

Noninvasive Ventilation After Extubation Improves Weaning Outcome After Respiratory Failure

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ABSTRACT

Background: The total prevalence of respiratory failure is unknown since it is a syndrome instead of a single disease happening. It's possible, but not certain, that race has an influence in the emergence of acute respiratory failure (ARF).

Aim: The purpose of the research was to contrast the efficiency of Noninvasive ventilation (NIV) with oxygen mask (OM) in individuals with ARF shortly following scheduled extubation.

Methods: The research was done between December 2012 and October 2014 at three different respiratory ICUs at the hospitals of Kasr Al-Ainy, El-Mehalla Chest, and El-Abbassia Chest. 56 cases with type II respiratory failure, who needed ventilator and intubation assistance for longer than two days, were included in the research; while 4 patients who had successfully extubated themselves were not. NIV group (26 patients): Cases were ventilated utilizing either a NIV ventilator or an ICU ventilator set to a pressure support ventilation mode with a PEEPext added. PEEPext was started at 5 cm H₂O and raised until oxygen saturation was maintained at >92% while P_{insp} was titrated to patient tolerance. Attaining these parameters (oxygen saturation 92 percent, respiratory rate 25 breaths/min, and pH > 7.35) was the goal. We increased the FiO₂ until we had a SaO₂ of 92%. Each patient wore a full-face mask while receiving treatment.

Results: NIV group had significantly lesser heart rate (HR) 1 hour after trial. HR non-significantly increased from MV to SBT in both groups. HR increased from SBT to 1 hour after trial in both groups, but the changes were significant only in SMT group.

Conclusion: Patients with chronic respiratory illness may benefit from utilization of non-invasive ventilation immediately following planned extubation as it decreases the rates of reintubation, VAP, and mortality in the ICU.

Keywords: Non-invasive ventilation; Extubation; Chronic respiratory disorders

INTRODUCTION

COPD is a kind of obstructive lung disease characterized by persistently reduced airflow; other names for this condition include chronic obstructive lung disease (COLD) and chronic obstructive airway disease (COAD). As time passes, it tends to get worse. Difficulty breathing, coughing, and mucous production are the primary indicators⁽¹⁾. The prevalence of COPD among those who suffer from chronic bronchitis is high⁽²⁾.

Approximately one-quarter of all deaths in the UK can be attributed to respiratory disorders. It is estimated that 20 percent or more of those with COPD admitted to the hospital for an exacerbation have respiratory acidosis. Rapid identification and treatment of acute ventilatory failure (AVF) can minimize morbidity and death, but this difficult-yet-common medical emergency is often misdiagnosed and hence left untreated⁽³⁾.

However, the true incidence of respiratory failure is unknown since it is a condition rather than a specific illness. The association among racial background and ARF is still up for discussion. Following controlling for variations in case mix, research by Khan *et al.*,⁽⁴⁾ stated no statistically significant variance in mortality amongst cases of Native Indian and Asian heritage who were hospitalized with acute critical illness.

Exacerbations of COPD by acidotic hypercapnic ventilatory failure are related to a significantly lesser risk of endotracheal intubation, hospital stay, and short- and long-term mortality if NIPPV is used⁽³⁾.

In instances of decompensated acute on chronic ventilatory failure, NIPPV is an effective first-line therapy for patients with conditions such as motor neuron disease, obesity-hypoventilation syndrome, muscular dystrophy, myopathies and chest wall problems such as kyphosis and thoracoplasty⁽⁵⁾.

Unfortunately, the prevalence of NIV use in ARF among the severely sick has only been the subject of a small number of epidemiological researches. To be more specific, there has been no population-based investigation of NIV's usefulness in a specific area⁽⁶⁾.

Our primary objective was to contrast the efficiency of NIV with OM in cases with ARF.

