Minor Airway Interventions in Elderly Patients Undergoing ERCP With High Flow Versus Conventional Nasal Cannula Oxygen Therapy: A Randomized Controlled Trial

Valentina Ješić[1,2], Tihana Magdić Turković[1] and Marinko Vučić[1]

[1] Department of Anesthesiology, Intensive Care Medicine and Pain Therapy, Sestre milosrdnice University Hospital Center, Zagreb, Croatia;
[2] Faculty of Health Sciences, University of Novo mesto, Novo mesto, Slovenia

CORRESPONDENCE TO Valentina Ješić
Department of Anesthesiology, Intensive Care Medicine and Pain Therapy, Sestre milosrdnice University Hospital Center, Vinogradska cesta 29, 10000 Zagreb, Croatia
+385 99 503 4197
valentina.matic@kbcsm.hr

RECEIVED December 4, 2025
ACCEPTED February 27, 2026

DOI 10.20471/acc.2026.65.02.11

SUMMARY

Intravenous sedation for endoscopic retrograde cholangiopancreatography (ERCP) in patients aged 65 years or older is associated with respiratory instability. During ERCP, oxygen therapy is commonly delivered using a conventional nasal cannula (CNC) or a high flow nasal cannula (HFNC). Respiratory instability may require minor airway interventions (MAI), including chin lift, secretion suctioning, the insertion of an oropharyngeal airway, or escalation from CNC to HFNC. This randomized controlled trial aimed to compare the incidence of MAI in patients receiving HFNC versus CNC during ERCP.

In this single center, prospective, randomized, controlled trial, 115 patients aged 65 years or older undergoing ERCP under intravenous sedation were randomized to HFNC (n = 58) or CNC (n = 57). The primary outcome was the incidence of MAI in each group.

MAI occurred in 30 patients (26.1%) overall and significantly less frequently in the HFNC group (7 of 58, 12.1%) than in the CNC group (23 of 57, 40.4%) ($P < 0.001$; relative risk (RR) 0.30, 95% confidence interval (CI) 0.14–0.64). Chin lift was the most frequent MAI. No associations between MAI and age, sex, or the American Society of Anesthesiologists (ASA) physical status were observed.

HFNC significantly reduces the incidence of MAI compared with conventional nasal cannula oxygen therapy.

KEYWORDS

Aged; *Airway management*; *Conscious sedation*; *Endoscopic retrograde cholangiopancreatography*; *High flow nasal cannula*; *Oxygen inhalation therapy*

Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) is one of the most complex endoscopic procedures performed under sedation or anesthesia, and it is particularly challenging in patients aged 65 years or older, due to reduced respiratory and cardiovascular reserve[1]. During procedures performed under sedation, hypoventilation[2], partial upper airway obstruction[3] and reduced blood oxygen saturation (hypoxemia) occur frequently. The risk is more pronounced in patients with a higher body mass index (BMI), concomitant comorbidities and reduced functional lung capacity[5,6]. Maintaining adequate oxygenation, therefore, represents a key prerequisite for patient safety, while the timely recognition and management of respiratory disturbances directly influence the outcome of the procedure.

The conventional nasal cannula (CNC) has traditionally been used as the standard method of oxygen supplementation during sedation; however, its effectiveness in preventing hypoxemia is often limited[7,8]. Over the past decade, high-flow nasal cannula (HFNC) therapy has been recognized as an innovative form of noninvasive respiratory support that delivers heated and humidified oxygen at high flow rates, providing a mild positive airway pressure and flushing of anatomical dead space[9]. Numerous studies have demonstrated that HFNC reduces the incidence of hypoxemia and the need for additional minor airway interventions (MAI) during endoscopy-guided procedures[10–13]. However, data in patients aged 65 years or older undergoing ERCP remain limited.

The incidence of MAI, such as chin lift, secretion suctioning, or the insertion of an oropharyngeal airway, is considered a practical and clinically relevant indicator of sedation safety and the adequacy of oxygen support[2,14]. The analysis of these interventions enables a noninvasive assessment of ventilation quality during the procedure. It may serve as an indicator of the effectiveness of the applied respiratory support in real-world clinical settings.

Building on previous findings, this study aimed to compare the incidence of MAI in patients undergoing ERCP with HFNC versus CNC, and to assess the feasibility of using MAI incidence as an objective indicator of sedation quality in a high-risk population.

Based on the stated aim, the following hypotheses were formulated:

1. **Primary hypothesis:** The use of HFNC during ERCP significantly reduces the incidence of MAI compared with CNC.
2. **Secondary hypothesis:** The distribution of specific types of interventions (chin lift, secretion suctioning, the insertion of an oropharyngeal airway, conversion to HFNC) differs between the HFNC and CNC arms.
3. **Additional hypothesis:** Demographic and clinical factors (age, sex and American Society of Anesthesiologists (ASA) status) are not significantly associated with the need for MAI during the procedure.

Materials and methods

This single-center, prospective, randomized, controlled trial was conducted at Sestre milosrdnice University Hospital Center, Zagreb, Croatia, and included 115 patients aged ≥ 65 years undergoing ERCP under intravenous sedation to analyze the incidence and types of MAI. Two methods of oxygenation support were compared during continuous intravenous sedation: HFNC and CNC. The primary objective was to determine which arm had a lower incidence of MAI and to identify the most frequent MAI types.

