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Review

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Efficacy of High-Flow Nasal Cannula in Preventing Hypoxemia During Sedated Endoscopic Procedures: A Literature Review

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Abstract

Introduction. Hypoxemia is a common and potentially serious complication during endoscopic procedures performed under sedation, particularly in patients with obesity, chronic respiratory disease, or reduced pulmonary reserve. The high flow nasal cannula (HFNC) delivers heated and humidified oxygen at high flow rates with a stable fraction of inspired oxygen (FiO_2), thereby reducing desaturation and improving oxygenation compared with conventional oxygen delivery methods.

Aim. This review evaluated the efficacy of HFNC in preventing hypoxemia during gastrointestinal endoscopy, bronchoscopy, and endoscopic retrograde cholangiopancreatography (ERCP) under sedation, focusing on clinical applicability and patient safety.

Methods. A systematic search of PubMed, Web of Science, and Scopus (2015-2025) identified English language studies, including randomized trials, comparative and observational studies, and reviews. Predefined inclusion criteria were applied, and outcomes included the incidence of hypoxemia, minimum SpO_2, and the need for airway interventions.

Results. Of 628 records screened, 30 studies met the inclusion criteria (13 randomized trials, 3 prospective comparative, 1 observational, 3 retrospective, and 10 systematic reviews or meta-analyses). Most confirmed that HFNC reduces hypoxemia, increases minimum SpO_2, and improves ventilation stability compared with conventional oxygen therapy. The greatest benefits were observed among high-risk patients such as elderly, obese, and those with respiratory disease. Optimal flow rates ranged from 50 to 60 L/min, ensuring efficacy, comfort, and safety.

Conclusion. HFNC provides effective oxygenation support during sedated endoscopic procedures, reducing desaturation and the need for airway interventions. Standardized protocols and further research on long term outcomes are recommended.

Introduction

Hypoxemia is one of the most common and serious complications during sedated endoscopic procedures, particularly in patients at increased risk due to respiratory diseases, obesity, or other factors that reduce pulmonary reserve (1). Conventional methods of oxygenation support, such as conventional oxygen therapy (COT) delivered via nasal cannula or face mask, are often insufficient to maintain adequate oxygenation in conditions of increased oxygen demand and reduced respiratory volume caused by sedation (2). Therefore, advanced non-invasive oxygenation methods are increasingly being applied in clinical practice, among which the high-flow nasal cannula (HFNC) is gaining an increasingly important role.

HFNC delivers heated and humidified oxygen at high flow rates (typically 30–60 L/min) with precise control of the fraction of inspired oxygen (FiO_2) (3). This technology provides partial positive pressure support (PEEP effect), reduces dead space in the upper airways, improves alveolar ventilation, and enhances overall gas exchange (4). HFNC increases the partial pressure of arterial oxygen (PaO_2), reduces respiratory effort, and improves patient comfort compared with traditional methods (5). In addition, continuous airflow through the upper airways prevents rebreathing of carbon dioxide (CO_2), thereby reducing the risk of hypercapnia, which is a common problem in sedated patients during procedures such as bronchoscopy, gastroscopy, or endoscopic retrograde cholangiopancreatography (ERCP).

The significance of HFNC is particularly evident in patients at high risk of developing hypoxemia, including elderly individuals, patients with elevated BMI, those with chronic lung diseases (e.g., COPD, interstitial lung disease), and patients undergoing prolonged or invasive endoscopic procedures (6,7). Numerous studies and meta-analyses report that HFNC reduces the incidence of hypoxemic episodes, the need for procedural interruptions, and additional airway interventions (e.g., mask ventilation, intubation), while simultaneously increasing minimum oxygen saturation (SpO_2). Compared with COT or low-flow oxygen therapy, HFNC provides more stable oxygenation and better control of ventilation parameters, thereby contributing to the safer performance of procedures (8).

Despite the increasing use of HFNC, its application in procedural sedation and endoscopy has not yet been standardized, and the determination of optimal flow rates and indications varies across clinical centers in different countries. In addition, considerable heterogeneity exists regarding study design, sedation protocols, and definitions of hypoxemia, which complicates the development of unified guidelines. Given the growing number of endoscopic procedures performed under sedation and the increasingly complex patient population, there is a need for a detailed analysis of the effectiveness of HFNC in this context. Numerous studies have shown that the incidence of hypoxemia during gastrointestinal endoscopy under sedation may range from as low as 1.8% to as high as 69% (9–12).

