Aswan University Medical Journal, volume 4 / No.1/ June 2024 (137-145) Online ISSN: **2735-3117**

REVIEW ARTICLE

High Flow Nasal Oxygenation versus Non-Invasive Ventilation for Patients with Blunt Chest Trauma

Haitham Mohamed Fahmy*, Ahmed Abdel Rahim Ahmed, Mohamed Kamel Ahmed, Huda Fahmy Mahmoud

Anaesthesia and Intensive Care Department, Faculty of Medicine, Aswan University

ABSTRACT

Keywords: High Flow Nasal Oxygenation, Non-Invasive Ventilation, Blunt Chest Trauma, Airway Pressure

***Corresponding author:** Haitham Mohamed Fahmy
Email: haithamfahmy987@gmail.com

Tel: : 01155405758

Chest interferes self-causes pain as well as patients' irritability. Additionally, it could be linked to facial injuries, thus reducing patients' ability to comply with NIV using a mask. HFNC enables oxygen delivery at elevated flow rates after heating it to match body temperature and saturating it with water. HFNC offers many advantages, involving an enhanced mucociliary clearance, favorable ventilation perfusion ratios, elevated oxygenation, decreased work of breathing along with inspiratory effort, elevated end-expiratory lung volume, lowering RR as well as HR. Additionally, it decreases mucosal damage. As opposed to NIV, it exhibits no impact on physical movements, oral administration, or speaking. Prompt and consistent NIV usage could effectively enhance the clinical outcomes for cases developing severe chest injuries by decreasing the intubation necessity along with shortening the duration within the ICU. HFNC is utilized during the first hospitalization stage. Additionally, it represents a safe method, representing a well-tolerated substitute for continuous positive airway pressure (CPAP).

INTRODUCTION

Six potentially fatal conditions that should be precisely assessed and managed, especially while performing initial examination for cases developing chest trauma. They involve airway obstruction, tension pneumothorax, open pneumothorax, severe hemothorax, flail chest, as well as pericardial tamponade. Even though trauma typically affects numerous tissues and organs, these potentially fatal disorders highlight the significance of pulmonary injuries in trauma patients [1].

Prompt and continuous non-invasive mechanical ventilation (NIV) usage could effectively enhance the prognosis for cases developing severe chest injuries through reducing the intubation's necessity along with shortening the period in the ICU [2]. High-flow nasal cannula (HFNC) oxygen therapy has become popular as a substate respiratory support approach for cases developing critical illnesses. Patients with acute respiratory failure (ARF) following chest trauma showed positive responses to NIV, leading to a potential decrease as regards the intubation's necessity, pneumonia occurrence, as well as fatality rates. However, utilizing NIV through a face mask often induce adverse events along with discomfort, thus rising failure rates up to 14.8% in cases developing chest trauma [3]. One distinctive characteristic of HFNC is its capacity to supply large volumes of warm as well as humidified gas, ranging from 20 to 70 liters per minute, with a FiO2 range of 0.21 to 1.0 [4].

Clinical findings of blunt trauma:

All thoracic structures, including the diaphragm, heart, ribs, lung, pleura, major arteries, and thoracic cage, can sustain damage. Due to the progress of imaging techniques, the importance of patients' history as well as physical examination may have been diminished. Thoracic trauma symptoms and signs involve fingers, face or lips' cyanosis, dyspnea, tachypnea, or bradypnea, bruises, cuts, perforations, distension, abnormal tracheal position or deviation, the chest wall paradoxical movement, distension jugular veins, reduced or missing breath sounds, discomfort or pain [5].

Injuries linked to Chest wall

1. Thoracic cage
2. Flail chest
3. Injuries involving the Pleura
    - Traumatic pneumothorax
    - Traumatic hemothorax
4. Injuries involving airway as well as pulmonary parenchyma
    - Pulmonary contusions
    - Pulmonary lacerations
    - Injuries involving trachea as well as bronchi

General Treatment for cases developing blunt chest trauma

One of the therapy's primary goals for life-threatening pulmonary conditions is to correct respiratory failure. After blunt chest injury, pulmonary contusion represents the usual consequence, leading to respiratory failure. Maintaining oxygenation, the ventilation/perfusion ratio, along with preventing lungs' damage linked to ventilators remains important to effectively manage respiratory failure. Depending on how severe the pulmonary damage is, invasive mechanical ventilation may be necessary. But mechanical ventilation raises the mortality rate [6].

