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Case Report

Noninvasive Respiratory Support for Acute Respiratory Failure in an Adult with Severe Asthma Exacerbation: Case Report

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Abstract

Acute severe asthma exacerbations may progress to acute respiratory failure (ARF), often requiring endotracheal intubation (ETI) and invasive mechanical ventilation. The role of noninvasive respiratory support (NIRS), including high-flow nasal cannula (HFNC) and noninvasive ventilation (NIV), in this setting remains uncertain, and evidence in adults is scarce. We report the case of a 24-year-old woman with poorly controlled asthma and obesity who presented to the emergency department with severe dyspnea, hypoxemic ARF, and a high work of breathing score, consistent with an acute severe asthma exacerbation. Initial management included systemic corticosteroids, inhaled short-acting bronchodilators, and HFNC (60 L/min, FiO_2 0.40). Despite partial improvement in oxygenation, she exhibited persistent tachypnea, expiratory wheezing, and only modest changes in arterial blood gases. Respiratory support was switch to intermittent NIV via oronasal mask (pressure support 12⟶8 cmH_2O, PEEP 8 cmH_2O, FiO_2 0.30), with HFNC used between sessions as a rest modality. This combined strategy resulted in rapid normalization of $PaCO_2$, improved oxygenation, and reduced work of breathing without ETI. Serial bedside pulmonary function tests demonstrated severely reduced peak expiratory flow and FEV_1 on day 1, with progressive recovery to >60% of predicted values by day 6, paralleling clinical improvement. The patient was discharged after 7 days without complications. This case suggests that sequential HFNC–NIV strategies, with continuous in-line bronchodilator delivery, may represent a safe and physiologically sound option to avoid intubation in carefully selected adults with severe asthma–related ARF, warranting further systematic evaluation.

Keywords: *Asthma; Non-Invasive Ventilation; High-Flow Nasal Cannula, Acute Respiratory Failure; Non-Invasive Respiratory Support.*

Introduction

Asthma is a chronic disease characterized by airway hyperresponsiveness and reversible airflow obstruction and remains a major global health burden, affecting millions of children and adults worldwide [1]. Acute exacerbations, driven by airway inflammation, bronchospasm, and mucus hypersecretion, can precipitate severe expiratory airflow limitation and, in a subset of patients, progression to acute respiratory failure (ARF), requiring urgent medical intervention [2]. Despite advances in the characterization of asthma phenotypes and endotypes that have refined maintenance and exacerbation management, approximately 5–10% of inadequately treated exacerbations still evolve to ARF, a life-threatening condition [3, 4].

The Global Initiative for Asthma (GINA) recommends prompt administration of conventional oxygen therapy (COT), inhaled short-acting bronchodilators, and systemic corticosteroids for the management of acute severe asthma. However, despite timely and aggressive standard therapy, some patients continue to exhibit severe dyspnea, tachypnea, and signs of increased inspiratory effort. In this context, the role of noninvasive respiratory support (NIRS)—including noninvasive ventilation (NIV) and high-flow nasal cannula (HFNC)—for ARF secondary to asthma exacerbations in adults remains an area of active investigation [5].

A Cochrane review of five randomized controlled trials evaluating NIV in this setting reported reductions in hospital admissions and emergency department (ED) length of stay, together with improvements in pulmonary function tests (PFTs). Nonetheless, these data were insufficient to demonstrate clear benefits in hard clinical endpoints such as endotracheal intubation (ETI) rates or mortality [6]. In contrast, evidence supporting HFNC in acute asthma is scarce. Although some studies suggest that HFNC may improve oxygenation and clinical symptoms compared with COT, its impact on ETI rates and mortality remains uncertain [7].

This case report describes the sequential use of HFNC and NIV in the management of ARF secondary to an acute severe asthma exacerbation in an adult patient and provides longitudinal follow-up with PFTs. To our knowledge, no previous reports have detailed the combined use of these NIRS modalities together with serial functional assessment in this clinical context.

