Review Article

Effects of Oxygen via High-Flow Nasal Cannula on Adult Oropharyngeal Swallowing: A Literature Review

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Purpose: The use of high-flow oxygen via nasal cannula has become increasingly more common in various patient populations given the multiple benefits for treating respiratory distress and failure. There is emerging, though varying research on the impact high-flow oxygen delivery may have on adult oropharyngeal swallowing function. The purpose of this literature review is to outline available research and examine study design, populations investigated, findings, and clinical considerations of these findings.
Method: After an extensive online database search, we found five available peer-reviewed research articles specifically investigating oropharyngeal swallowing function in adults receiving high-flow nasal cannula (HFNC) therapy. Each article was reviewed and summarized in detail with close attention paid to results and clinical implications. Limitations, indirectness, and/or methodologic flaws are highlighted for the readers' consideration.
Conclusions: Four prospective design studies and one retrospective data analysis collection have been published evaluating the effects of high-flow oxygen therapy on adult oropharyngeal swallowing. Three of the prospective design studies evaluated healthy adults; one prospective design and the retrospective analysis data collection investigated acute care patients requiring HFNC. Study findings varied greatly likely due to variability of each study's subject population, design, and methods. Variability of results may make it challenging for speech pathologists attempting to use evidence-based decision making in clinical practice. Additional studies investigating nonhealthy subjects undergoing instrumental swallow studies while on HFNC are warranted.

High-flow nasal cannula (HFNC; i.e., Opti-flow, AIRVO-2, Vapotherm) is an oxygen delivery system that heats and humidifies gas to 98.6 °F with a 100% relative humidity (Chikata et al., 2014). It can deliver 0.21–1.0 fraction of inspired oxygen (FiO2) at flow rates of up to 60 liters per minute (LPM). Flow rates and FiO2 can be independently titrated based on patient requirements (Roca et al., 2016; Ward, 2013). Patients in moderate respiratory distress often need both high flow rates of oxygen to meet respiratory demands and precise FiO2 for hypoxia (Roca et al., 2016). A question frequently asked is, "Which patient needs flow, and which needs FiO2?" The answer is that patients in moderate respiratory distress requiring HFNC typically need both.

Flow can be considered to do three things: create extrinsic positive end expiratory pressure, wash out oropharyngeal anatomical dead space with removal of carbon dioxide (CO_2), and match patient's flow demands or maintain minute ventilation (Groves & Tobin, 2007; R. L. Parke & McGuiness, 2013; R. Parke et al., 2009; Roca et al., 2016; Sztrymf et al., 2011). During normal tidal breathing, inspiratory flow rates are approximately 20–30 LPM. For those in acute respiratory distress, inspiratory flow rates can exceed 60 LPM and reach as high as 120 LPM in more severe cases (Katz & Marks, 1985). HFNC is set to deliver flow that meets or exceeds the patient's inspiratory flow demand (Chanques et al., 2013). Patients requiring high flow rates may include those with hypoxia in need of some positive end expiratory pressure (i.e., atelectasis), CO_2 retainers (i.e., chronic obstructive pulmonary disease or central apnea), and/or those that are short of breath and not receiving adequate tidal volumes with each breath (i.e., restrictive lung diseases, diffusion impairments, or reduced capacities). FiO2, on the other hand, manages hypoxia and lung perfusion issues (Roca et al., 2016). Patients requiring high FiO2 may include those with restrictive lung issues (i.e., interstitial lung disease or

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pulmonary fibrosis). In the clinical setting, it is helpful to correlate the patient's underlying pathology to their flow and FiO2 requirements. Other patient populations that may benefit from HFNC are those with do-not-resuscitate or -intubate statuses, patients intolerant of noninvasive positive pressure ventilation (continuous positive airway pressure [CPAP], bilevel positive airway pressure), or those with contraindications to CPAP/bilevel positive airway pressure (i.e., status post esophagectomy). Additional benefits of HFNC include reduced use of noninvasive positive pressure ventilation, reduced facial ulcers, and potential ability for patients to eat, drink, and verbally communicate (Nishimura, 2016; Roca et al., 2016; Ward, 2013). To better understand how HFNC may impact oropharyngeal swallowing, let us first review normal breathing and swallowing relationships.