Aim

The purpose of this paper is to systematically analyze the existing scientific literature on the effectiveness of high-flow nasal cannula (HFNC) in managing hypoxemia during endoscopic procedures. The study aims to identify the advantages of HFNC in comparison with conventional methods of oxygenation support. A particular emphasis was placed on outcomes such as improved oxygenation, reduced need for invasive ventilation, and patient safety.

Methods

A systematic literature search was conducted in July 2025 using the PubMed, Web of Science, and Scopus databases. Scientific articles published between 2015 and 2025 were reviewed. In accordance with PRISMA guidelines for systematic reviews, only articles classified as Clinical Trial, Controlled Clinical Trial, Multicenter Study, Observational Study, Randomized Controlled Trial, Review, and Systematic Review were included.

Inclusion criteria comprised studies focusing on the use of high-flow nasal cannula (HFNC) in adult patients with hypoxemia, including gastrointestinal endoscopy (gastroscopy, colonoscopy, EGD), bronchoscopy, and endoscopic retrograde cholangiopancreatography (ERCP) performed under sedation. Predefined search keywords were used: "high flow nasal cannula," HFNC, and hypoxemia. These terms were required to appear in the title, abstract, or keywords of the included articles to ensure their relevance.

Only studies published between 2015 and 2025 were included. This period was selected to capture the most recent decade of scientific evidence, reflecting advances in high-flow nasal cannula technology, evolving procedural sedation protocols, and the growing number of clinical trials in this field. Studies published before 2015 were excluded to avoid outdated technologies and practices that no longer represent current standards.

The authors predefined the search objectives, established inclusion and exclusion criteria (see Table 1), and focused the analysis on studies investigating the use of HFNC compared with COT in adult patients. The search was further limited to articles available in English and required to contain either an abstract or full text. After duplicate removal using the Zotero application, a total of 628 records were identified for review (Figure 1). Two independent authors screened the titles and abstracts (n = 628), excluding 384 studies that did not meet the basic inclusion criteria or were deemed irrelevant. Full-text articles were retrieved for 244 studies and assessed for eligibility. In the final selection round, 214 articles were excluded because they were not related to endoscopic procedures, resulting in 30 studies being included in the analysis, all directly addressing HFNC use in relation to endoscopic procedures.

Data extraction was conducted independently by two authors (VJ and JP), with accuracy verified through mutual comparison and consensus among all authors. The quality of the included studies was evaluated according to predefined criteria encompassing study design, sample size, outcome reporting, and overall methodological rigor.

Table 1. **Inclusion and exclusion criteria**

Inclusion criteria	Exclusion criteria
Studies published between January 2015 and June 2025	Studies published before 2015
Original research articles available in English with accessible abstract or full text	Articles in languages other than English; editorials, letters, commentaries, books, or conference abstracts
Clinical and review studies: randomized controlled trials (RCTs), controlled clinical trials, multicenter studies, observational (prospective and retrospective), systematic and narrative reviews	Case reports, study protocols, low-quality meta-analyses, animal experiments, or studies lacking accessible abstract/full text
Studies investigating the use of HFNC in adults with acute respiratory failure or hypoxemia during endoscopic procedures under sedation, including gastrointestinal endoscopies (gastroscopy, colonoscopy, EGD), bronchoscopy, and ERCP under sedation	Studies involving pediatric or neonatal patients; studies in non-acute or chronic settings (e.g., COPD); studies not related to endoscopic procedures (e.g., ARDS studies or ICU weaning protocols)
Studies reporting outcomes such as hypoxemia incidence, oxygenation parameters, airway interventions, or procedure interruptions	Studies without clinically relevant outcomes.

Results

This systematic review includes 30 studies published between 2015 and 2025. The included studies evaluated the effectiveness of high-flow nasal cannula (HFNC) in preventing hypoxemia during sedated endoscopic procedures, including gastrointestinal endoscopy, bronchoscopy, and endoscopic retrograde cholangiopancreatography (ERCP). The PRISMA diagram (Figure 1) illustrates the selection

