NON-INVASIVE POSITIVE PRESSURE VENTILATION VERSUS CONVENTIONAL OXYGEN THERAPY AFTER EXTUBATION IN PATIENTS WITH HYPERCAPNIC RESPIRATORY INSUFFICIENCY

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ABSTRACT

The need of reintubation after extubation and discontinuation of mechanical ventilation (MV) is not uncommon and is associated with increased morbidity and mortality. **Non invasive positive pressure ventilation** (NIPPV) has been suggested as promising therapy to avoid respiratory failure after extubation. ***The aim of this work*** is to study the effectiveness of NIPPV compared to conventional oxygen therapy after planned extubation on the rate of reintubation as well as weaning outcome in patients with hypercapnic respiratory insufficiency. ***Patients and methods:*** This study was carried out at Chest Department, Zagazig University Hospitals during the period from September 2011 to August 2013. The study included 100 invasively mechanically ventilated patients with hypercapnic respiratory failure (69 males and 31 females). According to the applied therapy after extubation, the patients were randomly classified into two equal groups, ***Group I*** received NIPPV and ***GroupII*** received conventional oxygen therapy after extubation.

Results: The rate of reintubation in group I (18%) was significantly lower than in group II (38%). The mortality rate in group I (8%) was significantly lower than in group II (24%). After extubation, the duration of ICU stay in group I (3.48 ± 1.4 days) was significantly shorter than in group II (4.4 ± 1.32 days) but no significant difference between the stay duration in general medical floor of both groups. The rate of occurrence of the various therapy related complications (tracheotomy, postextubation stridor, VAP, arrhythmias and heamodynamic affection) was significantly lower in group I than in group II. Gastric distention (22%) and mask related complications (20%) occurred only in group I patients.

Conclusions: The use of NIPPV immediately after extubation in patients with hypercapnic respiratory insufficiency can decrease reintubation and mortality rate, duration of ICU stay and the rate of occurrence of the various therapy related complications especially tracheostomy and VAP.

Key words: NIPPV, Conventional oxygen therapy, extubation.

INTRODUCTION

Endotracheal intubation and mechanical ventilation is a life saving intervention used in patients with respiratory failure. Weaning, the process of liberating the patient from the endotracheal tube, must balance the risk of complications not only due to the delay in extubation but also due to premature discontinuation and so the need for reintubation **[1].**

In the vast majority, once there is improvement of the underlying indication, mechanical ventilation (MV) can be withdrawn abruptly. However, the need for reintubation in the next 48–72 h ranges from 13% to 19% because of postextubation respiratory failure **[2].**

Patients who require reintubation have been noted to have a significantly higher rate of complications than those who are successfully extubated on the first attempt. Postextubation respiratory failure is defined as the appearance of signs of respiratory distress within 48–72 h after planned extubation. It is broadly identified by one or more of the following features: increase in respiratory rate more than 50% from baseline with use of accessory muscles of respiration or abdominal paradox, pH less than 7.35 with $PaCO_2$ more than 45 mmHg, SpO2 less than 90% or PaO_2 less than 80 mmHg on FIO_2 more than or equal to 50%. It is obviously different from weaning failure in which a patient develops signs of respiratory or hemodynamic intolerance during a spontaneous breathing trial **[2].**

Postextubation respiratory failure can arise from airway and non airway causes, with the latter more common, and is associated with increased mortality **[3].**

Non invasive positive pressure ventilation (NIPPV) augments the inspiratory and expiratory flow and pressure, thereby increasing the tidal volume and unloading the inspiratory muscles. This leads to accomplishment of an efficient breathing pattern and improvement in hypoxemia and hypercapnia **[4].**

Reintubation is sometimes necessary for management of respiratory failure after extubation and is undertaken in 6–23% of patients within 48–72 h of planned extubation**.** Although reintubation could indicate increased disease severity, it is a risk factor for nosocomial pneumonia, mortality and extended hospital stay **[5].**

Therefore, it appears conceptually of interest to apply NIPPV following extubation in order to reduce the risks of prolonged MV and those of potential re-intubation in cases of postextubation acute respiratory failure (ARF). The efficacy and clinical benefit of NIPPV in the initial management of ARF, mainly hypercapnic, as well as the decrease

of nosocomial infections and antibiotics consumption in ICU with NIPPV are finally strong arguments for proposing this type of NIPPV strategy **[6].**

Noninvasive ventilation (NIV) has been used in different indications during withdrawal of mechanical ventilation to Advance extubation in patients with difficult or prolonged weaning, to prevent the development of post-extubation respiratory failure and to avoid re-intubation in patients who have developed post-extubation respiratory failure **[7]**.