Study design and population

The study was conducted at the Department of Gastroenterology and Hepatology, Division of Internal Medicine, Sestre milosrdnice University Hospital Center, Zagreb, Croatia. This single-center randomized controlled trial enrolled 115 patients aged ≥ 65 years who were scheduled to undergo diagnostic or therapeutic ERCP under intravenous sedation. Participants were randomly assigned in a 1:1 ratio to either the HFNC arm (n = 58) or the CNC arm (n = 57). Randomization was performed using computer-generated random numbers.

The primary outcome was the incidence of MAI (chin lift, secretion suctioning, the insertion of an oropharyngeal airway, or escalation from CNC to HFNC). Secondary outcomes included the distribution of MAI types and their associations with demographic and clinical factors. Data were analyzed using chi-square and Fisher's exact tests, with RR and 95% CIs.

This trial was registered in the Deutsches Register Klinischer Studien (DRKS-ID: DRKS00038341; retrospectively registered on November 10, 2025). The registration covers all prespecified outcomes and methodological details consistent with the study protocol approved by the institutional Ethics Committee. The study was conducted and reported in accordance with the CONSORT 2025 guidelines, including the checklist and participant flow diagram.

All participants provided a written informed consent, and the study was approved by the Ethics Committee of the Sestre milosrdnice University Hospital Center (Class: 003-06/23-03/003; Reg. No.: 251-29-11-23-04; Decision No.: EP-23-003-HFNC). The inclusion and exclusion criteria are presented in Table 1. Patient recruitment and data collection were conducted between March 2023 and February 2024. The trial was completed as planned after enrollment of all eligible participants. No early termination occurred.

Table 1. Patient inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Age ≥ 65 years	Severe chronic obstructive pulmonary disease (COPD) or active respiratory infection
ASA physical status II–IV according to the American Society of Anesthesiologists classification	Unstable cardiovascular condition or hemodynamic instability
Stable overall health status as assessed by the anesthesiologist	Significant anatomical abnormalities of the upper airway
Scheduled diagnostic or therapeutic ERCP under intravenous sedation	Requirement for general anesthesia or planned intubation
Signed informed consent for study participation	Pregnancy, breastfeeding, or active oncological treatment

Procedure and variable monitoring

All patients received continuous intravenous sedation (propofol ± opioid) with standard ASA monitoring (SpO_2, noninvasive arterial pressure, pulse and bispectral index-BIS). Sedation was administered by an anesthesiologist and a nurse anesthetist, with continuous monitoring of vital parameters. All procedures were performed by an experienced endoscopy–anesthesiology team following the institution's standard protocol. Continuous capnography (sidestream end-tidal CO_2) was applied only in the CNC arm.

In the HFNC arm, heated, humidified high-flow oxygen was delivered via AIRVO™ 2 (Fisher & Paykel Healthcare, Auckland, New Zealand) at FiO_2 0.4–0.6 and 40–60 L/min using medium-size nasal cannulae. In the CNC arm, oxygen was delivered via a standard dual-prong nasal cannula (Intersurgical, Wokingham, UK) at 4–6 L/min (FiO_2 up to 0.4).

During the procedure, demographic and clinical data were recorded, including age, sex, ASA status, indication for ERCP, procedure duration, total sedative dose, SpO_2 values every five minutes, the occurrence of desaturation (SpO_2 < 90%) and the occurrence of MAI. The present analysis focused solely on the incidence and type of MAI, while other variables will be analyzed in separate studies.

All MAI were documented using a standardized form. For this study, MAI was operationally defined as any of the following actions:

1) Chin lift,
2) The insertion of an oropharyngeal airway,
3) Secretions suctioning,
4) Conversion from CNC to HFNC (oxygenation escalation).

Patients who did not require any of the above procedures were classified as having no MAI.

Variables and categorization

The only independent variable was the type of oxygenation support (HFNC/CNC). The dependent variables were the incidence (yes/no) and type (1–4 according to the predefined classification) of MAI.

If more than one MAI occurred in the same patient, all events were recorded; however, for the analysis of MAI types, each patient was counted once according to the most clinically relevant MAI.

The primary outcome of the study (safety indicator) was the proportion of patients with ≥ 1 MAI during ERCP. The secondary outcome was the distribution of MAI types between the HFNC and CNC arms.

Randomization and masking

Patients were randomized 1:1 to the HFNC or CNC arm using a computer-generated sequence with variable block sizes. Allocation was concealed in sealed, opaque, sequentially numbered envelopes opened immediately before sedation. Outcome assessors prospectively recorded MAI on a standardized form. Blinding the procedural team to oxygen modality was not feasible due to the nature of the intervention. The sequence was generated by an independent statistician; allocation envelopes were prepared by a research coordinator not involved in patient enrollment or study procedures.

Statistical analysis

The analysis was conducted according to the intention-to-treat principle and all participants were included in the final statistical model. Statistical analyses were performed in IBM SPSS Statistics, version 29 (IBM Corp., Armonk, NY, USA).

