Effects of high-flow nasal therapy on swallowing function: a scoping review

Claudia Crimi [1,2], Rita Chiaramonte [3,4], Fabio Vignera [1], Carlo Vancheri [1,2], Michele Vecchio [3,4], Cesare Gregoretti [5,6], Annalisa Carlucci [7,8], Tiina Andersen [9,10] and Andrea Cortegiani [5,11]

[1]Department of Clinical and Experimental Medicine, University of Catania, Catania, Italy. [2]Respiratory Medicine Unit, Policlinico "G. Rodolico-San Marco" University Hospital, Catania, Italy. [3]Department of Biomedical and Biotechnological Sciences, University of Catania, Catania, Italy. [4]Rehabilitation Unit, Policlinico "G. Rodolico-San Marco" University Hospital, Catania, Italy. [5]Department of Precision Medicine in Medical, Surgical and Critical Care (Me.Pre.C.C.), University of Palermo, Palermo, Italy. [6]Fondazione "Giglio", Cefalù, Italy. [7]Department of Medicina e Chirurgia, Università Insubria Varese-Como, Como, Italy. [8]Pulmonary Rehabilitation Unit, Istituti Clinici Scientifici Maugeri, Pavia, Italy. [9]Thoracic Department, Haukeland University Hospital, Bergen, Norway. [10]The Department of Health and Functioning, Western Norway University of Applied Science, Bergen, Norway. [11]Department of Anesthesia, Intensive Care and Emergency, Policlinico Paolo Giaccone, University of Palermo, Palermo, Italy.

Corresponding author: Claudia Crimi (claudia.crimi@unict.it)

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The available evidence on the impact of high-flow nasal therapy on swallowing function is insufficient and controversial https://bit.ly/3V7R2nx

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Abstract

Background High-flow nasal therapy is widely used in patients with respiratory failure in different clinical settings, but the effect of high-flow nasal therapy on respiratory-swallow coordination is unknown. Understanding this relationship is crucial, considering the necessity for patients to maintain adequate nutrition during daytime high-flow nasal therapy. This scoping review aims to synthesise available data on the effects of high-flow nasal therapy flow rates on swallowing function and the possible risk of aspiration during treatment, focusing on knowledge and evidence gaps.

Methods PubMed, Scopus, Web of Science and Google Scholar databases were searched from inception to 30 May 2023 for studies reporting data on swallowing assessment in healthy adults or patients with acute or chronic respiratory failure receiving high-flow nasal therapy. Data on study design, patients' characteristics and quality outcomes were extracted.

Results Eight studies were included, four including cohorts of healthy volunteers (n=148) and four including patients with acute or chronic respiratory failure (n=151). Study designs, patient populations and quality outcome measures were heterogeneous. Two studies indicated improvement while four articles showed impairment in swallowing function during high-flow nasal therapy; two studies showed that patients' overall clinical picture and underlying medical conditions influenced swallowing-breathing coordination rather than high-flow nasal therapy *per se*.

Conclusion This scoping review found limited and controversial evidence on the impact of high-flow nasal therapy on swallowing function. Remarkably, methods for swallowing function assessment were quite heterogeneous. Additional research is required to test the effect of high-flow nasal therapy on respiratory-swallowing coordination.

Introduction

The vital functions of both breathing and swallowing involve the upper airways, emphasising the critical need for coordinated interaction to protect the respiratory tract from aspiration [1]. This coordination can be impaired in individuals with respiratory diseases [2, 3] due to changes in patients' breathing patterns and modifications of the respiratory drive, which reduce the frequency of swallowing, shorten apnoeic periods and decrease glottis closure durations, ultimately increasing the likelihood of airway vulnerability [4, 5]. Signs of swallowing abnormalities are common in patients with acute respiratory failure without pre-existing dysphagia [5, 6]. Thus, weakness related to critical illness, including both pharyngeal and laryngeal muscles, has been demonstrated to impede a patient's ability to swallow [7, 8].

High-flow nasal therapy (HFNT) is a form of noninvasive respiratory support used as an alternative to conventional oxygen therapy and noninvasive ventilation in patients with acute and chronic respiratory failure [9–11]. It provides humidified gas at high flows (up to 60 $L \cdot min^{-1}$) that assure a continuous washout of CO_2 from the anatomical dead space, generating a slight positive end-expiratory pressure effect that may reduce the inspiratory effort and dyspnoea while improving oxygenation by delivering a stable inspiratory oxygen fraction (F_{IO_2}) [12, 13]. Moreover, HFNT improves secretion clearance, reduces the need for invasive mechanical ventilation in patients with *de novo* respiratory failure [14] and may be as comfortable as conventional oxygen therapy for patients and easy to use for clinicians [15]. HFNT has been widely used for treating acute respiratory failure of different aetiologies [16–21], including viral infections [22] and COVID-19 pneumonia [15, 23, 24]. It has also been proposed for long-term domiciliary treatment in selected patients [25–28]. HFNT is generally well tolerated by patients, and its compact nasal interface potentially allows unimpeded speaking, coughing and oral feeding during its use [29]; however, HFNT increases pharyngeal pressures [30, 31] and, as a result, it may affect airway protection mechanisms. This scoping review aims to synthesise available data on the effects of HFNT on swallowing function and the possible risk of aspiration during treatment.