The respiratory oxygenation (ROX) index:

A simple index recorded at bedside could help clinicians to identify patients at high risk of HFNO failure and to start MV rapidly. For this purpose, ROX index, defined as the ratio of pulse oximetry/fraction of inspired oxygen relative to respiratory rate ($SpO_2/FiO_2/RR$), was proposed recently in "de novo" hypoxemic acute respiratory failure (ARF) [7]. ROX index, combining SpO_2/FiO_2 and respiratory rate, can predict HFNC failure.

High Flow Nasal Oxygenation

The FIO_2 setting on the air/oxygen blender ranges from 0.21 to 1.0, with a maximum flow rate of 60 L/min **(Figure 1)**. The gas is sent into the heated circuit after its heating as well as humidification by the active humidifier. Gas given at high flow rates that is warm and suitably humidified appears to have positive physiological benefits. HFNC was frequently used to treat critically ill patients with a variety of underlying illnesses even before the results of big randomized clinical studies were published [8].

Adverse Effects of Lack of Humidification

Inhaling dry air induces a significant nasal mucosa dehydration, resulting in a potential decrease regarding nasal mucoclliary clearance rate through rheological properties' alterations or nasal mucus' adhesiveness as well as a potential ciliary pulses' reduction [9].

The absolute gas humidity administered utilizing oronasal masks throughout NIV differs amongst patients at equivalent humidifier settings and is influenced by the quantity of leakage and humidifiers' setting. Sometimes, Utilizing high-flow dry gas may induce thickened secretions that could potentially obstruct airways in a serious manner [10].

HFNC Devices' Humidification Performance:

HFNC is thought to provide patients with well-conditioned gas. It can provide a consistent vapor volume due to its open system with a steady flow. **Figure 2** displays the hotplate's electrical output for a heated humidifier (MR850) with a water chamber (MR290) (both from Fisher & Paykel, Auckland, New Zealand). Absolute humidity exhibited lower values at sixty L/min as opposed to at forty L/min. Additionally, electrical output was always 100% at this flow rate. We should be mindful that humidification may fall short of expectations while utilizing very high HFNC flow rates. The AIRVO 2 (from Fisher & Paykel) has a bigger water chamber than the MR290, and it can deliver more vapor than the Optiflow, which is made up of the MR290 and MR850 [11].

Physiological Effect

HFNC involves the gas' heating as well as humidification from an air/oxygen blender utilizing an active humidifier. before being fed via a heated circuit at a maximum flow rate of sixty L/min. Remember that this is an open system once more [11]. The reason for the improvement in thoraco-abdominal synchronization due to HFNC remains unclear, although it is reasonable to assume that less dead space leads to a decline in WOB, which in turn leads to a reduction in breathing frequency. In individuals with respiratory failure, masks and hoods are likely to enhance WOB [12].

Adverse Effects

For patients with respiratory decompensation, noninvasive respiratory assistance may delay the need for more intrusive therapy. Tracheal intubation is thought to be a second step in case NIV is unsuccessful, as well as being unquestionably more invasive than mechanical ventilation with endotracheal intubation. NIV was viewed as a more invasive or, at the very least, more potent (or aggressive) therapy when HFNC first emerged for respiratory support. Standard oxygen therapy was compared to HFNC. In cases of HFNC failure, respiratory support was escalated to NIV [8].

Adult ventilation systems lack pressure release valves and pressure monitors, in contrast to pediatric ventilation systems that have safety valves, thus avoiding high pressure. These issues could also affect adults [11].

