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Effect of Post-Extubation Noninvasive Ventilation on Weaning Outcomes in Patients with Respiratory Failure Due to Chronic Obstructive Pulmonary Disease

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Abstract: Background: Mechanical ventilation is a daily event in any ICU, using NIV as a weaning facilitating strategy for mechanically ventilated patients after passing Spontaneous Breathing Trial (SBT) recently considered to reduce complications associated with invasive ventilation. Also NIV used early to avoid invasive ventilation especially with COPD patients. **Aim of the Work:** to compare the efficacy of noninvasive ventilation (NIV) to conventional strategy with face mask (FM) in preventing reintubation, if NIV is used immediately after elective extubation, in patients with respiratory failure due to chronic obstructive lung disease (COPD) requiring mechanical ventilation for more than 72 hours. **Patients and Methods:** A prospective randomized controlled study was carried out from June 2018 till May 2019, including 50 patients admitted to the intensive care unit at Ain Shams University hospitals. Approval of the ethical committee of Ain Shams University was obtained before the start of patient's recruitment. **Results:** The overall reintubation rate was 20%. Ten of the 50 evaluated patients were reintubated within 48 hours after extubation. The reintubation rate was different in each group. ICU length of stay was statistically different between the groups, with a mean of 8.6 ± 2.1 days in the NIV group and 10.8 ± 3.9 days in the FM group ($P = 0.024$). Hospital mortality rate (within about 30 days) showed a statistically significant difference between groups, with one death (4%) during hospitalization in the NIV group and seven (28%) deaths in the FM group ($P < 0.04$). **Conclusion:** Noninvasive ventilation compared with face mask alone prevented reintubation and decreased hospital mortality if done immediately after planned extubation in ICU patients requiring invasive mechanical ventilation for more than 3 days because of respiratory failure due to COPD.

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Key words: Post-extubation noninvasive ventilation, weaning, respiratory failure, chronic obstructive pulmonary disease

1. Introduction

Noninvasive ventilation (NIV) has been recently developed for the management of weaning/ extubation from invasive mechanical ventilation (MV) and post-extubation acute respiratory failure (ARF) [(1)], the main goal being to shorten intubation time and to prevent or avoid reintubation and subsequent complications. The weaning/extubation period represents an important clinical issue for clinicians and patients, and prediction of its outcome may be difficult in most weak patients.

Difficult weaning requiring a progressive withdrawal from MV may occur, in fact, in 25% of intensive care unit (ICU) patients [(2)] and in 40 to 60% of patients with chronic obstructive pulmonary disease (COPD) [(1)]. The weaning time may also account for up to 40% of the total invasive MV duration. Moreover, reintubation may be necessary within 48 to 72 hours in 5 to 25% of planned extubation, even if a spontaneous breathing trial (SBT) has been successful [(2)]. Reintubation represents an independent risk factor for nosocomial pneumonia, increasing ICU and hospital stay as well as mortality. So, the ICU clinician has to find the optimal compromise between the risks of undesired prolonged intubation and those of too early weaning and extubation process [(4)]. Therefore, any strategy with the aim of reducing morbidity and mortality of prolonged invasive MV or reintubation appears relevant and should be developed to improve patient prognosis.

Consequently, NIV has been evaluated as an early weaning and extubation technique in difficult-to-wean patients [(5)]. Despite encouraging results regarding the incidence of reintubation, complications, and patient outcome, the role of NIV in this indication remains debated.

A recent meta-analysis found that post-extubation noninvasive weaning strategy could be of potential benefit as compared with conventional face

mask, particularly in patients with COPD [6]. However, these authors acknowledged that larger controlled trials were still needed. In addition, despite the negative results of NIV to treat post-extubation ARF (i.e., rescue post-extubation NIV) in medical patients [7], the interest of this approach probably requires further evaluation in more selected medical populations.

This study conducted a prospective randomized multicenter study to investigate the effectiveness of NIV as a post weaning/extubation technique in patients with chronic hypercapnic respiratory failure (CHRF). This study also evaluated the role of rescue post-extubation NIV when a post-extubation ARF occurred in these patients.

