in both the groups. The two groups received similar duration of mechanical ventilation and NCPAP. Moreover, NCPAP oral fed infants were discharged on similar level of oxygen supplementation as NCPAP-gavage fed infants. Thus respiratory disease status and discharge outcome of infants were similar in both the groups. The discharge weights were also similar in both the groups. Thus the aero-digestive and growth outcomes were similar groups potentially supporting the safety of the practice. The lengths of hospital stay and readmission rates were similar in both the groups. The lengths of hospital stay are determined by various other factors and probably were not reflective of earlier achievement of oral feeds.

The relationship between suck-swallow and swallow-respiration during later maturational stages can be modified by sensory experience, and it is hypothesized that by optimizing the infant's oral feeding experience, the oro-rhythmic patterning can improve to facilitate safe swallowing [22]. Our study suggests that oral feeding while on NCPAP is feasible through carefully defined criteria and safety monitoring techniques.

As with many retrospective studies, there are several limitations with our study. 1) This study was possible due to variations in feeding practices among the providers within one NICU. Thus the allocation of the infants to either practice was driven by physician preferences and was not randomly assigned. 2) Feeding assessments and management during symptoms can be subjective among providers; interventions may not be consistent between feeding therapists, and continued to evolve with time. Therefore, potential differences among feeding providers may bias the results. 3) Additionally, the quality of the nursing staff training and experience as well as their workload might influence their feeding sessions. Inability to take this variability due to limited sample size could be possible limitation of this study. 4) A 'Hawthorne effect' is a potential possibility. But the full oral feeding milestone in these infants was achieved several weeks after the feeding sessions during nasal CPAP were discontinued. Furthermore, the nurses feeding the infants after nasal CPAP were probably unaware of the differing feeding approach during nasal CPAP thereby minimizing the possibility of such an effect. However care should be taken minimize such an effect in future applications. 5) Another potential limitation of the study was that the mechanism of the swallow was not studied during bottle feeding on NCPAP. Video swallow studies are currently the most common method of studying a swallow and are not standard practice in the our NICU unless the infant demonstrates specific swallowing concerns such as coughing and choking with feeding, need for increased supplemental oxygen, or physiologic events with swallowing. Furthermore, swallowing studies are not feasible when infants are on NCPAP. With observed behavioral and physiologic signs of distress related to swallowing such as coughing, gagging, arching, or decline in oxygen saturation, [12] the infants were not eligible for oral feeding therapy. Further diagnostic measures based on physician discretion may have taken place upon the infant's transition off of positive pressure or when the infant reached a gestational age past term.

Although the mechanisms are unclear, a specific oral feeding program for infants on NCPAP could potentially accelerate the attainment of oral feeding milestones in infants with severe BPD. Potential mechanisms for improvement may include repetitive oral feeding memory, minimized oral feeding variability, and recognizing feeding cues at appropriate feeding intervals. The knowledge gained from this study can form the basis for potentially better feeding practices in infants on respiratory support.

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Figure 1. Full oral feeding milestones in NCPAP-oral fed group (n=20) vs NCPAP-gavage fed group (n=17)

A. NCPAP-oral fed group achieved oral feeding milestone at earlier chronologic age than NCPAP-gavage fed group. B. Though the GA at birth was similar in two groups, NCPAP-oral fed group achieved oral feeding milestones at earlier PMA than NCPAP-gavage fed group.

Figure 2. Resource utilization in NCPAP-oral fed group vs. NCPAP-gavage fed group
 A. NCPAP-oral fed group had similar length of hospital stay than NCPAP-gavage fed group. B. Readmission rate 30 days post discharge was similar in NCPAP-oral fed group than NCPAP-gavage fed group.

Table 1

Demographic and Clinical Characteristics

Characteristics	NCPAP - oral fed group (N=26)	NCPAP - gavage fed group (N=27)	P value
Gender, female, n (%)	10 (38.5%)	11.0 (40.7%)	0.87
Gestational age (GA), weeks	25.0 (24.0 – 26.0)	26.0 (25.0 – 27.0)	0.19
Birth weight (BW), grams	665 (589– 834)	640 (575.0 – 844.0)	0.73
Discharge weight, grams	3740 (3363 – 4513)	4075(3405– 4755)	0.56
IVH grades I & II, n (%)	12 (46.3%)	9 (33.3%)	0.50
PDA ligation, n (%)	11 (42.3%)	11.0 (40.7%)	0.91

Values expressed as Median (IQR) or as specified otherwise

Table 2

Aero-digestive Outcomes

Characteristics	NCPAP - oral fed group (N=26)	NCPAP - gavage fed group (N=27)	P value
Duration of mechanical ventilation, days	39.0 (19.8 – 57)	38.0 (11.0 – 57.0)	0.64
Duration of CPAP, days	41.5 (27.8 – 48.3)	41.0 (30.0 – 62.0)	0.38
Supplemental 100% oxygen at discharge, liters/min	0.50 (0.38–0.53)	0.40 (0.2– 0.6)	0.24
Gastrostomy tube, n (%)	6 (23%)	10 (37%)	0.37

Values expressed as Median (IQR) or as specified otherwise