SUBJECTS AND METHODS

The research was done between December 2012 and October 2014 at three different respiratory ICUs at the hospitals of Kasr Al-Ainy, El-Mehalla Chest, and El-Abbassia Chest.

Inclusion criteria: Type II respiratory failure individuals who had been on a ventilator for greater than 48 hours (hrs) were evaluated.

Exclusion criteria: Patients in a coma, those with a cervical spine injury, those with neuromuscular illnesses, those who are aggressive or uncooperative, those whose anatomy prevents them from wearing a mask, those with uncontrolled cardiac ischemia or arrhythmias, those who have just undergone face

surgery, and those with active upper gastrointestinal bleeding.

Data of the patients: The following clinical and socioeconomic data were examined:

baseline features of participants before to their participation in the research: Age (years), smoking (pack/year), gender (M/F), APACHE-II score on admission, APACHE-II score at entry into the study, type of chronic respiratory disease: (acute exacerbation of COPD who presenting with type I or type II respiratory failure), other comorbidities: (Immunosuppression, chronic heart disorders, liver cirrhosis, diabetes mellitus, neoplasm, chronic renal failure), previous intubation, previous use of non-invasive ventilation in hospital and mechanical ventilation (days), and causes of mechanical ventilation (Congestive heart failure, pneumonia, postoperative respiratory failure, neurological disease, sepsis, others).

Variables of the patients' physiological states before to participation in the research: respiratory rate (breaths per minute), HR (beats per minute), systolic blood pressure (mm Hg), arterial pH, partial pressure of carbon dioxide (mm Hg), partial pressure of oxygen (mm Hg), and arterial blood gas analysis (ABG) once daily at 8 am and during the possibility of an alteration in ventilator settings or FIO₂; while being re-intubated; and at the time of discharge from the ICU.

Weaning-eligible patients who had a successful 2-hour T-piece SBT were enrolled.

Weaning criteria ⁽⁷⁾: Improvement or resolution of the fundamental reason for ARF, correction of arterial hypoxemia (partial pressure of arterial oxygen [PaO₂] >60 mm Hg at a fraction of inspired O₂ [FIO₂] < 0.4 and positive end-expiratory pressure < 5 cm H₂O), not having fever (>38°C) or hypothermia (<35°C), blood hemoglobin concentration of 70 g/L or greater, hemodynamic stability as well as alertness and capacity to communicate.

Pre- and post-T-piece trial arterial blood gas data were collected.

Weaning failure:

When one of the following conditions was met throughout a spontaneous breathing experiment, it was considered a failure. Breathing at a rate of more than 35 breaths per minute. Pulse oximetry indicating an arterial oxygen saturation of fewer than 90 percent at FIO₂ of 0.4 or more. Either a HR of greater than 140 or fewer than 50 per minute. A systolic blood pressure reading of either over 200 or below 70 millimeters of mercury. Reduction in alertness, excitement, or perspiration. The use of supplementary respiratory muscle, retraction of the intercostal gaps and paradoxical motion of the abdomen are all clinical symptoms that point to

Table (1): Comparison among examined groups regarding age, sex and special habits

respiratory muscle exhaustion, greater labor of breathing, or both ⁽⁸⁾.

The accompanying physicians also provided the patients with the regular medical therapy they deemed necessary.

NIV group (26 patients): Cases were ventilated utilizing either a NIV ventilator or an ICU ventilator set to a pressure support ventilation mode with a PEEPext added. PEEPext was started at 5 cm H₂O and raised until oxygen saturation was maintained at >92% while Pinsp was titrated to patient tolerance. Attaining these parameters (oxygen saturation 92 percent, respiratory rate 25 breaths/min, and pH > 7.35) was the goal. We increased the FiO₂ until we had a SaO₂ of 92%. Each patient wore a full-face mask while receiving treatment.

Ethical Approval:

The experiment was conducted after the Ethics Board at Cairo University gave its approval, and all necessary information was provided to the subjects. All research participants provided written informed permission. The Declaration of Helsinki, a global standard for the ethical conduct of medical research including human participants, has been followed throughout this investigation.