Aim of the Work:

To compare the efficacy of noninvasive ventilation (NIV) to conventional strategy with face mask (FM) in preventing reintubation, if NIV is used immediately after elective extubation, in patients with respiratory failure due to chronic obstructive lung disease (COPD) requiring mechanical ventilation for more than 72 hours.

2. Patients and methods

Patients

This prospective randomized controlled study was carried out from June 2018 till May 2019, including 50 patients admitted to the intensive care unit at Ain Shams University hospitals. Approval of the ethical committee of Ain Shams University was obtained before the start of patient's recruitment.

Inclusion criteria

All patients who were admitted to the medical ICU of the critical care medicine, Ain Shams university, with respiratory failure (due to COPD exacerbation) and passed a successful spontaneous breathing trial after invasive ventilation ≥72 hrs duration were included in the study, after signing them / their kin approval to participate in the study.

Patients younger than 18 years, pregnancy, and patient's refusal to participate in the study., - Mechanically ventilated patients due to acute respiratory failure secondary to causes rather than acute exacerbation of COPD e.g.:, Cerebrovascular accidents., Post arrest., Primary metabolic disorders (renal failure, DKA, lac. acidosis) and chest trauma were excluded from the study.

Contraindications for the use of NIV, which are defined as: cardiac or respiratory arrest, severe encephalopathy (Glasgow coma scale < 10), bleeding of the upper gastrointestinal tract, hemodynamic instability or severe arrhythmia, facial surgery or trauma or deformity, severe upper-airway obstruction, inability to cooperate or protect the airways, inability to cough or clear respiratory secretions, absence of a gag reflex, and severe gastric distention.

Spontaneous breathing trial was done by placing the patient on PSV 10 cmH_2O, and peep 5 cmH_2O for a period of 30 minutes to maximum of 2 hours then to assess for success or failure of the trial.

Weaning protocol

The weaning protocol was based on a gradual reduction of pressure-support ventilation mode (PSV) combined with synchronized intermittent mandatory ventilation (SIMV). The adjustments of the mechanical ventilator were as follows: PSV to obtain an expiratory tidal volume of 8 ml/kg; SIMV with a respiratory rate of 10 and a tidal volume of 8 ml/kg, FIO2 ≤ 40%, PEEP required to obtain SaO_2≥ 90%, and pressure sensitivity of 0.5 cm H_2O. The pressure-support level was decreased by 2 cm H_2O every 2 hours until a PSV of 10 cm H_2O was reached. If f/TV >105, PSV was increased to the previous value for a minimum period of 6 hours, after which the protocol was then resumed. In the cases in which PEEP exceeded 5 cm H_2O, it was gradually decreased by 2 cm H2O every 6 hours until a value of 5 cm H_2O was reached.

The patient was considered ready for extubation, which was carried out in PSV of 10 cm H_2O, PEEP 5 cm H_2O, $SaO_2 \geq 90\%$, $FIO_2 < 40\%$, and f/TV < 105.

Methods

Patients who succeeded SBT trial and successfully extubated were equally randomized (sequential) to enter either NIV GROUP or FM GROUP.

NIV Group

Dräger savina 300 non dedicated ventilator with silicone full-face mask with two adult sizes: medium and large was used. First, to reduce the risk of aspiration, the head of the bed was raised to an angle of 45º and was kept elevated during NIV.

Then, the full-face mask was softly placed over the patient's face and was kept in position by a nurse for a few minutes until the patient was comfortable and completely synchronized with the ventilator. The mask was then secured by head straps to avoid a tight fit to the patient's face.

NIV was administered with a BiPAP in spontaneous mode for a period of 24 hours. After this period, it was replaced by a nebulization face mask with a flow of 5 L/min. For all patients, the initial expiratory positive airway pressure (EPAP) and delta inspiratory positive airway pressure (IPAP) values were 4 cm H_2O and 8 cm H_2O, respectively. Values were adjusted whenever required. In cases of hypoxemia, with $PaO_2 \leq 60$ mm Hg and/or $SaO_2 \leq 90\%$, EPAP was increased by 2 cm H_2O until hypoxemia improved, as well as the IPAP level (aim for maximum level ≤ 30 cm H_2O), to maintain the

delta inspiratory pressure value. IPAP was increased or decreased according to the F/TV ratio, or in cases of hypoventilation with $PaCO_2 \geq 50$ mm Hg, IPAP was increased until hypoventilation improved with minimal air leakage (15-30 L/min).

