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ORIGINAL RESEARCH

High-flow nasal cannula oxygen therapy in the weaning of severe burn patients: a preliminary report of data collection

Coletta Francesco[1], Pota Vincenzo[2,*], Tomasello Antonio[1], Sala Crescenzo[1], Pirolli Rossella[3], Giovanna Paola De Marco[1], Foreste Giuseppe[1], Del Prete Maurizio[2], Iorio Vittoria[2], Sansone Pasquale[2], Coppolino Francesco[2], Passavanti Maria Beatrice[2], Pace Maria Caterina[2], Villani Romolo[1]

[1]UOC TIGU-CAV-Anesthesiology in Emergency AORN "A. Cardarelli", 80131 Napoli, Italy
[2]Department of Women, Child, General and Specialistic Surgery. University of Campania "L. Vanvitelli", 80138 Napoli, Italy
[3]ASL Caserta, 81100, Caserta, Italy

***Correspondence**
vincenzo.pota@unicampania.it
(Pota Vincenzo)

Abstract

Inpatient care of severely burned patients is associated with a high morbidity and mortality rate. Burns, especially severe ones, are accompanied by an immune and inflammatory response and drastic metabolic changes that are hard to manage, which can shortly lead to multiple organ failure as well as lung failure. Weaning from mechanical ventilation represents the transition period from total ventilatory support to spontaneous breathing and can be performed with different strategies. The objective of this prospective study is to evaluate the clinical conditions of a series of patients weaned from mechanical ventilation with the aid of high flow nasal cannulas.

Keywords

HFNC; Weaning; Burns

1. Introduction

Inpatient care of severely burned patients is associated with a high morbidity and mortality rate. Burns, especially severe ones, are accompanied by an immune and inflammatory response and drastic metabolic changes that are hard to manage, which can shortly lead to multiple organ failure as well as lung failure [1]. The burned patient is at risk for lung injury via several mechanisms: direct smoke inhalation injury, indirect damage due to inflammatory response associated with large burn and finally subsequent infection. Up to 34% of all of these patients requiring mechanical ventilation develop acute respiratory distress syndrome (ARDS) [2]. Traditionally, endotracheal intubation (ETI) with mechanical ventilation (MV) has been the first line therapy, usually followed by tracheostomy, for lung failure in the acute burn setting, but these procedures may have short-term and long term complications (tracheal stenosis, tracheoesophageal fistula, and barotrauma or suction-catheter injuries to the airway, pneumonia, dysphonia) [3]. Weaning from MV represents the transition period from total ventilatory support to spontaneous breathing, and it can be performed with different strategies [4]. It is essential, especially in the Burn Intensive Care Unit (BICU), to proceed with caution, according to the weaning criteria because the attempt of extubation, or multiple ones, if unsuccessful, are traumatic events for the already compromised balance of these patients. Following the BICU patient's extubation, ventilatory support might be put in place to achieve complete ventilatory autonomy without mechanical aids, a phase that is still part of the weaning period from MV. Oxygen therapy (with nasal catheter or mask oxygenation) and non-invasive positive pressure ventilation (NPPV) have been widely used as the pre-treatment and sequential treatment after weaning from MV in hypoxemic patients. However, traditional oxygen therapy has poor efficacy in the treatment of hypoxemia, and NPPV is complex to implement with lower comfort and tolerance along with high incidence of complications such as reflux and aspiration, which limits its application [5]. Recently, the clinical application of high flow nasal cannula (HFNC) device has received increasing attention. HFNC provide a humidified blend of air and oxygen, which gives respiratory support for adults suffering from acute respiratory failure, and as a bridge in patient extubation to achieve effective spontaneous breathing [6]. With simple operation, easy management, and high comfort and tolerance has become one of the main methods of Non Invasive Ventilation (NIV) for treating patients with respiratory failure in the intensive care unit (ICU). It offers an opportunity to avoid many of the complications related to invasive MV with conventional ETI. Skin necrosis is also a frequent problem in patients receiving NIV using various face masks or helmets for extended periods [7]. Preexisting facial injury, like burn related injury, further complicates use of masks or plugs. Nowadays, we have HFNC available as a suitable device for weaning and its use has been shown to significantly reduce post-extubation respiratory failure, decrease respiratory rate, and increase PaO_2 safely and during planned extubation [8]. The focus of this study is preliminary analysis of a data collection to evaluate the clinical

conditions of a series of patients weaned from MV with the aid of HFNC.

2. Materials and methods

This data collection for 12 burn patients was conducted according to the Declaration of Helsinki and Good Clinical Practice guideline. We analyzed patients from the Burn Intensive Care Unit (BICU) of the AORN Antonio Cardarelli Hospital of Naples during the period between January 2021 and January 2022. The inclusion criteria were: severe flame injuries (>30% of total body surface area-TBSA) burn involving the head and neck district; invasive MV.

