RCSLT

Speech and Language Therapy in Neonatal Care: Feeding and Non-Invasive Respiratory Support

Position Paper

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Contents

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Key recommendations

I. Speech and language therapists (SLTs) are key members of the neonatal multi-disciplinary team (MDT), supporting early communication, feeding, and swallowing through skilled observation, assessment, collaborative management planning and education.

II. The impact of non-invasive respiratory support on communication, feeding, and swallowing should be managed by an experienced SLT who uses a collaborative MDT approach to shared clinical decision making, assessment, and intervention within the context of the changing physiological, anatomical, neurological, and developmental background of an infant.

III. Individualised SLT assessment and management of feeding infants requiring non-invasive ventilatory support which considers; medical complexity, gestational age, level of respiratory support, weight, developmental readiness, and suck feeding method(s) is essential and must be carried out in partnership with parents, families, and/or carers and the neonatal MDT within family integrated care and neuroprotective care frameworks.

IV. Currently there is a lack of guidance and varied opinion in the literature regarding feeding on non-invasive respiratory support. The SLT workforce can make a significant contribution in developing a more robust evidence base and improve the quality of care provided.

V. Research and innovation within the field should focus on the benefit SLT can contribute to the clinical decision-making process and therapeutic care for infants and their parents, families and/or carers in neonatal care receiving non-invasive respiratory support.

VI. Collaborative working with neonatal MDT colleagues to support and lead audits, quality improvement projects and research agendas is recommended.

Introduction

Over the past two decades there has been increasing acknowledgement that infant outcomes following admission to a neonatal unit need to extend beyond survival and discharge (Moore et al, 2012). The lack of appropriate Allied Health Professionals (AHPs) expertise within neonatal care has been formally recognised within national drivers for neonatal change (NHS England and NHS Improvement, 2019; Adams, Harvey and Sweeting, 2022; Adams Harvey and Sweeting, 2022; Ockenden, 2022: British association of Perinatal Medicine, 2021; Royal College of Speech and Language Therapists, 2018; All Wales Neonatal Standards, 2017; Neonatal expert advisory group, 2013; Neonatal network Northern Ireland, (no date)). Our expertise as SLTs in supporting communication and feeding through skilled observation, assessment, collaborative management planning and education is well suited to the neonatal setting (Murphy et al, 2021; Marks, Gordon and Parnell, 2022).

As we increase representation as a profession in neonatal care, we continue to develop our understanding of medical, environmental, and parental factors within family integrated care (FiCare) and neuroprotective care frameworks (Altimer and Phillips, 2016; Soni, Wel-Wel and Robertson, 2022; British Association of Perinatal Medicine, 2021). This will better inform our intervention to support communication and feeding outcomes for infants and families. Due to developmental, physiological, anatomical and/or neurological difficulties infants requiring neonatal care may need non-invasive respiratory support, meaning the transition to suck feeding for some infants can be more complex and has the potential to impact an infant's communication, feeding and swallowing (Shaker, 2018; Murphy, Harrison and Harding, 2018).

Scope

The purpose of this position paper is to review and summarise the literature and evidence base to date in the evolving field of neonatal infant respiratory care, and to act as a reference and provide guidance for SLTs supporting communication and feeding outcomes for infants requiring non-invasive respiratory support. It is intended that this position paper will generate discussion between SLTs, parents, families and/or carers, and members of the neonatal MDT, and guide individualised clinical decision-making for when to begin suck feeding opportunities for infants who require non-invasive respiratory support, with specific focus on nasal continuous airway pressure (nCPAP) and high flow nasal cannula (HFNC) (Shaker, 2018; Murphy, Harrison and Harding, 2018).

Currently there remains a lack of guidance and varied opinion regarding suck feeding when an infant requires non-invasive respiratory support (Murphy, Harrison and Harding, 2018; Canning et al, 2020), demonstrating that outcomes, practice, and conclusions are varied, thereby stressing the necessity for large number of randomised studies. Such studies may help to develop better evidence-based protocols to guide the best suck feeding interventions for infants receiving non-invasive respiratory support (Dalgleish, Kostecky, and Blachly, 2016; Bapat, Gulati and Jadcherla, 2019).

Several strategies are being investigated to ease the developmental transition for infants to develop their suck feeding skills, such as cue-based feeding, reducing milk flow, and pacing, trialled with the goal of reducing aspiration, while allowing the infant positive early oral-sensory feeding experiences and supporting infant-carer bonding (Harding et al, 2015; Thoyre et al, 2013; Shaker, 2017; Shaker, 2013). However, the risk of aspiration, mal-adaptive feeding behaviours, respiratory system morbidity and the negative influence of stress in the neonatal period continue to concern SLTs who want to safe-guard these infants' outcomes and long-term development (Ferrara et al 2017; Krűger et al, 2016). This position paper recommends both caution and shared clinical decision making with the neonatal MDT when supporting suck feeding for infants requiring non-invasive respiratory support.

The authors acknowledge this position paper will have limitations and will require a regular review process. This clinical area is an emerging field for SLTs and the literature and evidence base, although developing, is currently limited.

*Suck feeding definition: Includes oral feeds, orally feeding, oral feeding, orally fed, nipple feeding, breastfeeding, chest feeding, bottle-feeding.

Background

Infants in neonatal care requiring respiratory support

Infants born preterm have an immature respiratory system (Smith et al, 2010). As the preterm infant develops outside of the uterine environment, the normal process of lung development is interrupted. The lungs grow and mature in an environment not designed for this process, leading to respiratory compromise called Bronchopulmonary Dysplasia (BPD) and Chronic Lung Disease of Prematurity (CLD) (Bonadies et al, 2020). The physiology of respiratory compromise in term infants is different (Gallacher, Hart and Kotecha, 2016). Conditions causing respiratory compromise for term infants can include, congenital diaphragmatic hernia, meconium aspiration syndrome, cardiac anomalies, persistent pulmonary hypertension of the new-born (PPHN), congenital pneumonia, tracheo-oesophageal fistula (TOF), tracheomalacia, laryngomalacia, choanal atresia, subglottic stenosis, and neurological diagnoses. Both pre-term and term infants can experience both short and long-term respiratory compromise at parenchymal level and compromise of the central airways (Hysinger, 2021). All these infants can receive respiratory support to enable their survival, recovery, and optimise developmental outcomes (Murphy, Harrison and Harding, 2018).

Respiratory support can be in the form of:

- **Invasive ventilation:** positive pressure delivered to an infant's lungs via an endotracheal tube or a tracheostomy tube.
- **Non-invasive ventilation (NIV):** delivery of positive airway pressure in infant's who are breathing spontaneously.
    - **Continuous positive airway pressure (CPAP):** a continuous single-level pressure is introduced into the airways to constantly stent them open. This can be delivered via a face mask or nasal prongs, most commonly in infants nasal CPAP (nCPAP) is used.
    - **Bilevel positive airway pressure (BiPAP):** a continuous lower pressure is delivered to stent the airways open, then an additional higher pressure is delivered intermittently to support inspiration. This can be delivered at a pre-determined set respiratory rate or triggered by the infant starting to take a breath. This provides additional support, more than CPAP alone.
- **High flow nasal cannula (HFNC):** A technique delivering heated and humidified blended air/oxygen gas via nasal cannula, at high flow rates greater than 1 l/min delivering both high concentrations of oxygen and potential continuous distending pressure[31]. HFNC could be known on a neonatal unit as Optiflow (Fisher-Paykel)™, Airvo™, Vapotherm (Vapotherm Inc)™ and Fabian™ Therapy evolution (Vyaire Medical).

- **Low flow nasal cannula oxygen:** delivery of supplemental oxygen via nasal cannula.

Context

Neonatal care aims to provide lifesaving interventions alongside supporting the developmental needs of the infant and their families. Infants may reach a point where they are developmentally ready to experience suck feeding opportunities but still require non-invasive respiratory support. Increasingly, having some nutritive suck feeding opportunities is considered as providing some early positive oral-sensory motor benefits to mitigate any associated problems with oral-sensory motor development. Reported benefits include optimising neurodevelopmental outcomes, providing positive oral - sensory motor experiences, reducing the risk of long term sensory based feeding difficulties, and reduced hospital readmissions following discharge from neonatal care (Murphy, Harrison and Harding, 2018; Dalgleish, Kostecky and Blachly, 2016; Harding et al, 2015). However, due to possible risks of aspiration, suck feeding experiences for these infants remains controversial (Canning et al, 2020; Dalgleish, Kostecky and Blachly, 2016; Ferrara et al, 2017).