Normal breathing and swallowing patterns in adults consists of inhaling approximately 350–500 ml of air with each breath, exhalation onset, deglutitive apnea lasting approximately 1 s, and then completion of exhale after the swallow (Hiss et al., 2001; Klahn & Perlman, 1999). Studies have shown that these patterns can change with age (Hiss et al., 2001; Klahn & Perlman, 1999; Leslie et al., 2005; Shaker et al., 1992). Four respiratory-phase patterns found in normal aging adults, identified from most common to least, include exhale/exhale, inhale/exhale, exhale/inhale, and then inhale/inhale (Shaker et al., 1992). During normal breathing and swallowing, alveoli collapse toward their resting position during exhalation creating subglottic pressure that is higher than atmospheric pressure (Gross et al., 2003). This high subglottic pressure creates the ability to clear postswallow airway invasion of bolus material. Swallowing function can be negatively impacted by impaired respiratory conditions (Boden et al., 2009; Gross et al., 2003; Nishino et al., 1989, 1998). When considering patients with already compromised respiratory conditions, it is important to understand the physiologic effects HFNC produces for those requiring high levels of support.

Multiple studies have shown that HFNC creates positive nasopharyngeal airway pressure (Coghlan & Skoretz, 2017; Groves & Tobin, 2007; R. Parke et al., 2009), though findings vary in the amount of pressure created at different flow levels. Coghlan and Skoretz found that approximately 0.5–1 cmH2O of positive airway pressure is created with every 10 LPM. Parke et al. found an average of 2.7 cmH2O, but as high as 6-cmH2O positive airway pressure created at flow rates of 35 LPM with mouth closed. Groves and Tobin found 3.7-cmH2O positive airway pressure at 20 LPM, 7.2 cmH2O at 40 LPM, and 8.7 cmH2O at 60 LPM with mouth closed. Conversely, the two latter studies discovered a decrease in positive airway pressure created by HFNC with mouth open positioning compared to mouth closed (Groves & Tobin, 2007; R. Parke et al., 2009; see Table 1). As a reference, treatment of obstructive sleep apnea with CPAP uses between 4 cmH2O and 20 cmH2O of positive airway pressure. As previously described, the creation of positive airway pressure has significant benefits for patients in respiratory distress. However, the creation of positive pressures in the oropharynx may negatively impact patient's ability to adequately protect their airway during swallowing.

The combination of altered respiratory conditions that have been shown to impact safe swallowing function, high flow rates creating positive upper airway pressures while wearing HFNC, and the already compromised state of patient populations requiring HFNC makes many speech pathologists hesitant in proceeding with swallow evaluations. An extensive online database search was completed investigating oropharyngeal swallowing function in adults receiving oxygen via HFNC. The following electronic databases were searched: PubMed, PubMed Central, ERIC, Google Scholar, CINAHL, The Cochrane Library, ScienceDirect, and Wiley Online Library. Literature search terms included *high flow nasal cannula, heated humidified high flow nasal cannula, Opti-flow, Vapotherm, dysphagia, swallowing, high flow nasal cannula AND swallowing, high flow nasal cannula AND dysphagia, heated humidified high flow nasal cannula AND swallowing,* and *heated humidified high flow nasal cannula AND dysphagia.* Only peer-reviewed publications were included in the search (see Table 2).

Since 2016, five studies evaluating the effects of HFNC on adult oropharyngeal swallowing have been conducted. In addition to these peer-reviewed published studies, two abstracts and a poster session were found during our database search (Jaffe et al., 2018; Oomagari et al., 2015; Sarita et al., 2019). These abstracts have not yet been published as full peer-reviewed manuscripts, so they will not be discussed in this review. The following sections will review the five published peer-reviewed research studies conducted since 2016, in hopes of improving speech pathologists preparedness to appropriately evaluate and treat swallowing and swallowing disorders in patients receiving HFNC therapy.