We collected clinical data, comorbidities, body mass index (BMI), biochemical blood analysis, gas concentrations in arterial blood (entry-level and subsequent measurements) and modalities of ventilatory assistance of each patient (Table 1).

The data obtained were collected in an electronic database and differences in the ratio between partial pressure of O_2 in arterial blood (PaO_2) divided by the fraction (percent) of inspired oxygen expressed as a decimal (FiO_2), (P/F ratio) values before and after HFNC treatment.

MV was ensured up to improvements in American Burn Association (ABA) criteria and the extubation was scheduled behind a period of ventilatory stabilization, after complete weaning in pressure support ventilation (PSV).

All patients were extubated under sedation with continuous infusion of dexmedetomidine 0.6–1.2 mcg/kg/h. Extubation was followed by HFNC set at 34–37 °C and a flow ranging from 50–60 L/min. FiO_2 was selected to obtain a target of saturation of peripheral oxigen (SpO_2) ≥95%.

The endpoint was to evaluate the variation of lactate level in arterial blood and P/F ratio, since the stopping of MV until 48 hours later.

3. Results

In this study, 12 patients (7M, 5F) were enrolled. The mean age was 53 years (min 38, max 70, median 52), the mean duration of MV was 10.41 days (Standard Deviation, SD: 1.31 days, min 7, max 12, median 10.50). The mean baseline P/F ratio at the intubation was 142.66 ± 38.10 (min 95, max 200, median 142.7). After protracted MV, the P/F ratio of all patients increased (mean 369.33 ± 44.62, min 296, max 440, median 370). At the time of extubation, shortly before starting treatment with HFNC, the mean P/F ratio was 292.58 ± 41.25 (min 210, max 380, median 304) (Table 1).

Six hours after the beginning of the treatment with HFNC, no patient showed signs of respiratory distress or significant increases in blood of lactate levels, with a P/F ratio of 322.25 ± 39.98 (min 238, max 382, median 325). After 48 hours of oxygen therapy, patients showed a remarkable increase of P/F ratio compared with the begin of therapy, with a mean of 379.33 ± 31.56 (min 302, max 406, median 392.5) (Fig. 1). The assessment of lactate concentration did not significantly increase under oxygen administration by HFNC (Fig. 2). The increase of P/F ratio was incremental at 24, 48 and 72 hours, up to complete weaning from oxygen in 7 days.

4. Discussion

In this case series we have examined the possibility of using HFNC to enhance patient comfort after extubation, reducing the discomfort linked to interface devices and demonstrating a good compliance of patients, improving P/F ratio after extubation.

In burned patient, in combination with skin burns, inhalation injuries increase the incidence of pulmonary complications, such as compromised airway patency and respiratory failure, and they require adequate and timely airway management. These patients are also at risk for lung injury, both for direct causes and for invasive procedures such as ETI and tracheostomy. Furthermore, prolonged MV for critically ill patients is associated with adverse clinical outcomes such as the well-known ventilator associated pneumonia (VAP) [9]. When the VAP is associated with the very high intrinsic infective risk of the patient with extensive skin lesions, it implies a substantial increase in mortality in this cohort of patients. Consequently, in an attempt to reduce the morbidity and mortality associated with MV, clinical and research attention has focused on reducing the duration of MV by improving ventilator weaning processes.

In this study, after the admission to the BICU, all patients that met American Burn Association criteria as defined by the 2018 ABA guidelines were intubated and underwent to MV: hoarseness, stridor, sternal retraction, TBSA burn >40–50%, extensive and deep facial burns, burns inside the mouth, significant edema or risk for edema, difficulty swallowing, decreased level of consciousness, signs of respiratory compromise (inability to clear secretions, respiratory fatigue, poor oxygenation or ventilation) [10]. A total-body computed tomography scan was performed upon admission to the BICU, biochemical blood analysis and arterial blood gas analysis were also collected at different times of the hospitalization. During their hospitalization, all patients were treated with surgical escharotomy or eschar removal by bromelain based enzymatic debridement (Nexobrid®) and advanced skin lesion dressing [11]. The extubation was planned after a period of ventilatory stabilization and we have analyzed the efficacy of HFNC during the weaning.

Respiratory weaning requires the respect of the following parameters: the patient must have an adequate cough reflex; must not be subjected to any neuromuscular blocking agent; tracheobronchial secretion must be moderate and not indicative of infectious processes ongoing (to be verified with microbiological tests); none or moderate continuous infusion of sedative drugs; stable hemodynamic not supported by vasopressor and/or inotropic agents; central venous oxygen saturation ($ScVO_2$) >75%; SpO_2 >90% with FiO_2 <40%; minimal ventilation supports; positive end-expiratory pressure (PEEP) ≤8 cmH_2O; respiratory rate (RR) ≤35/minute; PaO_2 ≥60 and partial pressure of CO_2 in arterial blood ($PaCO_2$) ≤60 mmHg; no significant respiratory acidosis (pH ≥7.30); Hb >8 g/dL.