Statistical methods

The data that were obtained were then tabulated, coded, and statistically analyzed using IBM SPSS statistics (Statistical Package for the Social Sciences) software version 22.0, IBM Corp., Chicago, USA, 2013. For quantitative parametric data, descriptive statistics were calculated as the minimum and maximum of the range, the mean and standard deviation (SD). For quantitative non-parametric data, the median and the 1st and 3rd inter-quartile range (IQR) were calculated. For qualitative data, descriptive statistics were calculated as the number and percentage.

Data were handled using appropriate statistical tests of significance such as: Independent t-test and mann whitney test were used to calculate difference between quantitative variables in two groups, Paired t-test was used to compare between two dependent groups of normally distributed variables, Chi square test (χ²) and fisher exact was used to calculated difference between qualitative variables, Regression analysis using the stepwise method was used to determine the potential risk factor of hypomagnesemia and All statistical comparison were two tailed with significance level of p-value 0.05 indicates significant, p-value <0.001 indicates highly significant difference while p-value > 0.05 indicates non-significant difference.

RESULTS

No significant difference amongst study groups regarding age, sex and special habits (Table 1)

Measurement		NIV (N=26)	SMT (N=26)	P
Age	Mean±SD	60.3±11.0	60.5±11.0	#0.960

(years)	Range	43.0–83.0	45.0–87.0	
Sex	Male	22 (84.6%)	23 (88.5%)	^1.000
	Female	4 (15.4%)	3 (11.5%)	
Smoking	Smoker	17 (65.4%)	18 (69.2%)	^1.000
	Ex-smoker	5 (19.2%)	4 (15.4%)	
	Non-smoker	4 (15.4%)	4 (15.4%)	
Hashish		3 (11.5%)	4 (15.4%)	^1.000

#Independent t-test, ^Fisher Exact test

NVI: Noninvasive ventilation

SMT: Spinal manipulative therapy.

Figure 1 shows that there was no significant difference among NIV and SMT groups concerning respiratory rate during MV and SBT. NIV group had significantly lesser respiratory rate 1 hour after trial.

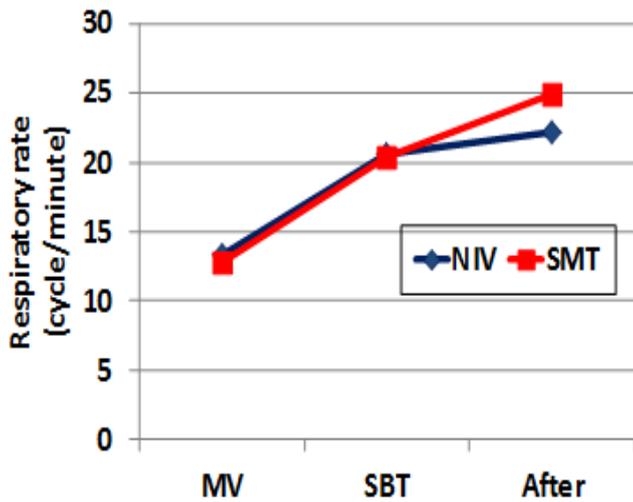


Figure (1): Mean respiratory rate of study groups.

NVI: Noninvasive ventilation

SMT: Spinal manipulative therapy

MV: Mechanical ventilation

SBT: Skin prick test

Table 2 and figure 3 show insignificant difference amongst NIV and SMT groups regarding HR during MV and SBT. NIV group had significantly lower HR 1 hour after trial. HR non-significantly increased from

MV to SBT in both groups. HR increased from SBT to 1 hour after trial in both groups, but the changes were significant only in SMT group.