Contraindication:

Physicians have been using HFNC for a range of illnesses and problems as it has been getting more and more attention. Absolute contraindications are also absent in the absence of appropriate, accepted criteria or evidence for the therapeutic application of HFNC. Prior to administering it to patients for whom NIV is contraindicated, careful thought is mostly necessary. HFNC is frequently a good substitute for NIV when the primary contraindication is claustrophobia or intolerance of tight interface contact [12].

Non-invasive Ventilation (NIV)

NIV refers to ventilatory assistance without utilizing invasive artificial airway, involving endotracheal tube or tracheostomy tube [13].

Delivery Approaches

1. Noninvasive positive-pressure ventilation
2. Noninvasive negative-pressure ventilation
3. High-flow nasal oxygen.

Clinical disorders appropriate for noninvasive ventilation (chosen cases) involve the following [13]:

- Following cessation of mechanical ventilation among COPD cases
- Pneumonia acquired outside hospitals (as well as COPD)
- Asthmatic cases
- Cases developing compromised immune systems (an established infiltrates' etiology)
- Respiratory failure or distress postoperatively
- Non-intubation cases
- Cases developing neuromuscular respiratory failure (more favorable among chronic cases as opposed to acute ones. It should be avoided if upper airway problems exist).
- Cases developing compensated obstructive sleep apnea or pulmonary hypertension.
- Fibrocystic conditions
- Early-phase Pneumocystis carinii pneumonia
- Fractures in ribs

Consider caution when utilizing for cases developing these disorders:

- Exacerbated idiopathic pulmonary fibrosis
- Consider utilizing helmet ventilation in cases of developing acute respiratory distress syndrome.

Ventilation Modes

The majority of cases receiving NIV are given pressure ventilation assistance, namely CPAP, representing the fundamental support level. It is particularly beneficial for those developing CHF or OSA [14]. And Biphasic positive airway pressure (BIPAP) is a system that permits unrestricted spontaneous breathing at any time during the ventilatory cycle. It is also known as a pressure-controlled mode of ventilation. BIPAP offers several advantages over traditional strategies to improve the pathophysiology in these patients, including gas exchange, cardiovascular function, and reducing the need for sedation. This is because BIPAP allows spontaneous breathing throughout the ventilatory cycle [15].

Success Predictors, in responding to an NIV trial (one to two hours), involve:

- $PaCO_2$ reduction above eight mm Hg
- A pH increases exceeding 0.06
- Respiratory acidosis' correction

Predictors indicating potential failure involve [16]:

- Illness severity was determined by an Acidosis (a pH level below 7.25), hypercapnia (indicating a carbon dioxide level over eighty), as well as an APACHE II score above twenty.
- Consciousness level determined by a Neurologic score exceeding four indicating a state of stupor, with alertness only following strong stimulation; inconsistent ability to obey directions), an encephalopathy score exceeding three, indicating significant

disorientation, daily drowsiness, or agitation), A Glasgow Coma Scale score below eight.
- Progress failure within twelve to twenty-four hours following NIV.

Failure Predictors for late admissions (more than forty-eight h) following NIV involve [17]:

- A reduced functional ability (an activity score below two, indicating a breathing difficulty during light exertions)
- Initial acidosis indicating a pH level equal to or below 7.22.
- Hospital-related adverse events, involving pneumonia, shock, as well as coma.

HFNC V.s NIV for Cases Developing Blunt Chest Trauma

The primary intervention for cases developing chest trauma related ARF was invasive mechanical ventilation, which was aimed at enhancing gas exchange along with promoting chest stabilization. Nevertheless, the adverse events, involving ventilator-associated pneumonia as well as barotrauma, were linked to extended ventilation periods. Additionally, they resulted in elevated fatality rates [18].

A novel NIV interface, in the form of a helmet, has been utilized to minimize adverse events linked to NIV along with enhancing tolerance for cases developing ARF resulting from severe pneumonia, exacerbated COPD, as well as acute cardiogenic pulmonary edema. Nevertheless, the efficacy of NIV utilizing a helmet remains unclear for cases developing ARF as a result of chest trauma [19].