Case Report

A 24-year-old woman with childhood-onset asthma and poor adherence to maintenance therapy in adulthood, using only as-needed inhaled salbutamol without controller medication, and obesity (body mass index 31.25 kg/m^2), presented to theED with acute shortness of breath. On arrival, she reported severe dyspnea with a visual analog scale (VAS) score of 7/10 and was able to speak only in short, incomplete sentences.

Clinical assessment showed a respiratory rate (RR) of 29 breaths/min, a work of breathing (WOB) score of 6/10 (assessed with a previously described 0–10 scale based on respiratory rate and visible use of accessory respiratory muscles [8]), oxygen saturation (SpO_2) of 87% on room air, and a heart rate (HR) of 140 beats/min. Arterial blood gas (ABG) analysis on supplemental oxygen at 5 L/min revealed a pH of 7.34, $PaCO_2$ 42 mmHg, PaO_2 70 mmHg, and HCO_3^- 22.3 mEq/L, consistent with mild hypoxemic ARF without significant acid–base disturbance. Additional laboratory tests were unremarkable. Lung ultrasound demonstrated an A-line pattern, compatible with the absence of alveolar consolidation or interstitial syndrome, and a chest radiograph was normal. Based on clinical severity criteria and Global Initiative for Asthma (GINA) recommendations, the episode was classified as an acute severe asthma exacerbation with ARF.

The patient was promptly treated with intravenous systemic corticosteroids and nebulized short-acting β_2-agonists combined with anticholinergics. Given the persistent respiratory distress and hypoxemia despite initial therapy, HFNC was initiated using an Airvo 2 device at a flow of 60 L/min, fraction of inspired oxygen (FiO_2) 0.40, and gas temperature of 37°C, delivered via a large asymmetrical nasal cannula. The patient underwent close monitoring at 2, 6, and 12 hours after HFNC initiation. Nebulized bronchodilators were administered every 4 hours using a vibrating mesh nebulizer (VMN) placed in-line with the HFNC circuit.

At 6 hours post-HFNC initiation, ABG analysis and clinical reassessment showed only modest improvement, with RR 26 breaths/min, HR 115 beats/min, SpO_2 97%, and persistent expiratory wheezing. ABG values at this time were pH 7.33, $PaCO_2$ 44 mmHg, PaO_2 63 mmHg, and HCO_3^- 22.7 mEq/L, indicating persistent hypoxemia and a slight increase in $PaCO_2$ despite HFNC (Table 1).

Given the limited clinical and gas-exchange response, respiratory support was switch to NIV via an oronasal mask. Pressure support ventilation (PSV) was initiated with a PSV of 12 cmH_2O, positive end-expiratory pressure (PEEP) of 8 cmH_2O, and FiO_2 0.30. NIV was delivered intermittently according to patient comfort and relief of respiratory symptoms, with HFNC used between NIV sessions as a rest modality. Bronchodilator therapy was continued through an in-line VMN during NIV. After several hours of NIV, ABG measurements at 6 hours post-NIV initiation showed clear improvement, with pH 7.40, $PaCO_2$ 40 mmHg, PaO_2 85 mmHg, and HCO_3^- 22.2 mEq/L (Table 1). Once a few hours of relative clinical stability were achieved, the patient was transferred to the Respiratory Intermediate Care Unit (RICU) for ongoing monitoring and treatment.

At 24 hours post-admission, bedside pulmonary function testing (PFT) revealed a peak expiratory flow (PEF) of 47 L/min (predicted: 316 L/min) and a forced expiratory volume in 1 second (FEV_1) of 0.46 L (predicted: 2.9 L), indicating severe expiratory airflow limitation. PEF and FEV_1 were measured using bedside spirometry and a peak flow meter, following ATS/ERS recommendations when feasible in the clinical context, and the

tests were performed with good patient cooperation. Following bronchodilator therapy administered during HFNC and NIV, PEF showed a modest improvement to 80 L/min, whereas FEV_1 remained essentially unchanged at 0.45 L.

