ORIGINAL ARTICLE

Impact of the Early Use of High-flow Nasal Cannula in Patients with Post-traumatic Lung Contusion: A Randomized Clinical Trial

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Abstract

Background: Patients with pulmonary contusion (PC) following blunt chest trauma are at risk of developing acute lung injury. High-flow nasal cannula (HFNC) is an established method for managing hypoxic respiratory failure (HRF).

Aim: This study aims to evaluate the efficacy of oxygen therapy delivered through HFNC vs venturi mask (VM) in patients with hypoxia following traumatic lung contusion, to reduce the need for intubation and ventilation.

Materials and methods: This is an open-label randomized controlled trial conducted on 120 patients with HRF following traumatic PC and a PaO_2/FiO_2 of 100–200 mm Hg. Patients were divided into two groups: Group A (60 patients) received oxygen therapy through HFNC, while group B (60 patients) received oxygen therapy through VM.

Results: High-flow nasal cannula significantly improved pulmonary oxygenation as early as 1 hour after randomization and the after with statistically significant improvement of PaO_2/FiO_2 over time ($p < 0.001$). However, it was associated with a nonsignificant reduction in the rate of intubation and mechanical ventilation ($p = 0.255$) and a nonsignificant reduction in the mortality rate ($p = 0.491$). The extent of PC was found to be an independent predictor of mortality ($p = 0.589$) and length of hospital stay ($p = 0.581$) by multivariate analysis.

Conclusion: The early use of HFNC is associated with a significant improvement in pulmonary oxygenation. We suggest that HFNC can be used as a first-line oxygen therapy in hypoxic patients with lung contusion following blunt chest trauma.

Keywords: Acute hypoxemic respiratory failure, Acute lung injury/acute respiratory distress syndrome, High-flow nasal cannula oxygen therapy, Unilateral pulmonary contusion, Venturi mask.

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Highlight

This study compares high-flow nasal cannula (HFNC) and venturi mask (VM) for oxygen therapy in hypoxic patients with pulmonary contusion (PC) after blunt chest trauma. High-flow nasal cannula significantly improved pulmonary oxygenation but did not reduce intubation, ventilation, or mortality rates. High-flow nasal cannula is recommended as a first-line therapy for these patients.

Introduction

Trauma is a significant contributor to mortality and poses a substantial social issue. In low- and middle-income countries, it accounts for 11% of all disability-adjusted life years.[1] Blunt thoracic trauma accounts for a quarter of trauma-related mortality. Lung contusion is the most frequent type of lung injury caused by blunt chest trauma.[2,3] Lung contusion occurs when rapid deceleration affects the human body, leading to injury of alveolar capillaries and subsequent leakage of blood into the pulmonary tissues, all without resulting in laceration of the lung tissue.[4] This condition can cause hypoxia due to impaired gas exchange from accumulated fluid in the pulmonary tissue.[5] It has been observed that 20% of patients with lung contusion develop acute lung injury,[6] and 50% of patients with significant lung contusion develop acute respiratory distress syndrome (ARDS).[7] Some cases may require intubation and mechanical ventilation to improve gas exchange and reduce the work of breathing.[8] The HFNC is an advanced delivery system that provides heated and humidified oxygen at a consistent FiO_2. This method offers several physiological benefits, including improved clearance of airway secretions, a positive end-expiratory pressure (PEEP) effect, and effective carbon dioxide elimination. The HFNC is increasingly utilized innovatively for critically ill patients experiencing respiratory failure.[9] The HFNC can deliver fresh gas flow (FGF) of 60 L/min with a fraction of inspired oxygen (FiO_2) reaching up to 1.0 HFNC has the potential to enhance oxygenation and ventilation, reduce anatomical dead space, provide modest PEEP.[10] The mechanical stress and strain imposed on the lungs due to excessive respiratory muscle activity have recently been

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Conflict of Interest: None

characterized as patient-self-inflicted lung injury (P-SILI).[11] The potentially harmful respiratory load placed on the fragile septic diaphragm can cause injury before intubation.[12] Various physiological effects of HFNC could potentially mitigate both mechanisms, preventing injury and promoting faster recovery.[13]

Aim

This study aims to compare the efficacy of a HFNC therapy vs a VM in patients suffering from hypoxia due to traumatic lung contusion and determine which method is more effective in reducing the necessity for intubation.