Numerical variables were presented as a mean ± standard deviation (SD) or a median with interquartile range (IQR), while categorical variables were expressed as frequencies and percentages. The normality of distribution was assessed using the Shapiro–Wilk test.

To compare the incidence of MAI, the chi-square test (χ^2) or Fisher's exact test (for small expected frequencies) was used. The relative risk (RR) with a 95% CI was calculated to estimate the strength of association between the type of oxygenation support and MAI incidence.

The independent samples t-test, with Levene's test for homogeneity of variance, was applied to compare the mean age between patients with and without MAI. The distribution of intervention types was presented descriptively and graphically (bar charts). Statistical significance was set at $P < 0.05$. There were no missing primary outcome data; analyses followed the intention-to-treat principle.

The sample size was based on feasibility, as all eligible patients during the study period were enrolled. A formal power calculation was not performed due to limited prior data on MAI frequency in elderly ERCP patients. No interim analyses or stopping rules were applied.

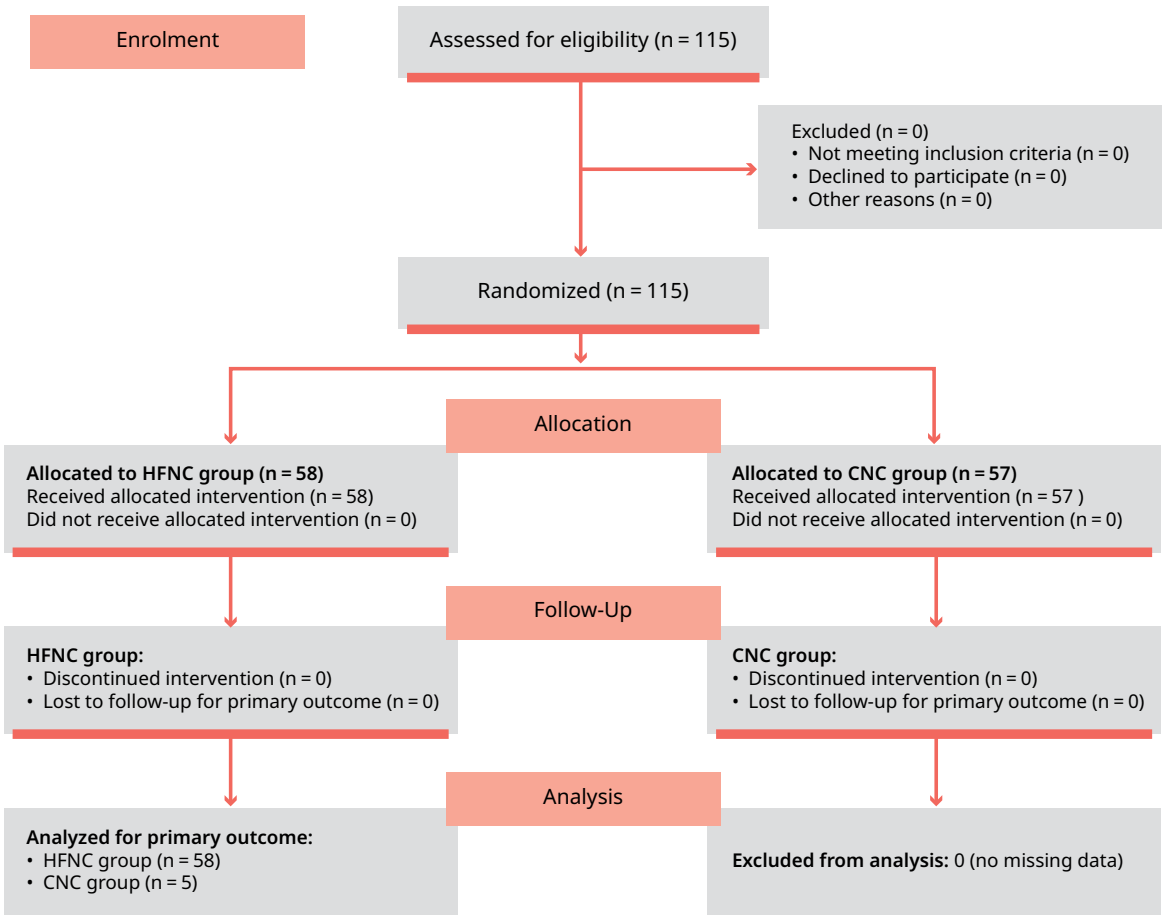

Figure 1 CONSORT 2025 Flow Diagram
Flow diagram of the progress through the phases of a randomized trial of two groups (that is, enrolment, intervention allocation, follow-up and data analysis)

Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki (2013) and the national ethical guidelines for research involving human participants. The study was approved by an independent institutional ethics committee and a written informed consent was obtained from all the participants.

Data were analyzed anonymously and used exclusively for scientific purposes. Patients and members of the public were not involved in the design, conduct, or reporting of this study. No procedure-related adverse events or harms were

observed; all MAI were minor, promptly managed and resolved without sequelae. The CONSORT 2025 checklist (Supplementary file 1) and flow diagram (Figure 1) accompany this report.

Results

The flow of participants through the trial is shown in Supplementary file 1 (CONSORT 2025 participant flow diagram).