Despite the limited improvement in PFT parameters, the patient's clinical condition improved, allowing a reduction in pressure support to 8 cmH_2O while PEEP was maintained at 8 cmH_2O. HFNC was employed during the daytime as a rest period from NIV, with strict clinical monitoring, whereas NIV was reserved for nocturnal use. Daily post-bronchodilator PEF measurements were obtained to track the evolution of expiratory flow limitation (Figure 1).

By 72 hours, the patient was successfully weaned from nocturnal NIV and continued on HFNC at 50 L/min with an FiO_2 of 0.21. Vital signs were stable, with RR 20 breaths/min, SpO_2 97%, and HR 90 beats/min. The patient was able to effectively expectorate large volumes of sputum. HFNC was maintained to exploit its heated and humidified gas delivery and its potential benefits in secretion clearance, until sputum production decreased and spirometric values showed further recovery (FEV_1 > 60% of predicted).

After six days of HFNC therapy, the patient was successfully weaned off all noninvasive respiratory support. The total hospital length of stay was 7 days, without complications. She was discharged with a personalized asthma action plan, including education on correct inhaler technique and recognition of early warning signs of exacerbation.

Time point	**pH**	**$PaCO_2$ (mmHg)**	**PaO_2 (mmHg)**	**HCO_3^- (mEq/L)**
Admission	7.34	42	70	22.3
6 h post-HFNC	7.33	44	63	22.7
6 h post-NIV	7.40	40	85	22.2

Table 1. Arterial blood gases at admission, after 6 hours of high-flow nasal cannula (HFNC), and after 6 hours of noninvasive ventilation (NIV).

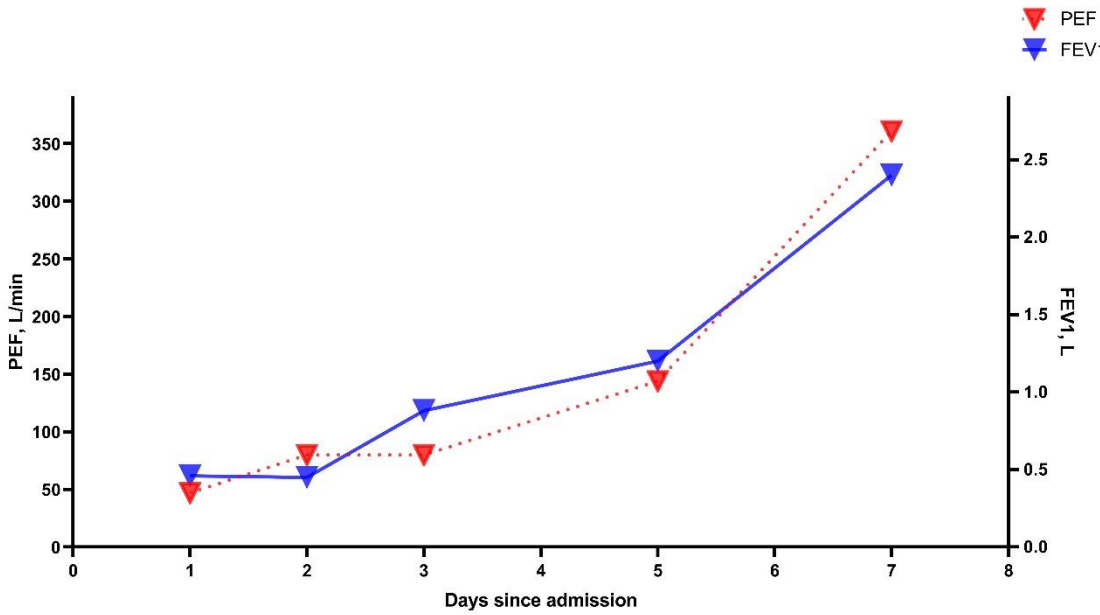

Figure 1. Evolution of peak expiratory flow (PEF) and forced expiratory volume in 1 second (FEV_1) during hospitalization.Post-bronchodilator PEF (left y-axis, L/min; red inverted triangles, dotted line) and FEV_1 (right y-axis, L; blue triangles, solid line) are shown over the first 7 days after admission. Both parameters demonstrate progressive improvement in expiratory airflow limitation, with a marked increase from day 5 onwards.