Materials and Methods

Study Location

A prospective randomized controlled clinical trial (RCT) conducted at the critical care unit of Ain Shams University from July 24, 2022, to December 28, 2023.

Trial Registration and Ethical Committee Approval

This trial was approved by the Ethical Committee of the Faculty of Medicine Ain Shams University (FAMSU R 116/2022) on August 18, 2022 "REC-FMASU@med.asu.edu.eg". The study was registered in the ClinicalTrials.gov database under ID number NCT05509088 https://clinicaltrials.gov/study/NCT05509088.

Randomization and Patient Allocation

The inclusion criteria for this study consisted of adults aged 18 years or older. Eligible participants were required to be hospitalized and receive medical care for blunt chest trauma within 24 hours of the injury, with a chest computed tomography (CT) scan confirming the presence of lung contusion. Additionally, they had to demonstrate hypoxemia, indicated by a PaO_2/FiO_2 ratio of 100 and 200 while breathing oxygen at an FGF rate of 10 L/min via an oxygen mask, or oxygen saturation (SpO_2) < 90% while on 10 L/min of oxygen, with a $PaCO_2 \leq 45$ mm Hg. Exclusion criteria included facial trauma, airway obstruction, chronic lung disease, intubation for any cause other than respiratory issues, hemodynamic instability, impaired consciousness, the need for emergency surgery, or the presence of a flail chest.

Study Interventions

Upon admission, patients were allocated to either: Group A (60 patients) received oxygen through a HFNC using the Precision Flow Hi-VNI (Vapotherm®, Inc.), or group B, the control group, which received oxygen therapy via a VM oxygen concentration adjusted to maintain SpO_2 >94%.

Sampling Size

By using power analysis and sample size software (PASS11) (V 11.0.08) for sample size calculation, setting the confidence level at 90% margin of error alpha error ± 0.05 and following the review of previous trials outcomes showing that intubation at 28 days was needed among patients who had an acute hypoxic respiratory failure (HRF) on HFNC vs those on oxygen masks (58.9% vs 24.7% respectively).[14] A sample size of 120 patients was sufficient, divided randomly into two groups (60 patients in each group).

Study Procedures

All patients in our study were initially managed according to Advanced Trauma Life Support guidelines. Once the emergency room (ER) team determined a patient to be stable, a chest CT scan was performed, along with any other diagnostic imaging procedures deemed necessary by the ER team. Following this, patients were transferred to the ICU, where their history was reviewed, and standard monitors were applied. The first arterial blood gas sample was also collected. An electrocardiography was performed for all patients, and echocardiography was conducted if a cardiac injury was suspected.

Upon enrollment, the severity of thoracic trauma was evaluated using the Thorax Trauma Severity Score (TTSS) (Table 1).[15] The extent of lung contusion was assessed by a radiologist and classified according to the Wagner and Jamieson grading system: lung contusion was considered mild when it involved less than 19% of total lung volume, moderate when it involved 19–27%, and severe when it involved 28% or more. This estimation was based on visual assessment, and any other significant findings from the CT chest were documented.

Management, including laboratory investigations and medications, was standardized according to our unit protocols. The mainstay of management was avoiding fluid overload after initial resuscitation, epidural, or paravertebral catheter if indicated by a numerical pain score of more than 4. Arterial blood gases were sampled daily unless the attending physician requested additional samples.