Methods

This scoping review was performed and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines (supplement S1) [32].

Data sources and search strategy

A comprehensive search of PubMed, Scopus, Web of Science and Google Scholar was made for articles published from database inception to 30 May 2023 for randomised and nonrandomised studies, with both retrospective and prospective designs. Case reports and case series were excluded. We restricted the search to studies published in the English language. The search strategy included the following MESH terms or keywords (according to the specific vocabulary of the databases): "high-frequency ventilation" or "high-flow oxygen" or "high flow nasal cannula" or "high flow nasal therapy" or "non-invasive ventilation" AND "deglutition" and "dysphagia" OR "swallowing" OR "aspiration" OR "inhalation". The full search output is available in supplement S2. We excluded conference proceedings, abstracts, book chapters or unpublished literature.

Article selection and eligibility criteria

According to the eligibility criteria and the following recommendations of the PRISMA-ScR [32] and the Population, Intervention, Comparison, Outcome and Study design (PICOS) criteria, studies were included if 1) the participants were adults, healthy volunteers or patients affected by acute or chronic respiratory failure (P); 2) the intervention was based on the use of HFNT (I); 3) there were no comparators or other forms of respiratory support (C); 4) and the outcomes of interest included the results of any type of bedside swallowing assessment, *e.g.* clinical symptoms evaluation, food/water swallow test, submental electromyography (EMG), fibre-optic endoscopic evaluation of swallowing (FEES) or blue dye test [33] (O). Characteristics of included studies are shown in table 1. Two reviewers (RC, CC) performed the inclusion/exclusion screening process and discrepancies at any stage were solved by consensus between the two reviewers.

Data extraction

Two study team members (RC and CC) independently charted and extracted data from all the studies.

The protocol of this review was registered on PROSPERO, registration ID: CRD42023421871. After performing the systematic search as indicated, it was determined that a formal systematic review and meta-analysis would not have been possible owing to the characteristics of available evidence. Thus, we decided to perform a scoping review as the best type of evidence synthesis in this case [42].

Results

Description of the articles

Identified articles were published in 2016 or later. From 2016 to 2023, the search strategy initially identified 250 243 potentially relevant papers. After title screening and duplicate removal, a total of 69 510 citations remained. After abstract screening, a total of 35 studies met the inclusion criteria and were therefore selected for full-text review. Of these, 27 were excluded for the following reasons: 10 did not

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TABLE 1 Characteristics and outcomes of studies included in the systematic review

Authors	Study design	Characteristics of subjects (n; age)	Status or comorbidities	Flow rates	Swallowing assessment	Statistical results	Conclusions
Allen *et al.* 2021 [34]	Prospective study	n=29; <60 years	Healthy volunteers	10, 20, 30, 40, 50, 60 L·min^{-1}	VFSS, duration of laryngeal vestibule closure, PAS scores	The amount of airflow *via* HFNT significantly influenced the duration of laryngeal vestibule closure, *F* (1, 810)=19.056, p<0.001. There was no association between normal/abnormal PAS score and no airflow/HFNT (p=0.610).	There is a flow-dependent influence on the duration of laryngeal vestibule closure, which increased with higher airflow. Modulation of duration of laryngeal vestibule closure in response to the amount of airflow highlights the ability of healthy adults to adapt to swallow conditions to protect the airways as needed.
Arizono *et al.* 2021 [35]	Prospective cohort study	n=30; 30 years	Healthy volunteers	0, 10, 20, 30, 40, 50 L·min^{-1}, in random order	WST for aspiration, RSST for swallow frequency, 0–100 mm VAS for swallowing effort	Nine subjects (30.0%) choked at 10, 40 and 50 L·min^{-1} during the WST (p<0.05). Swallowing effort was increased during flow rates ⩾20 L·min^{-1} *versus* 10 L·min^{-1} (p<0.05). Flow rates ⩾20 L·min^{-1} resulted in a lower number of swallows during the RSST compared to 0 and 10 L·min^{-1} (p<0.05).	HFNT flow rates ⩾40 L·min^{-1} are associated with choking (increased risk of aspiration). Greater swallowing efforts during HFNT flow rates ⩾20 L·min^{-1}.
Sanuki *et al.* 2016 [36]	Prospective study	n=9	Healthy volunteers	0, 15, 30, 45 L·min^{-1}	Submental EMG, mean latency times of the swallowing reflex while swallowing 5 mL of distilled water over 3 s	Mean latency times of the swallow reflex with 15 L·min^{-1} (9.8±2.9 s), 30 L·min^{-1} (9.0±2.7 s) and 45 L·min^{-1} (8.5±3.0 s) of HFNT were significantly shorter than those under control conditions (11.9±3.7 s; p<0.05).	HFNT enhances swallowing function with increasing levels of flow by reducing the latency time of the swallow reflex. HFNT allows the continuation of oral intake without aspiration during oxygen therapy.