Effect of Nasal High-Flow Oxygen Therapy on the Swallow Reflex: An In Vivo Volunteer Study

Method

This prospective design studied nine healthy males wearing HFNC during inducted swallowing (Sanuki et al., 2016). Two surface electrodes were attached to the skin of the submental region. Surface electromyography was low-pass filtered at a frequency of 30 Hz. Respiratory inductance plethysmography was recorded with two elastic bands around the subject's rib cage and abdomen. A catheter was placed on the retromolar gingiva for water administration. Transcutaneous monitoring electrode measured transcutaneous pCO_2 in the forearm. Each subject was assessed at rest without HFNC for 5 min and then exposed to four different flow rates (0 [control], 15, 30, and 45 LPM) with FiO2 concentration of 21% at a temperature of 37°C. The swallow was triggered via infusion and bolus administration of water through the catheter under each flow rate condition. Two minutes of equilibration time between each HFNC setting and 1 min between infusion and bolus administrations of water were allowed.

Table 1. Studies evaluating creation of positive airway pressure via HFNC.

Study	LPM deployed	Positive airway pressure created
Nasal High-Flow Therapy Delivers Low-Level Positive Airway Pressure (R. Parke et al., 2009)	35 LPM	HFNC with mouth closed: +2.7 cmH2O Range = 1.54 cmH20 to 6 cmH20 HFNC with mouth open: +1.2 cmH20 Facemask (comparison): −.1 to .03 cmH20 with mouth open and closed (basically no change compared to atmospheric pressure)
High-Flow Nasal Oxygen Generates Positive Airway Pressure in Adult Volunteers (Groves & Tobin, 2007)	20 LPM 40 LPM 60 LPM	Mouth closed at 20 LPM: +3.7 cmH20 Mouth closed at 40 LPM: +7.2 cmH20 Mouth closed at 60 LPM: +8.7 cmH20 Mouth open at 20 LPM: +1.4 cmH20 Mouth open at 40 LPM: +2.2 cmH20 Mouth open at 60 LPM: +2.7 cmH20

Note. HFNC = high-flow nasal cannula; LPM = liters per minute.

A bolus injection of 5 ml of distilled water was infused over 3 s to assess latency of swallow (time from start of bolus injection to onset of electromyography burst of the first swallow). The infusion of water was used to detect the effect of HFNC on coordination between swallowing and breathing with an infusion rate of 2 ml per minute. Surface electromyography and respiratory inductance plethysmography were recorded for the entire minute. Swallows were recorded as happening during inspiration, expiration, inspiratory–expiratory transition swallows, and expiratory–inspiratory transition swallows. Frequency of swallowing, number of swallows of each type, and respiratory rate per minute were counted.

Results

Respiratory rates at 30 LPM were significantly lower than under control condition, though not at 15 LPM or 45 LPM. Latency times of swallowing with HFNC at 15 LPM and 45 LPM were significantly shorter than control conditions. Frequency of swallowing and timing of swallows in relation to phase of respiration were similar under all conditions. Results suggest increasing HFNC flow rates may progressively enhance swallowing function in healthy adults.

Discussion and Considerations

The authors surmise that the fluctuation in positive airway pressure during HFNC might cause shortened latency of swallowing, though reasoning was unclear. Stimulation of receptors in the upper airway (soft palate, uvula, hard palate, faucial pillars, pharynx, and epiglottis) can initiate the swallowing reflex (Nishino, 2013; Nishino et al., 1989), so water infusion and light touch of catheter may have activated these receptors. Subsequent studies discussed later in this review (Allen & Galek, 2020; Flores et al., 2019) have also suggested that healthy adults may have the ability to cognitively engage and compensate to protect the airway when higher flow rates were deployed via HFNC.

Sanuki et al. found reduction of pCO_2 does not affect swallowing; however, prior research showed that retention of pCO_2 does have a negative impact on swallowing (Nishino et al., 1998). An additional study by Nishino et al. in 1989 found that positive airway pressure created by CPAP prolongs latency of swallowing in eight healthy males aged 28–48 years. These findings by Nishino et al. conflict with Sanuki et al. and may serve as an appropriate comparison given similar participant demographics.

Limitations

This study contained a small sample size and only evaluated healthy adults. Findings cannot be generalized to nonhealthy patients requiring HFNC or those with known dysphagia. Additionally, water was used as the sole stimulus and results may not apply to solid boluses.