In this study, the HFNC group received oxygen initiated at a flow rate of 40 liters per minute and fractional inspired oxygen of 0.6, with the oxygen being humidified and heated to a temperature range of 34–37°C. Disconnection from the HFNC was minimized and allowed only for ambulation, and patients were instructed to maintain mouth closure throughout the therapy. In contrast, the control group received oxygen through traditional ventilation methods with the same fractional inspired oxygen of 0.6. Therapy continued in both groups as long as there were no signs of respiratory distress (defined as a Tachypnea with a rate

Table 1: Thorax trauma severity score (TTSS)[15]

Grade	*PaO_2/FiO_2*	*Rib fractures*	*Lung contusion*	*Pleura*	*Age*	*Points[a,b]*
0	>400	0	No	No	<30	0
I	300–400	1–3	Unilobar unilateral	Pneumothorax	30–41	1
II	200–300	>3 unilateral	Unilobar bilateral or bilobar unilateral	Hemothorax (unilateral) or hemo/pneumothorax (unilateral)	42–54	2
III	150–200	>3 bilateral	Bilateral <2 lobes	Hemothorax (bilateral) or hemo/pneumothorax (bilateral)	55–70	3
IV	<150	Flail chest	Bilateral >2 lobes	Tension pneumothorax	>70	5

[a]For calculation of the total score, the points allotted to each component are summed. [b]A minimum value is 0 points (when all five components have a zero score) and a maximum value is 25 points (when all five components have a score of five)

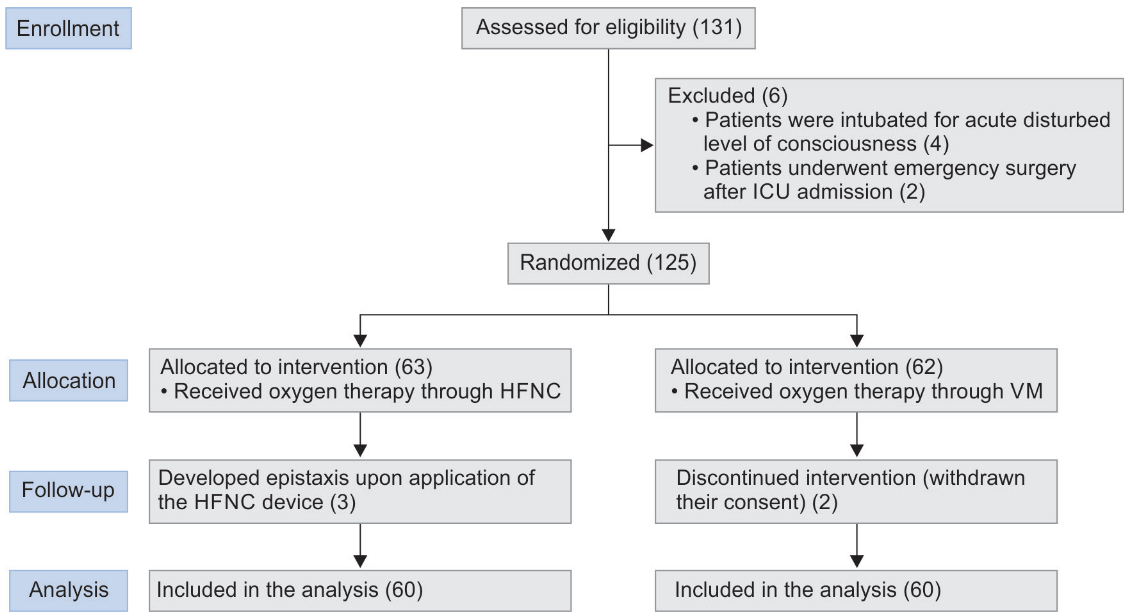

Fig. 1: Consort flowchart of the enrollment, randomization, and follow-up process in both study groups

of >30 breaths per minute, a PaO_2/FiO_2 ratio of 100 or less, or the use of accessory muscles for respiration); if these signs appeared, intubation or a trial for noninvasive ventilation (NIV) was considered, classifying the therapy as a failure, with the decision for intubation left to the treating physician.