Continued

TABLE 1 Continued

Authors	Study design	Characteristics of subjects (n; age)	Status or comorbidities	Flow rates	Swallowing assessment	Statistical results	Conclusions
Eng *et al.* 2019 [37]	Prospective, single-centre, cohort study	n=80; 35–65 years	Healthy volunteers		MBSS, MBSImP scores, PAS score	Mean±SE total MBSImP scores were higher on HFNT 60 L·min^{-1} (10.1063±0.3923) *versus* baseline (8.9257 ±0.3117), t(75)= −3.14, p=0.0024, *versus* HFNT 20 L·min^{-1} (8.9029±0.3289), t(75)= −3.36, p=0.0012, or HFNT 40 L·min^{-1} (9.2554 ±0.3393), t(75)= −2.16, p=0.0342. Flow rate affects the oral phase of swallowing, reducing lip closure and tongue control and increasing the oral residue. No effects of flow rates on PAS score.	HFNT impacts the swallowing dynamics in the oral stage. There is an impairment in swallowing performance with the increase in HFNT flow rate.
Flores *et al.* 2019 [38]	Retrospective study	n=9; 71 years	Respiratory failure, atrial fibrillation, tachycardia, COPD, acute asthma exacerbation	30, 35, 40, 50 L·min^{-1}	MBSS, MBSImP scores, PAS score, Functional Oral Intake Scale scores	100% of patients remained nil by mouth after bedside evaluation due to aspiration risk. After MBSS, 8 of 9 patients were started on a complete oral diet and 1 of 9 patients was started on a partial oral diet. 50% presented with silent aspiration on PAS scores.	The decision regarding the safety of oral intake in patients using HFNT depends on cognitive status, physical abilities and performance on MBSS.

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TABLE 1 Continued

Authors	Study design	Characteristics of subjects (n; age)	Status or comorbidities	Flow rates	Swallowing assessment	Statistical results	Conclusions
Leder *et al.* 2016 [39]	Prospective, single-centre, cohort study	n=50; 70 years	Acute respiratory disease	10 L·min^{-1} 5 s; 15 L·min^{-1} 3 s; 20 L·min^{-1} 14 s; 25 L·min^{-1} 2 s; 30 L·min^{-1} 17 s; 35 L·min^{-1} 1 s; 40 L·min^{-1} 4 s; 50 L·min^{-1} 4 s	FEES	Deemed appropriate for oral feeding: 78%; Oral feeding success: 100%.	The use of HFNT should not delay the introduction or resumption of oral feeding.
Rattanajiajaroen *et al.* 2021 [40]	Randomised crossover study	Group A: n=11; Group B: n=11; 56 years	Pneumonia, congestive heart failure, alteration of consciousness, lactic acidosis, asthmatic attack, COPD	Group A: HFNT 50 L·min^{-1} Group B: LFNO 5 L·min^{-1}	Electrocardiography-derived respiratory signals, submental EMG, swallowing frequency, timing of swallows in relation to respiratory phases, food intake	In the HFNT group, higher numbers of expiration swallow pattern (74.3% HFNT *versus* 67.6% LFNO; p=0.048) and lower numbers of inspiration swallow pattern (14.3% HFNT *versus* 23.1% LFNO; p=0.044).	HFNT may have some favourable effects on post-extubation patients' swallowing-breathing coordination.
Zerbib *et al.* 2020 [41]	Observational retrospective study	n=40; 51.2 ±18.7 years (oral diet n=11; enteral nutrition n=21; parenteral nutrition n=4; enteral +parenteral nutrition n=2; no nutrition n=2)	Respiratory distress due to infection, surgery, multiple trauma	45 L·min^{-1}		The oral nutrition group had the highest calorie and protein intake, 600 (IQR 459–850) kCal·day^{-1} and 22 (IQR 20–45) g protein·day^{-1}.	The administration of HFNT was associated with significant underfeeding.

VFSS: videofluoroscopic swallow studies; PAS: penetration-aspiration scale; HFNT: high-flow nasal therapy; WST: 30-mL water swallow test; RSST: repeated saliva swallowing test; VAS: 0–100 mm visual analogue scale; EMG: electromyography; MBSS: modified barium swallow studies; MBSImP: modified barium swallow impairment profile; FEES: fibre-optic endoscopic evaluation of swallowing; LFNO: low-flow nasal oxygen; IQR: interquartile range.

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consider HFNT, 10 did not have patient data (only descriptive or did not include respiratory disorders), six did not describe swallowing involvement and one was the protocol of a randomised control trial. The final selection included eight studies [34–41]: one randomised crossover trial, two retrospective studies and five prospective cohort studies. The inclusion/exclusion process is presented as a PRISMA flow diagram (figure 1). The selected eight articles described the influence of HFNT on swallowing in 148 healthy adults and 151 patients affected by acute or chronic respiratory failure. There was large variation among the studies concerning the general clinical characteristics, *e.g.* clinical presentation, severity of symptoms, duration of the disease (acute or chronic), methodology used to assess swallowing, time of starting oxygenation therapy and duration of treatment (table 1). This heterogeneity of the sample precluded the performance of a quantitative analysis of the data.

Characteristics of included studies

Involvement of swallowing during high-flow nasal cannula: studies on healthy volunteers

Sanuki *et al.* [36] showed that HFNT facilitated swallowing function during treatment with increasing flow rates by reducing the latency of the swallowing reflex, enabling a safe oral intake. The authors studied the swallowing latency time, which is the period between swallowing onset (when the patients were requested to swallow) and the start of the first wave in the surface EMG. Indeed, aspiration was linked to a longer latency time; therefore, the reduced latency time from high flow could result in a more effective and coordinated swallowing. The latency times of the swallowing reflex with high flow of 15, 30 and 45 $L \cdot min^{-1}$ were significantly shorter than those under control conditions (at 0 $L \cdot min^{-1}$). Moreover, the fluctuation in airway pressure during HFNT activated receptors in the upper airway and initiated the swallowing reflex, as opposed to what occurs with nasal continuous positive airway pressure (CPAP).

