ALBANIAN JOURNAL OF TRAUMA AND EMERGENCY SURGERY
Volume 10 | Issue 2 | July 2026
Pages: 2216-2219
DOI: https://doi.org/10.32391/ajtes.v10i2.420

PERSPECTIVE ARTICLE

High-Flow Nasal Cannula in Respiratory Failure: A Perspective Review

Blerim Arapi[1]*, Alma Cani[2], Gentian Huti[3], Asead Abdyli[3], Mustafa Bajraktari[4], Majlinda Naco[5]

[1] Anesthesia-Reanimation Service, Hygea Hospital, Tirana, Albania
[2] Anesthesia-Reanimation Service, University Hospital, "Shefqet Ndroqi" Tirana, Albania
[3] Anesthesia-Reanimation Service, American Hospital 3" Tirana, Albania
[4] Anesthesia-Reanimation Service, American Hospital 2" Tirana, Albania
[5] Anesthesia-Reanimation Service, University Hospital Center "Mother Teresa" Tirana, Albania

Corresponding author: Blerim Arapi, M.D., Ph.D.c
Anesthesia-Reanimation Service, Hygea Hospital, Tirana,
Email: blerimarapi@yahoo.it

Received: 14 May 2026 • Accepted: 19 June 2026 • Published online: 20 July 2026

ABSTRACT

Background: High-Flow Nasal Cannula (HFNC) therapy has grown significantly as an alternative non-invasive respiratory support for respiratory insufficiency, both acute and chronic. The treatment entails providing heated and humidified oxygen at high flow rates to enhance oxygenation, minimize anatomical dead space, lower the work of breathing, and increase patient tolerance than conventional oxygen therapy.
Materials and Methods: This narrative review study conducted searches in PubMed and other reputable medical databases to collect literature on the physiological effects, indications, benefits, downsides, and outcomes associated with HFNC for respiratory failure. Data were extracted from randomized trials, observational studies, systematic reviews, and guidelines.
Results: Available evidence suggests that HFNC has significant benefits for treating acute hypoxemic respiratory failure, COPD exacerbations, post-extubation respiratory support, pre-oxygenation for intubation, cardiogenic pulmonary edema, and respiratory insufficiency related to COVID-19. HFNC provides superior oxygenation, secretion removal, respiratory tolerance, and comfort compared to standard oxygen therapy. In selected patients, HFNC may be used to delay or avoid invasive ventilation. Delaying recognition of HFNC failure may impact the prognosis negatively.
Discussion: HFNC is widely recognized because of its physiological superiority and ease of use. HFNC should be carefully selected and continuously monitored, escalating to invasive ventilation early when necessary.
Conclusion: HFNC represents an effective and well-tolerated noninvasive respiratory support strategy, particularly in acute hypoxemic respiratory failure. Appropriate implementation and vigilant monitoring are crucial for maximizing therapeutic benefit and improving patient outcomes.
Keywords: High-flow nasal cannula; Respiratory failure; Oxygen therapy; Acute hypoxemic respiratory failure; Noninvasive respiratory support; Mechanical ventilation.

How to cite this article:
Arapi, B., Cani, A., Huti, G., Abdyli, A., Bajraktari, M., & Naco, M. (2026). High-flow nasal cannula in respiratory failure: A perspective review. Albanian Journal of Trauma and Emergency Surgery, 10(2), 2216-2219. https://doi.org/10.32391/ajtes.v10i2.420

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INTRODUCTION

Respiratory failure remains a major cause of morbidity and mortality worldwide and is one of the most frequent indications for intensive care unit admission. (1) Acute respiratory failure may present as hypoxemic failure, hypercapnic failure, or mixed forms depending on the underlying pathology. Conventional oxygen therapy, noninvasive ventilation, and invasive mechanical ventilation have historically represented the cornerstone of respiratory support. However, limitations associated with standard oxygen devices and intolerance to noninvasive ventilation stimulated the development of alternative noninvasive modalities. (1)

High-flow nasal cannula oxygen therapy is a noninvasive respiratory support system capable of delivering heated and humidified oxygen-air mixtures at flow rates up to 60–70 L/min through wide-bore nasal prongs. (1)

Physiologically, high-flow nasal cannula improves oxygenation by providing stable fraction of inspired oxygen, washing out nasopharyngeal dead space, generating low levels of positive end-expiratory pressure, reducing inspiratory resistance, and improving secretion clearance. (1,2)

The landmark FLORALI trial published by Frat and colleagues in 2015 substantially increased interest in high-flow nasal cannula for acute hypoxemic respiratory failure by demonstrating lower mortality and reduced intubation in selected patients compared with conventional oxygen therapy and noninvasive ventilation. (3) Since then, high-flow nasal cannula has expanded into multiple clinical settings, including acute respiratory distress syndrome, chronic obstructive pulmonary disease exacerbations, immunocompromised patients, post-extubation support, perioperative care, and coronavirus disease 2019-related respiratory failure. (2,4)

This narrative review summarizes current evidence regarding high-flow nasal cannula in respiratory failure, focusing on physiological rationale, major indications, disease-specific applications, predictors of treatment success and failure, and future directions.