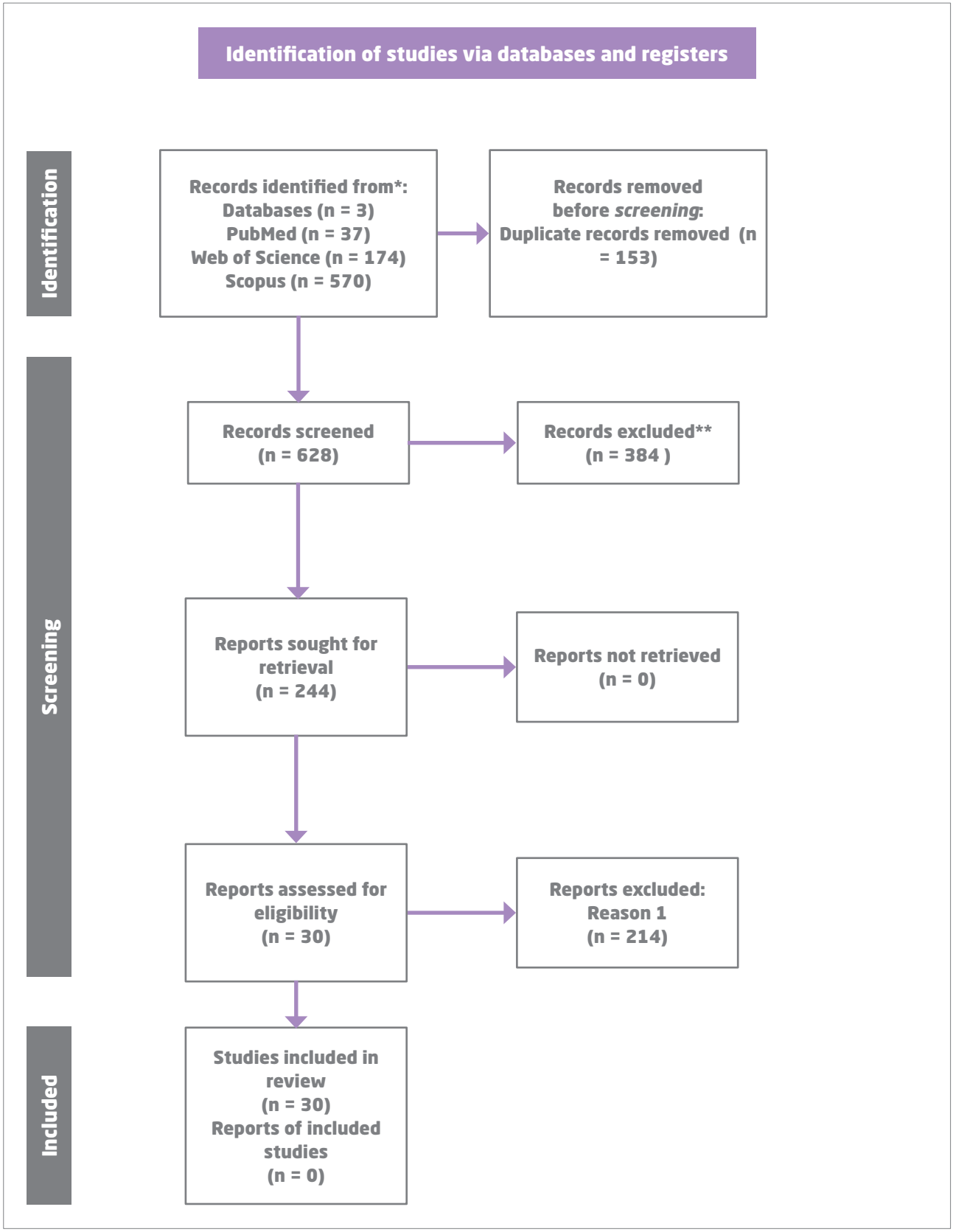

Figure 1. **PRISMA flow chart**

process, and Table 2 provides a detailed overview of the included studies, including authors, study design, population characteristics, and key findings. To avoid redundancy, detailed numerical results are summarized in Table 2.

Most of the studies were conducted in China (n = 13), with additional studies originating from Japan (n = 2), South Korea (n = 2), Australia (n = 2), Taiwan (n = 2), and Greece (n = 2), as well as single studies from Thailand, Egypt, Ecuador, France, India, and the United States. By study type, the included papers comprised 13 randomized controlled trials (RCTs), 3 prospective randomized comparative studies, 1 prospective observational study, 3 retrospective studies, and 10 systematic reviews and meta-analyses.

As shown in Table 2, most studies confirmed that HFNC significantly reduces the incidence of hypoxemia compared with COT and maintains higher minimum SpO_2 values. Systematic reviews and meta-analyses particularly highlighted the reduced risk of hypoxemia, fewer procedural interruptions, and a decreased need for airway interventions (13, 20, 23, 25, 31, 32, 35, 37–39).