Weaning Protocol

For weaning from a HFNC, when the PaO_2/FiO_2 ratio exceeded 300 for 24 hours, fractional inspired oxygen was gradually reduced by 0.1 per hour until reaching 0.3, followed by a reduction in flow rate by 10 liters per minute per hour until it reached 10 liters per minute, as long as no signs of respiratory distress were present, after which patients were switched to standard nasal oxygen therapy with a flow rate of 6 liters per minute. Similarly, for weaning from traditional ventilation methods, fractional-inspired oxygen was reduced by 0.1 per hour until it reached 0.4, after which patients were transitioned to standard nasal oxygen therapy with a flow rate of 6 liters per minute.

Outcomes and Measurements

Detailed baseline data were recorded upon admission, including demographics, comorbidities, TTSS, PaO_2/FiO_2, and $PaCO_2$. The primary outcome was the rate of intubation and invasive ventilation. Secondary outcomes were 28 days mortality, length of stay (LOS) in the hospital, predictors of mortality, and predictors of time till discharge from hospital alive. The efficiency of HFNC in pulmonary oxygenation compared with VM (Evaluation was done through comparing PaO_2/FiO_2 values measured 1 hour after enrollment and every 24 hours till the end of the intervention).

Results

Inferential statistics were done using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY) and DATAtab Team (2024). DATAtab: Online Statistics Calculator. DATAtab e.U. Graz, Austria. URL https://datatab.net.

The study enrolled 131 patients with traumatic lung contusion, with three patients excluded due to the development of epistaxis upon application of the HFNC device. Additionally, four patients were intubated due to an acutely disturbed level of consciousness, two patients underwent emergency surgery after ICU admission, and two patients withdrew their consent (Fig. 1). Consequently, 120 patients were included in our study. There were no statistically significant differences between the two groups concerning demographic data and baseline characteristics at the time of inclusion (Table 2).

Subjects who received HFNC demonstrated a modestly lower, yet statistically nonsignificant, rate of intubation and mechanical ventilation compared to standard treatment: five patients (8.3%) vs nine patients (15.0%), respectively ($p = 0.255$) (Table 2). The HFNC group was associated with a lower, yet statistically nonsignificant, ICU, hospital stays, and mortality rate (Table 3).

Table 4 was used to determine the independent predictors of mortality; we conducted a multivariable binary logistic regression analysis. Age (odds ratio = 0.742, 95% CI = 0.612–0.900, $p = 0.002$), lung contusion score (odds ratio = 1.222, 95% CI = 1.078–1.384, $p = 0.002$), and APACHE score (odds ratio = 14.958, 95% CI = 2.219–100.841, $p = 0.006$) were found to be independent predictors of mortality. However, HFNC was not associated with mortality (odds ratio = 0.66, 95% CI = 0.094–3.829, $p = 0.589$). There was a statistically significantly higher PaO_2/FiO_2 ratio in the HFNC group as early as the 1st hour after the initiation of therapy, and thereafter. Then repeated measures analysis of variance (RM-ANOVA) to compare trends of the PaO_2/FiO_2 ratio between the two groups (Table 5 and Fig. 2). The assumption of sphericity was violated (Mauchly's $W = 0.001$, $p < 0.001$, Greenhouse-Geisser $\varepsilon = 0.305$, Huynh-Feldt $\varepsilon = 0.310$), so we applied the Greenhouse-Geisser correction. The within-subjects effects test showed a marginally statistically significant effect of time ($F = 3.006$, df = 1.83, $p = 0.057$). Kaplan Meier curve for time to the event of improvement of PaO_2/FiO_2 to be >300 between two groups shows statistical significance by log-rank test (Fig. 3).