The demographic and clinical characteristics of the participants

A total of 115 patients aged 65 years or older undergoing ERCP were included in the study. The mean age of the participants was 71.8 ± 12.6 years (range 65–91). Men accounted for 53.9%, and women for 46.1% of the sample. The majority of the patients were classified as ASA physical status classification ASA II (57.4%) or ASA III (41.7%), while only one patient (0.9%) was categorized as ASA IV (Table 2). No participants were lost to follow-up or excluded after randomization.

MAI incidence (primary outcome)

Among the 115 patients, MAI occurred in 26.1%. The incidence of MAI was significantly lower in the HFNC arm compared with the CNC arm (12.1 % vs 40.4%; $\chi^2 = 11.93$; $P < .001$ (Fisher's exact test)).

The estimated RR was 0.30 (95% CI 0.14–0.64), indicating that the use of HFNC reduced the likelihood of having MAI by approximately 70% (Table 3).

Table 2. Demographic and clinical characteristics of the patients included in the study (N = 115)

Variable	N (valid)	Mean ± SD / n (%)	Range / Categories
Age (years)	115	71.8 ± 12.6	≥65–91
Sex	115	Male 62 (53.9%) / Female 53 (46.1%)	—
ASA status	115	II: 66 (57.4%) / III: 48 (41.7%) / IV: 1 (0.9%)	—

ASA = American Society of Anesthesiologists; SD = standard deviation.

Table 3. Incidence of MAI during ERCP according to oxygenation support (HFNC vs CNC)

Type of oxygenation support	MAI YES n (%)	MAI NO n (%)	χ^2 (df = 1)	*P*	RR (95% CI)
HFNC	7 (12.1%)	51 (87.9%)	11.93	< .001	0.30 (0.14–0.64)
CNC	23 (40.4%)	34 (59.6%)			
Total (N = 115)	30 (26.1%)	85 (73.9%)			

HFNC = high-flow nasal cannula; CNC = conventional nasal cannula; χ^2 = chi-square test; RR = relative risk; CI = confidence interval; $P < 0.05$ indicates statistical significance.

Types of performed MAI (secondary outcome)

Among the 30 patients with MAI during ERCP, the most frequent intervention was chin lift (70.0%), followed by secretion suctioning (16.7%), while the use of an oropharyngeal airway and conversion to HFNC were less common (each 6.7%).

When comparing arms, patients in the CNC arm had a notably higher need for chin lift (82.6%) and conversion to HFNC (8.7%), whereas in the HFNC arm, secretion suctioning (42.9%) and oropharyngeal airway placement (28.6%) were more frequent.

Differences in the distribution of intervention types between arms were statistically significant ($\chi^2 = 13.18$; df = 3; $P = .004$) (Table 4). No adverse or unintended events related to oxygen delivery were observed in either arm.

Additional analyses

Association between ASA status and MAI incidence

No statistically significant association was found between ASA physical status and MAI incidence during ERCP ($\chi^2 = 0.43$; $P = .806$). The incidence of MAI was similar among patients with ASA II (27.3%) and ASA III (25.0%) status, while no MAI were recorded in the ASA IV group (Table 5).

Table 4. Types of MAI according to oxygenation support during ERCP

Type of oxygenation support	Chin lift n (%)	Oropharyngeal airway n (%)	Secretion suctioning n (%)	Conversion to HFNC n (%)	Total n (%)
HFNC (patients with MAI, n = 7)	2 (28.6%)	2 (28.6%)	3 (42.9%)	0 (0.0%)	7 (23.3%)
CNC (patients with MAI, n = 23)	19 (82.6%)	0 (0.0%)	2 (8.7%)	2 (8.7%)	23 (76.7%)
Total (N = 30)	21 (70.0%)	2 (6.7%)	5 (16.7%)	2 (6.7%)	30 (100.0%)

Note: Percentages were calculated within the number of patients with at least one MAI in each arm (HFNC n = 7, CNC n = 23). Each patient was counted once according to the most clinically relevant MAI.
HFNC = high-flow nasal cannula; CNC = conventional nasal cannula; χ^2 = chi-square test; df = degrees of freedom; $P < 0.05$ indicates statistical significance

Table 5. Association between ASA status and MAI incidence during ERCP (N = 115)

ASA status	MAI YES n (%)	MAI NO n (%)	Total n (%)
II	18 (27.3%)	48 (72.7%)	66 (57.4%)
III	12 (25.0%)	36 (75.0%)	48 (41.7%)
IV	0 (0.0%)	1 (100.0%)	1 (0.9%)
Total	**30 (26.1%)**	**85 (73.9%)**	**115 (100.0%)**

χ^2 (df = 2) = 0.43; $P = .806$
ASA = American Society of Anesthesiologists; χ^2 = chi-square test; df = degrees of freedom; $P < 0.05$ indicates statistical significance

These results suggest that the level of anesthesiological risk (ASA classification) itself was not a decisive factor influencing the need for MAI in this cohort of older patients.

Sex differences in MAI incidence

In the male group, MAI were recorded in 19 patients (30.6%), while in the female group, the proportion was 11 patients (20.8%).

Despite a numerically higher intervention rate among men, the difference between sexes was not statistically significant ($\chi^2 = 1.45$; df = 1; $P = .229$).