Randomized controlled trials (n = 13) demonstrated the superiority of HFNC across different populations and procedures, including bronchoscopy, ERCP, gastroscopy, and endoscopic submucosal dissection (17, 19, 21, 24, 26, 28–30, 33, 36, 40–42). Several studies (14, 22, 34) observed that HFNC and other methods, such as NIV or low-flow oxygen, showed comparable efficacy; however, HFNC more consistently provided greater stability of oxygenation in high-risk patients.

Retrospective and prospective studies further confirmed that HFNC significantly reduces the occurrence of desaturation and maintains stable SpO_2 during procedures (14–16, 18, 21, 22, 27, 34).

A concise summary of these findings is presented in Table 2, which consolidates the numerical outcomes and key methodological details of all included studies.

In conclusion, the findings indicate that HFNC is most effective in preventing hypoxemia during sedated endoscopic procedures, with optimal flow rates of 50–60 L/min, and is associated with a lower risk of complications and reduced need for procedural interruptions (13, 19, 42).

Discussion

This systematic review analyzed evidence from randomized trials, observational studies, and meta-analyses, all of which consistently show that HFNC significantly reduces hypoxemia and improves oxygenation compared with COT. The following discussion summarizes key findings by procedure type and patient population.

HFNC during gastrointestinal endoscopy

Sedation during upper gastrointestinal endoscopic procedures often causes hypoventilation and airway obstruction, increasing the risk of hypoxemia. Numerous studies confirm that the use of HFNC significantly reduces this risk compared with standard low-flow oxygen therapy. Meta-analyses consistently report a 60–75% relative risk reduction with HFNC use (20,39).

For instance, Thiruvenkatarajan et al. (2023) demonstrated a lower incidence of hypoxemia and higher minimum oxygen saturation with HFNC (20), while Zhang et al. (2022) additionally reported a reduced need for airway interventions in patients undergoing sedated gastrointestinal endoscopy (37). In practice, HFNC markedly decreases desaturation episodes and maintains higher oxygen saturation levels than COT (37). In practice, HFNC markedly decreases desaturation episodes and maintains higher oxygen saturation levels than COT.

These findings have been further supported by randomized trials. The multicenter ODEPHI RCT by Nay et al. (2021) showed that HFNC substantially reduced critical desaturation events in high-risk patients compared with standard oxygen therapy (30). Beyond reducing hypoxemia incidence, HFNC also decreases the need for procedural interruptions and airway maneuvers (20,30). Other studies confirmed that HFNC lowers the need for airway maneuvers and procedural interruptions, with the most pronounced benefit observed in preventing severe desaturation (9,11,22,30,37,40). The meta-analysis by Khanna et al. (2023) involving more than 3,000 patients also demonstrated significant reductions in desaturation incidents and procedure interruptions, together with higher minimum oxygen saturation (39). Although

Table 2. **Overview of included studies on the use of HFNC in the prevention of hypoxemia during endoscopic procedures (2015–2025)**