Patients who required NIV more than 24 hrs was excluded from our current study and replaced with another one.

FM Group

Patients received oxygen immediately after extubation through a conventional facial mask with a flow of 5 L/min, to be increased if needed according to patient's S_aO_2(target ≥92). If patients considered failure of weaning on FM, we put NIV before reintubation if needed. Each patient of both groups was subjected to the following daily; Thorough clinical examination. Needed laboratory investigations according to patient's clinical condition (Na, K, Ca, Mg, Po4, Urea, Cr, Hb). Arterial blood gas (ABG) analysis (immediately, 2hrs, 6 hrs, 12 hrs, 24 hrs.post extubation for 1st 24 hrs.) then daily morning or if needed. The following was recorded Demographic data (age and gender). Duration of mechanical ventilation before extubation. Co morbidities and precipitating factors that led to respiratory failure were recorded for all patients. Clinical data; (at postextubation, 2 hours, 6 hrs, 12 hrs, and 24 hours after extubation for all patients). Glasscow coma scale (GCS). Heart rate. Mean Arterial Blood Pressure (MAP). Respiratory rate (RR). Arterial Blood Gases (ABG) including (PH, S_aO_2, P_aO_2, P_aCO_2, HCO_3) to be recorded at (postextubation, 2 hrs, 6 hrs, 12 hrs, and 24 hrs after extubation for all patients).

Primary outcomes

Postextubation failure and reintubation with resumption of invasive MV (within 48 hrs).

Reintubation criteria

Reintubation required within a period of 48 hours after extubation was considered weaning failure in any study group. The decision for reintubation was made by the staff physician at the ICU, in the persistent presence of one or more of the following criteria: - Systolic arterial pressure ≥ 180 mm Hg or ≤ 90 mm Hg & Heart rate ≥ 140 beats/min. -Life-threatening arrhythmia. - Decreased level of consciousness or intense agitation requiring sedation. - Respiratory rate ≥ 30/min. - $P_aO_2 \leq 60$ mm Hg or $S_aO_2 \leq 90\%$ on F_IO_2 >50, $P_aCO_2 \geq 50$ mm Hg, pH < 7.2, or significant difficulty in eliminating respiratory secretions.

Statistical analysis

Data were analyzed using Statistical Program for Statistical Program for Social Science (SPSS) version 25.0 for windows (SPSS Inc., Chicago, IL, USA) and NCSS 12 for windows (NCSS LCC., Kaysville, UT, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage. P-value was considered statistically significant when it is less than 0.05.

3. Results

Table (1): Comparison between the studied groups regarding the mechanical ventilation data.

Mechanical ventilation data	NIV (N=25)	FM (N=25)	Test	P-value
Indication of MV				
Pneumonia	15 (60%)	14 (56%)	0.082	0.774
Non-compliance to maintenance TTT	4 (16%)	4 (16%)		1.000
Exposure to trigger	1 (4%)	3 (12%)		0.609
Natural progression of COPD	2 (8%)	2 (8%)		1.000
NSAIDs	1 (4%)	1 (4%)		1.000
Acute HF	2 (8%)	1 (4%)		1.000
MV duration (days)				
Mean ± SD	5.9 ± 2.0	6.5 ± 2.3	-0.781	0.435

Mean ±SD, Chi-square test & Fisher's Exact test.

The values of pre-extubation ventilatory mechanics showed no significant difference (p NS) (table 2).

Table (2): Comparison between the studied groups regarding pre-extubation ventilatory mechanics.