Table (2): Comparison among study groups regarding heart rate (beat/minute)

Time	Measurement	NIV (N=26)	SMT (N=26)	P
MV	Mean±SD	100.2±9.3	101.9±9.0	# 0.500
	Range	82.0–117.0	80.0–120.0	
SBT	Mean±SD	97.2±12.2	99.8±8.8	# 0.387
	Range	73.0–121.0	78.0–120.0	
After	Mean±SD	98.2±12.1	108.7±17.2	# 0.014*
	Range	73.0–121.0	85.0–150.0	
SBT - MV	Median (IQR)	-2.0 (-10.0–3.0)	-1.0 (-10.0–10.0)	# 0.919
	Range	-29.0–16.0	-22.0–25.0	
	P	^0.139	^0.387	
After - SBT	Median (IQR)	1.0 (-9.0–10.0)	5.0 (-3.5–22.0)	# 0.150
	Range	-22.0–22.0	-12.0–45.0	
	P	^0.666	^0.008*	

#Independent t-test, ^Fisher Exact test

NVI: Noninvasive ventilation

SMT: Spinal manipulative therapy

Figure 2 shows non-significant distinction among NIV and SMT groups concerning systolic blood pressure during MV and SBT. NIV group had significantly lower systolic blood pressure 1 hour after trial. Systolic blood pressure significantly increased from MV to SBT in both groups. Systolic blood pressure significantly decreased from SBT to 1 hour after trial in NIV group, with no significant change in SMT group.

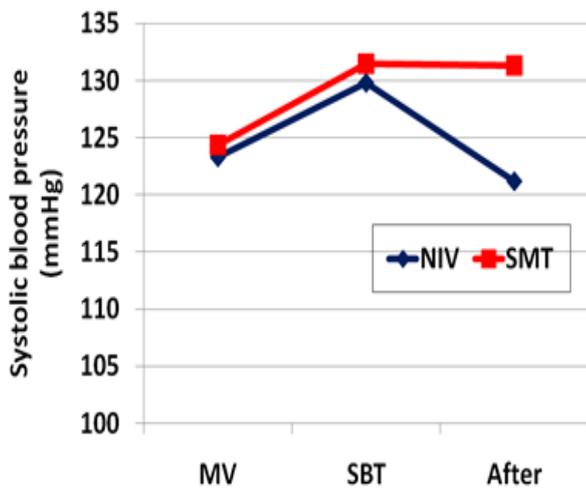


Figure (2): Mean systolic blood pressure of study groups

NVI: Noninvasive ventilation
SMT: Spinal manipulative therapy
MV: Mechanical ventilation
SBT: Skin prick test

Figure 3 shows that there was no significant difference amongst NIV and SMT groups as regards blood pH during MV and SBT. SMT group had significantly lower blood pH 1 hour after trial. Blood pH non-significantly decreased from MV to SBT in both groups. Blood pH non-significantly changed from SBT to 1 hour after trial in SMT group, but non-significantly increased from SBT to 1 hour after trial in NIV group.

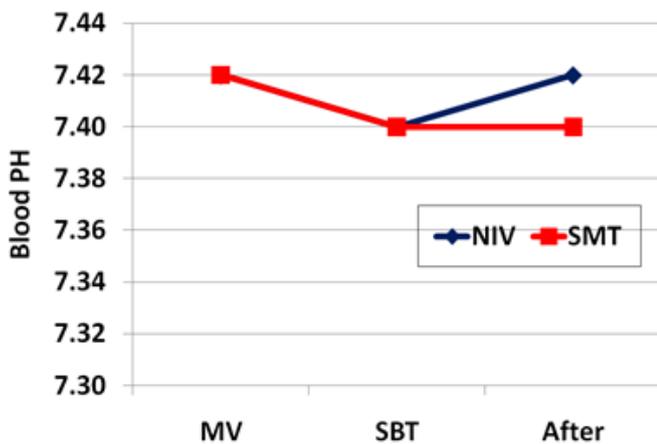


Figure (3): Mean blood pH of study groups

NVI: Noninvasive ventilation
SMT: Spinal manipulative therapy
MV: Mechanical ventilation
SBT: Skin prick test.