These findings indicate that sex was not a significant factor influencing the occurrence of MAI during the procedure (Table 6).

Table 6. MAI incidence according to patient sex during ERCP (N = 115)

Sex	MAI YES n (%)	MAI NO n (%)	Total n (%)
Male	19 (30.6 %)	43 (69.4 %)	62 (53.9 %)
Female	11 (20.8 %)	42 (79.2 %)	53 (46.1 %)
Total	**30 (26.1 %)**	**85 (73.9 %)**	**115 (100.0 %)**

χ^2 (df = 1) = 1.45; P = .229
χ^2 = chi-square test; df = degrees of freedom; $P < 0.05$ indicates statistical significance

Table 7. Difference in mean age between patients with and without MAI during ERCP

Patient group	N	Mean age (Mean ± SD)	t (df)	*P*
MAI – YES	30	72.6 ± 15.3		
MAI – NO	85	71.5 ± 11.6	0.42 (113)	.674

SD = standard deviation; t = independent samples t-test; df = degrees of freedom; $P < 0.05$ indicates statistical significance

Age and MAI incidence

The mean age of the patients who required MAI was 72.6 ± 15.3 years, while the mean age among those without MAI was 71.5 ± 11.6 years. The results of the t-test showed that the difference between the groups was not statistically significant (t = 0.42; df = 113; $P = .674$), indicating that age was not associated with an increased likelihood of MAI during the procedure (Table 7).

Discussion

This study, conducted in a population aged 65 years or older, showed that using HFNC during ERCP reduces the incidence of MAI compared to CNC, directly supporting the primary hypothesis. This finding aligns with previously published results.

In the study *Clinical efficacy of high-flow nasal oxygen in patients undergoing ERCP under sedation*, the application of HFNC was associated with a lower incidence of hypoxemia and a reduced need for rescue maneuvers[15]. Similarly, in a randomized controlled trial by Lee et al., HFNC use during ERCP was confirmed to decrease the incidence of hypoxemia and MAI[12]. Furthermore, meta-analyses by Thiruvenkatarajan et al. consistently indicate a more favorable safety profile of HFNC compared to conventional oxygen therapy[11].

The physiological mechanism underlying our observations aligns with the well-described effects of HFNC: namely, the delivery of a more stable and higher FiO_2, washout of anatomical dead space, and generation of a mild positive end-expiratory pressure (PEEP), which collectively reduce upper airway collapse and hypoventilation during sedation[16,17]. Consequently, in clinical practice, the incidence of MAI, such as chin lift, is reduced. This effect is particularly clinically relevant in patients aged 65 years or older, in whom respiratory reserves are

diminished, and the threshold for requiring intervention is lower.

The secondary hypothesis that the types of MAI differ between arms was also supported by our findings. In our data, the need for chin lift predominated in the CNC arm, whereas in the HFNC arm, when interventions were required, secretion suctioning and short-term oropharyngeal support were more frequent.

A similar pattern has been described in recent studies on sedated upper gastrointestinal endoscopy and ERCP, where the use of HFNC was associated with a reduction in episodes requiring mechanical airway opening or procedure interruption. At the same time, the interventions that still occurred were most often brief suctioning or a temporary application of supraglottic aids[18–21]. The observed effects of HFNC are consistent with clinical experience, indicating that humidified and heated high-flow oxygen improves oxygenation and procedural tolerance. However, it does not eliminate the need for basic airway hygiene maneuvers during longer procedures.

Our additional hypothesis, which proposed that demographic and clinical factors such as age, sex and ASA status are not significantly associated with the need for MAI during ERCP, was confirmed by our results. This finding is consistent with recent literature. In a prospective study by Prosenz et al. analyzing the incidence of desaturation during ERCP, age and sex were also not significant predictors of respiratory events, whereas an elevated BMI had a greater impact[22]. Similarly, in a study on predictive factors for hypoxemia during endoscopy, Li et al. found no difference in ASA status between patients with and without hypoxemic episodes, supporting the assumption that the ASA classification alone does not always reflect the actual respiratory risk under controlled conditions of procedural sedation[23]. Geng et al. developed a predictive model for hypoxemia in which variables such as age and sex showed a weak predictive value[24], whereas BMI, snoring and procedure duration were identified as more significant risk factors. Similar trends were observed in more recent studies by Liu et al. and Nay et al., where BMI and depth of sedation were significant predictors of hypoxemia, whereas age and sex showed no independent association with respiratory complications[25,26].

The absence of a clear effect of age in our study can be methodologically explained by the homogeneous sample of older patients, whose physiological reserves are generally reduced, thereby limiting interindividual variability. Sex differences in respiratory outcomes occasionally reported in the literature are most often mediated by differences in body weight, fat distribution and sedation depth rather than by sex itself. Furthermore, ASA status in our sample was not a predictive factor for the need for intervention, which is consistent with the findings of Kim et al. and Laffin et al., who demonstrated that the clinical context of the procedure, its duration and the sedative dose have a stronger influence on respiratory stability than the formal ASA classification[27,28]. These results collectively indicate that under procedural conditions such as ERCP, the dominant risk factors for respiratory interventions are functional and technical in nature, such as sedation depth, procedure duration, patient positioning and the modality of oxygen delivery, whereas demographic variables in the older population contribute less substantially to the overall risk.