Arizono *et al.* [35] showed that a flow rate of $\geqslant$20 $L \cdot min^{-1}$ resulted in a reduction in the number of swallows and an increase in swallowing effort. The authors described that, as the flow increased up to 40 $L \cdot min^{-1}$ and above, it caused choking and coughing in a quarter of healthy volunteers (26.6%); flow

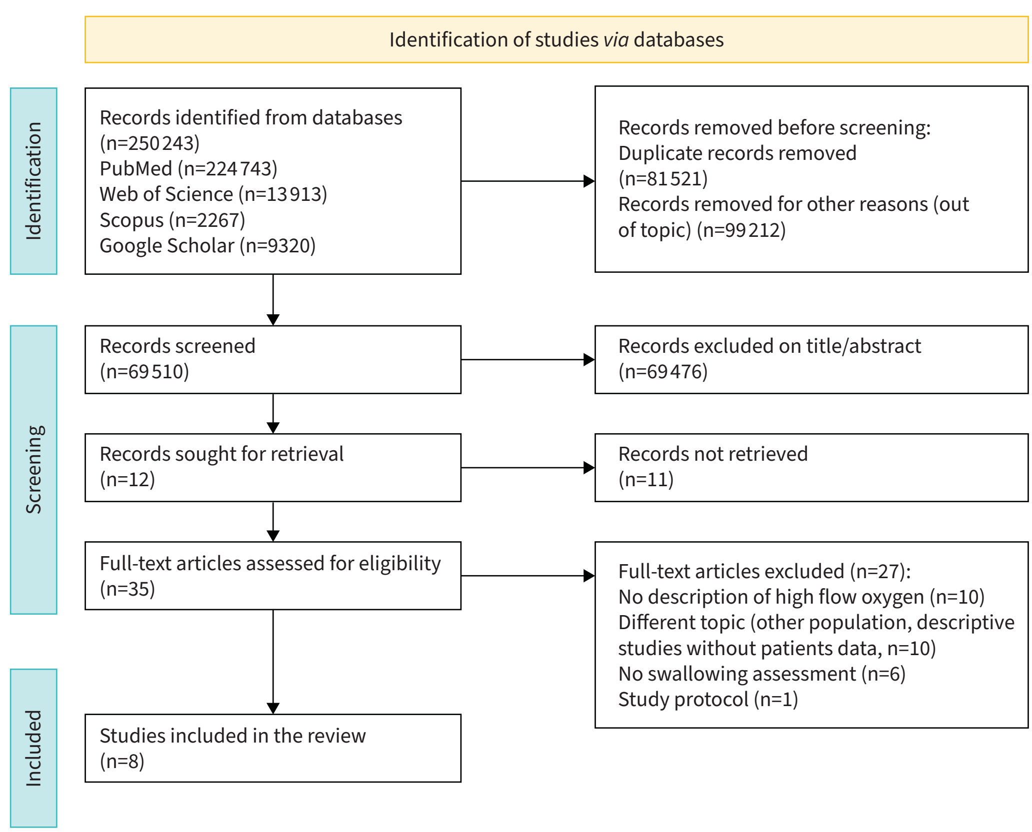

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of included studies.

rates of 50 L·min^{-1} reduced the numbers of swallows from 10.7 at 0 L·min^{-1} to 6.8 at 50 L·min^{-1}. Allen *et al.* [34] highlighted another concept to consider in the duration of laryngeal vestibule closure (time for one swallow), which captured significant changes across airflow conditions. In particular, healthy individuals were able to modulate the duration of laryngeal vestibule closure during swallowing in response to changes in bolus volumes and flow rate, showing their ability to adapt to swallowing conditions as needed to protect the airway from aspiration. However, higher flow rates were subjectively perceived by individuals as causing more difficulty swallowing [34].

Eng *et al.* [37] showed that changes in swallowing performance occur in healthy volunteers with increased HFNT flow rates. In particular, they observed an increase in the Modified Barium Swallow Impairment Profile scores during HFNT compared to baseline, which were higher at flow rates of 60 L·min^{-1}. The increase in flow rate affected the oral phase of swallowing, reducing lip closure and tongue control and increasing the oral residue.

Overall, in healthy volunteers, high flow rates seem to exert a significant influence on swallowing mechanics, making swallowing more difficult and increasing the risk of coughing and the chance of aspiration by prolonging the duration of laryngeal vestibular closure [34, 35, 37].