Other areas cited as parameters of interest in offering suck feeding opportunities to infants on non-invasive respiratory support, are whether time to full suck feeds have achieved shorter hospital stays leading to discharge home sooner. These parameters are of interest because they have financial and psychosocial implications (Canning et al, 2020; Ferrara et al, 2017). Concerns highlighted are that by delaying the introduction of suck feeding until non-invasive respiratory support is stopped, feeding milestones can be delayed. Establishing suck feeding is one of the last milestones to achieve and later oral feeding trials can delay the discharge of an infant from the neonatal unit; this motivates the thinking that starting suck feeding sooner may enable discharge home to happen faster. The difficulty with this belief is its focus on volumes of intake rather than quality and sustainability of suck feeding skills and behaviours. It not only matters how quickly an infant achieves suck feeding, but rather the quality of feeding experiences and the success of those feeds (Harding et al, 2015; Thoyre et al, 2013; Shaker, 2017; Shaker, 2013). The quality of feeding has a more substantial impact on longer term feeding outcomes than time taken to reach full suck feeds. The arguments of offering suck feeds to infants requiring non-invasive respiratory support are outlined in the literature review below.

Methodology

Working group

Members of the Royal College of Speech and Language Therapists (RCSLT) Neonatal Clinical Excellence Network (CEN) identified a lack of national guidance for infants and suck feeding whilst requiring non-invasive respiratory support. In February 2021 a working group was formed to review the literature and evidence-base to develop a position paper to support best practice. This was in response to increasing requests from RCSLT CEN members for clinical guidance. Members of the working group included SLTs currently working predominantly in neonatal care and navigating decisions around feeding on non-invasive respiratory support.

Writing of the position paper

In March 2021 a working group was set up with the aim of writing a position paper. The entire process took 24 months. The working group initially consisted of 3 members and later grew to 11.

Members of the working group were assigned pieces of literature to review and sections to contribute to. Frequent online meetings were held in which issues were discussed and tasks were assigned and agreed upon.

Following the member consultation, the authors came together to finalise the content of the paper. The paper went through several drafts of consultation.

Member consultation

The profession was alerted to the position paper whilst it was in development and was subsequently invited to review the document and comment. A draft copy was made available to RCSLT Neonatal CEN members, relevant RCSLT Clinical Excellence Networks (CENS), British Association of Perinatal Medicine (BAPM), Neonatal Nursing Association (NNA), Allied Health Professional (AHP) and Clinical Psychology colleagues, medical colleagues and the RCSLT. Multiple reviewers made comments which were taken into consideration and changes were made. There were no major disagreements as to content and all parties agreed on the paper after review.

Literature review

A detailed literature review was completed with references ranging over the last ten years from 2012 to March 2022. A preliminary search was conducted using five platforms including Google Scholar, Springer, ResearchGate, PubMed and CINHAL The search terms and Boolean operators used were: “oral feeding” AND “respiratory support” OR “CPAP” OR “HFNC” OR “nasal CPAP” OR “high flow nasal canula” OR “non-invasive respiratory support” OR “respiratory devices” AND “neonate” OR “preterm infant” Additional papers were identified by searching the reference lists of the identified papers. Due to the evolving nature of the topic and rapid new publications appearing a repeat literature search was conducted in 2022 from April 2022 to November 2022. An additional source of literature references was the Infant Feeding Care seminar entitled ‘Is it safe to feed infants on HFNC/CPAP: A review of the data’ by Dr Britt Pados in 2022.

The Pados (2022) framework factors for literature analysis relating to “safe feeding” was used in this position paper. The framework is based on her categorisation of the literature relating to ‘safe feeding’, which Pados divides into, 1) maintaining physiologic stability, 2) behavioural signs of distress, 3) airway protection, 4) achievement of full suck (oral) feeds and 5) discharge home. Assessing the safety of an infant's feeding and swallowing is the remit of the SLT working on a neonatal unit and this is a useful framework to focus on when considering the literature to guide clinical decision making for infant’s receiving non-invasive respiratory support and suck feeding.

The table below details the articles reviewed using the Critical Appraisal Skills Programme (CASP). There were articles about the basic mechanisms of non-invasive respiratory support and how different mechanisms are used for various reasons. Animal studies were then included, followed by adult studies. The literature pertaining to neonates was then listed and discussed, followed by scoping reviews that looked at clinical decision-making processes in practice. Where ‘n/a’ is used, it means that the information being commented on was not within the aim of the study.

Mechanisms of non-invasive respiratory support

Reference	Study Design	Title and Aim	Sample	Method	Outcome	Framework Factors	Limitations
JadcherlaS.R., et al, 2016	Prospective comparative cohort study	**Title:** Effect of nasal non-invasive respiratory support methods on pharyngeal provocation-induced aerodigestive reflexes in infants. **Aim:** to characterize and compare the aerodigestive adaptive responses evoked upon pharyngeal stimulation in a cohort of infants receiving different types of oxygen delivery methods, i.e., nCPAP, nasal cannula (NC) or room air (RA).	N=38	Comparisons between NC (n=19), nCPAP (n=9), RA (n=10). Infants underwent pharyngoesophageal manometry and respiratory inductance plethysmography to determine effects of graded pharyngeal stimuli on upper and lower oesophageal sphincters, swallowing and deglutition-apnoea.	NC or nCPAP (vs. RA) had: 1) delayed feeding milestones (P < .05), 2) increased pharyngeal waveform recruitment and duration, greater upper oesophageal (UES) pressure, decreased oesophageal contraction duration, decreased distal oesophageal contraction amplitude, and decreased completely propagated oesophageal peristalsis (all P < .05), and 3) similarly developed UES contractile and lower oesophageal sphincter (LES) relaxation reflexes (P > .05).	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** aerodigestive reflex were similarly developed in infants using non-invasive respiratory support with adequate upper and lower aerodigestive protection. **Achievement of full suck (oral) feeds**: NC and nCPAP (VS. RA)	Subject selection was random and so not equal across all three groups.

						had delayed feeding milestones. **Discharge home:** length of hospital stay was similar between NC & nCPAP groups.	
AmendoliaB., et al, 2014	Single centre retrospective study	**Title:** Feeding tolerance in preterm infants on non-invasive respiratory support. **Aim:** to evaluate differences in feeding tolerance between infants maintained on continuous positive airway pressure (nCPAP) and infants receiving high flow (nasal) cannula (HFNC) with or without nCPAP.	N = 185	2 groups of very low birth weight infants (750-1500g) were compared based on respiratory support (1) infants born between January 2002 and December 2004 treated with nCPAP and (2) infants born between January 2005 and December 2006 treated with HFNC with or without nCPAP. The groups were compared to determine which of the two achieved full suck (oral) feeding sooner.	No statistical difference in time to full enteral feedings between the 2 groups. There was no difference in time and initiation of suck (oral) feeding or days to full suck (oral) feeding between the 2 groups. The use of HFNC was not associated with changes in feeding tolerance in preterm infants.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No data available. **Discharge home:** No data available.	Management of preterm infants varies between providers and neonatal units. Grouping the infants into two time periods may have introduced confounding variables if overall management changed over the time period. Practice variation, clinical judgement and individual preferences exist in the neonatal

							unit clinical environment. Small sample size of infants receiving HFNC.
Hong, H., et al 2021	Meta-analysis	**Title:** High-flow nasal cannula versus nasal continuous positive airway pressure for respiratory support in preterm infants: a meta-analysis of randomized controlled trials. **Aim:** to evaluate and compare the efficacy and safety of HFNC and nCPAP for respiratory support in preterm infants.	21 RCTs	Searched for articles from their inception to December 2018. Search terms included: preterm infant, premature infant, newborn infant, high-flow nasal cannula, and continuous positive airway pressure. All published RCTs evaluating and comparing effects of HFNC and nCPAP were included.	(1) for primary respiratory support, rates of treatment failure at trial entry were similar between HFNC and nCPAP (relative risk 1.03, 95% confidence interval 0.79–1.33), and HFNC had reduced nasal trauma (p< .00001); and (2) for respiratory support after extubating. nCPAP was associated with a lower likelihood of treatment failure than HFNC (relative risk 1.23, 95% confidence interval 1.01–1.50). The incidences of nasal trauma and pneumothorax in the	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds**: No data available. **Discharge home:** No data available.	Heterogeneity of the characteristics of participants and interventions and the lack of a standardised assessment of treatment failure and nasal trauma. Some studies did not report primary and secondary outcome parameters. For infants at a Gestational age (GA) <28 weeks or birth weight (BW) <1000g, data regarding the use of HFNC for

					HFNC group were significantly lower than that in the nCPAP group (p < .0001 and p = .03). Serious adverse events did not significantly differ.		respiratory support are lacking.
Manley, B. J., & Owen, L. S., 2016	Review of randomised control trials	**Title:** High-flow nasal cannula: mechanisms, evidence and recommendations **Aim:** to compare nCPAP and HFNC for respiratory support post extubating of preterm infants.	N/A	This review considered (a) clinical trials of HFNC as primary respiratory support after birth in preterm infants and included randomized studies of HFNC vs nCPAP as primary support and randomized studies of HFNC vs nasal intermittent positive pressure ventilation (NIPPV) as primary support and (b) clinical trials of HFNC to prevent extubation failure in preterm infants including randomized trials of HFNC vs nCPAP to prevent extubation failure and comparison of different HFNC devices to prevent extubation failure. The review also discussed two randomized studies using	HFNC is a good alternative to nCPAP in post extubation support for preterm infants and reduces nasal trauma in infants. However, HFNC in place of nCPAP can result in longer duration of respiratory support and longer hospitalisation. The best and quickest way to wean off HFNC is uncertain.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds**: No data available. **Discharge home:** No data available.	Limited data are available from randomized trials comparing HFNC with nCPAP as primary support. There are currently inadequate data on the use of HFNC in extremely preterm infants born <28 weeks' GA.