The strengths of this study include its prospective, randomized design and a primary outcome that is clinically meaningful, easily measurable and suitable for integration into quality management systems, such as the MAI rate per 100 sedated ERCP procedures. Limitations include its single-center design, moderate sample size, especially for secondary comparisons, the inability to blind participants and staff, and the lack of analysis of certain key covariates like BMI, cumulative propofol dose per kilogram and procedure duration. Additionally, although the definition of “minor intervention” was specified and systematically recorded preoperatively, it is a composite safety outcome that has

not yet been universally validated, though similar composite metrics are increasingly used in recent gastrointestinal studies on HFNC. Since continuous capnography was only used in the CNC arm, this asymmetry in monitoring may introduce a slight detection bias. Another limitation is the fact that the trial was registered retrospectively, although all primary and secondary outcomes were prespecified before data analysis.

The finding of a reduced need for interventions with HFNC in older patients suggests that HFNC should be considered the preferred oxygenation support in cases of anticipated deeper sedation, longer procedures, or technically challenging ERCPs. From a quality perspective, we recommend including indicators such as the rate of one or more MAI and the rate of procedure interruptions due to respiratory reasons, along with routine monitoring of hypoxemia and any necessary escalation of ventilatory support. This approach translates the clinical outcome into a measurable metric that can be easily audited and linked to organizational decisions, such as the standard availability of HFNC in the ERCP suite.

Larger, multicenter, randomized, controlled trials in the older population are needed, with planned stratification by BMI, procedure type and sedation depth, along with a detailed recording of sedative doses and procedure duration. Including validated composite safety outcomes and assessing cost-effectiveness would further strengthen the evidence base and accelerate the implementation of HFNC as the standard of care in high-risk ERCP patients.

Conclusion

The results of this randomized study demonstrated that the use of HFNC during ERCP in patients aged 65 years or older significantly reduces the incidence of MAI compared with the use of a conventional nasal cannula. This effect reflects more stable oxygenation and better respiratory tolerance during sedation. The distribution of MAI types further confirmed that HFNC decreases the frequency of mechanical maneuvers such as chin lift, while the remaining interventions were shorter and less invasive. Age, sex and ASA status were not associated with MAI incidence, suggesting that respiratory risk in the older population depends more on technical and procedural factors.

These findings support the clinical use of HFNC as the preferred oxygenation method during sedated ERCP in patients aged 65 years or older, particularly for longer or more complex procedures. Additional multicenter studies with larger sample sizes and stratification by BMI and sedative dose could further validate the effectiveness of HFNC and help establish guidelines for its routine implementation.

Routine use of HFNC may enhance patient safety and could be integrated into quality improvement metrics for sedation-related airway events.

ACKNOWLEDGMENTS The authors gratefully acknowledge the cooperation and support of the Department of Gastroenterology and Hepatology, Division of Internal Medicine, and the Department of Anesthesiology, Intensive Care Medicine and Pain Therapy, Sestre milosrdnice University Hospital Center, Zagreb, Croatia, whose professional assistance greatly contributed to the successful completion of this research.

CONCEPTUALIZATION V.J.; Methodology: V.J., M.V., T.M.T.; Investigation: V.J.; Formal analysis: V.J.; Writing the original draft: V.J.; Writing, review and editing: V.J., M.V., T.M.T.; Supervision: M.V., T.M.T.

DISCLOSURE OF CONFLICT OF INTEREST This study received partial financial support through the HDMSARIST project. No additional external or commercial

funding was received. The authors declare no conflicts of interest.

ETHICS APPROVAL The study was approved by the Ethics Committee of the Sestre milosrdnice University Hospital Center, Zagreb, Croatia (Class: 003-06/23-03/003; Reg. No.: 251-29-11-23-04; Approval ID: EP-23-003-HFNC). All procedures were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

TRIAL REGISTRATION The trial was registered in the Deutsches Register Klinischer Studien (DRKS ID: DRKS00038341, https://drks.de/register/de/trial/DRKS00038341/preview) on November 10, 2025.

DATA SHARING STATEMENT The data that support the findings of this study are available on request from the corresponding author.