The aim of the work was to study the effectiveness of noninvasive positive pressure ventilation (NIPPV) compared to conventional oxygen therapy after planned extubation on the rate of reintubation as well as weaning outcome in patients with hypercapnic respiratory insufficiency.

Patients:

This study was carried out at Chest Department, Zagazig University Hospitals during the period from September 2011 to August 2013.

Inclusion criteria:

The study included 100 invasively mechanically ventilated patients with hypercapnic respiratory failure (69 males and 31 females).

According to the applied therapy after extubation, the patients were randomly classified into two equal groups:

Group I received NIPPV after extubation.

GroupII received conventional oxygen therapy after extubation.

Methods:

On admission to respiratory intensive care unit (RICU) the following data were carried out and recorded for all patients:

1) Full medical history from the patient (if possible) or his relatives including smoking status, history of previous intubation and / or ventilatory support.
2) Full clinical examination.
3) Radiologic evaluation plain chest and heart X – ray and HRCT.
4) Ventilatory pulmonary function test.
5) Arterial blood gas analysis.
6) Laboratory investigations:

a- Liver and kidney function tests.

b- Complete blood count (CBC).

c- Serum electrolytes (Na, K). Presence of other co morbidities.

7) Previous polysomnography if available with the patients.
8) Assessment of APACHE III score (Acute Physiology and Chronic Health Evaluation score).
9) Assessment of Glasgow Coma Score (GCS).
10) Assessment of Sequential Organ Failure score (SOFA).
11) Mechanical ventilation

All patients were intubated orally using an endotracheal diameter of 7.5 mm. Patients was on Synchronized Intermittent Mandatory Ventilation with pressure support mode (SIMV+PS). When patients fulfilled weaning criteria a 2 hours Spontaneous Breathing Trials (SBT) through T tube was performed. Patients were observed during the 2hs SBT for any signs of distress. Patients who showed no signs of distress with 2h SBT were, followed by extubation within 24 hours. Patients who revealed signs of distress were reventilated for 24hs and another weaning trial was done by gradual method of weaning.

12) NIPPV vs. Conventional oxygen therapy:

One hours after successful extubation arterial blood gases were repeated, and the patients were classified to receive either NIPPV or conventional oxygen therapy.

- ***Noninvasive Positive Pressure Ventilation (group I):*** All patients were ventilated using a ventilator specifically designed for NIPPV. A total face mask were applied to 35 patients and nasal mask to 15 patients. Inspiratory pressure support was initially set at 10 cmH_2O and then increased to the maximum tolerated with extrensic PEEP (2-6 cm H_2O). These settings aimed to achieve respiratory rate $\leq$ 25 breaths/min and satisfactory gas exchange, that is, arterial oxygen saturation (SaO_2) $\geq$ 90%, with pH $\geq$ 7.35. After the first 48 hrs, if patient is clinically stable, NIPPV was withdrawn.
- ***Conventional Oxygen Therapy (group II)***

Oxygen therapy was delivered through venturi mask to achieve $SaO_2 \geq 90\%$.

Patients also received standard medical treatment as bronchodilators, corticosteroids, mucolytics beside antibiotics if indicated to both groups.

Outcome:

The primary end point is the need for reintubation in the ICU. The secondary end points are ICU and hospital mortality or successful discharge.

Statistical analysis: Statistical analysis was performed with SPSS version19 software package (SPSS, Inc.Chicago). P value <0.05 was considered significant.

RESULTS

Statistically, there was no significant difference between the various demographic characteristics of both groups (tab. 1).