Physiological Basis of High-Flow Nasal Cannula

High-flow nasal cannula provides several physiological advantages compared with standard oxygen systems. (1,2,5) Delivery of heated and humidified gas improves mucociliary function and secretion clearance. High flow rates exceed inspiratory demand, ensuring stable fraction of inspired oxygen delivery. Nasopharyngeal dead-space washout reduces carbon dioxide rebreathing. Mild positive airway pressure promotes alveolar recruitment. Reduced inspiratory resistance decreases work of breathing and respiratory effort. High-flow nasal cannula also demonstrates superior patient tolerance compared with noninvasive ventilation because patients can eat, speak, and expectorate more comfortably while receiving respiratory support. (5)

High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure

Pneumonia and Early Acute Respiratory Distress Syndrome

Acute hypoxemic respiratory failure, especially secondary to pneumonia and early acute respiratory distress syndrome, represents the strongest indication for high-flow nasal cannula (3). The FLORALI trial randomized patients with no hypercapnic acute hypoxemic respiratory failure to high-flow nasal cannula, conventional oxygen therapy, or noninvasive ventilation and demonstrated improved survival and lower intubation rates among patients with severe hypoxemia receiving high-flow nasal cannula. (3)

Subsequent studies and meta-analyses confirmed that high-flow nasal cannula decreases intubation rates compared with conventional oxygen therapy and offers similar or superior comfort compared with noninvasive ventilation. (2,4)

High-flow nasal cannula is particularly beneficial in community-acquired pneumonia, viral pneumonia, early acute respiratory distress syndrome, and postoperative hypoxemia. Nevertheless, patients with severe respiratory distress or rapidly progressive acute respiratory distress syndrome require close monitoring because delayed intubation is associated with increased mortality. (2,4)

High-Flow Nasal Cannula in Coronavirus Disease 2019 Respiratory Failure

The coronavirus disease 2019 pandemic markedly expanded high-flow nasal cannula utilization worldwide. (2,4) High-flow nasal cannula became an important strategy to avoid invasive ventilation in patients with severe hypoxemia while preserving patient comfort and reducing sedation requirements. (2)

High-flow nasal cannula combined with awake prone positioning demonstrated improved oxygenation and reduced intubation in selected patients with coronavirus disease 2019-associated acute respiratory distress syndrome. (2,4) However, prolonged unsuccessful high-flow nasal cannula therapy may delay invasive mechanical ventilation and worsen outcomes. (2)

Current evidence supports high-flow nasal cannula as first-line noninvasive support for moderate coronavirus disease 2019 hypoxemic respiratory failure when close monitoring and escalation protocols are available. (2,4)

High-Flow Nasal Cannula in Hypercapnic Respiratory Failure and Chronic Obstructive.

Pulmonary Disease:

Acute Exacerbations of Chronic Obstructive Pulmonary Disease

Noninvasive ventilation remains the gold standard for acute hypercapnic respiratory failure in chronic obstructive pulmonary disease exacerbations, particularly in respiratory acidosis (6,7). However, high-flow nasal cannula has emerged as a potential alternative in selected patients due to its ability to wash out dead space and decrease respiratory workload. (6)

Studies suggest that high-flow nasal cannula may improve comfort and reduce arterial carbon dioxide levels in mild-to-moderate hypercapnic respiratory failure. (7) A randomized trial by Li and colleagues demonstrated improved outcomes compared with conventional oxygen therapy in acute compensated hypercapnic chronic obstructive pulmonary disease exacerbations. (7)

Meta-analyses comparing high-flow nasal cannula and noninvasive ventilation indicate similar intubation and mortality outcomes in selected chronic obstructive pulmonary disease populations, although noninvasive ventilation remains superior in severe acidosis. (8)

High-flow nasal cannula may therefore be considered in patients with intolerance to noninvasive ventilation, mild hypercapnia, during breaks between noninvasive ventilation sessions, and during weaning from noninvasive ventilation.