Authors, year	Type of study	Aim	Country	Key findings
Wei C, Ma SY, Jiang LL, Wang JW, Yuan LP, Wang YY, 2024 (13)	Meta-analysis of 12 RCTs (2004–2024), conducted using RevMan 5.4	To evaluate the clinical effects of HFNC compared with COT during gastrointestinal endoscopic procedures.	China	HFNC significantly reduced the incidence of hypoxemia (OR = 0.39, 95% CI: 0.29–0.53), increased minimum SpO_2 (MD = 4.07, 95% CI: 3.14–5.01), and decreased the need for airway interventions (OR = 0.16, 95% CI: 0.05–0.53). No significant differences were observed in SpO_2, hypercapnia, or procedure duration.
Saksitthichok B, Petnak T, So-ngem A, Boonsamgsuk V, 2019 (14)	Prospective randomized comparative study	To compare HFNC and NIV in maintaining oxygenation during flexible bronchoscopy	Thailand	HFNC and NIV showed similar efficacy in preventing hypoxemia, but NIV provided more stable oxygenation in patients with PaO_2 < 60 mmHg.
Arias-Sanchez PP, Ledesma G, Cobos J, Tirape H, Jaramillo B, Ruiz J, et al., 2023 (15)	Observational study	To compare HFNC and standard oxygen therapy during fiberoptic bronchoscopy	Ecuador	HFNC reduced the drop in SpO_2 during bronchoscopy (94% vs 90%, p = 0.04) and demonstrated less variability in oxygen saturation compared with standard therapy.
Chung SM, Choi JW, Lee YS, Choi JH, Oh JY, Min KH, et al., 2019 (16)	Retrospective observational study	To assess the effectiveness of HFNC during diagnostic and therapeutic bronchoscopy	South Korea	HFNC maintained stable SpO_2 (95–99.4%) during bronchoscopy, with no hypoxemic episodes during diagnostic procedures and improved oxygenation after therapeutic interventions.
Kim SH, Bang S, Lee K-Y, Park SW, Park JY, Lee HS, et al., 2021 (17)	Randomized controlled trial	To compare HFNC and COT during sedation in the prone position	South Korea	HFNC significantly reduced hypoxemia incidence and improved oxygenation compared with COT.
Lee S, Choi JW, Chung IS, Kim DK, Sim WS, Kim TJ, 2023 (18)	Retrospective observational study	To compare HFNC and COT during deep sedation for ESD	South Korea	HFNC significantly reduced hypoxemia (11.4% vs 35.2%) and the need for interventions but was associated with a higher rate of postprocedural radiological abnormalities.
Wang L, Zhang Y, Han D, Wei M, Zhang J, Cheng X, et al., 2025 (19)	Multicenter RCT	To evaluate the effect of HFNC in obese patients during GI endoscopy	China	HFNC significantly reduced hypoxemia (2% vs 21.2%), subclinical respiratory depression, and severe hypoxemia without increasing other adverse events.
Thiruvenkatarajan V, Sekhar V, Wong DT, Currie J, Van Wijk R, Ludbrook GL, 2023 (20)	Systematic review and meta-analysis	To evaluate HFNC versus COT during procedural sedation	Australia	HFNC reduced the risk of hypoxemia (RR 0.37), increased minimum SpO_2, and decreased the need for procedural interruptions.

Table 2. **Overview of included studies on the use of HFNC in the prevention of hypoxemia during endoscopic procedures (2015-2025)**

Authors, year	Type of study	Aim	Country	Key findings
Ayuse T, Kurata S, Mori T, Kuroda S, Ichinomiya T, Yano R, et al., 2023 (21)	Randomized comparative study	To assess the effect of HFNC on hypoxemia and hypercapnia during ERCP sedation	Japan	HFNC reduced hypoxemia and improved ventilation compared with a standard cannula.
Mohamed AM, Selima WZ, 2025 (22)	Prospective randomized study	To compare HFNC and COT during prolonged UGE in the ICU	Egypt	HFNC significantly reduced hypoxemia incidence (5.7% vs 51.4%) and improved safety.
Tao Y, Sun MY, Miao MR, Han YQ, Yang YT, Cong XH, Zhang JQ, 2022 (23)	Systematic review and meta-analysis	To evaluate the effectiveness of HFNC in endoscopic procedures	China	HFNC significantly reduced hypoxemia (RR 0.32), need for interventions, and procedural interruptions.
Teng WN, Ting CK, Wang YT, Hou MC, Chang WK, Tsou MY, et al., 2019 (24)	Randomized clinical trial	To evaluate the effectiveness of HFNC in endoscopic procedures	Taiwan	HFNC and MA reduced hypoxemia (18% and 12% fewer events, respectively) and the need for interventions.
Su CL, Chiang LL, Tam KW, Chen TT, Hu MC, 2021 (25)	Systematic review and meta-analysis of RCTs	To evaluate the effect of HFNC during bronchoscopy	USA	HFNC reduced hypoxemic events (RR 0.25) and increased minimum SpO- during procedures.
Zhaxi D, Ci D, Quan X, Laba C, 2024 (26)	Randomized controlled trial	To compare HFNC and COT during bronchoscopy in hypoxemic patients	China	HFNC reduced hypoxemia (9.3% vs 36.8%) and severe hypoxemia (0% vs 11.3%).
Luo XH, Xiang F, 2024 (27)	Retrospective study	To compare HFNC and COT during bronchoscopy in hypoxemic patients	China	HFNC significantly reduced SpO_2 < 90% events (3.8% vs 17.5%) and adverse effects (7.7% vs 20.1%).
Yin X, Xu W, Zhang J, Wang M, Chen Z, Liu S, Xu Y, Xu S, Ji D, Wang J, Gu W, 2024 (28)	Prospective randomized controlled trial	To compare HFNC and CNC in preventing hypoxemia in elderly patients during gastroscopy under sedation	China	HFNC significantly reduced hypoxemia (3.2% vs 22.6%, p = 0.001) and increased minimum SpO_2 compared with CNC.
Ben-Menachem E, McKenzie J, O'Sullivan C, Havryk AP, 2020 (29)	Randomized controlled trial (post-transplant patients)	To compare HFNC and LFNO during flexible bronchoscopy in lung transplant recipients	Australia	HFNC significantly reduced desaturation (SpO_2 < 94%: 43.2% vs 89.7%, p < 0.001) and procedural interruptions compared with LFNO.
Nay M-A, Fromont L, Eugene A, Marcueyz J-L, Mfam W-S, Baert O, Remerand F, Ravry C, Auvet A, Boulain T, 2021 (30)	Multicenter RCT (ODEPHI)	To evaluate the effect of HFNC on desaturation during gastrointestinal endoscopy under deep sedation	France	HFNC reduced the incidence of SpO_2 ≤ 92% (9.4% vs 33.5%, p < 0.001) and the need for airway maneuvers.