Table 2: Baseline data of both study groups

Variable		*HFNO (N = 60)*	*Control (N = 60)*	*p-value*
Age (years)	mean ± SD	39.7 ± 7.6	41.2 ± 7.9	0.280
Male sex	*n* (%)	49 (81.7%)	47 (78.3%)	0.648
Weight (kg)	mean ± SD	92.7 ± 13.4	94.4 ± 14.0	0.498
Height (cm)	mean ± SD	173.0 ± 4.2	171.8 ± 4.9	0.131
BMI (kg/m²)	mean ± SD	31.0 ± 5.0	32.1 ± 5.3	0.266
Smoker	*n* (%)	42 (70.0%)	39 (65.0%)	0.559
Mechanism of injury				
Motor vehicle accident	*n* (%)	56 (93.3%)	55 (91.7%)	>0.999
Fall from height		4 (6.7%)	5 (8.3%)	
CT findings				
Rib fracture		54 (90.0%)	57 (95.0%)	0.491
Pneumothorax	*n* (%)	23 (38.3%)	13 (21.7%)	0.046
Hemothorax		20 (33.3%)	25 (41.7%)	0.346
Lung contusion grade				
Nil		0 (0.0%)	0 (0.0%)	>0.999
Unilateral unilobar		50 (83.3%)	50 (83.3%)	
Unilobar bilateral or bilateral unilobar	*n* (%)	8 (13.3%)	8 (13.3%)	
Bilateral < 2 lobules		2 (3.3%)	2 (3.3%)	
Bilateral ≥ 2 lobules		0 (0.0%)	0 (0.0%)	
Thorax trauma severity score (TTSS)	Median (1Q, 3Q)	9 (9,10)	9 (9,10)	0.138
Wagner and Jamieson lung contusion score (%)	mean ± SD	12 ± 7	13 ± 6	0.463
Respiratory rate	mean ± SD	18 ± 2	18 ± 2	0.512
$PaCO_2$ on admission (mm Hg)	mean ± SD	35 ± 5	36 ± 6	0.503
PaO_2/FiO_2 on room air	mean ± SD	125.7 ± 19.8	126.4 ± 16.8	0.834
Hemoglobin (gm/dL)	mean ± SD	12.1 ± 1.1	11.8 ± 1.2	0.228
Serum creatinine (mg/dL)	mean ± SD	0.93 ± 0.13	0.91 ± 0.17	0.579
APACHE score	Median (1Q, 3Q)	4 (4,5)	4 (4,5)	0.136

Values are presented as mean ± SD or median (1Q, 3Q). APACHE, acute physiology and chronic health evaluation; BMI, body mass index; CT, computed tomography; HFNO, high-flow nasal oxygen; $PaCO_2$, partial pressure of carbon dioxide; PaO_2/FiO_2, ratio of arterial oxygen partial pressure to fraction of inspired oxygen. For the groups: *N*, number of participants; *n*, number of occurrences

Table 3: Main outcome measures in both groups

Variable		*HFNO (N = 60)*	*Control (N = 60)*	*p-value*
Need for intubation and mechanical ventilation	*n* (%)	5 (8.3%)	9 (15.0%)	0.255*
ICU stay (days)	median [IQR]	6 (5,7)	6 (5,7)	0.662†
Hospital stays (days)	median [IQR]	11 (10,12)	12 (10.75,13)	0.117‡
Mortality	*n* (%)	3 (5.0%)	6 (10.0%)	0.491§

Values are presented as the number of occurrences (%) or median (1Q, 3Q). HFNO, high-flow nasal oxygen; ICU, intensive care unit. *Pearson chi-squared test, $\chi^2 = 1.2938$. †Pearson chi-squared test, $\chi^2 = 1.0811$. ‡Mann–Whitney *U* test ($U = 1716$, $r = 0.04$, large effect). §Mann–Whitney *U* test ($U = 1500.5$, $r = 0.15$, small effect)