Figure 4 shows that there was no significant difference among NIV and SMT groups concerning PCO₂ during MV and SBT. SMT group had significantly higher PCO₂ 1 hour after trial. PCO₂ non-significantly increased from MV to SBT in both groups. PCO₂ increased from SBT to 1 hour after trial in both groups, but the changes were significant only in SMT group.

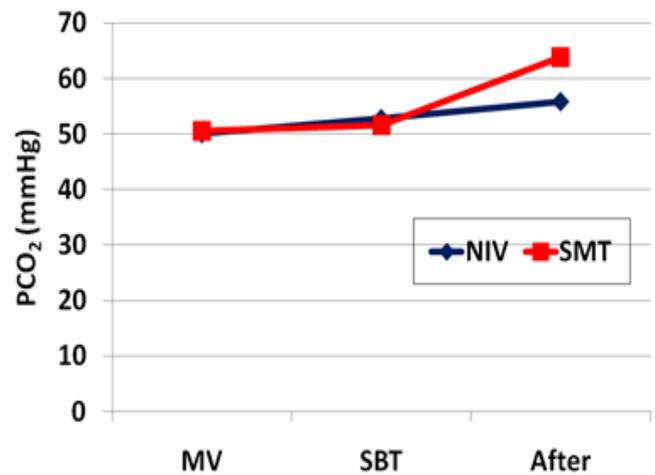


Figure (4): Mean PCO₂ of study groups

NVI: Noninvasive ventilation
SMT: Spinal manipulative therapy
MV: Mechanical ventilation
SBT: Skin prick test

No significant variance amongst NIV and SMT groups as regards PO₂ during MV and SBT. SMT group had significantly lower PO₂ 1 hour after trial. PO₂ non-significantly decreased from MV to SBT in both groups. PO₂ decreased from SBT to 1 hour after trial in both groups, but the changes were significant only in SMT group.

Figure 5 shows that there was no significant difference among NIV and SMT groups as regards SO₂ during MV and SBT. SMT group had non-significantly lower SO₂ 1 hour after trial. SO₂ significantly decreased from MV to SBT in both groups. SO₂ non-significantly decreased from SBT to 1 hour after trial in both groups.

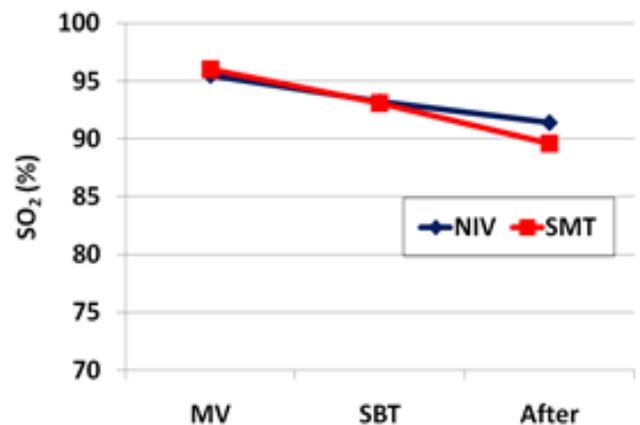


Figure (5): Comparison among study groups concerning SO₂

NVI: Noninvasive ventilation
SMT: Spinal manipulative therapy
MV: Mechanical ventilation
SBT: Skin prick test

Figure 6 shows that there was no significant difference among NIV and SMT groups concerning PO_2/FiO_2 during MV, SBT 1 hour after trial. PO_2/FiO_2 significantly increased from MV to SBT in both groups. PO_2/FiO_2 significantly decreased from SBT to 1 hour after trial in both groups.