Managing cases developing blunt trauma chest mostly involves stabilizing fractures, ensuring proper pulmonary toilet, administering appropriate physiotherapy, along with promptly and adequately reducing pain. They could possess significant chances significant chances of developing respiratory failure. Several studies have addressed that as many as twenty percent of cases developing blunt chest trauma could exhibit ALI or ARDS. The rates of intubation vary between 23% and 75%, they are influenced by factors, involving trauma severity, the underlying lung disease degree, as well as the early management intensity and monitoring. Positive pressure ventilation has reduced the overall negative events along with death rates linked to traumatic chest injuries. However, utilizing endotracheal intubation as well as mechanical ventilation is linked to significant chances for hospital-acquired pneumonia along with longer mechanical support [20].

The HFNC role:

Study results address a moderate correlation between first HFNC delay and the entire hospitalization duration (r s = 0.36, p = 0.001) for cases who were not administered MV before HFNC. It could be advantageous for cases developing thoracic injuries to commence HFNC once promptly upon ICU admission. Additionally, efforts are implemented to establish that as the care standard at the study institute. Another reason for commencing HFNC promptly is due to rapid patients' enhancements following HFNC starting. ARF cases exhibited an enhancement in one hour after starting the therapy, utilizing HFNC for a short period showed a good impact on respiratory effort as well as oxygenation. Though these two studies' cases did not develop trauma, the HFNC physiologic impact was documented immediately following the treatment initiation. Additionally, it could induce comparable effects in traumatic cases [21]. HFNC represents a straightforward as well as easy method, it induces a prompt respiratory support initiation, along with reducing chances for utilizing MV [22].

The NIV role:

The efficacy of either CPAP or NPPV in managing cases developing traumatic chest injuries has not been determined. While several observational studies have evaluated the CPAP as well as NPPV safety for cases developing blunt thoracic injuries, the data concerning the NIV usage in this context is inconclusive. The data obtained from extensive multicenter studies assessing the NIV usage for hypoxemic patients cannot be applied to these patients, since these trials involved few individuals developing traumatic injuries. Two recent guidelines have either implemented a "no recommendation" or a "low-grade recommendation" about utilizing NIV for cases developing blunt chest trauma. Nevertheless, these recommendations do not include the whole of the accessible evidence for such a clinical condition [23].

CONCLUSION: Our study revealed that HFNC represents an initial efficient therapy for respiratory support during early hospitalization. As a safe therapy, it has a low intubation as well as mortality incidence. In certain cases, it could be a well-tolerated substitute for CPAP.

REFERENCES

1. Gilbertson J, Pageau P, Ritcey B, Cheng W, Burwash-Brennan T, Perry JJ, et al. Test Characteristics of Chest Ultrasonography for Rib Fractures Following Blunt Chest Trauma: A Systematic Review and Meta-analysis. Ann Emerg Med 2022; 79:529-539.

2. Jabaudon M, Blondonnet R, Constantin JM ARDS in patients with chest trauma: Better safe than sorry. Anaesth Crit Care Pain Med 2019; 38:221-222.

3. Curtis K, Kourouche S, Asha S, Considine J, Fry M, Middleton S, et al. Impact of a care bundle for patients with blunt chest injury (ChIP): A multicentre controlled implementation evaluation. PLoS One 2021; 16:e0256027.

4. Frat JP, Ricard JD, Quenot JP, Pichon N, Demoule A, Forel JM, et al. Non-invasive ventilation versus high-flow nasal cannula oxygen therapy with apnoeic oxygenation for preoxygenation before intubation of patients with acute hypoxaemic respiratory failure: a randomised, multicentre, open-label trial. Lancet Respir Med 2019; 7:303-312.

5. Saric P, Ravaee BD, Patel TR, Hoit BD Acute severe mitral regurgitation after blunt chest trauma. Echocardiography 2018; 35:272-274.