Pre-extubation ventilatory mechanics	NIV (N=25)	FM (N=25)	Test	P-value
PAP (cm/H_2O)				
Mean ± SD	32.4 ± 2.2	31.7 ± 3.0	0.918	0.363
PP (cm/H_2O)				
Mean ± SD	29.2 ± 2.9	27.8± 3.4	1.522	0.135
PO_2/FiO_2				
Mean ± SD	333.8 ± 18.9	335.8 ± 19.7	-0.367	0.715

Mean ±SD & Independent samples Student's t-test. PAP (peak airway pressure), PP (plateau pressure).

Analysis of mechanical ventilation data, days under invasive mechanical ventilation before weaning and diseases that led to respiratory failure showed no statistically significant differences between groups (table 3).

A 6 x 2 mixed ANOVA revealed a significant overall difference of the effect of the post-extubation method of ventilation (whether NIV or FM) on the pCO_2 (Arterial PCO2 was significantly higher in FM group than NIV group); F = 7.693, p = 0.008.

There was a significant difference between the effect of NIV vs FM on the pCO_2 immediately post-extubation, after 2 hours, 6 hours, 12 hours and 24 hours: p = 0.016, 0.010, 0.011, 0.048 and 0.006 respectively (table 3).

A 6 x 2 mixed ANOVA revealed a significant overall difference of the effect of the post-extubation method of ventilation (whether NIV or FM) on the PO_2 (Arterial PO_2 was significantly higher in NIV group than FM group); F = 6.421, p = 0.015.

There was a significant difference between the effect of NIV vs FM on the pO_2 mmediately post-extubation, after 2 hours, 6 hours, 12 hours and 24 hours: p = 0.009, <0.001, 0.001, 0.004 and <0.001 respectively (table 4).

Table (3): Comparison between the studied groups regarding the pCO_2 (mmHg).

pCO_2 (mmHg)	**NIV (N=25)**	**FM (N=25)**	Test	P-value
Pre-extubation				
Mean ± SD	53.8 ± 8.5	54.5 ± 5.4	-0.403	0.689
Immediately post-extubation				
Mean ± SD	53.0 ± 4.9	57.1 ± 6.3	-2.403	0.016 *
2 hours post-extubation				
Mean ± SD	52.9 ± 6.5	58.8 ± 9.3	-2.582	0.010 *
6 hours post-extubation				
Mean ± SD	52.5 ± 6.0	59.8 ± 11.3	-2.542	0.011 *
12 hours post-extubation				
Mean ± SD	52.2 ± 3.1	58.0 ± 9.8	-1.980	0.048 *
24 hours post-extubation				
Mean ± SD	54.4 ± 3.6	58.1 ± 4.5	-2.887	0.006 *

Mean ±SD & Independent samples Student's t-test. * Significant difference.

Table (4): Comparison between the studied groups regarding the pO_2 (mmHg).

pO_2 (mmHg)	**NIV (N=25)**	**FM (N=25)**	Test	P-value
Pre-extubation				
Mean ± SD	78.4 ± 7.0	79.8 ± 7.5	-0.804	0.422
Immediately post-extubation				
Mean ± SD	81.3 ± 4.9	77.0 ± 6.1	2.609	0.009 *
2 hours post-extubation				
Mean ± SD	80.5 ± 3.3	73.2 ± 6.4	5.086	<0.001*
6 hours post-extubation				
Mean ± SD	79.2 ± 6.4	72.7 ± 6.2	3.523	0.001 *
12 hours post-extubation				
Mean ± SD	75.0 ± 4.9	72.7 ± 3.2	2.841	0.004 *
24 hours post-extubation				
Mean ± SD	77.8 ± 6.1	71.0 ± 2.1	4.532	<0.001*

Mean ±SD & Independent samples Student's t-test. * Significant difference.

A 6 x 2 mixed ANOVA revealed a non-significant overall difference of the effect of the post-extubation method of ventilation (whether NIV or FM) on the HCO_3; F = 0.041, p = 0.841.

There was a non-significant difference between the effect of NIV vs FM on the HCO_3 immediately post-extubation, after 2 hours, 6 hours, 12 hours and 24 hours: p = 0.517, 0.606, 0.872, 0.845 & 0.551 respectively (table 9).