Table 2. **Overview of included studies on the use of HFNC in the prevention of hypoxemia during endoscopic procedures (2015-2025)**

Authors, year	Type of study	Aim	Country	Key findings
Doulberis M, Sampsonas F, Papaefthymiou A, Karamouzos V, Lagadinou M, Karampitsakos T, Stratakos G, Kuntzen T, Tzouvelekis A, 2022 (31)	Systematic review and meta-analysis	To evaluate the risk of hypoxemia with HFNC in gastrointestinal endoscopy compared with COT	Greece	HFNC reduced hypoxemia and procedural interruptions compared with COT.
Sampsonas F, Karamouzos V, Karampitsakos T, Papaioannou O, Katsaras M, Lagadinou M, Zarkadi E, Malakounidou E, Velissaris D, Stratakos G, Tzouvelekis A, 2022 (32)	Systematic review and meta-analysis (6 RCTs)	To evaluate HFNC versus LFNC during bronchoscopy	Greece	HFNC reduced hypoxemic episodes and procedural interruptions compared with LFNC.
Zhang W, Wang J-L, Fu S, Zhou J-M, Zhu Y-J, Cai S-N, Fang J, Xie K-J, Chen X-Z, 2022 (33)	Randomized controlled trial	To compare HFNC and face mask in patients at risk of hypoxemia during bronchoscopy	China	HFNC significantly reduced desaturation (4.6% vs 29.2%, $p < 0.001$) and the need for mask ventilation.
Sawase H, Ozawa E, Yano H, Ichinomiya T, et al., 2023 (34)	Prospective randomized single-center clinical trial (n = 75)	To compare HFNC with low-flow oxygen during ERCP under sedation for the prevention of hypercapnia and hypoxemia	Japan	HFNC at 40-60 L/min did not significantly reduce hypercapnia or hypoxemia compared with low-flow O_2 ($p > 0.05$).
Lee CC, Ju TR, Lai PC, Lin HT, Huang YT, 2022 (35)	Systematic review and meta-analysis of 8 RCTs	To evaluate the efficacy of HFNC in GI endoscopy compared with COT	Taiwan	HFNC reduced severe hypoxemia (RR 0.38, 95% CI: 0.20-0.74) but did not significantly affect overall hypoxemia incidence.
Zhang W, Yin H, Xu Y, Fang Z, et al., 2022 (36)	Prospective randomized single-blind trial (n = 369)	To compare HFNC with different FiO_2 levels (50% and 100%) and standard cannula during gastroscopy in elderly patients	China	HFNC significantly reduced hypoxemia compared with COT ($p < 0.05$); no difference between FiO_2 50% and 100%.
Zhang YX, He XX, Chen YP, Yang S, 2022 (37)	Systematic review and meta-analysis (7 RCTs, n = 2998)	To evaluate the efficacy of HFNC in sedated gastrointestinal endoscopy	China	HFNC reduced hypoxemia (OR 0.24, 95% CI: 0.09-0.64) and airway intervention requirements (OR 0.15, 95% CI: 0.03-0.69).
Wei C, Ma SY, Wang JW, Yang N, et al., 2024 (38)	Systematic review and meta-analysis of 12 studies (n = 1631)	To compare HFNC with other methods during bronchoscopy	China	HFNC significantly reduced hypoxemia (RR 0.27, 95% CI: 0.18-0.41) and improved minimum SpO_2.