Involvement of swallowing during high-flow nasal cannula: studies on patients with respiratory diseases

In a retrospective cohort study [38], silent aspiration was reported in five (50%) of 10 critically ill patients with respiratory distress who underwent a modified barium swallow study while receiving HFNT during hospitalisation. Conversely, Leder *et al.* [39] showed that when considered appropriate from medical perspectives, adult patients admitted to the intensive care unit requiring HFNT successfully restarted oral alimentation, highlighting that it is not the use of HFNT *per se* but rather patient-specific determinants of feeding readiness and underlying medical conditions that impact decisions for oral alimentation. Zerbib *et al.* [41] demonstrated that the administration of HFNT in intensive care unit settings was associated with significant underfeeding so that, in order to reach the optimal caloric and protein intake, parenteral nutrition had to be considered in the presence of swallowing disorders associated with the use of higher flow rate. Additionally, Rattanajiajaroen *et al.* [40] showed that the use of HFNT during the post-extubation period improved the coordination between swallowing and breathing, thanks to an increase in the likelihood of swallowing during the expiratory phase by lengthening the expiratory period and protecting the airways from aspiration. The potential positive and negative effects of HFNT on swallowing function are displayed in figure 2.

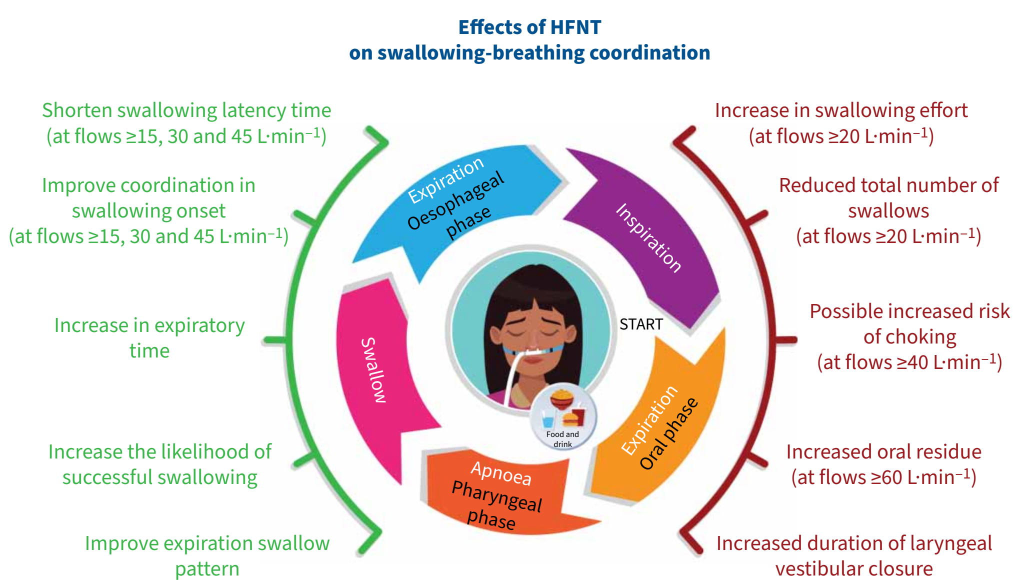

FIGURE 2 Hypothetical potential positive and negative effects of high-flow nasal therapy (HFNT) on swallowing function. Of note, the body of evidence supporting these findings is of low quality.

Discussion

This scoping review showed conflicting results on the effects of HFNT on swallowing function and, therefore, its impact on oral feeding and risk of aspiration during treatment both in healthy subjects and in patients with respiratory disorders. In this regard, some of the included studies indicated improvement in swallowing function during HFNT [36, 40] while others showed a decrease in swallowing function during HFNT [34, 35, 37, 41]; one study showed no impact of HFNT on swallowing [39] and another highlighted the need for a deep investigation of swallowing physiology [38].

HFNT is frequently and widely used in clinical practice to manage patients with various types of acute respiratory failure in different clinical settings with varying nurse-to-patient ratios among facilities; therefore, careful consideration of the safety implications of concurrent oral feeding during treatment is required. Furthermore, recent evidence showed that HFNT has beneficial effects even in chronic respiratory failure [10], boosting its use in long-term domiciliary settings and reinforcing the importance of obtaining safety data on concurrent oral intake while on treatment. To the best of our knowledge, this is the first scoping review examining evidence on the impact of HFNT on swallowing function.

The majority of the studies included in our review were published within the past decade, indicating a growing interest in understanding and addressing the problem of safety of swallowing during HFNT. Early reports in healthy subjects showed favourable airway protective adaptation during HFNT, including a decreased latency of swallow initiation with increased flow rates, a compensatory pharyngeal response during swallowing at HFNT rates of up to 60 $L \cdot min^{-1}$ and a dose-dependent lengthening of the duration of laryngeal vestibule closure and concurrent signs of airway protection on videofluoroscopic examination [34]. However, we are unable to determine if similar protection mechanisms are present in patients with acute or acute-on-chronic lung diseases. Thus, in patients affected by acute respiratory failure, the breathing pattern, the presence of underlying chronic respiratory diseases, comorbidities, cognitive status, physical abilities and performance status can influence the decision regarding the safety of oral intake while on treatment with any noninvasive oxygenation strategies [38]. Indeed, oropharyngeal dysphagia is more common in chronic respiratory diseases because swallowing more often occurs during the expiration–inspiration transition and not during expiration as it should [6]. Moreover, COPD patients tend to assume a hunched posture, consequently reducing the coordination between the diaphragm and rectus abdominis, which is crucial to control physiological apnoea during swallowing [43]. In chronic respiratory diseases, the coordination between swallowing and breathing can be impaired due to muscle dysfunction, changes in breathing pattern and lung capacity, and the presence of dyspnoea, which may increase swallowing frequency and generate laryngeal irritation [4]. In addition, survivors of severe acute respiratory failure present with abnormalities of laryngeal structure and sensation and swallowing physiology, reduced pharyngeal squeeze/medialisation and upper airway oedema that may increase the risk of developing dysphagia [5]. A recent survey [44] on clinicians' feeding practices during HFNT showed great variability among different facilities without any specific protocol in this regard, with physicians and respiratory therapists considering oral intake during HFNT safe for stable patients with no need for swallowing evaluation and speech-language pathologists favouring a bedside clinical swallowing screening for patients on HFNT before eating or drinking.