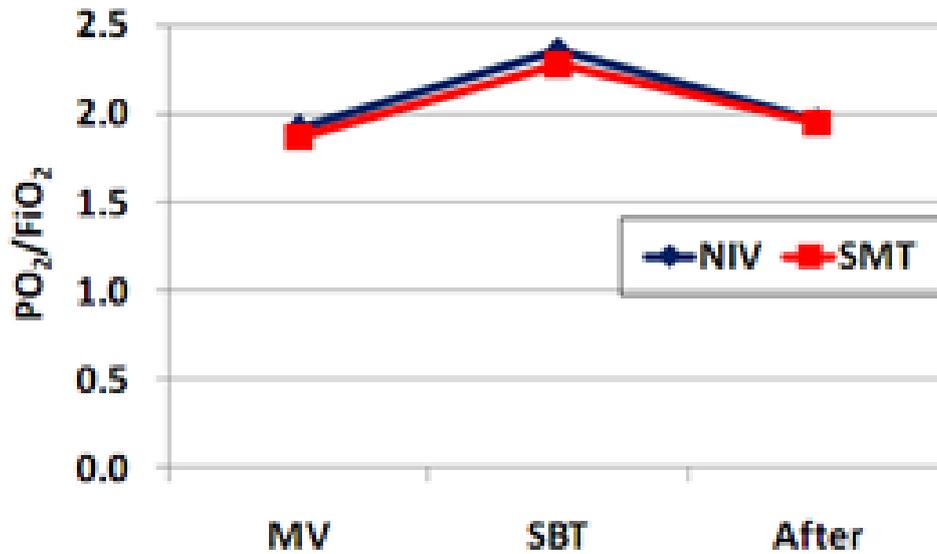


Figure (6): Comparison among study groups concerning PO_2/FiO_2

NVI: Noninvasive ventilation
SMT: Spinal manipulative therapy
MV: Mechanical ventilation
SBT: Skin prick test

Figure 7 shows that when compared to the SMT group, the NIV group's trial time was significantly shorter. Even though the NIV group had shorter ICU stays than the SMT group, the distinction was not statistically significant.

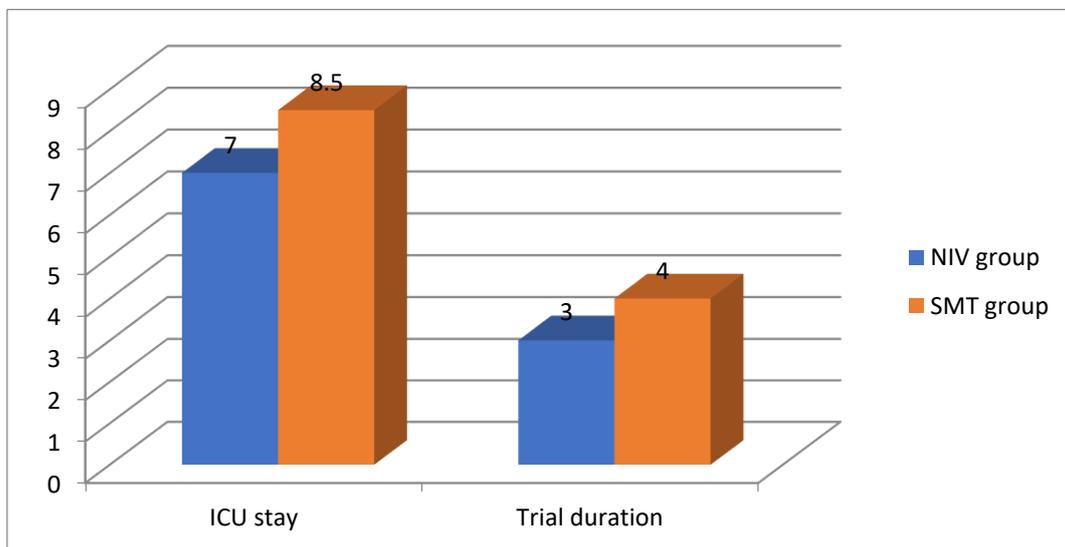


Figure (7): Median trial duration and ICU stay in study groups

NVI: Noninvasive ventilation
SMT: Spinal manipulative therapy
MV: Mechanical ventilation
SBT: Skin prick test

Figure 8 shows that the rate of reintubation and respiratory failure was lower in the NIV group compared to the SMT group, even though the distinction was not statistically significant. However, the distinction among the trial-failure intervals in the NIV and SMT groups was not statistically significant.