Chronic Hypercapnic Chronic Obstructive Pulmonary Disease

Long-term domiciliary high-flow nasal cannula has shown promise in stable hypercapnic chronic obstructive pulmonary disease patients. (9) Studies reported reductions in exacerbation frequency, hospital admissions, and improved quality of life. (9)

High-Flow Nasal Cannula in Immunocompromised Patients

Respiratory failure in immunocompromised patients is associated with high mortality and increased risk of invasive ventilation complications. (10) High-flow nasal cannula has been proposed as an attractive strategy because it improves oxygenation while avoiding intubation-related complications. (10) The HIGH randomized clinical trial compared high-flow nasal cannula with standard oxygen therapy in immunocompromised patients with acute respiratory failure. (10) Although mortality benefit was not significant, high-flow nasal cannula improved respiratory comfort and oxygenation. (10)

High-Flow Nasal Cannula in Post-Extubating Respiratory Failure

High-flow nasal cannula is increasingly used following extubating in high-risk patients (11). Post-extubating respiratory failure contributes significantly to intensive care unit morbidity and reintubation risk (11). Randomized trials demonstrated that high-flow nasal cannula is noninferior to noninvasive ventilation in preventing reintubation among selected high-risk patients after extubating while offering better tolerance and fewer interface complications. (11) High-flow nasal cannula appears especially useful in elderly patients, obese patients, cardiothoracic surgery patients, and patients requiring prolonged mechanical ventilation.

High-Flow Nasal Cannula in Cardiogenic Pulmonary Edema

High-flow nasal cannula improves oxygenation and reduces respiratory distress in cardiogenic pulmonary edema through mild positive end-expiratory pressure generation and reduction in inspiratory effort. (5) However, noninvasive ventilation remains preferred in severe pulmonary edema associated with marked respiratory acidosis or hypercapnia. (5) High-flow nasal cannula may serve as an alternative in patients intolerant to noninvasive ventilation or during transition phases of respiratory support.

High-Flow Nasal Cannula in Peri-Intubation Oxygenation

High-flow nasal cannula can prolong safe apnea time during intubation by providing continuous oxygen delivery during laryngoscopy. (5) This concept of apneic oxygenation has become increasingly utilized in critically ill patients with severe hypoxemia. (5) Although studies demonstrated improved oxygenation during intubation preparation, evidence regarding reduction in severe desaturation events remains mixed. (5)

Predictors of High-Flow Nasal Cannula Failure

Early recognition of high-flow nasal cannula failure is critical to avoid delayed intubation. (2, 5) Several predictors have been proposed, including respiratory rate, oxygenation indices, and work of breathing. The ROX index is widely used:

$$ROX\ Index = \frac{SpO_2/FiO_2}{Respiratory\ Rate}$$

Lower ROX index values are associated with higher risk of high-flow nasal cannula failure and intubation. (2) Additional predictors of high-flow nasal cannula failure include persistent tachypnea, increased respiratory

effort, hemodynamic instability, altered mental status, worsening hypoxemia, and progressive hypercapnia. Timely escalation to invasive mechanical ventilation remains essential in deteriorating patients. (2,4)

CONCLUSIONS

High-flow nasal cannula has become an integral component of modern respiratory support strategies. Through delivery of heated and humidified high-flow oxygen, high-flow nasal cannula improves oxygenation, decreases work of breathing, enhances secretion clearance, and increases patient comfort. (1,2,5) Current evidence strongly supports its use in acute hypoxemic respiratory failure, particularly pneumonia and early acute respiratory distress syndrome. (3,4) Additional applications include coronavirus disease 2019 respiratory failure, chronic obstructive pulmonary disease exacerbations, immunocompromised patients, post-extubation respiratory support, peri-intubation oxygenation, and selected cases of cardiogenic pulmonary edema. (6–11) Despite increasing evidence, high-flow nasal cannula should not delay invasive mechanical ventilation when clinical deterioration occurs. Careful patient selection, continuous monitoring, and use of predictive tools such as the ROX index are essential to optimize outcomes (2,5). Future research should clarify optimal flow settings, disease-specific protocols, long-term home high-flow nasal cannula strategies, and integration with other noninvasive respiratory support modalities.

COI Statement: This paper has not been submitted in parallel, presented fully or partially at a meeting, podium, or congress, published, or submitted for consideration beforehand.

This research received no specific funding from public, commercial, or non-profit sectors. The authors declare that they, their relatives, or next of kin have no financial relationships with external companies that could be considered relevant or minor.

Disclosure: The authors declared no conflict of interest. No funding was received for this study.

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