HFNT at different flow rates (15, 30 and 45 $L \cdot min^{-1}$) seems to enhance swallowing function, reducing the latency times of the reflex in healthy subjects [36]. Similarly to HFNT, nasal CPAP at low pressure (5, 10 and 15 cmH_2O) attenuates the swallowing reflex [6] (already compromised in chronic respiratory diseases with consequent increased latent time to trigger the reflex) owing to the mechanical increment of the airway generated by the positive pressure, inhibition of the swallowing receptors and the reduction of peripheral sensation mechanisms [45]. However, unlike HFNT devices, CPAP reduces the inspiration after swallowing frequency, increases the swallowing-associated non-inspiratory flow occurrence and normalises the timing of swallowing, alleviating the risk of aspiration in patients with COPD [46]. None of the included studies evaluated the association between different temperatures and F_{IO_2} as effect modifiers on swallowing function.

Based on our findings, the relationship between HFNT and swallowing function has not yet been clearly established, and the currently available literature offers conflicting evidence. On the one hand, oral feeding should not be withheld or delayed exclusively based on ongoing treatment with HFNT. On the other, the potential impact of HFNT flow rates on swallowing physiology and aspiration-related concerns should be considered based on patient-specific factors, and bedside clinical or instrumental evaluation of swallowing should be performed for selected clinical scenarios based on clinical judgment. Clinicians should carefully evaluate starting, keeping or stopping oral intake in patients on HFNT as for every noninvasive respiratory support, considering the underlying disease and comorbidities, cognitive status, cough effectiveness and ability to clear secretions, age, sedation and possible pharmacological interaction and obliged position. Given the contradictory effects of HFNT on swallowing described by a few, heterogeneous, short-term studies, it is reasonable to consider that the risk of unsafe swallowing may change over time in candidates for long-term intra-hospital or home-based treatment when considering several confounding factors (*i.e.* physiological adaptation to changes in flow and pressure status in the upper airways, changes in pulmonary gas exchange, impact on respiratory muscle distress). Standardised protocols for a full clinical swallowing assessment or multidisciplinary teams, including speech and swallowing pathologists, should be considered for optimal nutritional management and aspiration risk assessment of patients on noninvasive respiratory support in the acute setting and for the transition from hospital to home.

Knowledge gaps

The results of our scoping review suggest a limited amount of literature addressing the issue of swallowing function during HFNT and highlight important research gaps, including 1) an evidence gap due to a low number of studies and included participants, which report contradictory findings on different populations; 2) a methodological gap due to lack of standardised methods to assess the interaction between HFNT and swallowing function and outcomes; and 3) a practical knowledge gap because no studies have evaluated the effect of HFNT on the swallowing–breathing interaction with a practical focus on important patient outcomes in a study with a pragmatic design.

Implications for future research

Our findings support the need for additional research focused on assessing the impact and potential consequences of HFNT on swallowing function as well as investigating the possible influence of different flow rates, temperature, F_{IO_2}, bolus quantity and quality, breathing patterns and the potential role of an adjuvant head posture during treatment using appropriate standardised and homogeneous swallowing evaluation tests in order to fill important knowledge gaps. Future research should also aim to establish gold standard diagnostic criteria for swallowing evaluation during HFNT, enabling clinicians to better characterise patients at risk of aspiration during treatment.

Strengths and limitations

This scoping review has been conducted according to the current methodological standards, in line with PRISMA-ScR requirements. The comprehensive search, including studies on both healthy volunteers and participants with acute and chronic respiratory failure, led to the identification of knowledge gaps and implications for future research concerning the effects of HFNT on swallowing function. We also tried to provide a multidisciplinary, balanced interpretation of available data, helping clinicians to navigate the uncertainty concerning this topic. The limitations of this study relate to the characteristics of available evidence. First, the heterogeneity of disease severity and underlying respiratory disease was highlighted by the included studies. Second, different types of swallowing evaluation were used for assessing swallowing function during HFNT across the included studies. Indeed, the clinical bedside evaluation of swallowing alone is not accurate enough in determining swallowing disorders, especially in the presence of silent aspiration; thus, some research findings should be considered carefully because they did not use appropriate instrumentation for swallowing evaluation, such as FEES or submental EMG. Third, it was unclear (or not investigated) whether alterations in swallowing function were caused by the treatment with HFNT *per se*, promoted by the underlying respiratory disease, or both.

Conclusion

This scoping review clearly shows that there is insufficient data on the impact of HFNT on swallowing function, leading to inconsistent evidence in favour of or against the practice of oral intake during HFNT use. Owing to the lack of safety data from adequately designed clinical trials, clinicians should proceed with caution when making decisions about oral feeding in patients with acute respiratory failure on treatment with HFNT and consider patient-specific factors.