The data are not publicly available due to privacy or ethical restrictions. ■

References

1. Tokmak S, Cetin MF, Torun S. Efficacy and safety of endoscopic retrograde cholangiopancreatography in the very elderly by using a combination of intravenous midazolam, ketamine, and pethidine. Geriatr Gerontol Int. 2021;21(10):887-892. doi:10.1111/ggi.14252.
2. Lin OS. Sedation for routine gastrointestinal endoscopic procedures: a review on efficacy, safety, efficiency, cost and satisfaction. Intest Res. 2017;15(4):456-466. doi:10.5217/ir.2017.15.4.456.
3. Pozin IE, Zabida A, Nadler M, Zahavi G, Orkin D, Berkenstadt H. Respiratory complications during recovery from gastrointestinal endoscopies performed by gastroenterologists under moderate sedation. Clin Endosc. 2023;56(2):188-193. doi:10.5946/ce.2022.033.
4. Chen M, Sun Y, Li X, Zhang C, Huang X, Xu Y, et al. Effectiveness of single loading dose of dexmedetomidine combined with propofol for deep sedation of endoscopic retrograde cholangiopancreatography (ERCP) in elderly patients: a prospective randomized study. BMC Anesthesiol. 2022;22(1):85. doi:10.1186/s12871-022-01630-8.
5. Choe JW, Hyun JJ, Son SJ, Lee SH. Development of a predictive model for hypoxia due to sedatives in gastrointestinal endoscopy: a prospective clinical study in Korea. Clin Endosc. 2024;57(4):476-485. doi:10.5946/ce.2023.198.
6. Cummings LC, Liang C, Mascha EJ, Saager L, Smith ZL, Bhavani S, et al. Incidence of sedation-related adverse events during ERCP with anesthesia assistance: a multicenter observational study. Gastrointest Endosc. 2022;96(2):269-281.e1. doi:10.1016/j.gie.2022.03.023.
7. Kim SH, Bang S, Lee KY, Park SW, Park JY, Lee HS, et al. Comparison of high flow nasal oxygen and conventional nasal cannula during gastrointestinal endoscopic sedation in the prone position: a randomized trial. Can J Anaesth. 2021;68(4):460-466. doi:10.1007/s12630-020-01883-2.
8. Tao Y, Sun M, Miao M, Han Y, Yang Y, Cong X, et al. High flow nasal cannula for patients undergoing bronchoscopy and gastrointestinal endoscopy: a systematic review and meta-analysis. Front Surg. 2022;9:949614. doi:10.3389/fsurg.2022.949614.
9. Liew W, Singh P. High-flow nasal cannula: a narrative review of current uses and evidence. Airway. 2020;3(2):66-72. doi:10.4103/ARWY.ARWY_21_20.
10. Wang L, Zhang Y, Han D, Wei M, Zhang J, Cheng X, et al. Effect of high flow nasal cannula oxygenation on incidence of hypoxia during sedated gastrointestinal endoscopy in patients with obesity: multicentre randomised controlled trial. BMJ. 2025;388:e080795. doi:10.1136/bmj-2024-080795.
11. Thiruvenkatarajan V, Sekhar V, Wong DT, Currie J, Van Wijk R, Ludbrook GL. Effect of high-flow nasal oxygen on hypoxaemia during procedural sedation: a systematic review and meta-analysis. Anaesthesia. 2023;78(1):81-92. doi:10.1111/anae.15845.