6. Martinez T, Belveyre T, Lopez A, Dunyach C, Bouzit Z, Dubreuil G, et al. Serratus Plane Block Is Effective for Pain Control in Patients With Blunt Chest Trauma: A Case Series. Pain Pract 2020; 20:197-203.

7. Girault C, Bubenheim M, Boyer D, Declercq P-L, Schnell G, Gouin P, et al. ROX index performance to predict high-flow nasal oxygen outcome in Covid-19 related hypoxemic acute respiratory failure. Annals of Intensive Care 2024; 14:13.

8. Eugene A, Fromont L, Auvet A, Baert O, Mfam WS, Remerand F, et al. High-flow nasal oxygenation versus standard oxygenation for gastrointestinal endoscopy with sedation. The prospective multicentre randomised controlled ODEPHI study protocol. BMJ Open 2020; 10:e034701.

9. Nishimura M High-flow nasal cannula oxygen therapy in adults: Physiological benefits, indication, clinical benefits, and adverse effects. Respiratory Care 2016; 61:529-541.

10. Slessarev M, Cheng J, Ondrejicka M, Arntfield R Patient self-proning with high-flow nasal cannula improves oxygenation in COVID-19 pneumonia. Can J Anaesth 2020; 67:1288-1290.

11. Shippam W, Preston R, Douglas J, Taylor J, Albert A, Chau A High-flow nasal oxygen vs. standard flow-rate facemask pre-oxygenation in pregnant patients: a randomised physiological study. Anaesthesia 2019; 74:450-456.

12. Dogani B, Månsson F, Resman F, Hartman H, Tham J, Torisson G The application of an oxygen mask, without supplemental oxygen, improved oxygenation in patients with severe COVID-19 already treated with high-flow nasal cannula. Critical Care 2021; 25:319.

13. Popowicz P, Leonard K Noninvasive Ventilation and Oxygenation Strategies. Surg Clin North Am 2022; 102:149-157.
14. Bello G, De Santis P, Antonelli M Non-invasive ventilation in cardiogenic pulmonary edema. Ann Transl Med 2018; 6:355.
15. Salem SS, Hussein K, Badawy MS, Gad Gs, Rashad A Biphasic positive airway pressure in the management of acute respiratory distress syndrome: a comparative study. The Egyptian Journal of Bronchology 2023; 17:23.
16. Liang YR, Lan CC, Su WL, Yang MC, Chen SY, Wu YK Factors and Outcomes Associated with Failed Noninvasive Positive Pressure Ventilation in Patients with Acute Respiratory Failure. Int J Gen Med 2022; 15:7189-7199.
17. Thomrongpairoj P, Tongyoo S, Tragulmongkol W, Permpikul C Factors predicting failure of noninvasive ventilation assist for preventing reintubation among medical critically ill patients. Journal of Critical Care 2017; 38:177-181.
18. Liu Q, Shan M, Zhu H, Cao J, Chen R Noninvasive ventilation with a helmet in patients with acute respiratory failure caused by chest trauma: a randomized controlled trial. Sci Rep 2020; 10:21489.
19. Singh AK, Kaur M, Patel N, Aggarwal R, Trikha A Simple but significant modifications of high-flow nasal cannula. Cureus 2022; 14:e22641.
20. Papazian L, Klompas M, Luyt CE Ventilator-associated pneumonia in adults: a narrative review. Intensive Care Med 2020; 46:888-906.
21. Cheng LC, Chang SP, Wang JJ, Hsiao SY, Lai CC, Chao CM The Impact of High-Flow Nasal Cannula on the Outcome of Immunocompromised Patients with Acute Respiratory Failure: A Systematic Review and Meta-Analysis. Medicina (Kaunas) 2019; 55.
22. Rochwerg B, Einav S, Chaudhuri D, Mancebo J, Mauri T, Helviz Y, et al. The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline. Intensive Care Med 2020; 46:2226-2237.
23. Non-invasive ventilation in acute respiratory failure. Thorax 2002; 57:192.