TABLE 1. Clinical data collection of BICU's patient of the AORN Antonio Cardarelli Hospital (Naples) treated with HFNC during the period between January 2021 and January 2022.

	Patient	Gender	Age	BMI	TBSA %	P/F in ETI base	P/F in ventila-tion	P/F in extubation	P/F HFNC 3 h	P/F HFNC 6 h	P/F HFNC 48 h	Days of Ventila-tion	Lactate mml/L on ventila-tion	Lactate mml/L on HFNC 3 h	Lactate mml/L on HFNC 6 h	Lactate mml/L on HFNC 48 h
	1	M	42	29	35	101	305	210	203	280	302	10	2.0	2.1	2.0	1.2
	2	F	38	33	30	200	440	309	312	380	396	9	0.9	1.0	1.1	1.0
	3	M	70	24	40	152	380	270	284	320	338	11	1.3	1.2	1.0	1.0
	4	M	52	34	35	160	350	305	302	330	357	8	2.2	1.8	1.2	1.0
	5	F	53	26	40	182	420	380	350	382	398	12	1.3	1.5	1.3	0.8
	6	M	48	28	30	170	402	311	315	345	401	11	0.8	1.2	1.0	1.9
	7	F	63	24	35	95	350	282	275	310	390	12	0.9	1.8	1.4	1.0
	8	M	57	23	40	136	336	249	245	301	402	9	1.7	2.0	1.8	1.0
	9	F	52	30	30	190	407	312	318	335	395	10	1.2	1.9	1.8	1.2
	10	M	49	29	40	108	360	305	301	338	378	12	1.0	1.4	1.2	0.9
	11	M	50	28	40	120	386	303	296	308	406	10	2.0	2.2	2.2	1.3
	12	F	65	35	40	98	296	275	226	238	389	11	2.3	2.5	2.0	1.8
Mean			53.2	28.5	36.2	142.6	369.3	292.5	285.5	322.2	379.3	10.4	1.4	1.7	1.5	1.1
sd			9.2	3.9	4.3	38.1	44.6	41.2	42.1	39.9	31.5	1.3	0.5	0.4	0.4	0.3
CI			5.6	2.3	2.6	23.0	26.9	24.9	25.4	24.1	19.0	0.7	0.3	0.2	0.2	0.2

BICU: Burn Intensive Care Unit; HFNC: High Flow Nasal Cannula; BMI: Body Mass Index; TBSA %: Total Body Surface Area %; P/F: PaO_2/FiO_2 ratio; ETI: Endotracheal intubation. M: Male; F: Female; CI: Confidential Interval.

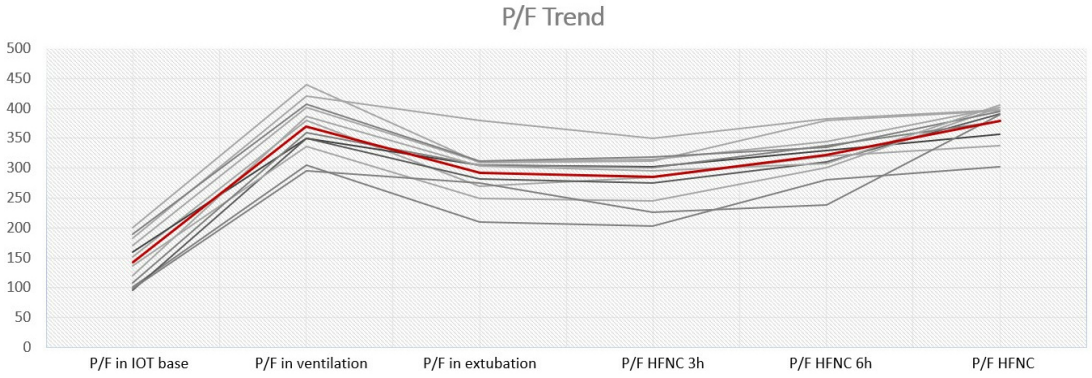

FIGURE 1. P/F ratio trend. HFNC: high flow nasal cannula; IOT: Orotracheal Intubation.