12. Lee MJ, Cha B, Park JS, Kim JS, Cho SY, Han JH, et al. Impact of High-Flow Nasal Cannula Oxygenation on the Prevention of Hypoxia During Endoscopic Retrograde Cholangiopancreatography in Elderly Patients: A Randomized Clinical Trial. Dig Dis Sci. 2022;67(8):4154-4160. doi:10.1007/s10620-021-07272-z.
13. Hung KC, Chang YJ, Chen IW, Soong TC, Ho CN, Hsing CH, et al. Efficacy of high flow nasal oxygenation against hypoxemia in sedated patients receiving gastrointestinal endoscopic procedures: a systematic review and meta-analysis. J Clin Anesth. 2022;77:110651. doi:10.1016/j.jclinane.2022.110651.
14. Early DS, Lightdale JR, Vargo JJ 2nd, Acosta RD, Chandrasekhara V, Chathadi KV, et al. Guidelines for sedation and anesthesia in GI endoscopy. Gastrointest Endosc. 2018;87(2):327-337. doi:10.1016/j.gie.2017.07.018.
15. Cha B, Lee MJ, Park JS, Jeong S, Lee DH, Park TG. Clinical efficacy of high-flow nasal oxygen in patients undergoing ERCP under sedation. Sci Rep. 2021;11(1):350. doi:10.1038/s41598-020-79798-7.
16. Nishimura M. High-Flow Nasal Cannula Oxygen Therapy in Adults: Physiological Benefits, Indications, Clinical Benefits, and Adverse Effects. J Intensive Care. 2015;3:15. doi:10.1186/s40560-015-0084-5.
17. Ricard JD, Roca O, Lemiale V, Corley A, Braunlich J, Jones P, et al. Use of nasal high flow oxygen during acute respiratory failure. Intensive Care Med. 2020;46(12):2238-2247. doi:10.1007/s00134-020-06228-7.
18. Sawase H, Ozawa E, Yano H, Ichinomiya T, Yano R, Miyaaki H, et al. Respiratory support with nasal high flow without supplemental oxygen in patients undergoing endoscopic retrograde cholangiopancreatography under moderate sedation: a prospective, randomized, single-center clinical trial. BMC Anesthesiol. 2023;23(1):156. doi:10.1186/s12871-023-02125-w.
19. Carron M, Tamburini E, Safaee Fakhr B, De Cassai A, Linassi F, Navalesi P. High-flow nasal oxygenation during gastrointestinal endoscopy. Systematic review and meta-analysis. BJA Open. 2022;4:100098. doi:10.1016/j.bjao.2022.100098.
20. Zhang YX, He XX, Chen YP, Yang S. The effectiveness of high-flow nasal cannula during sedated digestive endoscopy: a systematic review and meta-analysis. Eur J Med Res. 2022;27(1):30. doi:10.1186/s40001-022-00661-8.
21. Khanna P, Haritha D, Das A, Sarkar S, Roy A. Utility of high-flow nasal oxygen in comparison to conventional oxygen therapy during upper gastrointestinal endoscopic procedures under sedation: a systematic review and meta-analyses. Indian J Gastroenterol. 2023;42(1):53-63. doi:10.1007/s12664-022-01308-6.
22. Prosenz J, Lang RP, Bernhofer S, Maieron A. A prospective study on incidence of desaturations in ERCP with non-anesthesiologist sedation and adverse event awareness of endoscopists. Sci Rep. 2025;15(1):22781. doi:10.1038/s41598-025-04922-4.
23. Li N, Wu J, Lu Y, Zhang J, Sun Z, Cao X, et al. Predictive value of NoSAS questionnaire combined with the modified Mallampati grade for hypoxemia during routine sedation for gastrointestinal endoscopy. BMC Anesthesiol. 2023;23(1):126. doi:10.1186/s12871-023-02075-3.
24. Geng W, Jia D, Wang Y, Jin S, Ren Y, Liang D, et al. A prediction model for hypoxemia during routine sedation for gastrointestinal endoscopy. Clinics (Sao Paulo). 2018;73:e513. doi:10.6061/clinics/2018/e513 .
25. Liu F, Zhang C, Wang X, Qi B, Zheng L, Zhao Y, et al. Efficacy of high-flow nasal oxygen in preventing hypoxia during gastrointestinal endoscopy: a retrospective cohort study. BMC Anesthesiol. 2025;25(1):287. doi:10.1186/s12871-025-03155-2.
26. Nay MA, Fromont L, Eugene A, Marcueyz JL, Mfam WS, Baert O, et al. High-flow nasal oxygenation or standard oxygenation for gastrointestinal endoscopy with sedation in patients at risk of hypoxaemia: a multicentre randomised controlled trial (ODEPHI trial). Br J Anaesth. 2021;127(1):133-142. doi:10.1016/j.bja.2021.03.020.
27. Laffin AE, Kendale SM, Huncke TK. Severity and duration of hypoxemia during outpatient endoscopy in obese patients: a retrospective cohort study. Can J Anaesth. 2020;67(9):1182-1189. doi:10.1007/s12630-020-01737-x.
28. Kim H, Hyun JN, Lee KJ, Kim HS, Park HJ. Oxygenation before Endoscopic Sedation Reduces the Hypoxic Event during Endoscopy in Elderly Patients: A Randomized Controlled Trial. J Clin Med. 2020;9(10):3282. doi:10.3390/jcm9103282.

SAŽETAK

Manje intervencije na dišnom putu u starijih bolesnika tijekom ERCP-a uz primjenu visokoprotočne u usporedbi s konvencionalnom nosnom kanilom za terapiju kisikom: randomizirano kontrolirano ispitivanje

Valentina Ješić, Tihana Magdić Turković i Marinko Vučić

Intravenska sedacija tijekom endoskopske retrogradne kolangiopankreatografije (ERCP) u starijih bolesnika povezana je s respiratornom nestabilnošću. Tijekom ERCP-a terapija kisikom najčešće se primjenjuje konvencionalnom nosnom kanilom (CNC) ili visokoprotočnom nosnom kanilom (HFNC). Respiratorna nestabilnost može zahtijevati manje intervencije na dišnom putu (MAI), uključujući podizanje brade, aspiraciju sekreta, postavljanje orofaringealnog tubusa ili eskalaciju s CNC-a na HFNC. Ovo randomizirano kontrolirano ispitivanje imalo je za cilj usporediti incidenciju MAI-ja u starijih bolesnika koji tijekom ERCP-a primaju HFNC u odnosu na CNC.

U ovom jednocentričnom, prospektivnom, randomiziranom, kontroliranom ispitivanju 115 bolesnika u dobi od 65 godina ili više podvrgnutih ERCP-u u intravenskoj sedaciji randomizirano je u skupinu s HFNC-om (n = 58) ili u skupinu s CNC-om (n = 57). Primarni ishod bila je incidencija MAI-ja u svakoj skupini.

MAI je zabilježen u ukupno 30 bolesnika (26,1 %) te se značajno rjeđe javljao u skupini s HFNC-om (7 od 58, 12,1 %) nego u skupini s CNC-om (23 od 57, 40,4 %) ($P < 0,001$; relativni rizik 0,30; 95 % CI 0,14 – 0,64). Najčešći MAI bio je podizanje brade. Nije utvrđena povezanost MAI-ja s dobi, spolom ni klasifikaciji fizikalnog statusa prema Američkom društvu anesteziologa (ASA).

HFNC značajno smanjuje incidenciju MAI-ja u starijih bolesnika tijekom ERCP-a u usporedbi s terapijom kisikom putem konvencionalne nosne kanile.

KLJUČNE RIJEČI

Starija dob; Zbrinjavanje dišnog puta; Svjesna sedacija; Endoskopska retrogradna kolangiopankreatografija; Visokoprotočna nosna kanila; Terapija kisikom