FIGURE LEGENDS:

Figure 1: Basic setup for high-flow nasal cannula oxygen delivery. An air-oxygen blender, allowing from 0.21 to 1.0 FIO_2, generates up to 60 L/min flow. The gas is heated and humidified through an active heated humidifier and delivered via a single limb heated inspiratory circuit. The patient breathes adequately heated and humidified medical gas through large-diameter nasal cannulas.

Figure 2: Electrical output of the hotplate of an MR850 heated humidifier with an MR290 water chamber (both from Fisher & Paykel). The MR850 was set to maintain temperature at the water chamber outlet at 37°C and at the distal end of the inspiratory limb at 40°C. When the flow was 60 L/min, electrical output was always 100%.

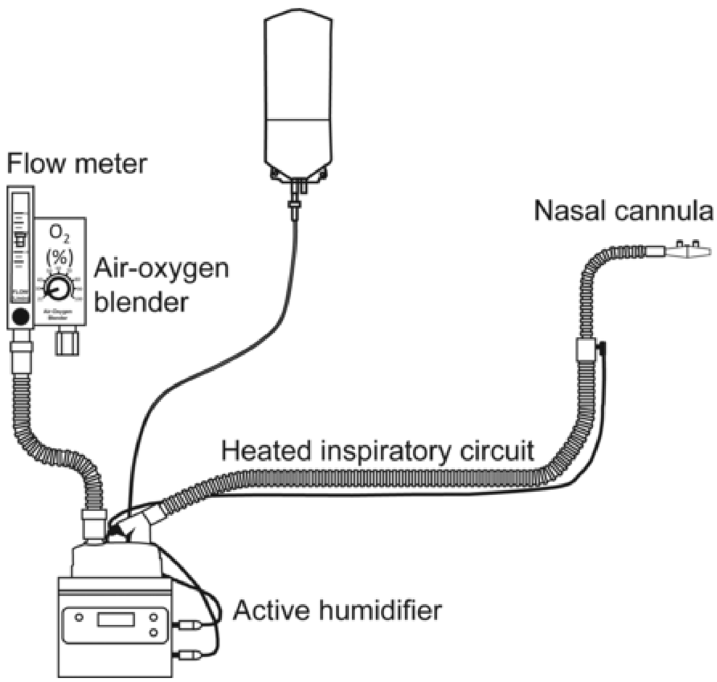

Figure 1: Basic setup for high-flow nasal cannula oxygen delivery. An air-oxygen blender, allowing from 0.21 to 1.0 FIO_2, generates up to 60 L/min flow. The gas is heated and humidified through an active heated humidifier and delivered via a single limb heated inspiratory circuit. The patient breathes adequately heated and humidified medical gas through large-diameter nasal cannulas [9]

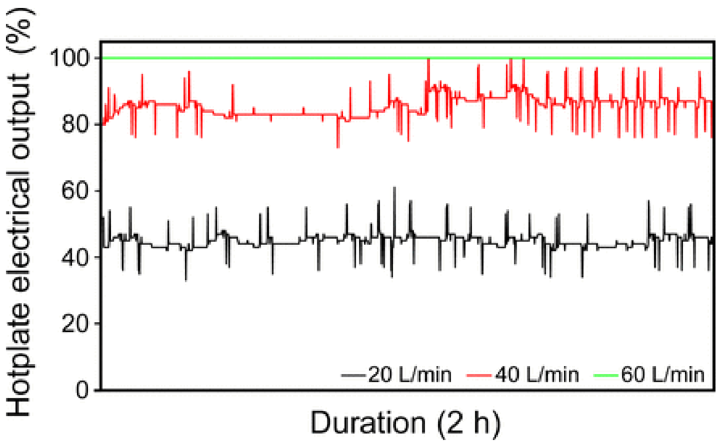

Figure 2: Electrical output of the hotplate of an MR850 heated humidifier with an MR290 water chamber (both from Fisher & Paykel). The MR850 was set to maintain temperature at the water chamber outlet at 37°C and at the distal end of the inspiratory limb at 40°C. When the flow was 60 L/min, electrical output was always 100% [9]