				HFNC to wean preterm infants from nCPAP.			
Manley, B. J., et al 2012	Literature review	**Title:** High-flow nasal cannula for respiratory support of preterm infants: a review of the evidence **Aim:** To present and discuss the available evidence for the use of HFNC in the preterm population.	19 studies	Internet based literature search for relevant, original research articles (both randomised studies and not) on the use of HFNC in preterm infants.	Distending pressure generated by HFNC in preterm infants increases with increasing flow rate and decreasing infant size and varies according to the amount of leak around the prongs. HFNC may be as effective as nCPAP at improving respiratory parameters such as tidal volume and work of breathing in infants, but probably only at flow rates >2 L/min.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds**: No difference noted in time to achieve full suck feeds. **Discharge home:** No difference noted in discharge time.	Studies included in the review have variable levels of evidence. Inadequate data on extremely preterm infants <28 weeks.
Pourazar, F., et al 2018	Prospective crossover study	**Title:** Comparison of the Effects of Prone and Supine Positions on Abdominal Distention in the	N=37	This clinical trial was conducted over six months with a randomized block crossover design selected for the supine and prone	In the analysis of variance, comparison of the changes in the abdominal circumference at 15,	**Physiologic stability:** No data available.	Lack of congenital disorders. Breastfed infants only.

		Premature Infants Receiving Nasal Cannula Positive Airway Pressure (nCPAP). **Aim:** to compare the effects of supine and prone positions on the abdominal distention of the newborns with nCPAP.		positions on the back and abdomen, respectively. Samples were breastfed infants receiving non-invasive respiratory support, who were kept in the mentioned positions for two hours. Data analysis was performed using descriptive and inferential statistics.	30, 60, 90, and 120 minutes in the supine position (P=0.004) and prone position (P=0.001) with repeated sizes indicated a significant difference in at least one of the mentioned timings Prone position while feeding could effectively reduce abdominal distention in the neonates receiving nCPAP.	**Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds**: No data available. **Discharge home:** No data available.	Limited details regarding method of feeding.
Liew. Z., et al 2020	A prospective randomised crossover study	**Title**: Physiological effects of high- flow nasal cannula therapy in preterm infants **Aim**: to investigate the effects of HFNC on respiratory physiology.	N=44	Infants in three current weight groups were studied: <1000 g, 1000–1500 g and >1500 g. Infants were randomised to either first receive HFNC flows 8–2 L/ min and then nCPAP 6 cm H2 O or nCPAP first and then HFNC flows 8–2 L/min. Nasopharyngeal end-expiratory airway pressure	Increasing flows from 2 to 8 L/min significantly increased pEEP (mean 2.3–6.1 cm H2 O) and reduced pEECO2 (mean 2.3%–0.9%). Tidal volume and transcutaneous CO2 were unchanged. Significant differences were seen between	**Physiologic stability:** no data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available.	There are significant limitations to the use of TCCO2 in premature infants, but it is non- invasive. It was argued that arterial blood gas

				(pEEP), tidal volume, dead space washout by nasopharyngeal end-expiratory CO2 (pEECO2), oxygen saturation and vital signs were measured.	pEEP generated in open and closed mouth states across all HFNC flows (difference 0.6–2.3 cm H2 O). Infants weighing <1000 g received higher pEEP at the same HFNC flow than infants weighing >1000 g. Variability of pEEP generated at HFNC flows of 6–8 L/min was greater than nCPAP (2.4–13.5 vs 3.5–9.9 cm H2 O).	**Achievement of full suck (oral) feeds:** No data available. **Discharge home:** No data available.	measurements were impractical. Multiple factors impact the pEEP delivered by HFNC in preterm infants leading to considerable variability. No details given regarding co-morbidities of infants.

Animal studies

Reference	Study Design	Title and Aim	Sample	Method	Outcome	Framework Factors	Limitations
Bernier A., et al, 2012	Experimental study	**Title:** Effects of nasal continuous positive-airway pressure on nutritive swallowing in lambs.	N=8	Lambs were bottle-fed under 5 randomised nCPAP conditions, including without any nCPAP or nasal mask and nCPAP of 0,4, 7, and 10 cmH2O.	Application of nCPAP in the full-term lamb had no deleterious effect on feeding safety and efficiency or on nutritive	**Physiologic stability:** No data available **Behavioural signs of distress:** No data available.	Full term lambs: not generalisable to preterm infants.

		Aim: to provide a first assessment of the effect of various levels of nCPAP on bottle feeding in a neonatal ovine model, including feeding safety, feeding efficiency and nutritive swallowing-breathing coordination.			swallowing-breathing coordination.	**Airway protection:** Mentioned 'safety', but no objective measurement technique offered. **Achievement of full suck (oral) feeds**: No data available. **Discharge home:** No data available.	No mention of physiologic or behavioural stability.
Samson, N., et al 2018	Experimental study	**Title:** Effects of Nasal Continuous Positive Airway Pressure and High-Flow Nasal Cannula on Sucking, Swallowing, and Breathing during Bottle-Feeding in Lambs. **Aim:** to assess the impact of nCPAP and HFNC on safety and efficiency of bottle	N=8	8 full term lambs were instrumented to record sucking, swallowing, and respiration as well as electrocardiogram and oxygenation. Lambs were bottle-fed in a standardised manner during three randomly ordered conditions: nCPAP 6 cmH2O, HFNC 7 L/min, and no respiratory support.	nCPAP reduced feeding duration [25 vs 31 s (control) vs 57 s ~(HFNC), p=,03] and increased the rate of milk transfer [.4 vs 1.9 mL/s (control) vs 1.1 mL/s (HFNC), p=.03]	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral)**	Full term lambs, not generalisable to premature infants.

		feeding on full term lambs.				**feeds**: No data available. **Discharge home:** No data available.	
Djeddi D., et al 2013	Experimental randomised control study	**Title:** Absence of effect of nasal continuous positive-airway pressure on the esophageal phase of nutritive swallowing in newborn lambs. **Aim:** to assess effects of nCPAP on suck feeding by assessing its effects on the oesophageal phase of nutritive swallowing.	N=6	Six full-term lambs, ages 2 to 3 days, underwent oesophageal multichannel intraluminal impedance-pH monitoring. Lambs were bottle-fed under 2 randomized conditions, namely spontaneous breathing and nCPAP 6 cmH2O.	Beyond confirmation of unaltered feeding efficiency, analysis of multiple variables measured by impedance monitoring revealed that nCPAP 6 does not alter nutritive oesophageal deglutition in any way (nCPAP vs spontaneous breathing, P > .1 for all variables).	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds**: No data available. **Discharge home:** No data available.	Full term lambs, not generalisable to premature infants. Findings comment on 'nutritive oesophageal deglutition', but this is not defined. The swallow is not mentioned, nor is airway protection.

Adult studies

Reference	Study Design	Title and Aim	Sample	Method	Outcome	Framework Factors	Limitations
Leder, S.B., et al, 2016	Prospective cohort study	**Title:** Oral alimentation in neonatal and adult populations requiring high-flow oxygen via nasal cannula. **Aim:** To investigate the impact of HFO2-NC use on feeding in neonates and adult ICU patients.	N=100 Neonatal and adult demographics and respiratory support grouped by oral feeding status. Age differences noted in neonates but did not reach statistical significance. Similarly, no statistical differences between adults.	NICU (n=50) MICU (n=50) Decision to initiate suck feeds with neonates was made jointly by neonatology and nursing teams using set criteria. Decision to resume oral feeding with adults made by medical intensivist, SLT and nursing using specific criteria.	17/50 (34%) neonates requiring HFO2-NC deemed appropriate to resume suck feeding. All 17 (100%) successful with initiating suck feeding supplemented by continued enteral tube feeding. 39/50 (78%) adults requiring HFO2-NC deemed appropriate to resume oral feeding. All 39 (100%) successful with resumption feeding without need for supplemental enteral tube feeding.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** Noted that there were no clinical signs of aspiration. **Achievement of full suck (oral) feeds:** No data available. **Discharge home:** No data available.	Adult population: Limited applicability to neonates. Reported no clinical signs of aspiration however does not account for silent aspiration.