A 5 x 2 mixed ANOVA revealed a significant overall difference of the effect of the post-extubation method of ventilation (whether NIV or FM) on the MAP (MAP was significantly higher in FM group than NIV group); F = 9.152, p = 0.004.

There was a statistical significant difference between the effect of NIV vs FM on the MAP immediately post-extubation, after 2 hours; p = 0.02 and <0.001 respectively, meanwhile there was no

significant difference of MAP at 6 hours, 12 hours and 24 hours: p = 0.187, 0.057 & 0.117 respectively (table 5).

Table (5): Comparison between the studied groups regarding the MAP (mmHg).

MAP (mmHg)	NIV (N=25)	FM (N=25)	Test	P-value
Immediately post-extubation				
Mean ± SD	75.1 ± 5.9	79.5 ± 7.0	-2.403	0.020 *
2 hours post-extubation				
Mean ± SD	72.1 ± 4.5	82.1 ± 5.9	-5.963	<0.001 *
6 hours post-extubation				
Mean ± SD	75.5 ± 5.9	78.0 ± 7.5	-1.340	0.187
12 hours post-extubation				
Mean ± SD	76.2 ± 6.2	79.7 ± 5.3	-1.956	0.057
24 hours post-extubation				
Mean ± SD	76.3 ± 6.1	79.4 ± 6.5	-1.605	0.117

Mean ±SD & Independent samples Student's t-test. * Significant difference

A 5 x 2 mixed ANOVA revealed a significant overall difference of the effect of the post-extubation method of ventilation (whether NIV or FM) on the HR (HR was significantly higher in FM group than NIV group); F = 35.371, p<0.001.

There was a significant difference between the effect of NIV vs FM on the HR immediately post-extubation, after 2 hours, 6 hours, 12 hours and 24 hours: p = 0.029, <0.001, 0.006, 0.008 & 0.001 respectively (table 6).

Table (6): Comparison between the studied groups regarding the heart rate (beat/min).

Heart rate (beat/min)	NIV (N=25)	FM (N=25)	Test	P-value
Immediately post-extubation				
Mean ± SD	77.8 ± 12.6	85.4 ± 11.4	-2.253	0.029 *
2 hours post-extubation				
Mean ± SD	79.6 ± 12.6	93.3 ± 10.6	-4.106	<0.001 *
6 hours post-extubation				
Mean ± SD	78.4 ± 8.5	83.4 ± 8.3	-2.731	0.006 *
12 hours post-extubation				
Mean ± SD	78.4 ± 5.5	83.6 ± 6.8	-2.774	0.008 *
24 hours post-extubation				
Mean ± SD	78.3 ± 3.9	82.3 ± 3.1	-3.576	0.001 *

Mean ±SD & Independent samples Student's t-test. * Significant difference.

A 5 x 2 mixed ANOVA revealed a significant overall difference of the effect of the post-extubation method of ventilation (whether NIV or FM) on the RR (RR was significant higher in FM group than NIV group); F = 21.059, p < 0.001.

There was a non-significant difference between the effect of NIV vs FM on the RR immediately post-extubation, after 6 hours; p = 0.331 and 0.077 respectively while there was a significant difference after 2 hours, 12 hours and 24 hours: p <0.001, <0.001, 0.001 respectively (table 7).

Table (7): Comparison between the studied groups regarding the respiratory rate (breath/min).

Respiratory rate (breath/min)	NIV (N=25)	FM (N=25)	Test	P-value
Immediately post-extubation				
Mean ± SD	18.6 ± 2.7	20.2 ± 4.8	-0.972	0.331
2 hours post-extubation				
Mean ± SD	18.3 ± 4.8	24.9 ± 5.8	-4.695	<0.001 *
6 hours post-extubation				
Mean ± SD	16.5 ± 4.2	19.0 ± 5.3	-1.768	0.077
12 hours post-extubation				
Mean ± SD	18.0 ± 1.9	22.6 ± 5.3	-4.098	<0.001 *
24 hours post-extubation				
Mean ± SD	17.7 ± 1.5	20.7 ± 4.1	-3.312	0.001 *

Mean ±SD & Independent samples Student's t-test. * Significant difference.