Evaluation of Swallowing Function on Healthy Adults While Using HFNC

Method

This prospective design studied 80 healthy participants aged 35–65 years, separated into three groups: 35–44 years (n = 22), 45–54 years (n = 28), and 55–65 years (n = 30; (Eng et al., 2019)). All subjects underwent four *videofluoroscopic swallowing studies* (VFSS). FiO2 was set to 21% to mimic room air. Pretest VFSS were performed with subjects receiving 0 LPM via HFNC to serve as the control. HFNC was then titrated to 20 LPM with a 10-min acclimation period with repeat VFSS, then 40 LPM, and then 60 LPM. Investigators monitored subjects' baseline heart rate, respiratory rate, and room air O2 saturations. Vitals were recorded at each flow rate immediately preceding the next round of VFSS. Bolus trials were administered in order and amount defined by the Modified Barium Swallow Impairment Profile (MBSImP) protocol (Martin-Harris et al., 2008).

Results

There was no statistically significant effect of each age group tested and no statistically significant interaction effect of flow rate and age group. There was statistically

Table 2. Studies evaluating effect of high-flow nasal cannula (HFNC) on adult oropharyngeal swallowing.

Study	Design	Subjects	General outcomes
Effect of Nasal High-Flow Oxygen Therapy on the Swallowing Reflex: An In Vivo Volunteer Study (Sanuki et al., 2016)	Prospective design	9 healthy adults	Their conclusion: HFNC may progressively enhance swallowing with increased O2.
Evaluation of Swallow Function on Healthy Adults While Using High-Flow Nasal Cannula (Eng et al., 2019)	Prospective design	80 healthy adults	Oral swallowing changes occur in healthy adults wearing HFNC at a high-flow rate (60 LPM). Authors postulate that healthy adults are able to compensate for swallowing changes while wearing HFNC.
The Influence of Airflow Via High-Flow Nasal Cannula on Duration of Laryngeal Vestibule Closure (Allen & Galek, 2020)	Prospective design	29 healthy adults	The duration of laryngeal vestibular closure increased when LPM increased and vice versa, suggesting that healthy adults adapt to the amount of airflow in order to protect their airway during the swallow. Change in airflow did not impact PAS scores in healthy adults.
Oral Alimentation In Neonatal and Adult Populations Requiring High-Flow Oxygen via Nasal Cannula (Leder et al., 2016)	Prospective design	100 acute care patients. 50 neonates, 50 adults	Patients requiring HFNC who are identified as having feeding or swallowing issues should be referred for swallowing evaluations using the same criteria as patients who do not require HFNC, as it is not the use of HFNC but rather patient-specific determinants of feeding and swallowing readiness and their underlying medical conditions that impact readiness for oral alimentation status.
Initiation of Oral Intake in Patients Using High-Flow Nasal Cannula (Flores et al., 2019)	Retrospective data collection	10 acute care patients	HFNC should not be a barrier to patient's oral intake. The importance of instrumental evaluation, especially in compromised patients, suggests impaired airway protection. The clinical bedside evaluation is insufficient alone to discern a patient's readiness for oral alimentation while on HFNC therapy. Instrumental swallow assessments are imperative.
Swallowing Function During High-Flow Nasal Cannula Therapy (Oomagari et al., 2015)	Abstract only No full manuscript published		
Electromyographic Swallowing Study During High Flow Oxygen Therapy Compared With Low Flow Oxygen Therapy in Post-Extubated Patients (Sarita et al., 2019)	Abstract only No full manuscript published		
Risk of Aspiration in Patients on High-Flow Oxygen Therapy (Jaffe et al. 2018)	Poster session only No full manuscript		

Note. LPM = liters per minute; PAS = penetration–aspiration scale.

significant effect of flow rate on MBSImP scores. Subjects had a statistically higher total MBSImP score at a flow rate of 60 LPM than at baseline. No statistically significant effects for flow rate, age group, and the interaction of flow rate and age group for penetration–aspiration scale (PAS) scores (Rosenbek et al., 1996).