Dodrill, P., et al, 2016	N/A	**Title:** FIRST, DO NO HARM: A Response to "Oral Alimentation in Neonatal and Adult Populations Requiring High-Flow Oxygen via Nasal Cannula" **Aim:** to express concern about the design and conclusions presented in the Leder et al., 2016 study.	N/A	Critique of the Leder et al., 2016 study.	Critiques included: no direct feeding evaluation (either formal clinical assessment or instrumental assessment), observational study (not RCT), cross section (not longitudinal) study, insufficient data to determine if the practice of offering the infants suck feeds while on HFNC benefited / harmed the infants.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No data available. **Discharge home:** No data available.	Critique of Leder., et al 2016 not original research.
Oomagari, M., et al. 2015	Prospective cohort study	**Title:** *Swallowing function during high-flow nasal cannula therapy.* **Aim:** to assess the effect of high flow nasal cannula therapy on swallow function	N=32	Subjects underwent HFNC at different flow rates chosen at random (0, 10, 20, 30, 40, and 50 L/min). All subjects underwent the 30-mL water swallow test (WST) and the repetitive saliva swallowing test (RSST) during use of HFNC. Difficulty swallowing water during the WST was evaluated using a visual analogue scale.	In the WST, five subjects (15.6%) choked at flow rates of 40 and 50 L/min ($p < .05$). A flow rate of > 20 L/min was lower number of swallows during the RSST and greater difficulty	**Physiologic stability:** no data available. **Behavioural signs of distress:** no data available. **Airway protection:** a	Subjects are healthy adults therefore results cannot be generalised to infants.

				The swallowing time and number of swallows in 30 seconds were evaluated during the RSST.	swallowing than a flow rate of 0 L/min ($p < .05$). The change in the swallowing time was significantly associated with difficulty swallowing at 40 and 50 L/min ($p < .05$). Logistic regression analyses were performed to identify which WST and RSST parameters were associated with choking during HFNC. In the adjusted model, the change in swallowing time was an independent predictor of choking during HFNC (OR = 1.02, 95% CI = 1.01–1.04).	HFNC flowrate of >40 L/min was associated with decreased swallowing function in healthy subjects. **Achievement of full suck (oral) feeds:** no data available. **Discharge home:** no data available.	

Neonatal feeding studies

Reference	Study Design	Title and Aim	Sample	Method	Outcome	Framework Factors	Limitations
Dalgleish, S.R., et al, 2016	Quality improvement project	**Title:** *Eating in "SINC": Safe Individualized Nipple-feeding Competence, a quality improvement project to explore infant-drive oral feeding for very premature infants requiring non-invasive respiratory support.* **Aim:** to safely initiate and advance nipple feeding for very preterm neonates (born at <32 weeks gestation) who had a respiratory morbidity requiring nCPAP therapy. (N= 196)	5 NICUs	Pre (Jan 1 – Jun 30, 2012); Post (Jul 1 – Dec 31, 2013) Strong emphasis on breastfeeding Infant fed when physiologically stable and showing alertness and hunger cues (even in still on nCPAP) Stepwise progression from NNS using 10 incremental increases in volume and time of practice. Emphasis was on stopping at first sign of stress.	Infants fed according to SINC algorithm had a longer NICU stay (39 0/7 vs 38 2/7, p=.1) and were less likely to be discharged from NICU still requiring tube feeding (p=.08).	**Physiologic stability:** suck feeding trials halted due to physiologic instability. **Behavioural signs of distress**: suck feeding opportunities halted due to behavioural instability. **Airway protection:** there were no cases of suspected aspiration based on clinical or radiographic observation. **Achievement of full suck (oral) feeds:** Not reported in this pilot study. **Discharge home:** clinical significance, the infants fed according to SINC algorithm had a slightly longer NICU	Only evaluated on a pilot basis. Chest x ray is not a reliable indicator of aspiration. It is a late sign so might miss earlier aspiration events. No clinical signs of aspiration do not equate to no aspiration – most infants who aspirate do so silently.

						stay and were less likely to be discharged from the NICU still requiring tube feeding.	
Dumpa, V., et al, 2020	Retrospective pre–post analysis	**Title:** *The effects of oral feeding while on nasal continuous positive airway pressure (nCPAP) in preterm infants.* **Aim:** To determine whether delaying suck (oral) feeding until coming off nCPAP will alter feeding and respiratory-related morbidity in preterm infants.	N=99 No difference in comorbidities were noted.	Group 1 (n=39) initiated feeding while on nCPAP. Group 2 (n=60) initiated feeding while no longer on nCPAP.	Group 1 initiated suck (oral) feeding earlier (p=.0001) Days to reach full suck (oral) feeding (p=.003) Group 1 took longer = 16 days Group 2 = 10 days	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** Mean post menstrual age (PMA) at full suck (oral) feeding for all groups was between 37.2- and 37.6-weeks PMA. **Discharge home:** Length of stay not significantly different.	Retrospective study, several factors may have influenced outcomes. There were no significant clinical practice changes recorded in the study period. A ventilator-derived, variable-flow nCPAP system used in the study, for which the findings may not apply to those infants on other types of nCPAP. The differential effect on the outcomes regarding breast milk versus formula was not studied. Study conducted on preterm infants ≤32 weeks GA, which is a group with the most immature suck and swallow mechanisms, the results may not apply to other GA infants. A small sample size increases the margin of error.

Ferrara, L., et al, 2017	Prospective cross-over study	**Title:** *Effect of nasal continuous positive airway pressure on the pharyngeal swallow in neonates. To assess the effects of nCPAP on pharyngeal swallowing in neonates.* **Aim:** This study was designed to assess the effects of nCPAP on pharyngeal swallowing in neonates.	N=7	Receiving nCPAP with a RAM cannula. Taking >50% of their feeding orally. Videofluoroscopic swallow study on nCPAP and off nCPAP (on nasal cannula, 1 1lpm flow).	Deep penetration (p=.03) and aspiration (=.01) significantly less off nCPAP. Incidence of mild penetration (p=.65) and nasopharyngeal reflux (p=.87) remained the same under both conditions.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No cough response noted (but where silent aspiration occurs there would be no cough, so cannot be used as a sole behavioural measure). **Airway protection:** Objective measure used to assess. *Only study noted to offer this level of evidence. **Achievement of full suck (oral) feeds:** No data available. **Discharge home:** No data available.	Small number of participants. Inclusion criteria did not include a specific gestational age requirement. 6 participants were preterm, and 1 participant was born full term.
Hanin, M., et al, 2015	Retrospective cohort study	**Title:** *Safety and Efficacy of oral feeding in infants with Bronchopulmonary*	N=53 Data from infants with BPD (37-42	Suck (oral) feeding on nCPAP (n=26) Exclusively gavage fed on nCPAP (n=27) Data from infants suck (oral) feeding	PMA at full suck (oral) feeding (p=.03) Suck (oral) feeding group: 41.6 weeks Non-suck (oral) feeding group: 45.5 weeks	**Physiologic stability:** No data available. **Behavioural signs of distress:** 46% oral feeding sessions were	Extremely controlled conditions: Elevated side lying, pacing, slow flow nipple and an experienced dysphagia trained professional feeding. Not

		Dysplasia (BPD) on nasal CPAP. **Aim:** to examine safety and efficiency of suck (oral) feeding in infants with BPD on nCPAP.	weeks PMA) No difference in demographics or clinical characteristics	while on nCPAP was compared to those that were exclusively gavage fed on nCPAP. Used SOFFI framework for all feedings Monitored and documented internal regulation and behavioural responses before, during and after feeds Fed by Occupational Therapist 1 session per day Feeding discontinued if infants exhibited increased RR, decreased O2 saturations, bradycardia, coughing, gagging or other behavioural signs of distress. Fed by nursing only after off nCPAP.	Length of stay Suck (oral) feeding group: 142.5 days Non-suck (oral) feeding group: 160 days Readmissions Suck (oral) feeding group: 7.7% (n=2) Non-suck (oral) feeding group: 22.2% (n=6) No “clinically significant aspiration pneumonia” while eating on nCPAP	discontinued due to behavioural stress cues. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No data available. **Discharge home:** Does not result in faster discharge home.	likely to mirror the feeding circumstances on most neonatal units as a standard. Nearly half of sessions were stopped due to stress signs, this is not considered in the conclusion and recommendation.
Leibel, S. L., et al, 2020	Randomized control pilot study	**Title:** *Comparison of Continuous positive airway pressure versus*	N=25	Between 2014-2016 40 infants (born <28 weeks GA) dependant on nCPAP at 34+0	The days to full oral feeds between the nCPAP and HFNC groups were 36.5 days	**Physiologic stability:** No data available.	Study design is valid but methodologically not sound. There was a mix of