Table 4: Multivariable binary logistic regression for predictors of mortality

Variable	*B*	*SE*	*Wald*	*p-value*	*Exp(B)*	*95% CI*
HFNO (=1)	–0.511	0.946	0.292	0.589	0.600	0.094–3.829
Age (years)	–0.298	0.098	9.185	0.002	0.742	0.612–0.900
Wagner and Jamieson lung contusion score (%)	0.200	0.064	9.842	0.002	1.222	1.078–1.384
APACHE score	2.705	0.974	7.721	0.006	14.958	2.219–100.841
Constant	–6.795	3.300	4.241	0.040		

Values are presented as B (regression coefficient), SE (standard error), Wald (wald statistic), *p*-value, Exp(B) (odds ratio), and 95% confidence interval (CI). APACHE, acute physiology and chronic health evaluation; HFNO, high-flow nasal oxygen

Table 5: PaO_2/FiO_2 ratio over time

Time	*Mean ± Std.*	*95% CI for Mean*	*T-statistic*	*p-value*	*F-ratio*	*p-value*
PaO_2/FiO_2 on admission (room air)						
HFNO	125.73 ± 19.78	120.62–130.84	–0.21	0.831*		
Control	126.45 ± 16.77	122.12–130.78				
PaO_2/FiO_2 at 1st hour						
HFNO	210.38 ± 46.47	198.38–222.39	4.71	<0.001*		
Control	173.42 ± 39.26	163.27–183.56				
PaO_2/FiO_2 day 1						
HFNO	217.42 ± 43.05	206.3–228.54	5.86	<0.001*		
Control	175.83 ± 33.19	167.1–184.56				
PaO_2/FiO_2 day 2						
HFNO	227.33 ± 42.86	215.96–238.71	6.49	<0.001*	4.84	<0.001†
Control	180.3 ± 32.45	171.43–189.16				
PaO_2/FiO_2 day 3						
HFNO	295.56 ± 33.08	286.61–304.51	–7.39	<0.001*		
Control	234.21 ± 51.35	219.9–248.52				
PaO_2/FiO_2 day 4						
HFNO	330.93 ± 40.84	319.88–341.98	8.24	<0.001*		
Control	251.04 ± 58.02	234.7–267.37				
PaO_2/FiO_2 day 5						
HFNO	339.35 ± 39.66	328.62–350.07	3.97	<0.001*		
Control	312.82 ± 27.62	305.05–320.6				

Values are presented as mean ± SD and as a 95% confidence interval (CI). PaO_2, partial pressure of arterial oxygen; FiO_2, fraction of inspired oxygen. *p-value for a two-sample t-test at each time point. †p-value for repeated measures ANOVA

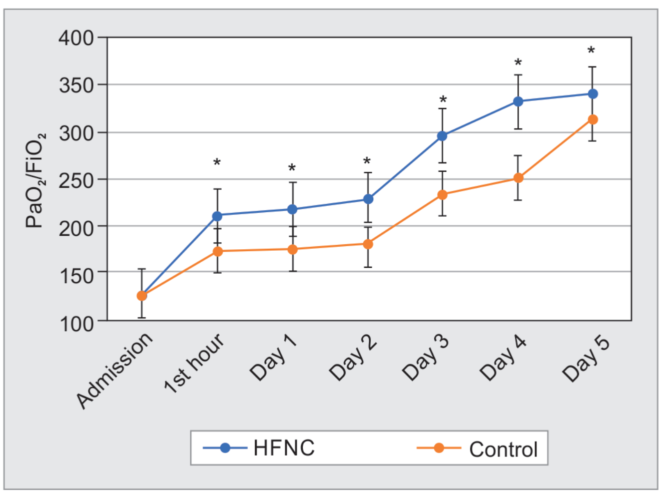

Fig. 2: Mean PaO_2/FiO_2 over timeline graph with standard error A mixed model ANOVA was performed to test whether there was a significant difference between groups (repeated measures). Admission: Statistically substantial differences "marked by asterisk *" were found at each time point after admission ($p < 0.001$). Time Points: PaO_2/FiO_2 at hour 1, hour 24, hour 48, hour 72, hour 96, and hour 120