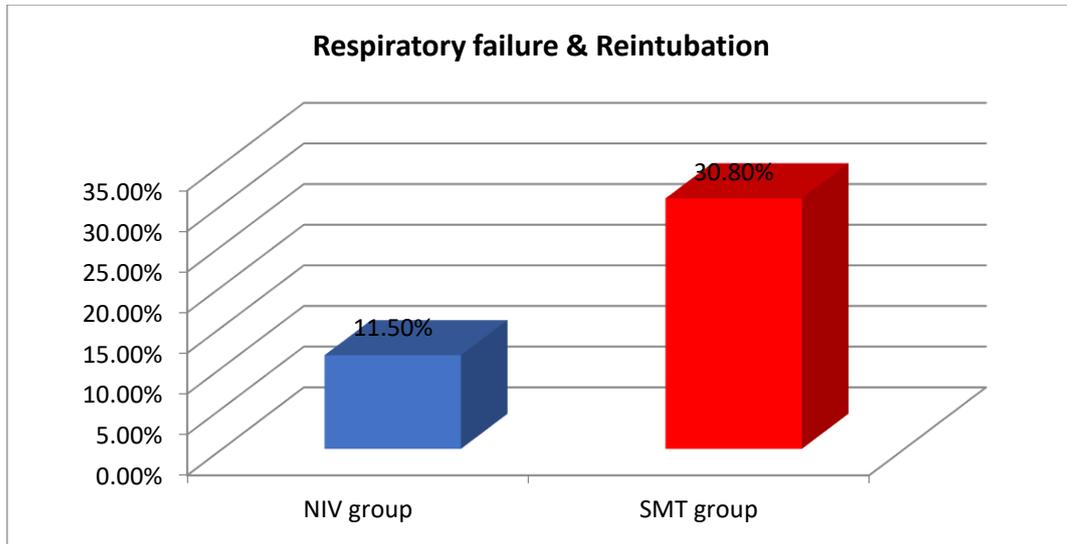


Figure (8): Respiratory failure in study groups

NVI: Noninvasive ventilation

SMT: Spinal manipulative therapy

Table (3): Comparison among examined groups concerning complications

Measurement	NIV (N=26)	SMT (N=26)	P
Myocardial infarction	1 (3.8%)	1 (3.8%)	^1.000
Cardiac arrest	1 (3.8%)	2 (7.7%)	^1.000
Pneumonia	0 (0.0%)	1 (3.8%)	^1.000

NVI: Noninvasive ventilation

SMT: Spinal manipulative therapy

DISCUSSION

The objective of this work was to assess if NIV was effective in reducing ICU stays after extubation. 56 individuals with type respiratory failure who needed intubation and ventilator assistance for more than 48 hours were included in the research; 4 patients who successfully extubated themselves were not. All eligible participants were included in the trial, with 26 assigned to the NIV group and 26 to the control (SMT) group.

Therefore, the effectiveness of this technique was contrasted with that of standard early treatment in all patients who received a scheduled extubation in this trial.

The benefits of NIV on gas exchange and hemodynamic status following intubation were established. This agreed with the results of a physiological research by **Kilger et al.** (9) in individuals with persistent ARF but without COPD following early extubation to study the effects of NPPV on intrapulmonary shunt fraction (Qs/Qt), pulmonary gas exchange, oxygen consumption (VO2), breathing pattern, as well as resting energy expenditure (REE).