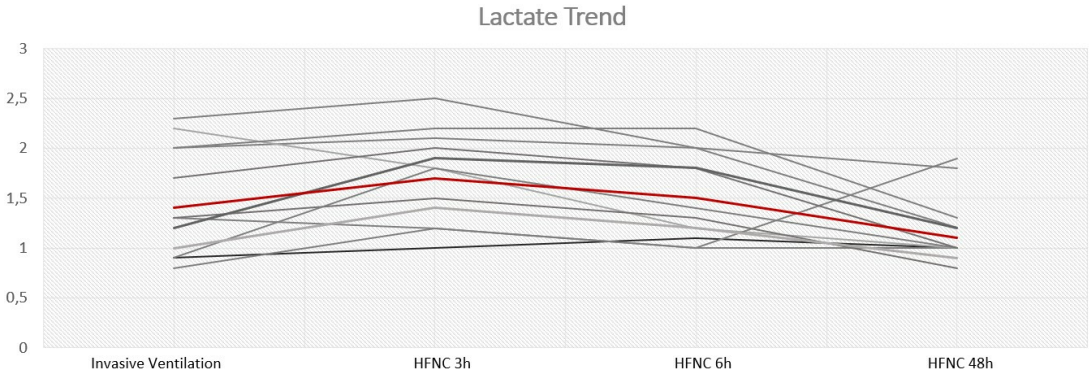

FIGURE 2. Lactate trend.

When all of these criteria are met, a spontaneous breathing test is performed by PSV with low pressure level, lasting at least 30 minutes up to 2 hours. If the patient continues to be hemodynamically stable and has blood gas analysis values that fall within the parameters above, extubation can be carried out [5]. The presence of serious injuries to the patient's back and/or severe limited burns to the head and neck areas make the adoption of such supports not feasible, impoverishing the therapeutic choices, which are uncomfortable and often painful in patients with head and neck II–III degree burns.

HFNC is a NPPV, that gives less probability of tracheal reintubation than conventional oxygen therapy (COT). However, there are not many large-scale studies that have compared HFNC and NPPV [12]. We agree that the use of HFNC operates a relative alveolar de-recruitment as a flow of 60 L/min develops a maximum PEEP of about 5 cmH_2O. Instead the MV can reach higher PEEP [11]. Several papers have been published regarding the management of the extubation procedure in patients with Sars-Cov2 pneumonia [13]. The use of HFNC in severe burn patients is almost unexplored, particularly as a bridge to effective spontaneous breathing after extubation. In fact, these cohort of patients often have deep skin lesions that do not allow the use of NPPV with full-face masks, thus reducing the opportunity for ventilatory support after extubation.

In this specific cohort of patients, the use of HFNC could represent a proper weaning strategy due to the reduced impact on facial skin lesions [5]. All patients had a gradual reduction in the concentration of O_2 in the administered air-O_2 mixture through HFNC. The concentration of lactates, which in these patients can also be high in the first days after the burn did not significantly increase compared to baseline [14, 15]. In addition, this low-contact interface allowed the patients to practice respiratory physical therapy (PT) through an incentive spirometer. Our clinical experience has suggested that gradual weaning from ventilatory support is desirable for patients with head, neck and airway burns. Therefore, the combined effect of HFNC and respiratory PT allowed a faster and more complete recovery of the patients in the study, compared to those who were treated only with passive PT, with a worse outcome. The manageability of the HFNC system allows greater comfort for patients because it reduces the contact area with the skin surface and the possibility of moderate changes in position; it is therefore particularly valuable for awake patients in the ICU environment and to easy nursing management. Moreover, it reduces risk of infections related to the plastic surfaces of the unit as they are smaller than other assisted ventilation tools. These characteristics necessarily translate into greater compliance by the patient both to support ventilation with nasal cannula and to rehabilitation techniques, especially when these involve the region of the head and neck. In this regard, the isometric forms of PT of the neck, shoulders and chest are facilitated thanks to the advantages offered by HFNC.

The preliminary result that we presented suggest that this method should be taken in serious prospective interest and further tested, in order to make this respiratory assistance a standard procedure in burn patient who needs the support of O_2.

The limitation of this study is the small size of the test sample. It is not possible to say that the use of HFNC is effective and safe in weaning from the MV of patients suffering from extensive burns of the head and neck district. We need such a wide multicentric randomized controlled trial in order to give strength to this technique in that specifical setting.

5. Conclusions

The study proposed a new approach to weaning and administering O_2 in patients with severe burns who cannot use full-face interface devices. We have examined that the use of HFNC improved patient comfort after extubation, reducing the discomfort linked to interface devices. The use of HFNC should be a reasonable therapeutic opportunity for weaning from ventilatory support; however, other supporting studies are desirable due to the limitation of this study and to the almost total absence of literature on the subject.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

CF, TA, SC, PR, GDM, FG—performed the research. PV, CF, PMC, VR—designed the research study. DPM, IV, SP, CP, PMB—analyzed the data. CF, PV—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

We obtained Ethics Committee "Università Federico II—AORN Cardarelli" approval n. 11.2022 for data analysis from patients and it was stored. We obtained the written consent for data collection.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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