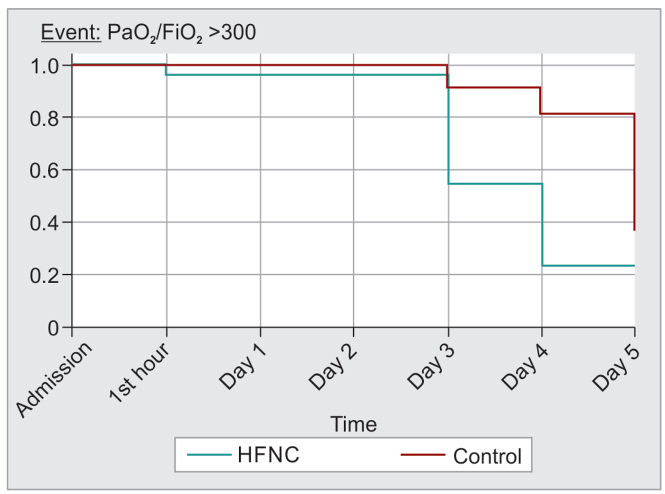

Fig. 3: Kaplan–Meier curve for time to event: Survival analysis according to Kaplan–Meier curve showing the time to event ($PaO_2/FiO_2 > 300$) and statistical significance by log-rank test ($p < 0.001$)

Discussion

The American College of Physicians recommends that clinicians opt for high-flow nasal oxygen (HFNO) over NIV when managing acute hypoxemic respiratory failure in hospitalized adults.[10] However, limited studies have shown the beneficial effects of HFNC in patients with thoracic trauma, particularly blunt trauma.[16,17] Its impact on lung contusions has not been specifically studied. Our results suggest that while HFNC efficiently improved oxygenation, it did not reduce mortality or hospital LOS in patients with lung contusions following blunt chest trauma. Additionally, we found that the extent of PC, as evaluated by the Wagner and Jamieson lung contusion score, was a significant predictor of mortality and an independent predictor of the time to discharge from the hospital alive.[18]

In the current study, the application of HFNC therapy was linked to a slight reduction in, yet statistically non-significant, rate of intubation. These findings are consistent with the finding that applying HFNC in patients with hematological malignancies presenting with HRF did not statistically reduce the intubation incidence compared to oxygen therapy delivered by nasal prongs or a VM.[19] Similarly, in a meta-analysis of nine studies involving mixed populations with acute respiratory failure, the intubation rates showed a nonsignificant difference between HFNC and conventional oxygen therapy (either face mask or nasal cannula).[20]

In the context of traumatic lung injury, a retrospective study involving patients experiencing HRF following lung contusion, supported the role of HFNC therapy, reporting an intubation rate of 18%, aligning with other trauma literature on mechanical ventilation following non-invasive ventilation.[21] Notably, PC was reported in only 34% of patients in the study, limiting the evaluation of HFNC value in this specific group. Moreover, no significant difference in intubation rates was observed between HFNC and an oxygen mask in patients with HRF.[22] Interestingly, they noted that HFNC significantly reduced the intubation rate in a subgroup of cases with a PaO_2/FiO_2 ratio $\leq$ 200, finding a significant interaction between the PaO_2/FiO_2 ratio at the time of admission and intubation rates in a posthoc analysis.