		High flow nasal cannula for Oral feeding Preterm infants (CHOmP): randomized pilot study. **Aim:** To assess the feasibility of conducting a study comparing nCPAP vs heated humidified HFNC on suck (oral) feeding in preterm infants.		weeks corrected gestational age (CGA) were randomized to two intervention groups. Of these, 15 were transferred or broke protocol. 25 concluded the trail (12 in nCPAP, 13 in HFNC). All infants enrolled in the study were placed on a suck (oral) feeding protocol with breast and/or bottle feeds. Secondary outcomes included time in NIV, BPD, apnea accompanied by desaturation and/or bradycardia, feeding intolerance and weight gain. Statistical analysis of the primary outcome was performed with Wilcoxon Rank Sum test.	and 29 days respectively, p=.35. There were no statistical differences in the secondary outcomes between the two groups.	**Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** Infants orally fed on nCPAP take longer to reach full suck (oral) feeds than those orally fed on HFNC. **Discharge home:** No data available.	bottle and breast feeding in each group. Limited information on the possible adverse effects of feeding on ventilation.
Shetty, S., et al, 2016	Retrospectiv e cohort	**Title:** *High-flow nasal cannula oxygen and nasal*	N=72	Between 2011 and 2013 infants post extubation were	Postnatal age of first suck (oral) feeds earlier in nCPAP/HFNC group	**Physiologic stability:** No data available.	Infants with major congenital abnormalities or those who failed to

	comparative study	*continuous positive airway pressure and full oral feeding in infants with bronchopulmonary dysphagia.* **Aim:** to determine whether the time to achieve full suck (oral) feeding differed between infants with bronchopulmonary dysplasia (BPD) supported by nCPAP compared to those supported by nCPAP and subsequently transferred to heated HFNC.		supported by nCPAP, from 2013 infants were supported by nCPAP and then HFNC. The post-natal age at which suck (oral) feeds were first trialled and full suck (oral) feeds established was measured. The length of respiratory support as either nCPAP or nCPAP/HFNC and the total length of respiratory support and hospital stay were also determined. Sub analysis was undertaken of infants requiring support beyond 34 weeks.	(p=.012), but infants were a shorter time on nCPAP compared with nCPAP/HFNC (p=.003). On subgroup analysis the age to full suck (oral) feeding was earlier in the nCPAP/HFNC group (p=<.001).	**Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No difference noted in time to achieve full suck (oral) feeds. **Discharge home:** No difference noted in discharge time.	achieve full suck (oral) feeds by discharge were excluded.
Shimizu, D., et al, 2019	Retrospective case control	**Title:** *Impact of High Flow nasal cannula (HFNC) therapy on oral feeding in very low birth weight (VLBW)*	N=45	HFNC (n=11) supported by HFNC at suck (oral) feeding initiation, and a non-HFNC group (n=34) that could start suck	Timing of suck (oral) feeding initiation and full suck (oral) feeding achievement in both groups were not significantly different: 35.3 vs 35.5 (p=.91) for	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available.	Retrospective study with a small sample size. Significant differences between the HFNC and non-HFNC groups in gestational age, body, weight, and CLD.

		infants with chronic lung disease (CLD). **Aim:** to elucidate whether HFNC could prevent the delay in feeding and achievement of full suck (oral) feeding in very low birth weight (VLBW) Infants with CLD.		(oral) feeds without HFNC.	HFNC and 36.6 vs. 36.7 (p=.29) for the non-HFNC.	**Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No difference noted in time to achieve full suck (oral) feeds. **Discharge home:** No difference noted in discharge time.	Unable to evaluate the effect of psychomotor development because the infants did not reach 10 months of age.
Taha, D. K., et al, 2016	Retrospective data analysis	**Title:** *High flow nasal cannula use is associated with increased morbidity and length of hospitalization in extremely low birth weight infants.* **Aim:** to determine the difference in the incidence of BPD or death in extremely low birth weight infants managed on HFNC vs nCPAP.	N=2487 Demographics, clinical characteristics, and neonatal outcomes were compared between infants who received HFNC and nCPAP, or HFNC +/- nCPAP.	Retrospective data analysis from the Alere Database for infants born between January 2008-July 2013, weighing <1000g, received HFNC or nCPAP. 941 infants on CPAP, 333 infants on HFNC, 1546 infants on HFNC +/- nCPAP	Primary outcome of BPD or death was significantly higher in the HFNC group (56.8%) compared with the nCPAP groups (50.4%), p=<.05). Similarly, adjusted odds of developing BPD or death was greater in the HFNC +/- nCPAP group compared with the nCPAP group (p=.001). The number of ventilator days, postnatal steroid use, days to room air, days to initiate or reach full	**Physiologic stability:** no data available. **Behavioural signs of distress:** no data Airway protection: no data available. **Achievement of full suck (oral) feeds:** significantly longer in infants in the HFNC group compared with the nCPAP group. **Discharge home:** significantly longer in infants in the HFNC	Retrospective study. Infants were not randomized to receive HFNC or nCPAP. The litre flow of HFNC and the pressure of the nCPAP were not in the database. The order in which the infants were exposed to HFNC and nCPAP in the HFNC +/- nCPAP group is unknown. Not all eligible infants in the study sites were enrolled.

					oral feeds, and length of hospitalisation were significantly higher in the HFNC and HFNC +/- groups compared with the nCPAP.	group compared with the nCPAP group.	
Glackin, S.J., et al, 2017	Single centre randomised controlled trial	**Title:** *High flow nasal cannula versus nCPAP, duration to full oral feeds in preterm infants: a randomised controlled trial.* **Aim:** to compare the time taken by preterm infants with evolving chronic lung disease to achieve full suck (oral) feeding when supported with humidified HFNC or nCPAP.	N=44	Infants randomised in a 1:1 ratio to receive HFNC or nCPAP. Participants monitored daily until full suck (oral) feeding established and infant off respiratory support.	44 infants randomised (22 HFNC vs 22 nCPAP). No statistical differences between groups in relation to patient characteristics. The mean time to achieve full suck (oral) feeding was not different between the groups (HFNC 36.5 (+/- 18.2) days vs nCPAP 34.1 (+/- 11.2) days, p=0.61). Preterm infants treated with HFNC did not achieve full suck (oral) feeding more quickly than infants treated with nCPAP.	**Physiologic stability:** There was no difference in the number of episodes of desaturations or apnoea's. **Behavioural signs of distress:** No data available. **Airway protection:** Comment about there being no aspiration but no data to support this. **Achievement of full suck (oral) feeds:** No difference in time it took to achieve suck (oral) feeds.	Small sample. Paper comments 'no aspiration was noted' but there is no data in the results section to support this comment. Caregivers and outcome assessors were not masked to the infants group assignment.

						Discharge home: No difference in the time it took to discharge home.	
Bapat, R., et al, 2019	Quality improvement project	**Title:** *Impact of SIMPLE Feeding Quality Improvement Strategies on Aerodigestive Milestones and Feeding Outcomes in Bronchopulmonary Dysplasia (BPD) Infants.* **Aim:** to compare aerodigestive milestones and length of stay in BPD infants after implementing a quality improvement program to improve feeding outcomes.	N=279	Authors implemented the simplified, individualized, milestone-targeted, pragmatic, longitudinal, and educational (SIMPLE) feeding strategy to enhance feeding and aerodigestive milestones among BPD infants. The key interventions addressed were: (1) enteral feed initiation and advancement protocol; (2) oral feeding progression guidelines, optimization of respiratory support, feeding readiness scores, non-nutritive breastfeeding, and cue-based feeding; (3) active multidisciplinary	Full enteral feeding, first suck (oral) feeding, full suck (oral) feeding, and length of stay milestones were (all *P* < .05) achieved sooner in the SIMPLE feeding group. Although the overall prevalence of BPD in the 2 groups is similar, the incidence of moderate BPD has decreased (*P* < .05) and severe BPD has increased (*P* < .05) in the SIMPLE feeding group.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data. But mentioned that the intervention group had worsening BPD. **Achievement of full suck (oral) feeds:** Faster time to full suck (oral) feeds. **Discharge home:** No difference in the time it took to discharge home.	Exclusion criteria: Infants with complex disorders. The intervention group was a whole week older than the control group at the start of the study, so it is hard to attribute all success to intervention and not developmental acquisition.

				collaboration; and (4) family-centered care. Comparisons were made between baseline (N=92, between January 2009 to March 2010) and SIMPLE feeding strategy (N=187, between May 2010 to December 2013) groups. Both groups included infants between 23 0/7 and 32 6/7 weeks' birth gestation, and ≤34 weeks' postmenstrual age at admission and discharge.			
Lam,. R et al, 2020	Prospective randomized controlled trial	**Title:** *The Effect of Extended Continuous Positive Airway Pressure on Changes in Lung Volumes in Stable Premature Infants: A Randomized Controlled Trial.* **Aim:** to compare changes in lung volumes, as	N=44 No differences noted between the groups.	Infants born at ≤32 weeks of gestation requiring ≥24 hours of CPAP were randomized to 2 weeks of extended CPAP vs discontinuation CPAP when meeting CPAP stability criteria. Functional residual capacity (FRC) was measured with the	The infants randomized to extended CPAP vs discontinuation CPAP had a greater increase in FRC from randomization through 2 weeks (12.6 mL vs 6.4 mL; adjusted 95% CI, 0.78–13.47; *P* = .03) and from randomization through discharge (27.2 mL vs	**Physiologic stability:** No data available. Behavioural signs of distress: No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No difference noted in	Exclusion criteria: Infants with congenital cardiac, genetic, or chromosomal abnormalities, twins, and clinical instability.