Table 2. **Overview of included studies on the use of HFNC in the prevention of hypoxemia during endoscopic procedures (2015–2025)**

Authors, year	Type of study	Aim	Country	Key findings
Khanna P, Haritha D, Das A, Sarkar S, Roy A, 2023 (39)	Systematic review and meta-analysis (9 studies, n = 3294)	To assess the utility of HFNC in upper GI endoscopy under sedation	India	HFNC reduced desaturation (OR 0.23, 95% CI: 0.11–0.48) and procedural interruptions (OR 0.11, 95% CI: 0.02–0.60).
Wang R, Li H-C, Li X-Y, Tang X, Chu H-W, Yuan X, Tong Z-H, Sun B, 2021 (40)	Prospective randomized controlled trial	To compare modified HFNC and COT during bronchoscopy in reducing SpO_2 < 90%	China	HFNC significantly reduced hypoxemia (12.5% vs 28.8%, p < 0.001) and maintained higher SpO_2 during and after bronchoscopy.
Feng Y, Chen Z, Wang J, 2024 (41)	Randomized controlled trial	To investigate the effect of transnasal HFNC therapy on gag reflex and oxygenation in elderly patients during fiberoptic bronchoscopy	China	HFNC improved SpO- , reduced hypoxemia and gag reflex, with no significant impact on hemodynamics.
Zhang W, Yuan X, Shen Y, Wang J, Xie K, Chen X, 2024 (42)	Prospective randomized controlled trial	To determine the optimal HFNC flow rate for preventing desaturation during bronchoscopy	China	The optimal HFNC flow rate for preventing desaturation in 95% of patients was 43.2 L/min (95% CI: 36.4–56.0); 50–60 L/min is recommended.

Lee et al. (2016) did not find a significant difference in overall hypoxemia rates, their results indicated that HFNC reduces the risk of severe hypoxemia compared with COT (8).

Collectively, the evidence shows that HFNC enhances respiratory safety during sedated gastrointestinal endoscopy, leading to fewer and less severe desaturation events and reducing the need for airway interventions.

HFNC during bronchoscopy

Similar benefits of HFNC have been reported during sedated bronchoscopy. Patients, especially those with impaired lung function, are highly susceptible to hypoxemia due to sedation and airway obstruction. Several studies indicate that HFNC is more effective than COT in maintaining oxygenation in this setting. The systematic review and meta-analysis by Su et al. (2021), including five RCTs, showed that HFNC significantly reduced hypoxemic events and increased minimum SpO_2 compared with COT (25). In practice, this means patients receiving HFNC were less likely to reach critically low saturation levels during the procedure.

HFNC has also been compared with other oxygenation techniques. The RCT by Saksitthichok et al. (2019) found comparable protection against desaturation between HFNC and NIV in high-risk hypoxemic patients, with no significant difference in lowest SpO_2 (14). Only in the most severely hypoxemic subgroup (baseline PaO_2 < 60 mmHg) did NIV provide slightly more stable oxygenation, suggesting a marginal advantage of mechanical support in that population.

Observational studies (15,16) further confirmed that HFNC maintains stable SpO_2 levels, often above 95%, without significant hypoxemia or procedural interruptions. Overall, HFNC improves oxygenation reserve, allowing safer and more continuous bronchoscopy with fewer complications related to oxygen deficiency.

High-risk patient populations and specific procedural conditions

The advantages of HFNC are particularly evident in vulnerable patient populations and specific procedural conditions. In a recent multicenter RCT (2025) in obese patients (BMI ≥ 28) undergoing sedated endoscopy, HFNC markedly reduced the incidence of hypoxemia, from 21% with COT to only 2%. Subclinical respiratory depression (SpO_2 90–94%) also decreased from 36% to 5%, while severe hypoxemia was virtually eliminated (0% vs 4%) (19). These results highlight the importance of HFNC in obese patients, who desaturate more rapidly due to obstructive physiology.

Similarly, in elderly patients and those with comorbidities, HFNC has shown clear superiority over COT. Yin et al. (2024) found that among geriatric patients (>65 years) undergoing sedated gastroscopy, hypoxemia occurred in only 3% with HFNC versus 23% with standard therapy, with higher minimum SpO_2 values (28). This suggests that older patients, often more sensitive to sedatives, derive substantial benefit from HFNC.

The method has proven effective even under extreme environmental conditions. At high altitude (3600 m), HFNC significantly reduced hypoxemia incidence during endoscopic procedures (9% vs 37% with COT), completely preventing severe desaturation (26). This demonstrates its potential beyond conventional hospital settings, including environments with baseline hypoxemia caused by hypobaric conditions.