Oxygenation improvement is primarily attributed to the (PEEP) effect, which can reach up to 3 cmH_2O for every 10 L/min of oxygen flow when the patient's mouth is closed.[23] The PEEP enhances functional residual capacity and reduces pulmonary shunting, thereby improving oxygenation.[24] Notably, by the 5th day, there was an improvement in the control group, supporting the theory that PC is typically self-limited and improves within 3–5 days. This suggests that supportive care, oxygen supplementation, avoiding fluid overload, and close observation are generally sufficient.[25]

We did not find any significant benefit of HFNC in reducing hospital LOS. Similarly, several other studies have provided low-certainty evidence, suggesting that HFNC may not reduce hospital LOS compared to conventional oxygen therapy.[26–28] These studies did not specifically focus on PC, nor did they assess the severity of lung contusion or its correlation with outcomes. Supporting the potential of HFNC in reducing ICU LOS, a retrospective study in a mixed medical and surgical population found that delaying HFNC initiation by one day increased ICU LOS by one and a half days. However, it is important to note that only 39.3% of the subjects in that study had thoracic trauma.[16] Additionally, another retrospective study found that a delay in the first use of HFNC was associated with increased hospital LOS in patients with blunt thoracic trauma.[21]

The extent of lung contusion was a predictor of hospital LOS, consistent with findings from previous studies.[29,30] However, this contrasts with a retrospective study that found extensive lung contusion was not a determinant of hospital LOS. However, they excluded patients with PCs only visible on CT scans, considering them clinically insignificant, which defines a different patient population from our study.[31]

Several studies have raised doubts about the survival benefits of HFNC in patients with respiratory failure.[16,19,32] Our study found that HFNC did not significantly reduce mortality compared to the VM. However, age, the extent of lung contusion, and APACHE score were independent predictors of mortality. Contrary to our findings, Frat et al.[14] Showed a significantly reduced mortality with HFNC compared to an oxygen mask in Type I respiratory failure, attributing this to lower intubation rates in the HFNC group.

PC is a recognized activator of toll-like receptor 4 (TLR4), which leads to a surge of inflammatory mediators and cytokines, e.g., (IL-1β, IL-6, IL-8), and an exaggerated immune response to nosocomial infections, known as the "second hit phenomenon."[33] It is also a strong predictor of ARDS, exhibiting 90% specificity when more than 20% of the total lung volume is compromised.[34] The correlation between the severity of lung contusion and patient prognosis has been studied before and found that a contusion occupying more than 50% of total lung volume was associated with significantly higher mortality.[35] In our study, the involvement of lung volume was relatively less than in the studies, likely leading to a better prognosis (mean $\pm$ SD: 12 $\pm$ 7% in the HFNC group and 13 $\pm$ 6% in the VM group).

Contrary to our findings, a retrospective study of 52 pediatric patients with PC resulting from blunt chest trauma found no direct correlation between lung condition and mortality.[36] However, their results cannot be generalized due to the specific age group studied and the typically favorable prognosis of blunt chest trauma in pediatric patients.[37,38] Furthermore, another retrospective study indicated a non-significant relationship between the severity of PC and the mortality rate. However, they did not detail how the extent or severity of the lung contusion was measured.[39] Notably, age was identified as an independent predictor of mortality in their study, aligning with our findings. Numerous systematic reviews have highlighted the lack of randomized controlled studies assessing the device's effectiveness and reported the absence of evidence to support its use.[40,41]

In adults admitted to the ICU with respiratory distress, HFNC has been proven to reduce hospital LOS and prevent intubation.[22,42] In the postoperative setting, HFNC is effective in terms of oxygenation when compared with other modalities of oxygen therapy.[43,44]

Limitations

The current study faces some limitations. Firstly, the small sample size and the study design were open-label. Secondly, a HFNC allows for more precise titration of the FiO_2, facilitating accurate calculation of the PaO_2/FiO_2 ratio, whereas this accuracy cannot be guaranteed in the VM group. Thirdly, the quantification of pulmonary consolidation was subjective to radiologist interpretation. Lastly, the pulmonary consolidation volume range relative to total lung volume was narrow thus limiting the evaluation of its correlation with clinical outcomes.

Conclusion

The early application of a HFNC in hypoxic patients with PCs following blunt chest trauma may improve pulmonary oxygenation. However, it does not surpass the VM in preventing intubation, reducing mortality, or shortening the length of hospital stay. We recommend that HFNC be considered the first-line oxygen therapy in these cases.

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