Table(1): Demographic characteristics of both groups.

Demographic characters		Group I NIPPV (n=50)		Group II Conventional O_2 therapy (n=50)		Student t test	
		Mean ± SD		Mean ± SD		t	p
Age (years)		58.4 ± 8.9		56.3 ± 10.0		1.08	0.28
		No	%	No	%	X^2	p
Sex	Male	35	70 %	34	68 %	0.05	0.82
	Female	15	30 %	16	32 %		
Smoking		12	24 %	17	34 %	1.2	0.27
Previous MV		6	12 %	8	16 %	0.044	0.84
Previous NIV		2	4 %	1	2 %	2.04	0.15
Co morbidities	**DM**	11	22 %	10	20 %	0.06	0.81
	HPN	9	18 %	12	24 %	0.54	0.46
	Cardiac	9	18 %	7	14 %	0.3	0.59
	Renal	4	8 %	5	10 %	0.12	0.73
	Hepatic	3	6 %	3	6 %	0.0	1.0

Also there was no significant differences between the corresponding percentages of the various causes of hypercapnic respiratory failure in both groups (tab.2).

Table (2): The percentages of the various causes of hypercapnic respiratory failure in both groups.

Causes of hypercapnic respiratory failure.	Group I NIPPV (n=50)		Group II Conventional O_2 therapy (n=50)		Chi-square test	
	No	%	No	%	X^2	p
COPD	29	58 %	33	66 %	0.00	1.0
Obstructive sleep apnea	7	14 %	5	10 %		
Bronchiectasis	10	20 %	6	12 %		
Bronchial asthma	4	8 %	6	12%		

The values of the various parameters of ABG (pH, PaO2, PaCO2 and SaO2) 24 hours after application of the corresponding therapy were significantly better in group I than in group II (tab. 3).

Table (3): The values of the various parameters of ABG (pH, PaO2, PaCO2 and SaO2) 24 hours after application of the corresponding therapy on the studied groups.

ABG parameters	Group I NIPPV (n=50)	Group II Conventional O_2 therapy (n=50)	Student t test	
	Mean ± SD	Mean ± SD	t	p
pH	7.37±0.05	7.34±0.05	2.8	0.005
PaO_2(mm Hg)	66.34±7.15	62.04±7.12	3.01	0.003
$PaCO_2$ (mm Hg)	52.86±8.02	57.66±8.55	2.89	0.005
SaO_2 (%)	92.9±1.9	91.29±2.2	3.9	0.001

APACHE II, GCS and SOFA scores **24** hours after extubation were significantly better in group I than in group II (tab.4).

Table (4): APACHE II, GCS and SOFA scores 24 hours after extubation in both groups.

Scoring systems	Group I NIPPV (n=50)	Group II Conventional O_2 therapy (n=50)	Student t test	
	Mean ± SD	Mean ± SD	t	P
APACHE II scores	21.6±1.6	22.88±2.75	-2.5	0.01
GCS	14.14±1.43	12.86±2.1	3.46	0.001
SOFA score	3.7±0.95	4.28±1.16	-2.6	0.016

The rate of reintubation in group I (18%) was significantly lower than in group II (38%) (tab.5).

Table (5): The rate of reintubation in both groups.

Need of reintubation	GroupI NIPPV (n=50)		Group II Conventional O_2 therapy (n=50)		Chi-square test	
	No	%	No	%	X^2	P
No need for reintubation	41	82%	31	62%	4.93	**0.026**
A Need of reintubation	9	18%	19	38%		

The mortality rate in group I (8%) was significantly lower than in group II (24%) (tab. 6).

Table (6): The mortality rate in both groups.

Outcome	Group I NIPPV (n=50)		Group II Conventional O_2 therapy (n=50)		Chi-square test	
	No	%	No	%	X^2	P
Survival	46	92 %	38	86 %	4.8	0.029*
Death	4	8 %	12	24 %		

After extubation, the duration of ICU stay in group I (3.48 ± 1.4 days) was significantly shorter than in group II (4.4 ± 1.32 days) but no significant difference between the stay duration in general medical floor of both groups (tab 7).