Mechanically ventilated for more than 48 hrs and at danger for respiratory failure upon extubation, 97 consecutive cases were included in a multicenter study in Italy. A weaning experiment was completed, and the resulting split of patients was 48 on NIV for at least 8 hrs a day for the first 48 hrs and 49 on regular medical

care. Reintubation was less common among patients who were given NIV compared to those who were given conventional medical care (p=0.027). Use of NIV was related with a lower risk of death in the ICU (-10%, p0.01), but the necessity for reintubation was related with a higher likelihood of death. In a group at risk for post-extubation respiratory failure, the authors found that NIV outperformed conventional medical care in avoiding this consequence (10).

Despite the fact that the results of the current research were consistent with the findings of the studies that were mentioned before, the amount of time patients spent in the ICU, as well as the incidence of respiratory failure, were reduced. On the other hand, in compared to the previous research, the current one had a very small sample size, which might explain why there weren't any statistically significant results. In addition, only patients who were at risk of suffering post-extubation respiratory failure participated in the trials that were addressed before.

Different study designs led to pinpoint potential dangers. For example, hypercapnia, ineffective coughing, congestive heart failure, and excessive tracheobronchial secretions; greater than one failed weaning trial; greater than one comorbid condition; upper airway obstruction (10), cardiac failure as the trigger of intubation, age > 65, APACHE II score >12 on the day of extubation (7), and BMI ≥35 kg (11).

Nevertheless in this particular trial, we did not define any particular categories of patients who were at risk to be involved, and NIV was administered without regard to patient characteristics so as to forestall the onset of postextubation respiratory failure.

It is possible that this had an effect on the findings, as identifying individuals who were at risk is predicted to show a more clear advantage.

Because of the large percentage of unplanned extubation, which was the primary factor in determining bad result, one of the probable explanations for why

NIV did not seem to be beneficial is that there was not a strong criterion selection of patients. This might be the case.

In both the current trial and the studies that came before it, NIV was utilized as a means of serving as a preventative measure against the development of respiratory failure following extubation. There are several investigations that evaluated the function of noninvasive ventilation (NIV) in the therapy of respiratory failure postextubation. In these studies, NIV was only started if the patient experienced respiratory failure after the extubation ⁽¹²⁾.

There were a very small number of COPD patients who participated in these studies, which is surprising when one considers that this demographic provides the most compelling data about the effectiveness of NIV. It is evident that this was the case ⁽¹³⁾. This suggests that the observed lack of benefit might be explained by the existence of a diverse patient population.

An after-the-fact analysis of **Farrero et al.** ⁽¹⁴⁾ work lends credence to this interpretation. Among the 23 patients who were diagnosed with COPD, decreased reintubation rates were seen in the NIV group (50 percent versus 67 percent, $p=0.67$) than in the usual medical treatment group. However, it was not possible to make meaningful conclusions due to the limited sample size.

It is plausible to hypothesize that "prophylactic" postextubation NIV, if appropriately implemented, may show to be a helpful supplementary strategy in patients in light of these findings, the wealth of physiological data, and the clearly established efficacy in other circumstances. However, NIV appears to be ineffective for established postextubation respiratory insufficiency, therefore caution is recommended in this situation. NIV has potential in a number of circumstances, suggesting it may be an exception for people with COPD. There needs to be further investigation and confirmation.

CONCLUSION

Up on the data obtained in this piece of work, it was concluded that patients with respiratory failure type II had shorter ICU stays, lower risks of respiratory failure following extubation, and lower death rates when non-invasive ventilation was used soon following extubation.

DECLARATIONS

- **Consent for publication:** I certify that all authors consent to submission.
- **Availability of data and material:** Available
- **Competing interests:** None
- **Funding:** No fund
- **Conflicts of interest:** no conflicts of interest.

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