		measured by functional residual capacity (FRC), through to discharge in stable infants randomised to 2 weeks of extended CPAP vs CPAP discontinuation.		nitrogen washout technique. Infants were stratified by gestational age (<28 and ≥ 28 weeks) and twin gestation. A linear mixed-effects model was used to evaluate the change in FRC between the 2 groups. Data were analysed blinded to treatment group allocation.	17.1 mL; adjusted 95% CI, 2.61–17.59; *P* = .01).	time to achieve full suck (oral) feeds. **Discharge home:** No difference in the time it took to discharge home.	
La Tuga, M.S., 2019	Retrospective case control study	**Title:** *Clinical characteristics of premature infants who orally feed on continuous positive airway pressure* **Aim:** Compare the clinical characteristics and duration of intubation in infants that initiate suck (oral) feeding on nCPAP to infants that did not begin suck	N=243	Infants with gestational age < 32 admitted from 2008 to 2014. Included infants who required CPAP at 32 weeks PCA. Suck (oral) feeding was defined as any suck (oral) feed ≥5 ml. Duration of intubation was defined as the number of intubated days prior to 32 weeks PCA.	Of the 243 infants on CPAP at 32 weeks PCA, 31% (n = 76) began suck (oral) feeding on CPAP. Infants who initiated suck (oral) feeding on CPAP were of younger GA at birth (median 26 versus 27 weeks, p < 0.001) and remained intubated for longer (median 10.5 versus 2 days, p < 0.001).	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** longer time to achieve full suck (oral) feeds. **Discharge home:** longer hospital stays were reported.	Retrospective study. Did not include infants with gastrointestinal surgery and congenital anomalies.

		(oral) feeding on nCPAP.					
Hoffman, S. B., et al, 2016	Retrospective chart review	**Title:** Impact of High Flow Nasal Cannula Use on Neonatal Respiratory Support Patterns and Length of Stay. **Aim:** to evaluate the effect of introducing HFNC on length of respiratory support and stay.	N=163	A chart review was conducted on subjects at 24 –32 weeks gestation requiring mid-level support, 1 y before and after HFNC implementation. 2 groups, pre-HFNC (N=80) and post HFNC (N=83), were compared for clinical and demographic data using t test or chi-square analysis. Further, multivariate linear and logistic regression was done to determine significant risk factors for outcomes controlling for covariates.	The post-HFNC group had higher rates of retinopathy of prematurity (P = .02) and a trend toward higher bronchopulmonary dysplasia rates (P = .063). The post-HFNC subjects had longer duration of mid-level support and were older at the time they were weaned to stable low-flow nasal cannula (P < .05). Although the length of respiratory support and stay and CGA at discharge were similar, those in the pre-HFNC period were more likely to be receiving full suck (oral) feeds and be discharged home versus being transferred to an intermediate care facility (P < .05).	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** longer time to achieve full suck (oral) feeding when HFNC was introduced as opposed to nCPAP alone. **Discharge home:** longer hospital stays were reported when HFNC was introduced as opposed to nCPAP alone.	Feeding outcomes were not the main aim of the study so little detail around when or how feeds were introduced (although it does note flow rate level of HFNC for suck (oral) feeds to be considered).

Mohamed, A.M., et al 2021	Single centre retrospective analysis	**Title:** *Cue-Based Feeding as Intervention to Achieve Full Oral Feeding in Preterm Infants Primarily Managed with Bubble CPAP.* **Aim:** to examine the association of cue-based feeding with time of introduction and completing suck (oral) feeding in infants primarily managed with bubble CPAP.	N=311 No differences between groups regarding demographic or clinical variables.	Outcomes of preterm infants ≤32 weeks' GA and ≤2,000 g birth weight were compared after a practice change from volume-based feeding (N=117) advancement to cue-based feeding (N=194). Continuous variables were compared by using *t*-test and multilinear regression analysis to control for confounding variables.	PMA of initial feeding assessment was less in the cue-based feeding group. Age of first per oral (PO) feeding and when some PO was achieved every feed was mildly delayed in the cue-based feeding compared with comparison group, 34 (±1.3) versus 33.7 (±1.2) weeks, and 36.2 (±2.3) versus 36.0 (±2.4) weeks, ($p < 0.01$) respectively. However, the age of achieving full PO did not differ between groups, 36.8 (±2.2) versus 36.4 (±2.4) weeks ($p = 0.13$). There was no difference between groups regarding growth parameters at 36 weeks' PMA or at discharge. Similar results were obtained when examining subcategories of infants ≤1,000 g and 1,001 to 2,000 g.	**Physiologic stability:** No data available. **Behavioural signs of distress:** No data available. **Airway protection:** No data available. **Achievement of full suck (oral) feeds:** No difference between comparison groups reported. **Discharge home:** No difference between comparison groups in terms of discharge home.	Stated in article 'it has been well established in the NICUs who adopt bubble CPAP as the primary mode of non-invasive respiratory support.' But there no randomized controlled trials available to support the safety of this practice. Historical comparison not a randomized trial. Small sample size may affect elaborating some of the significance in the correlation analysis.

Decision making process

Reference	Study Design	Title and Aim	Sample	Method	Outcome	Framework Factors	Limitations
Canning, A., et al, 2020	Survey	**Title:** *Oral Feeding for Infants and Children Receiving Nasal Continuous Airway Pressure and High-Flow Nasal Cannula Respiratory Supports: A Survey of Practice.* **Aim**: To investigate suck (oral) feeding practices for infants and children receiving nCPAP and HFNC respiratory support	49 units	Practice survey of NICU and PICU settings in Australia and New Zealand.	Overall, on nCPAP - 53% never / rarely fed Overall, on HFNC - 21% never / rarely fed - What was considered HFNC differed across units and in 2 of the 49 units the definition was unknown. When fed on nCPAP - 55% breastfeeding - 51% bottle feeding When fed on NHNC - 82% breastfeeding - 76% bottle feeding	**Physiologic stability:** no data available. **Behavioural signs of distress:** no data available. **Airway protection:** no data available. **Achievement of full suck (oral) feeds**: no data available. **Discharge home:** no data available.	Not all units responded to this survey. The survey was developed for this project and was not piloted or validated. Data was collected using a four-point likert scale. A limitation is that the terms "sometimes" and "often" were not defined. Information regarding the volumes of feeds was not collected. The survey is a snapshot of practices at a specific time and practices continue to develop in this field.
Murphy, R., et al, 2018	Qualitative study	**Title:** *Feeding infants on high-flow nasal cannula oxygen therapy (HFNC): An exploration of*	N=9	Qualitative interviews using open-ended questions. Data transcribed orthographically and	5 themes and 15 subthemes were identified. These included: role of the SLT, factors to be mindful of when	**Physiologic stability:** no data available. **Behavioural signs of distress:** no data available.	Small sample, all female SLTs. Interviews conducted using different methods (i.e. face to face or telephone).

		speech-language pathologist's decision-making process. **Aim**: to explore the views and experiences of speech-language pathologists about the decision-making processes undertaken about feeding infants on HFNC		thematically analysed using the Framework Approach.	considering oral feeding, pre-feeding, feeding definitions, setting dependency. Conflicting opinions and no set protocols exist to guide SLTs for suck (oral) feeding decisions with preterm infants on HFNC.	**Airway protection:** no data available. **Achievement of full suck (oral) feeds**: no data available. **Discharge home:** no data available.	
Hirst, K., et al, 2017	Literature review	**Title:** *Non-invasive respiratory support and feeding in the neonate.* **Aim**: a structured literature review that sought to determine the evidence to support the practice of feeding neonates in the neonatal intensive care unit (NICU) by	5 studies	Systematic search of PubMed completed to identify relevant, peer-reviewed literature reporting original data that addresses the evidence to support guiding neonates suck (oral) feeds whilst on nCPAP or HFNC.	5 studies identified that related to suck(oral) feeding and/or swallowing while on nCPAP or HFNC in neonates. Given the limited evidence to support giving neonates suck (oral) feeds while on nCPAP or HFNC, and the potential for adverse respiratory events related to	**Physiologic stability:** no data available. **Behavioural signs of distress:** no data available. **Airway protection:** no data available. **Achievement of full suck (oral) feeds**: no data available. **Discharge home:** no data available.	Small number of studies.

		mouth while on nCPAP or HFNC.			underlying respiratory disease, the authors urge caution with this practice and highlight the need for further research.		