The overall reintubation rate was 20%. Ten of the 50 evaluated patients were reintubated within 48 hours after extubation. The reintubation rate was different in each group. The causes for reintubation in both groups are (respiratory muscle fatigue, atelectasis, bronchospasm, decreased level of consciousness). Relative risk for reintubation (ratio of the incidence of reintubation among both groups) when using NIV after extubation was 0.25; Absolute risk reduction (the difference in event rate between the two groups) showed a decrease of 24% (Tables 8,9).

ICU length of stay was statistically different between the groups, with a mean of 8.6 ± 2.1 days in the NIV group and 10.8 ± 3.9 days in the FM group (P = 0.024) (table 8).

Hospital mortality rate (within about 30 days) showed a statistically significant difference between groups, with one death (4%) during hospitalization in the NIV group and seven (28%) deaths in the FM group (P < 0.04) (tables 8,10). It is necessary to stress that all patients that died (in both groups) had been reintubated. The causes of death were pneumonia associated with sepsis, acute heart failure, and multiple organ dysfunction syndromes.

Table (8): Comparison between the studied groups regarding the outcome.

Outcome	**NIV (N=25)**	**FM (N=25)**	Test	P-value
Weaning result				
Successful weaning	23 (92%)	17 (68%)	4.500	0.034 *
Weaning failure & re-intubation	2 (8%)	8 (32%)		
ICU stay (days)				
Mean ± SD	8.6 ± 2.1	10.8 ± 3.9	-2.260	0.024 *
Mortality				
Survivals	24 (96%)	18 (72%)		0.049 *
Deaths	1 (4%)	7 (28%)		

Table (9): Comparison between the studied groups regarding the probability to remain without re-intubation using Kaplan Meier curve.

Group	**Mean**				Log Rank (Mantel-Cox)	P-value (Sig.)
	Estimate	Std. Error	95% Confidence Interval			
			Lower Bound	Upper Bound		
NIV	155.080	8.764	137.903	172.257	4.208	0.040 * (S)
FM	118.840	14.382	90.651	147.029		
Overall	136.960	8.802	119.708	154.212		

* Significant difference.

Table (10): comparison between the studied groups regarding estimated hospital survival.

Group	**Mean**				Log Rank (Mantel-Cox)	P-value (Sig.)
	Estimate	Std. Error	95% Confidence Interval			
			Lower Bound	Upper Bound		
NIV	29.400	0.588	28.248	30.552	5.255	0.022 * (S)
FM	25.720	1.417	22.943	28.497		
Overall	27.560	0.810	25.972	29.148		

* Significant difference.

4. Discussion

Recent relevant published evidence revealed that in patients with a respiratory failure due to COPD, early extubation with immediate application of NIV has a positive impact on important outcomes, turning to advantage when compared with continuous invasive weaning [(7)]. Its use decreases the occurrence of ventilator-associated pneumonia, length of ICU and hospital stay, and total duration of mechanical ventilation, besides reducing patient mortality [(6)]. However, the benefit of using it immediately after usual or planned extubation instead of the face mask to prevent the occurrence of weaning failure has not been totally established.

We conducted a prospective randomized controlled study over 12 months duration starting from June 2018 till May 2019, at Ain Shams university hospitals, the study included 50 COPD patients mechanically ventilated ≥72 hrs due to respiratory failure and passed a successful SBT, patients were equally randomized before planned extubation into; 25 on non-invasive MV after extubation and 25 on conventional simple face mask with O2.

Our primary objective was to evaluate non-invasive ventilation immediately post planned extubation and its effect on clinical outcome and incidence of reintubation after weaning from. Our secondary objectives were to evaluate clinical outcome, ICU length of stay and hospital mortality.

Our results showed higher P_aO_2 & lower PCO_2 in NIV group immediate, 2 hrs, 6 hrs, 12 hrs, and 24 hrs post extubation, and lower rate of reintubation compared to face mask group. ICU length of stay and hospital mortality was also significantly different between the groups, with a lower incidence in NIV group than FM group.