In transplant populations with reduced respiratory reserve, HFNC has also shown benefit. In a randomized trial in post-lung transplant patients, Ben-Menachem et al. (2020) reported that HFNC nearly halved desaturation events (43% vs 90%) and reduced procedural interruptions compared with COT (29). Collectively, evidence confirms that high-risk populations, including obese, elderly, hypoxemic, and post-transplant patients, experience the greatest clinical advantage from HFNC.

Comparison of HFNC with other methods of oxygenation support

HFNC has become a valuable tool for preventing hypoxemia during invasive procedures under sedation, yet its limitations and comparison with alternative strategies remain relevant. Compared with non-invasive ventilation (NIV), HFNC provides similar oxygenation support in most patients (14). Its main advantages are simplicity, comfort, and patient preference for nasal cannula over pressurized masks (43). However, in severely compromised patients, NIV can offer stronger positive pressure and ventilatory assistance, outperforming HFNC in preventing profound hypoxemia or hypercapnia (44).

Not all studies have reported uniform benefits. In the trial by Sawase et al. (2023) during ERCP under moderate sedation, HFNC was applied with room air only (FiO_2 21%, 40–60 L/min) and compared with low-flow O_2. Under these conditions, HFNC did not significantly reduce hypoxemia or hypercapnia compared with COT (8% vs 5%; p = 0.674) (34). These results suggest that the effectiveness of HFNC depends on the delivered FiO_2 and that benefits are more pronounced when oxygen-enriched flow (40–100% O_2) is used, as is typical in clinical practice.

Regarding safety, most studies have not identified an increased rate of adverse events such as arrhythmias, aspiration, or post-procedural complications (19,29,39,45). Moreover, Lee et al. (2016) reported that HFNC significantly reduced the need to escalate to more invasive support methods, including mask ventilation or NIV, in three of four analyzed trials (46). HFNC is generally safe and well tolerated, with minimal risk of mucosal dryness due to heated and humidified gas. Proper device setup, flow adjustment, and cannula fixation are essential for optimal performance.

Cumulative evidence supports HFNC as an effective standard for sedated endoscopic procedures in patients at increased respiratory risk (20). Its capacity to reduce hypoxemia and emergent airway interventions represents a major advance in procedural safety (30). Consequently, many centers have incorporated HFNC into routine practice, especially for elderly, obese, and pulmonary patients. Future studies should refine application protocols, including optimal flow rates, FiO_2 levels, and duration. Based on current data, HFNC makes a substantial contribution to respiratory safety and deserves wider clinical implementation (20).

Limitations

This systematic review has several methodological limitations. First, the literature search was restricted to three databases (PubMed, Web of Science, and Scopus) and to articles available in English which may

have introduced language and publication bias. Second, most of the included studies were conducted in Asian countries, particularly in China, which may affect the generalizability of the findings due to potential differences in sedation protocols, clinical practice, and population characteristics. Third, heterogeneity across studies, including variable definitions of hypoxemia, different saturation thresholds and inconsistent flow and FiO_2 settings, makes direct comparison of results and meta-analytic conclusions more challenging. Finally, several of the included studies analyzed relatively small patient populations which may limit the statistical power and precision of the estimated effects of HFNC.

Conclusion

The analyzed studies clearly confirm that HFNC is a more effective method than COT for the prevention of hypoxemia during sedated endoscopic procedures. In addition to reducing the risk of desaturation, HFNC provides better oxygenation and decreases the need for additional airway interventions. Optimal flow rates of 50–60 L/min have proven to be the most effective and well tolerated.

From a nursing perspective, understanding the principles, indications, and clinical application of HFNC can significantly improve peri-procedural patient management, particularly in high-risk populations. Integrating HFNC protocols into routine nursing practice enhances respiratory safety, supports timely recognition of hypoxemia, and reduces the need for emergency interventions.

Future research should aim to define standardized protocols for HFNC use, compare different flow and FiO_2 settings, and evaluate long-term outcomes and cost effectiveness across diverse clinical environments. Further interdisciplinary studies are encouraged to assess nursing-led education, monitoring strategies, and the role of nurses in optimizing HFNC implementation and patient outcomes.

Author Contributions

Conceptualization (VJ, JP, MV, TMT, MS); Data Curation (VJ), Formal Analysis (VJ, JP, MS); Writing – Original Draft (VJ), Writing – Review & Editing (VJ, JP, MV, TMT, MS). All authors reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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