Table (7): The duration of stay (day) in each of ICU and general medical floor after extubation in both groups.

	Group I NIPPV (n=50)	Group II Conventional O_2 therapy (n=50)	Student t test	
	Mean ± SD	Mean ± SD	t	P
ICU stay (days)	3.48 ± 1.4	4.4 ± 1.32	-3.3	0.001
General medical floor stay (GMF) (days)	17.0 ± 3.8	18.4 ± 4.0	-1.78	0.077

The rate of occurrence of the various therapy related complications (tracheotomy, postextubation stridor, VAP, arrhythmias and hemodynamic affection) was significantly lower in group I than in group II. Gastric distention (22%) and mask related complications (20%) occurred only in group I patients (tab. 8).

Table (8): The rate of occurrence of the various therapy related complications in both groups.

Complications	Group I NIPPV (n=50)		Group II Conventional O_2 therapy (n=50)		Chi-square test	
	No	%	No	%	X^2	P
Tracheotomy	6	12%	14	28%	4.0	0.046
Postextubation stridor	3	6%	9	18%	3.4	0.65
Ventilator associated pneumonia	6	12%	15	30%	4.3	0.032
Arrhythmias	5	10%	13	26%	4.1	0.039
Heamodynamic affection	9	18%	19	38%	4.9	0.026
Gastric distention	11	22%	-	-	12.4	0.0001
Mask related complications	10	20%	-	-	11.1	0.001

DISCUSSION

Patients with respiratory failure often require mechanical ventilation to unload the respiratory muscles and support gas exchange until the pathophysiology leading to respiratory failure improves. Invasive ventilation maintains a patent airway but when used over a prolonged period of time might lead to many complications especially ventilator associated pneumonia. This, in turn, is associated with increased morbidity and trends towards increased mortality **[8].**

For these reasons, clinicians caring for patients who need invasive ventilation strive to reduce the duration of invasive ventilation while optimizing the chance for successful extubation **[9].**

Non-invasive ventilation provides an alternative method of supporting a patient's respiration by using positive pressure ventilation with either an oronasal, nasal, or total face mask at the patient-ventilator interface. Non-invasive ventilation preserves the patient's ability to speak and cough and has been shown to reduce complications related to intubation, especially ventilator associated pneumonia **[10].**

Similar to invasive ventilation, non-invasive ventilation can reduce the frequency of breathing, augment tidal volume, improve gas exchange, and rest the muscles of respiration **[11].** Non-invasive ventilation has been widely investigated as an initial treatment to prevent intubation and intubation related complications and improve clinical outcomes in selected patients **[12].**

So, the present work aimed to study the effectiveness of noninvasive positive pressure ventilation (NIPPV) compared to conventional oxygen therapy after planned extubation on the rate of reintubation as well as weaning outcome in patients with hypercapnic respiratory insufficiency.

From this study it was found that, the values of the various parameters of ABG (pH, PaO2, PaCO2 and SaO2) 24 hours after application of the corresponding therapy were significantly better in NIPPV group than in conventional oxygen therapy group. These detected findings are in agreement with ***Ornico et al.,*** **[14].** They found a higher PaO_2 and lower $PaCO_2$ in the NIV group compared with the OM group during the 24-hour period. In contrast ***Khilnani et al.,*** **[13]** found no statistical significance but better parameters of NIPPV group than conventional treatment group.

The present study revealed that, APACHE II, GCS and SOFA scores **24** hours after extubation were significantly better in NIPPV group than in conventional oxygen therapy group. This is in contrary with the conclusions of ***Ornico et al.,*** **[14]** who reported that there is no influence of NIPPV and conventional oxygen therapy on APACHE II scores.