Discussion and Considerations

There was an effect of slow rate on oral components of lip closure, tongue control, and oral residue and also on total MBSImP score. The authors queried if HFNC impacts at least the oral stage of swallowing due to healthy adults possibly preferring open mouth position to compensate for increased pharyngeal pressures created by HFNC. As a result, subjects had higher oral stage MBSImP scores in the areas of lip closure, tongue control during oral bolus hold, and oral residue. As previously discussed, an open mouth posture has been shown to result in loss of flow and reduction in positive airway pressures compared to closed mouth positioning (Groves & Tobin, 2007; R. L. Parke et al., 2015). If participants did prefer open mouth positioning, one could postulate that the pharyngeal swallow could be less likely impacted given reduction of positive airway pressure.

There were no statistically significant effects of HFNC on pharyngeal component scores. It was suggested that this may be due to the healthy adult population with no medical comorbidities examined. Additionally, healthy adults may have been able to cognitively compensate during swallowing in order to counteract swallowing difficulties. Compensation may have been observed as holding the bolus in the oral cavity longer for improved respiratory-swallowing timing, cognitive engagement in triggering the swallow reflex, and increasing swallow effort and thus muscle contraction to overcome positive airway pressure.

The authors postulate that HFNC would negatively affect swallowing outcomes for patients with cognitive deficits. This same team did find cognition to be a critical factor in clinical decision making in a prior case study of a patient population wearing HFNC in the acute care setting where degree of cognitive impairment correlated with degree of diet modification (Flores et al., 2019). This article will be reviewed in subsequent sections.

Limitations

This single institution study only investigated healthy adults; thus, results cannot be generalized to nonhealthy patients requiring oxygen via HFNC. Additionally, indirect measurement of pharyngolaryngeal sensation (VFSS does not measure sensation) and sequential titration of HFNC may have contributed to fatigue or accommodation to HFNC in populations at highest flow rate.

The Influence of Airflow via HFNC on Duration of Laryngeal Vestibule Closure

Method

This prospective design investigated the influence of airflow (LPM) delivered via HFNC on duration of laryngeal vestibule closure (dLVC) and described airway invasion during various LPM deliveries (Allen & Galek, 2020). Twenty-nine healthy adults were included. Any participants with a history of respiratory disease, neurologic deficits, dysphagia or difficulty swallowing, or current pregnancy were excluded. Participants were fitted with HFNC. FiO2 remained at 21% to mimic room air. Airflow conditions were set to 0 (control), 10, 20, 30, 40, 50, and 60 LPM. Videofluoroscopy was performed with each participant swallowing 20-ml thin liquid barium under each condition. The sequence of airflow rates were randomly generated, so participants were blind to the level of LPM delivered. Participants were instructed to hold 20 ml in the mouth until cued to swallow by the research assistant. Five raters (two experienced speech pathologists and three novice undergraduate students) reviewed swallow videos to determine dLVC and PAS scores. Raters were blinded to participants and airflow conditions. dLVC was defined as the time between the first frame of complete LVC to the first frame of LV re-opening.

Results

Twenty-nine participants recorded a total of 812 swallows. LVC was complete on all swallows. There was a positive relationship between airflow and dLVC, meaning when airflow increased, dLVC increased; when airflow decreased, dLVC decreased. Change in airflow did not impact PAS scores in healthy adults.

Discussion and Considerations

An understandable concern that speech pathologists consider when evaluating patients receiving oxygen via HFNC is the creation of a CPAP effect “blowing” the glottis open or “blowing” swallowed material in to the airway before, during, or after the swallow. This study found that HFNC did not stent the airway open during swallowing for healthy adults. The authors postulate that healthy adults adapt dLVC to the amount of airflow in order to protect the airway during the swallow. Greater variability of dLVC and participant subjective reports of increased difficulty swallowing were noted at higher flow rates (50 and 60 LPM). Variability of dLVC at higher LPM may be evidence for increased difficulty maintaining airway closure during the swallow. The question still remains if nonhealthy adults with respiratory distress requiring HFNC would be able to adapt to the demands of airflow rates the same way in which healthy participants can.