Summary of literature review

The literature review reflects the variation in practice when it comes to introducing suck feeds in infants who are receiving non-invasive respiratory support. There is a lack of consistent guidance available for the clinical decision-making processes (Murphy, Harrison and Harding, 2018; Canning et al, 2020; Hirst, Dodrill and Gosa, 2017; Canning et al, 2021). The challenges of the lack of guidance for SLTs supporting feeding for infants on non-invasive respiratory support on neonatal units is acknowledged.

The reasons for starting suck feeds for infants who are receiving non-invasive respiratory support are cited as being due to a need to provide oral input at the developmentally correct time regardless of their respiratory needs. Many infants born preterm are on non-invasive respiratory support for long periods that range well past term PMA, and it is felt that these infants should be suck feeding as this would be developmentally appropriate. Other reasons cited in the literature are measures of achieving suck feeds faster which leads to discharge home sooner.

With a lack of specific guidance to aid clinical decision-making, a review of the available literature can enable some direction. The two systematic reviews available both conclude that further research is needed to determine the safety and efficacy of suck feeding on nCPAP and HFNC for infants and children (Hirst, Dodrill, and Gosa, 2017; Canning et al, 2021). Detail from individual studies available provided the following conclusions based on Pados (2022) definition of the term 'safe feeding' and her literature review:

- ***Maintaining physiologic stability:*** Dalgleish et al, 2016, mention that all participants on nCPAP stopped suck feeds at some point due to physiological and behavioural instability. Glackin, et al, 2017 stated that there was no difference in the number of episodes of desaturations or apnoea's.
- ***Behavioural signs of distress:*** Hanin, et al, 2017 mention that 46% of the suck feeding trials on nCPAP in their study were discontinued due to behavioural stress. As mentioned above, Dalgleish et al, 2016, reported that all participants on nCPAP stopped suck feeds at some point due to instability.
- ***Airway protection:*** Two studies (Dalgleish, Kostecky and Blackly, 2016; Hanin et al, 2014) use clear chest x-rays as a measure of swallow safety. Leder et al (2016) mention that there were no 'clinical signs of aspiration or worsening respiratory status' when feeding on HFNC. The latter cannot be relied on as it dismisses silent aspiration, and the former cannot be relied on as chest x-rays are not a clear indication and assessment of aspiration. Only one study used the gold standard objective measure of video fluoroscopy (VFSS) to assess airway protection during swallowing on nCPAP, although this was limited as it was only during bottle feeding (Ferrara et al, 2017).
- ***Achievement of full suck (oral) feeds***: Some studies found no difference (Shetty et al, 2016; Shimizu et al 2019; Glackin et al, 2017; Lam et al, 2020), some found that suck feeds took longer to achieve if infants were fed on non-invasive respiratory support and 2 studies found that infants achieved suck feeds sooner (Bapat, Gulati and Jadcherla, 2019;

Hanin et al, 2014). In the Bapat study (2019) the intervention group was a week older than the control group which isn't accounted for in the conclusion. In the Hanin study (2014) infants were fed with supportive strategies (elevated side lying feeding position, pacing, slow flow teats, fed by an experienced feeding therapist), these results cannot easily be applied to the reality of many neonatal unit settings.

- ***Discharge home:*** studies found that it did not lead to earlier discharge (Dalgleish, Kostecky, and Blachly, 2016; Bapat, Gulati and Jadcherla, 2019; Dumpa et al, 2020; Hanin et al 2014; Shetty et al, 2016; Shimizu et al, 2019; Glackin et al, 2017). Two studies found that suck feeding on non-invasive respiratory support prolonged hospital stay (Taha et al, 2016; LaTuga et al, 2019).

Most studies have focussed on nCPAP and not HFNC. The study that demonstrated airway penetration and aspiration whilst suck feeding (Ferrara et al, 2017) was with nCPAP. Based on current available evidence our position is that extreme caution and consideration of all factors for clinical decision-making as described below is advised when considering suck feeding on nCPAP. There are currently no studies with objective data for suck feeding whilst on HFNC. This, together with the factors for clinical decision-making, needs to be considered in the process when deciding whether to feed on HFNC.

In the absence of definitive guidance from review of available literature, it is important to also consider other available tools and considerations for clinical decision making.

Role and scope of practice of SLTs

SLTs, as part of their assessment and management, will utilise clinical decision-making as to when to offer suck feeds to infants who require non-invasive respiratory support. Effective feeding requires co-ordination of sucking and swallowing with respiration. An infant requiring non-invasive respiratory support may have more issues with co-ordination for feeding due to a number of medical and clinical factors (Harding et al, 2015; Wolf and Glass, 1992; Bagnall, 2005; Browne and Ross, 2011; Genna, 2017). An infant's non-invasive respiratory flow rate, in addition to their gestational age and coordination of their suck-swallow-breathe pattern, forms part of the assessment to determine readiness for suck feeding (eLearning for health, 2022; Mizuno and Ueda, 2003; Harding, Mynard and Hills, 2017; Harding et al, 2016).

SLT assessment and management should be individualised to each infant and their parents, families and/or carers. Information gathering to support clinical decision-making will include discussion with parents, families and carers, the neonatal MDT and other allied health professionals (AHPs), and review of the medical and nursing notes. Parents, families, and carers are key partners. They know their infant's individual likes and behaviours. SLTs should approach them as experts in their infant (Edney, and McHugh, 2021). Further information for consideration for clinical decision making for feeding infants requiring non-invasive respiratory support in neonatal care are described below.

Tools available to support clinical decision-making

Wolf and Glass have presented the "Risk assessment for oral feeding on HFNC" tool (2014). This tool provides a starting point to guide clinical decision-making when considering the introduction of breast or bottle feeds for infants receiving HFNC.

The decision to use this risk assessment tool can be helpful as currently there is a paucity of data and evidence on HFNC and its effect on the complex neonatal swallow mechanism. The tool supports the suggestion that decision-making should not be made based on flow rate alone.

Other factors should be considered including an infant's wake pattern and feeding readiness cues, state and behavioural cues, stability, co-existing aetiologies and joint discussions and decisions with the neonatal MDT including parents/carers (Murphy, Harrison and Harding, 2018; Dalgleish, Kostecky and Blachly, 2016).

Risk assessment for oral feeding on HFNC **(Wolf and Glass, 2014)**

	2	**1**	**0**
Full oral feeding prior to HHFNC	None	< 3 weeks	≥ 3 weeks
Medical Complexity	Very complex	Moderately complex	One system only
Respiratory Status	Extremely fragile; high FiO2	Stable with significant support; mod FiO2	Weaning respiratory support regularly; RA
Airway Protection / Aspiration Risk	High risk or known aspirator	Moderate risk	Respiratory status is the only risk factor
Flow Rate (based on corrected age)	< 37 wk: ≥ 4L ≥ 37 wk: ≥ 5L ≥ 2 mo: ≥ 6L	< 37 wk: 2.5 -3.5L ≥ 37 wk: 3.5 – 4.5L ≥ 2 mo: 4.5 – 5.5 L	< 37 wk: ≤ 2L ≥ 37 wk: ≤ 3L ≥ 2 mo: ≤ 4L

Score: 0-10

Score 0,1, 2: Low risk; consider oral feeding (if meets general criteria for oral feeding – adequate gest age, appropriate RR, adequate state of alertness and feeding readiness cues)

Score 3, 4: Greater risk; Needs discussion; may be a candidate for therapeutic or limited oral feeding

Score ≥ 5: Highest risk; Not a good candidate for oral feeding

Considerations in the clinical decision-making process for feeding infants requiring non-invasive respiratory support in neonatal care

Medical complexity

Medical complexity should be discussed with the medical team to consider the symptomatic and severity of impact of any issues from the cardiovascular, respiratory, neurological, gastrointestinal, and or metabolic systems. Consideration will also be made for surgical issues (Harding et al, 2015; Wolf and Glass, 1992; Bagnall, 2005).

Gestational age

Prematurity is defined as infants who are born before 37 weeks of pregnancy are completed (eLearning for Health, 2022). There are sub-categories of preterm birth, based on gestational age:

- Very preterm: < 28+0 weeks of gestation
- Moderately preterm: 28+0 – 33+6 weeks of gestation
- Late preterm: 34+0 – 36+6 weeks of gestation
- Early term: 37+0 – 38+6 weeks of gestation
- Full term: 39+0 – 41+6 weeks of gestation
- Post term: ≥ 42+0 weeks of gestation

It is important to correct for an infant's prematurity to give an accurate assessment of their developmental abilities. Infants can co-ordinate sucking, swallowing, and breathing from around 32-36 weeks' gestation (Browne and Ross, 2011; Harding, Mynard and Hills, 2017; Harding et al, 2016). Sucking, swallowing, and breathing coordination continues to develop until around 42 weeks corrected gestational age, however individualised to an infant and their developmental progress (Thoyre et al, 2013; Shaker, 2017; Browne and Ross, 2011).