Provenance: Submitted article, peer reviewed.

Conflict of interest: C. Crimi reports honoraria for lectures from AstraZeneca, GSK, Sanofi, Novartis, Resmed, Fisher & Paykel and Vitalair, outside the submitted work; and a patent pending (number 102023000013077) not discussed in the present study. C. Gregoretti reports honoraria for lectures from Vivisol, Vyare and Philips, outside the submitted work; a patent in association with the University of Palermo (number 102019000020532, Italian Ministry of Economic Development) and a patent pending (number 102023000013077), not discussed in the present study. A. Carlucci reports honoraria for lectures from Breas, Resmed, Fisher & Paykel and Vitalaire, outside the submitted work. A. Cortegiani reports honoraria for lectures from Fisher & Paykel outside the submitted work;

and a patent in association with the University of Palermo (number 102019000020532, Italian Ministry of Economic Development) not discussed in the present study. The remaining authors have nothing to disclose.

References

1 Martin-Harris B, Kantarcigil C, Reedy EL, *et al.* Cross-system integration of respiration and deglutition: function, treatment, and future directions. *Dysphagia* 2023; 38: 1049–1058.
2 Nishino T, Yonezawa T, Honda Y. Effects of swallowing on the pattern of continuous respiration in human adults. *Am Rev Respir Dis* 1985; 132: 1219–1222.
3 Shaker R, Li Q, Ren J, *et al.* Coordination of deglutition and phases of respiration: effect of aging, tachypnea, bolus volume, and chronic obstructive pulmonary disease. *Am J Physiol* 1992; 263: G750–G755.
4 Nishino T, Hasegawa R, Ide T, *et al.* Hypercapnia enhances the development of coughing during continuous infusion of water into the pharynx. *Am J Respir Crit Care Med* 1998; 157: 815–821.
5 Langmore SE, Krisciunas GP, Warner H, *et al.* Abnormalities of aspiration and swallowing function in survivors of acute respiratory failure. *Dysphagia* 2021; 36: 831–841.
6 Ghannouchi I, Speyer R, Doma K, *et al.* Swallowing function and chronic respiratory diseases: systematic review. *Respir Med* 2016; 117: 54–64.
7 Macht M, Wimbish T, Bodine C, *et al.* ICU-acquired swallowing disorders. *Crit Care Med* 2013; 41: 2396–2405.
8 Zuercher P, Moret CS, Dziewas R, *et al.* Dysphagia in the intensive care unit: epidemiology, mechanisms, and clinical management. *Crit Care* 2019; 23: 103.
9 Oczkowski S, Ergan B, Bos L, *et al.* ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure. *Eur Respir J* 2022; 59: 2101574.
10 Weinreich UM, Juhl KS, Soby Christophersen M, *et al.* The Danish Respiratory Society guideline for long-term high flow nasal cannula treatment, with or without supplementary oxygen. *Eur Clin Respir J* 2023; 10: 2178600.
11 Rochwerg B, Einav S, Chaudhuri D, *et al.* The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline. *Intensive Care Med* 2020; 46: 2226–2237.
12 Cortegiani A, Crimi C, Noto A, *et al.* Effect of high-flow nasal therapy on dyspnea, comfort, and respiratory rate. *Crit Care* 2019; 23: 201.
13 Goligher EC, Slutsky AS. Not just oxygen? Mechanisms of benefit from high-flow nasal cannula in hypoxemic respiratory failure. *Am J Respir Crit Care Med* 2017; 195: 1128–1131.
14 Pitre T, Zeraatkar D, Kachkovski GV, *et al.* Noninvasive oxygenation strategies in adult patients with acute hypoxemic respiratory failure: a systematic review and network meta-analysis. *Chest* 2023; 164: 913–928.
15 Crimi C, Pierucci P, Renda T, *et al.* High-flow nasal cannula and COVID-19: a clinical review. *Respir Care* 2022; 67: 227–240.
16 Pelaia C, Armentaro G, Lupia C, *et al.* Effects of high-flow nasal cannula on right heart dysfunction in patients with acute-on-chronic respiratory failure and pulmonary hypertension. *J Clin Med* 2023; 12: 5472.
17 Cortegiani A, Longhini F, Madotto F, *et al.* High flow nasal therapy versus noninvasive ventilation as initial ventilatory strategy in COPD exacerbation: a multicenter non-inferiority randomized trial. *Crit Care* 2020; 24: 692.
18 Cortegiani A, Crimi C, Sanfilippo F, *et al.* High flow nasal therapy in immunocompromised patients with acute respiratory failure: a systematic review and meta-analysis. *J Crit Care* 2019; 50: 250–256.
19 Crimi C, Noto A, Cortegiani A, *et al.* High flow nasal therapy use in patients with acute exacerbation of COPD and bronchiectasis: a feasibility study. *COPD* 2020; 17: 184–190.
20 Hui D, Mahler DA, Larsson L, *et al.* High-flow nasal cannula therapy for exertional dyspnea in patients with cancer: a pilot randomized clinical trial. *Oncologist* 2021; 26: e1470–e1479.
21 Bramati PS, Azhar A, Khan R, *et al.* High flow nasal cannula in patients with cancer at the end of life. *J Pain Symptom Manage* 2023; 65: e369–e373.
22 Crimi C, Noto A, Cortegiani A, *et al.* Noninvasive respiratory support in acute hypoxemic respiratory failure associated with COVID-19 and other viral infections. *Minerva Anestesiol* 2020; 86: 1190–1204.
23 Crimi C, Noto A, Madotto F, *et al.* High-flow nasal oxygen versus conventional oxygen therapy in patients with COVID-19 pneumonia and mild hypoxaemia: a randomised controlled trial. *Thorax* 2023; 78: 354–361.
24 Crimi C, Murphy P, Patout M, *et al.* Lessons from COVID-19 in the management of acute respiratory failure. *Breathe (Sheff)* 2023; 19: 230035.
25 Crimi C, Nolasco S, Campisi R, *et al.* Long-term domiciliary high-flow nasal therapy in patients with bronchiectasis: a preliminary retrospective observational case-control study. *J Clin Med* 2022; 11: 7323.
26 Crimi C, Cortegiani A. High-flow nasal therapy in acute and chronic respiratory failure: past, present, and future. *J Clin Med* 2023; 12: 2666.
27 Crimi C, Cortegiani A. Home high flow nasal therapy for patients at end of life: benefits, hopes, and goals of care. *J Pain Symptom Manage* 2023; 66: e649–e651.