One small trial assessed noninvasive positive-pressure ventilation after extubation and found no benefit [8]. This study has limited generalizability because it included a high proportion of patients with self-extubations. The present study, however, showed that patients undergoing invasive mechanical ventilation for more than 72 hours (our mean mechanical ventilation time was 6 days), due to respiratory failure caused by COPD exacerbation, had a lower reintubation rate if NIV was immediately applied after extubation when compared with those undergoing conventional therapy with an oxygen mask (8% versus 32%). Our hypothesis is that the major cause for the high success rate in the NIV group was the early application of the ventilatory technique, immediately after a programmed extubation, which probably kept the upper airways open, improving ventilation and oxygenation, thus preventing the overload of the respiratory muscles, the development of atelectasis, ventilation/perfusion disorders, and respiratory distress. A critical issue related to the success of NIV in our study was the adjustment of IPAP and EPAP levels according to each patient's needs. IPAP was adjusted for ventilation adequacy, whereas EPAP was adjusted for the maintenance of airways and alveolar stability. These individualized adjustments to the levels of NIV support may have had a pivotal role in the avoidance of reintubation in our population.

It is necessary to stress that NIV must be used immediately after extubation to avoid respiratory failure and consequent reintubation after elective extubation. **Keenan and colleagues** [7] showed that if NIV is administered to patients that develop respiratory distress after extubation to face mask, NIV will not be able to prevent reintubation. Corroborating the results of Keenan and colleagues, **Esteban and colleagues** [3] showed that applying NIV to treat post-extubation respiratory failure in non-selected populations may not be effective and could even be deleterious. NIV is not indicated now in cases that develop respiratory failure after extubation. In this situation, patients should be reintubated and mechanically ventilated.

Four recent RCTs (randomized controlled trials) suggested benefit from noninvasive positive-pressure ventilation after extubation in patients who were at high risk of deterioration [1]. High-risk patients were defined differently among the RCTs: (a) older than 65 years, heart failure as the cause of intubation, or APACHE II score greater than 12 at the time of extubation [9]; (b) more than one of the following: failure of consecutive weaning trials, chronic heart failure, arterial pressure of carbon dioxide greater than 45 mmHg after extubation, more than one noncardiac comorbidity, or weak cough or stridor after extubation not requiring immediate intubation [1]; or (c) history of chronic respiratory disease with ventilation for more than 48 hours and hypercapnia during the spontaneous breathing trial [3]. Although the four trials defined higher risk differently, they reported consistent decreases in rates of reintubation and ICU mortality, but less benefit in terms of hospital mortality.

In our study, relative risk analysis showed beneficial results of the use of NIV immediately after extubation. The use of NIV to avoid reintubation in patients with respiratory failure due to COPD was approximately 4 times more frequent when compared with the face mask. According to our results, the use of NIV after our weaning protocol avoided reintubation in one of every four patients when compared with the FM group, justifying its use immediately after extubation from invasive mechanical ventilation in patients with respiratory failure that needed more than 3 days of mechanical ventilation.

Another crucial issue related to our study results was the finding that the hospital mortality rate was higher in the FM group. It is noteworthy that all patients who died had been reintubated, and the causes of death were pneumonia associated with sepsis, acute heart failure, and multiple organ dysfunction syndrome. This fact was previously reported in literature, indicating that reintubation is a risk factor for death in this population [3]. Therefore, all care should be taken to avoid reintubation after elective extubation in the ICU mechanical ventilation population setting.

Recently, **Vaschetto and colleagues** [10], reported a pilot study aimed to assess the feasibility of early

extubation followed by immediate NIV compared with conventional weaning, in 20 randomized patients with resolving respiratory failure. They observed that it is possible to extubate respiratory failure patients early with no significant statistical differences in extubation failure, ICU and hospital mortality, tracheotomies, septic complications, days and rates of continuous sedation, and ICU length of stay. As most of our patients (60% in both groups) had pneumonia as the main cause of acute respiratory failure, this recent study supports our favorable results.

Conclusions

Noninvasive ventilation compared with face mask alone prevented reintubation and decreased hospital mortality if done immediately after planned extubation in ICU patients requiring invasive mechanical ventilation for more than 3 days because of respiratory failure due to COPD.

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