Level of respiratory support required

Caution is recommended when initiating suck feeds with infants on nCPAP (Ferrara et al, 2017). The impact of prematurity and the impact of HFNC on the swallow is unknown. Flow rate delivery is between 1 and 2 litres per kg with adjustments being made individually depending on the infants work of breathing, oxygen saturation and the type of non-invasive respiratory device being used. There are no universally agreed guidelines regarding flow rates and feeding. As a result, neonatal unit MDTs may create individual policies relating to their own patient population and devices used.

Weight

Low birth weight, along with early gestational age, can make it difficult for infants to achieve spontaneous breathing and can be known to increase the incidence of respiratory distress (Yadav, Lee and Kamity, 2022). Prematurity is one of the most common causes of Low Birth Weight (LBW), along with Intrauterine Growth Restriction (IUGR) (eLearning for Health, 2022).

Infant weight is a factor when determining the flow rate delivered by non-invasive respiratory support. An infant's weight, flow rate, their mouth position and leak around the nasal cannula all affect the positive airway pressures and degree of turbulence created by non-invasive respiratory support. This is helpful to consider in terms of the impact on intra-oral pressure and airway protection (Liew et al, 2020).

Developmental readiness for suck feeding

Preterm infants usually start some suck feeding opportunities at around 32 to 36 weeks gestational age. Initiation depends on multiple factors; their physiological status and stability, comorbid conditions, behavioural regulation, and positive infant-led feeding experiences supported by parents, families, and carers (Harding et al, 2015; Thoyre et al, 2013; Shaker, 2013; Bagnall, 2005; eLearning for Health, 2022). A preterm infant or a term infant who is medically fragile, communicates how they are coping and feeling and their readiness for interaction, through their behaviours. These behaviours reflect the subtle changes and interplay between their autonomic, motor, state and/or attention/interaction sub-systems (Shaker, 2013; Als, 1982). These behavioural systems and how an infant respond within these enable us to interpret their behaviours to support communication and feeding development (Shaker, 2013; Als, 1982).

Feeding readiness refers to when infant show signs they are ready to be offered suck feeds (Borwne and Ross, 2011; Harding, Mynard and Hills, 2017; Harding et al, 2016). Readiness for suck feeds is determined by observations and assessment of an infant's general state, behaviour, movements, and readiness to engage in shared interactions for suck feeds. This includes:

- The infant's resting respiratory rate, for example, a respiratory rate > 60 breaths per minute can impact on suck-swallow-breathe coordination.
- The infant's saturation (SpO_2) and heart rate at rest.
- The infant's respiratory patterns, for example, stridor, stertor, rib cage flaring, sternal retraction, and intercostal retraction.
- The infant's state of alertness, arousal, and behavioural cues.
- Moving the tube from orogastric (OGT) to nasogastric (NGT) can encourage tongue movements and better attachment for breastfeeding Aloysius et al, 2019).
- Working alongside parents, families and carers and the neonatal MDT to share observations about their infant's behaviours, cues and response to interaction and readiness for feeding.

Breast or bottle: differences in physiology of feeding skills

Milk flows from the breast by the stimulation of oxytocin that triggers milk ejection resulting in a series of bursts of rapid milk flow. The breastfed infant will suck to trigger milk flow and then swallow milk as it is let down, this may require a number of suck and swallows in succession to manage milk flow. This variation in milk flow rate throughout a breastfeed is synchronised with swallowing and breathing by the infant. The mechanics of milk flow and consequent pattern of suck-swallow-breathe, therefore, shows more variation in its pattern compared to bottle feeding (Genna, 2017; Geddes and Sakalidis, 2015; Goldfield et al, 2006). Breastfeeding is infant led and relies on responding to infant cues for initiating and stopping feeding. Bottle-feeding can be "done to" an infant and override their cues potentially increasing the risk that they may be fed when not in an appropriate behavioural state when they are able to effectively co-ordinate sucking with swallowing and breathing (Moral et al, 2010).

Aspiration of breast milk and artificial formula

It is important to consider the composition and benefits of breast milk. This composition not only includes nutritional elements such as carbohydrates, proteins, and vitamins but also biological elements that protect the infant such as antibodies and human milk oligosaccharides. Infants who are exclusively feeding with breast milk are at less at risk of respiratory illness and hospitalisation (Wilson et al, 1998). Breast milk may result in fewer respiratory consequences if aspirated than artificial formula (Hersh et al, 2022). The protective factors and antibacterial content of breast milk may support recovery from aspiration and prevention of respiratory illness. However, there is minimal research to support or negate this theory. Further research regarding the incidence of aspiration for infants receiving suck feeds on non-invasive respiratory support, with analysis of the milk type and recovery, may give some insight into this.

Positive oral touch

Infants may reach a point where they are developmentally ready to suck but continue to require respiratory support. If the neonatal MDT decide that an infant on non-invasive respiratory support isn't ready for nutritive suck feeds, the SLT still has a role in supporting positive oral touch experiences. This is often in the form of pre-feeding oral stimulation opportunities, positive oral touch, taste, smell, and non-nutritive sucking. Studies have not identified any negative outcomes of pre-feeding oral stimulation programmes and have consistently identified beneficial effects, including supporting the parent and infant relationship, future suck feeding progress, improved breastfeeding rates and decreased length of hospital stay (Arvedson et al, 2010; Boiron et al 2007; Fucile, Gisel and Lau, 2005; Pimenta et al, 2008; Pinelli and Symington, 2010; Rocha et al, 2007; Tolppola, 2022).

Infants with persistent feeding difficulties

Within the population of infants on the neonatal unit requiring non-invasive respiratory support it is important to recognise the increased risk of dysphagia related to poor airway protection.

These infants may have anatomical differences compared to the healthy, full-term infant, such as a high arched palate, changes in muscle tone (cheeks, tongue, larynx) as well as more generalised differences in size of oral cavity and absence of fat pads in the cheeks (Wolf and Glass, 1992; Bagnall, 2005; Genna, 2017). These infants may also have developmental, physiological, or neurological differences due to neurological, respiratory, cardiac, or gastro-intestinal conditions. To establish successful nutritive suck feeding, feeding skills need to be assessed by an SLT as part of the neonatal MDT alongside the infant's parents, families, and/or carers (Krűger et al, 2016; Jadcherla, 2016; SEnekki-Florent and Walshe, 2021; Park et al, 2015).

Leadership and influencing

There is emerging research regarding infants receiving non-invasive respiratory support having suck feeding opportunities. However currently there remains a lack of guidance available. Development of standardised guidelines and standard operating procedures (SOPs) are based on clinical consensus rather than quality evidence.

The SLT workforce can make a significant contribution in developing a more robust evidence base and improve the quality of care provided. Collaborative working with neonatal MDT colleagues to support and lead research agendas is recommended. Research and innovation within the field should focus on the benefit SLT can make to the clinical decision-making process and therapeutic care for infants and their parents, families and/or carers in neonatal care receiving non-invasive respiratory support. SLTs should be active in continually appraising the impact of the role of SLT in neonatal care related to feeding and non-invasive respiratory support. Regular audits and quality improvement projects are recommended.

Future steps

MDT peer review of individual case studies, research, audits and attending conferences in infant respiratory support should be encouraged. Gathering the evidence base in this area to work towards developing protocols and SOPs regarding working with infants and their parents, families and/or carers with respiratory needs in neonatal care is the aim of discussions stimulated by this position paper. This would enable well guided and appropriate clinical assessment, intervention, guidelines, and best practice for infants born early or at term with medically complex conditions receiving respiratory care on a neonatal unit.

Conclusion

Currently there is a lack of guidance and varied opinion in the literature regarding feeding on non-invasive respiratory support thus demonstrating the need for more randomised studies and multi-centre trials. Following a review of the literature this position paper recommends both caution and shared clinical decision-making when considering suck feeding opportunities for infants requiring non-invasive respiratory support. Individualised SLT assessment and intervention which considers; medical complexity, gestational age, level of respiratory support, weight, developmental readiness, and suck feeding method(s) is essential and must be carried out in partnership with parents, families, and/or carers and the neonatal MDT within family integrated care and neuroprotective care frameworks. The impact of non-invasive respiratory support on communication, feeding, and swallowing should be managed by an experienced SLT who uses a collaborative MDT approach to shared clinical decision making, assessment, and intervention within the context of the changing physiological, anatomical, neurological, and developmental background of the infant.

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The Royal College of Speech and Language Therapists (RCSLT) is the professional body for speech and language therapists in the UK. As well as providing leadership and setting professional standards, the RCSLT facilitates and promotes research into the field of speech and language therapy, promotes better education and training of speech and language therapists, and provides its members and the public with information about speech and language therapy.

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