Discussion

This case illustrates a favourable response to NIRS in an adult with ARF due to severe asthma exacerbation avoiding the need for ETI Although current evidence does not provide robust support for NIRS in acute asthma in terms of hard outcomes such as ETI rates or mortality [6, 7], our report suggests that the sequential use of HFNC and NIV may offer relevant physiological benefits in carefully selected patients.

HFNC may contribute to clinical improvement in this setting through several mechanisms. By delivering heated and humidified gas at high flow, HFNC can reduce inspiratory effort, generate a small amount of positive airway pressure, and wash out nasopharyngeal dead space, thereby improving oxygenation and alleviating dyspnea. In addition, optimal conditioning of the inspired gas may enhance mucociliary clearance and help to prevent the bronchoconstrictive effects associated with cold, dry oxygen delivered by conventional oxygen therapy (COT) devices devices [9]. In our patient, however, persistent tachypnea, expiratory wheezing, and only modest changes in gas exchange after several hours of HFNC indicated that this modality alone was insufficient to fully unload the respiratory muscles.

In this context, escalation to NIV provided an additional level of support. The application of pressure support combined with an appropriate level of positive end-expiratory pressure (PEEP) likely contributed to reducing the work of breathing and counteracting intrinsic PEEP, while maintaining adequate oxygenation. The rapid improvement in arterial blood gases after NIV initiation—normalization of pH and $PaCO_2$ together with an increase in PaO_2—supports this interpretation. Importantly, NIV was delivered intermittently via an oronasal mask, with HFNC used between sessions as a "rest" modality, which may have improved comfort and tolerance while maintaining stable oxygenation. Recent data in hypoxemic ARF suggest that combined NIRS strategies can be used both as an escalation pathway (HFNC to NIV) and as a de-escalation pathway (NIV to HFNC) [10]; our case extends this concept to the context of severe asthma.

Another relevant aspect of this case is the continuous administration of bronchodilators through in-line nebulization systems during both HFNC and NIV support, minimizing treatment interruptions. Our group has recently reported the safe and effective use of in-line bronchodilator delivery with HFNC in adults with asthma exacerbations, and this approach is increasingly recognized as a standard option for patients with obstructive airway diseases such as asthma and COPD [11]. In the present case, this strategy allowed sustained delivery of inhaled therapy while respiratory support was being optimized.

Finally, we observed a notable dissociation between clinical improvement and spirometric parameters. Despite persistent, severely reduced PEF and FEV_1 during the first 24 hours, the patient's work of breathing, gas exchange, and overall clinical status improved substantially. This underscores that decisions regarding escalation to ETI should not rely exclusively on isolated pulmonary function values, but rather on a comprehensive assessment of clinical trajectory, mental status, gas exchange, and response to NIRS. Although this is a single case and causal inferences cannot be drawn, it reinforces the notion that, in selected cooperative patients without imminent signs of respiratory arrest, a carefully monitored trial of combined HFNC and NIV may be a reasonable strategy to avoid intubation.

Conclusion

This case illustrates that the sequential use of noninvasive respiratory support can be a safe and effective strategy for managing acute respiratory failure due to severe asthma exacerbation in a carefully monitored adult patient. By leveraging the complementary physiological effects of HFNC and NIV, clinical stability was achieved without the need for endotracheal intubation and in the absence of adverse events. This approach may help reduce exposure to invasive mechanical ventilation, optimize gas exchange, and support recovery in

selected, cooperative patients. Further studies are warranted to confirm these observations and to better define which patients with acute severe asthma are most likely to benefit from combined NIRS strategies.

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