Limitations

Similar to previously discussed studies investigating healthy adults, results cannot be generalized to nonhealthy patients requiring oxygen via HFNC. Additionally, there was low PAS score interrater reliability upon review of video swallows.

Oral Alimentation in Neonatal and Adult Populations Requiring High-Flow Oxygen via Nasal Cannula

Method

This prospective design investigated the impact of HFNC use on oral alimentation in neonatal and adult intensive care unit patients (Leder et al., 2016). One hundred consecutive inpatients included 50 neonates and 50 adults. For neonates, 17/50 were deemed medically appropriate by a neonatologist and registered nurse using certain criteria to begin oral intake. Thirty-three of 50 remained nil per os given their medical fragility. For the purposes of this literature review, we will focus on the adult populations examined in this study. In the adult cohort, 39/50 were deemed medically appropriate to begin oral intake by the medical intensivist, speech-language pathologist, and registered nurse using the following inclusionary criteria: stable respiratory status on 10–50 LPM HFNC, adequate mental status to participate in meal times, passing of the Yale Swallow Protocol (Suiter et al., 2014; if failed, a fiberoptic endoscopic evaluation of swallowing [FEES] was performed immediately), and ability to handle oral secretions.

Results

One hundred percent (17/17) of appropriate neonates began oral intake successfully, though not necessarily meeting adequate nutritional needs. One hundred percent (39/39) of appropriate adults began oral intake successfully, five of these requiring an FEES given failed screening criteria. The authors suggested that it is not the use of HFNC therapy but rather the patient-specific determinants of feeding and swallowing readiness and their underlying medical conditions that impact readiness for PO.

Discussion and Considerations

When dissecting the number of adult patients included in this study, please consider that 11/50 patients were excluded given their medical fragility and/or unstable respiratory status. Additionally, 5/39 included subjects failed the Yale Swallow Protocol and underwent an FEES revealing the need for thickened liquids and/or compensatory techniques. This indicates that 16/50 or 32% of all recruited adults receiving HFNC were either not appropriate for oral intake and excluded from this study, or aspirated on an FEES. These numbers highlight the importance of appropriate patient selection and the utilization of instrumental swallow studies for those receiving HFNC. It would be beneficial for the readers to have more information on excluded patients' clinical presentation and HFNC settings. We question if these excluded patients may be those whom would be negatively impacted by positive pressure created by high flow rates in the oropharynx. It is important to note that the most common HFNC settings for included patients were 26.6 LPM and 66% FiO2. This is a relatively low flow rate for HFNC and may not adequately represent patient populations requiring higher LPM or those that are more dyspneic. Finally, given limited research and variability of findings, one cannot make a conclusion that HFNC should not be a barrier to patient's oral intake; rather, the results suggest further research is needed to confidently make this claim or assumption.

Limitations

This study included small sample size, limited follow up and monitoring of diet tolerance, and the need for evaluation of patients with higher HFNC flow requirements. Additionally, most included patients (34/39) did not undergo instrumental swallow assessment formally evaluating physiologic components of the pharyngeal swallow.

Initiation of Oral Intake in Patients Using HFNC: A Retrospective Analysis

Method

Retrospective data were gathered via chart review for patients requiring HFNC who participated in a VFSS (Flores et al., 2019). Demographics included medical history, oxygen settings, cognitive status, MBSImP scores, PAS scores, Functional Oral Intake Scale scores (Crary et al., 2005), mobility status, and pre/post VFSS diet orders. Ten patients aged 44–92 years met inclusion criteria. HFNC flow rates ranged from 30 to 50 LPM with FiO2 ranging from 35% to 99%.

Results

All patients (10/10) remained nil per os prior to VFSS. Post VFSS, nine out of 10 patients were recommended complete oral diets with no supplemental nutrition/hydration. Eight of these patients were recommend dysphagia diets, with seven of these eight requiring liquid modification or no liquids.