28 Pitre T, Abbasi S, Kachkovski G, *et al*. Home respiratory strategies in COPD patients with chronic hypercapnic respiratory failure: a systematic review and network meta-analysis. *Respir Care* 2024: respcare.11805. http://dx.doi.org/10.4187/respcare.11805
29 Singer P, Rattanachaiwong S. To eat or to breathe? The answer is both! Nutritional management during noninvasive ventilation. *Crit Care* 2018; 22: 27.
30 Groves N, Tobin A. High flow nasal oxygen generates positive airway pressure in adult volunteers. *Aust Crit Care* 2007; 20: 126–131.
31 Parke R, McGuinness S, Eccleston M. Nasal high-flow therapy delivers low level positive airway pressure. *Br J Anaesth* 2009; 103: 886–890.
32 Tricco AC, Lillie E, Zarin W, *et al.* PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018; 169: 467–473.
33 O'Horo JC, Rogus-Pulia N, Garcia-Arguello L, *et al.* Bedside diagnosis of dysphagia: a systematic review. *J Hosp Med* 2015; 10: 256–265.
34 Allen K, Galek K. The influence of airflow via high-flow nasal cannula on duration of laryngeal vestibule closure. *Dysphagia* 2021; 36: 729–735.
35 Arizono S, Oomagari M, Tawara Y, *et al.* Effects of different high-flow nasal cannula flow rates on swallowing function. *Clin Biomech (Bristol, Avon)* 2021; 89: 105477.
36 Sanuki T, Mishima G, Kiriishi K, *et al.* Effect of nasal high-flow oxygen therapy on the swallowing reflex: an *in vivo* volunteer study. *Clin Oral Investig* 2017; 21: 915–920.
37 Eng KF MJ, Gerrity E, Sinha N, *et al.* Evaluation of swallow function on healthy adults while using high-flow nasal cannula. *Perspect ASHA Spec Interest Groups* 2019; 4: 1516–1524.
38 Flores MJE K, Gerrity E, Sinha N. Initiation of oral intake in patients using high-flow nasal cannula: a retrospective analysis. *Perspect ASHA Spec Interest Groups* 2019; 4: 522–531.
39 Leder SB, Siner JM, Bizzarro MJ, *et al.* Oral alimentation in neonatal and adult populations requiring high-flow oxygen via nasal cannula. *Dysphagia* 2016; 31: 154–159.
40 Rattanajiajaroen P, Kongpolprom N. Effects of high flow nasal cannula on the coordination between swallowing and breathing in postextubation patients, a randomized crossover study. *Crit Care* 2021; 25: 365.
41 Zerbib O, Rattanachaiwong S, Palti N, *et al.* Energy and protein intake in critically ill people with respiratory failure treated by high-flow nasal-cannula oxygenation: an observational study. *Nutrition* 2021; 84: 111117.
42 Peters MDJ, Marnie C, Tricco AC, *et al.* Updated methodological guidance for the conduct of scoping reviews. *JBI Evid Synth* 2020; 18: 2119–2126.
43 Ayuse T, Hisamatsu N, Yamaguchi T, *et al.* Efficacy of nasal high flow therapy on the coordination between breathing and swallowing of saliva during daytime nap in chronic obstructive pulmonary disease patients: a single center, randomized crossover controlled study. *Medicine (Baltimore)* 2020; 99: e21778.
44 Charlton ME, Peterson SJ, LaGorio LA, *et al.* a survey of feeding practices during high-flow nasal cannula oxygen therapy. *Respir Care* 2023; 68: 1229–1236.
45 Nishino T, Sugimori K, Kohchi A, *et al.* Nasal constant positive airway pressure inhibits the swallowing reflex. *Am Rev Respir Dis* 1989; 140: 1290–1293.
46 Hori R, Ishida R, Isaka M, *et al.* Effects of noninvasive ventilation on the coordination between breathing and swallowing in patients with chronic obstructive pulmonary disease. *Int J Chron Obstruct Pulmon Dis* 2019; 14: 1485–1494.