From the present study it was found that, the rate of reintubation in NIPPV group (18%) was significantly lower than in conventional oxygen therapy group (38%). This finding is in agreement with some workers. ***Ferrer et al.,*** **[5]**. found that, respiratory failure after extubation was less frequent in patients assigned non-invasive ventilation than in those allocated conventional oxygen therapy (8 [15%] *vs* 25 [48%]) ($p<0.0001$). ***Ornico et al.,*** **[14]**found that , the rate of reintubation in NIPPV group was 5% and 39% in OM group ($P = 0.016$). Also in ***Ferrer et al.,*** **[15]** respiratory failure after extubation was less frequent in noninvasive ventilation group, (n=13, 16%) vs. (n=27, 33%) in conventional management with oxygen therapy group ($p = 0.029$). In contrast with the present study, in mixed populations of patients with respiratory failure after extubation, use of non-invasive ventilation to avoid reintubation was successful in fewer patients (28%) with no advantages noted over standard medical treatment **[16].**

From this study it was found that, the mortality rate in NIPPV group I (8%) was significantly lower than in conventional oxygen therapy group (24%). This is in agreement with some workers. ***Ornico et al.,*** **[14]** reported that hospital mortality rate showed statistically significant differences between the NIPPV group and the conventional oxygen therapy groups, with no deaths during hospitalization in the NIPPV group and four (22.2%) deaths in conventional oxygen therapy group. ***Ferrer et al.,*** **[15],** reported that, ICU mortality was 0% in NIPPV group and 18% in conventional oxygen therapy group ($p=0.003$). Hospital mortality was 4% in NIPPV group and 41% in conventional oxygen therapy group ($p=0.035$). A recent meta-analysis that revealed that, mortality rate was decreased in NIPPV group, and this decrease reached a statistical significance. However, subgroup analysis showed the effect of noninvasive weaning on mortality was significant only in COPD subgroup. One potential reason is that patients with COPD usually present chronic and stable pathologies, while patients in mixed group tend to present with acute pathological processes **[17].** On the other

hand, ***Esteban et al.,*** **[18]** and ***Girault et al.,*** **[19]** found no statistically significant differences between NIPPV group and conventional oxygen therapy group as regard ICU and hospital mortality.

The present study also revealed that, after extubation, the duration of ICU stay in NIPPV group (3.48 ± 1.4 days) was significantly shorter than in conventional oxygen therapy group (4.4 ± 1.32 days) but no significant difference between the stay duration in general medical floor of both groups This in agreement with the ***El Solh et al.,*** **[20]** who found that ICU stay in NIPPV group was (11.8±7.9) days and in conventional oxygen therapy group it was (18.2± 11.2) days ($p<0.001$). Hospital stay was (20.6±10.6) days in NIPPV group and (26.0± 11.3) days in conventional oxygen therapy group ($p=0.007$). ***Ornico et al.,*** **[14]** revealed no statistically significant differences as regard ICU stay, but it was less in NIPPV group (16.8±11.6 days) than in conventional oxygen therapy group(18.4±12.2days) ($p=0.68$). In contrast to this study, ***Ferrer et al.,*** **[15]** and ***Khilnani et al.,*** **[13]** found that noninvasive ventilation and conventional oxygen therapy didn't contribute significantly to the length of ICU and hospital stays.

From this study it was found that, the rate of occurrence of the various therapy related complications (tracheotomy, postextubation stridor, VAP, arrhythmias and heamodynamic affection) was significantly lower in NIPPV group than in conventional oxygen therapy group. Gastric distention (22%) and mask related complications (20%) occurred only in NIPPV group patients. This in agreement with the reported findings of ***Ferrer et al.,*** **[5].** They reported a higher frequency of VAP in patients with conventional therapy when compared with those receiving NIPPV. Also, in the study of ***Girault et al.*** **[19],** the most commonly reported complications were postextubation stridor, nosocomial pneumonia and atelectasis which were more in patients receiving conventional therapy when compared with those receiving NIPPV with no statistically significant differences between the studied groups. Gastric distention and mask intolerance were found in 7% in patients treated with NIPPV group. ***Ornico et al.,*** **[14]** reported that adverse effects related to the use of NIV were observed in two patients and were related to the nasal mask, consisting of ulceration at the nasal area with a good.

Conclusion: The use of NIPPV immediately after extubation in patients with hypercapnic respiratory insufficiency can decrease reintubation rate, mortality rate, duration of ICU stay and the rate of occurrence of the various therapy related complications especially tracheostomy and VAP.

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