Fifty percent of patients displayed silent laryngeal penetration and/or aspiration on the VFSS. Four patients who silently aspirated had no neurologic diagnosis or laryngeal trauma. The authors questioned if the positive airway pressure created by HFNC had a desensitization effect on the peripheral afferent function or an inhibitory effect at the level of the central nervous system (Ebihara et al., 2012; Nishino, 1993, 2013; Nishino et al., 1989; Ramsey et al., 2005; Steele & Miller, 2010). Reduced integrity of the cough reflex given pulmonary compromise and inability to cough against positive pressure created by HFNC may have also contributed to silent aspiration (Addington et al., 1999; Coghlan & Skoretz, 2017; Ebihara et al., 2012; Niimi et al., 2003). We would also consider factors related to level of alertness, potential sedation medication effects, or other unknown baseline medical conditions not detailed that may contribute to silent aspiration or reduced integrity of the cough reflex.

When monitoring diet tolerance, two patients transitioned to comfort care and their diets were liberalized. Of the eight remaining, six demonstrated diet tolerance, one had worsening respiratory status unrelated to aspiration, and the other did demonstrate aspiration-related decline.

Discussion and Considerations

This study suggests that HFNC alone should not be a barrier to patient's oral intake. The majority of included patients receiving HFNC therapy were able to initiate oral diets after an instrumental swallow study. Per the authors, "this underscores the importance of instrumental evaluation of swallowing physiology, especially in compromised patients whose clinical characteristics (active pulmonary infection, presence of HFNC) suggest impaired airway protection. The clinical bedside evaluation, although informative, is insufficient alone to discern a patient's readiness for oral alimentation while on HFNC therapy." Additionally, patients on most liberal diets were cognitively appropriate and had better ambulatory status. Patients on more restricted diets were cognitively impaired and limited in mobility status.

Limitations

This single-institute, retrospective examination had a limited sample size and heterogeneous population, lack of control group, modification of standard protocols due to patient safety concerns, and subjective monitoring of diet tolerance.

Conclusions and Future Research

This literature review summarized five available studies evaluating the effects of HFNC therapy on adult oropharyngeal swallowing. Findings and results of each study varied greatly. It is important that the findings of studies evaluating healthy adults not be generalized to nonhealthy patient populations. Patients with increased comorbidities and critical illness requiring extended hospitalization undergo a high degree of deconditioning, which may impact swallowing function (Hathaway et al., 2014; Langmore et al., 1998; Simning & Simning, 2013). Only two studies (Flores et al., 2019; Leder et al., 2016) investigated patients in respiratory distress requiring oxygen via HFNC. These studies revealed that nearly all included patients deemed medically stable and appropriate for swallow interventions were able to initiate oral diets; however, a high percentage of those required dysphagia diets and/or liquid modification given aspiration on instrumental swallow studies. Conversely, there were patients that displayed reduced readiness for oral intake given the severity of their medical and respiratory statuses, and were excluded from investigation.

To ensure patients' readiness for swallow interventions and oral intake, we suggest an interdisciplinary approach by discussing the patient's respiratory status and trajectory with the nurse, respiratory therapist, and/or physician. If the patient's respiratory status is declining such that HFNC requirements are increasing, awaiting medical stabilization prior to any swallow evaluation is imperative. Once the patient is deemed stable and appropriate for swallow evaluations, the next step should be optimizing them for success. Given the evidence that higher flow rates increase positive airway pressures in the oropharynx, it is prudent to ensure flow rates are at the lowest appropriate setting prior to swallow interventions. Collaborating with the respiratory therapist or physician to determine if flow rates have been weaned as much as possible prior to swallow evaluations would not only serve the patient well for active weaning but could also reduce the amount of positive pharyngeal airway pressure created by increased flow rates.

Once the patient is optimized, we strongly recommend performing instrumental swallow studies on this vulnerable population given their already compromised respiratory status and higher risk for adverse complications related to dysphagia and aspiration. When dissecting the number of patients in the Leder et al. and Flores et al. studies that underwent instrumental swallow studies, 13/15 or 86% required dysphagia diets, modified liquids, and/or no liquids given aspiration. This suggests that the clinical swallow evaluation may provide helpful information regarding patients' readiness for PO intake, however, is not sufficient to assess the pharyngeal swallow and determine appropriate diet recommendations. Additional prospective design studies investigating nonhealthy subjects undergoing instrumental swallow studies while on HFNC are warranted to help guide evidence-based decision making in this patient population.

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