

Predictors of failure of early shift from invasive to noninvasive ventilation in weaning chronic obstructive pulmonary disease patients who have failed the initial spontaneous breathing trial: a prospective cohort study

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Context Noninvasive ventilation (NIV) is a well-established modality for difficult and prolonged weaning of chronic obstructive pulmonary disease (COPD) patients. Although several studies have addressed the early shifting to NIV, predictors of its success remain to be determined.

Aims The aim of the study was to find predictors of success of early shift of COPD patients who have failed the spontaneous breathing trail (SBT) to NIV.

Design and settings This investigation was designed as a double-centered prospective cohort study involving the ICUs of Critical Care Medicine of Cairo University and Shebin El-Kom Teaching Hospital.

Patients and methods Consecutive COPD patients who failed the initial SBT were extubated and shifted to NIV. We compared arterial blood gases, lung mechanics, and spontaneous breathing parameters in successful patients with these parameters in those who failed the early shift to NIV.

Results Out of the 30 patients, 21 (70%) were successfully weaned by early shift to NIV. The failed group had a significantly higher autopoitive end-expiratory pressure ($P < 0.001$), rapid shallow breathing index (RSBI) ($P < 0.05$), and significantly lower static compliance and negative inspiratory pressure (NIP) ($P < 0.001$) on admission.

Introduction

The optimum timing for initiation of weaning remains a challenging quest and hard to predict with certainty [1]. In this respect, the success of spontaneous breathing trials (SBTs) has resolved many of those queries; however, questions pertaining to those who fail the SBT, such as the reasons for failure, remain unanswered [2–4]. Several studies used noninvasive ventilation as a transition step in the weaning process, after failure of an SBT, with variable success rates [5–10]. Others have suggested the pulmonary infection control window as an optimum timing for shifting from invasive to noninvasive ventilation to decrease the incidence of ventilator-associated pneumonia (VAP) [11–13]. In general, predictors of success of NIV have been pursued [14–16]; however, to date predictors of success in early shifting to NIV have not been evaluated. Through this study we have sought to find mechanics and arterial blood gas (ABG) predictors for success in early shifting from invasive to NIV after failure of SBT [17].

Admission RSBI and NIP were the only predictors of failure of early shift to NIV. Just before SBT, the failed group had a significantly higher autopoitive end-expiratory pressure ($P < 0.001$), RSBI ($P < 0.001$), and airway resistance (Raw) ($P < 0.001$) and significantly lower static compliance, NIP, and PO_2/FIO_2 (P/F) ratio. Raw and NIP before SBT were the only predictors of success of early shift to NIV.

Conclusion RSBI, NIP, and Raw, rather than arterial blood gases, are the most important predictors for success of early shift to NIV in COPD patients who have failed the initial SBT.

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Keywords: airway resistance, early transition, lung mechanics, negative inspiratory pressure, rapid shallow breathing index, spontaneous breathing trail

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Patients and methods

Study design and settings

This is a prospective, uncontrolled study that was performed in two ICUs of the Critical Care Medicine Department of Cairo University and Shebin El-Kom Education University during 2009–2013.

Patients

All consecutive COPD patients admitted to the ICU for acute hypercapnic respiratory failure (AHRF) and who required mechanical ventilatory support were eligible for enrollment. After the acute phase (48–72 h), all eligible patients were subjected to an initial SBT; patients who did well in the SBT were extubated and excluded from the study. Only patients who failed the initial SBT were enrolled into the study

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for early shift to NIV, provided they were tolerating a total inspiratory support pressure (pressure support + continuous positive airway pressure) less than 25 cmH₂O and had no contraindication for NIV (e.g. impaired conscious level, copious secretion, repeated vomiting, recent gastrointestinal bleeding) [5]. The study protocol was approved by both institutional review boards, and all patients or their next in kin gave written informed consent.

Protocol

All patients were then managed as per the protocol used in our department for COPD patients with AHRF. Patients were initially ventilated in volume-controlled mode with intensive care unit ventilators (Galileo Gold; Hamilton Medical AG, Bonaduz, Switzerland); during this period lung mechanics were assessed.

After 48–72 h, patients who were appraised to have reached satisfactory clinical, radiologic, and ABG status [including satisfactory neurologic status, afebrile status, stable hemodynamics, SaO₂ ≥ 88% for a FiO₂ of 0.5, and nonacidotic pH (i.e. a ready to wean status)] were given a T-piece SBT. Immediately before the trial, lung mechanics and spontaneous breathing variables were measured.

The maximum SBT duration was 120 min. We considered the SBT to have failed if patients had any of the following: a respiratory rate more than 35 breaths/min, a PaO₂ less than 60 mmHg for an FiO₂ of 0.5, heart rate more than 140 beats/min or sustained increase or decrease in the heart rate of more than 30%, severe arrhythmia, systolic blood pressure more than 180 mmHg or less than 90 mmHg, agitation, anxiety, or diaphoresis. Patients in whom the SBT was a success were extubated and monitored for any extubation failure for 48 h, and excluded from the study.

Shifting to noninvasive ventilation

Patients who failed the initial SBT, provided they tolerated a total inspiratory support pressure of less than 25 cmH₂O and had no contraindication for NIV, were enrolled in our study. Before extubation, patients were subjected to a rest period (30–60 min) during which they were reconnected to the ventilator in assist/control mode until the previous spontaneous parameters and PaCO₂/pH values were reached. After assessment of airway protection reflexes (cough, pharyngeal gag, and laryngeal closure) and lung mechanics, the patients were extubated and shifted to NIV.

Noninvasive ventilation settings

The patients were reconnected to the same ventilator on the NIV mode with leak compensation capabilities, using a conventional double circuit tubing and oronasal masks (Gibeck Respiration AB, Stockholm, Sweden) with an inflatable soft cushion seal. Pressure support ventilation was used for all patients. The initial settings typically started with a low positive end-expiratory pressure (PEEP) level of 3–5 cmH₂O and an inspiratory airway pressure of 8–12 cmH₂O to facilitate patients' tolerance. Pressures were then gradually increased to reach sufficient level, not exceeding 25 cmH₂O, aiming to obtain oxygen saturation above 93% and exhaled tidal volume of about 4–6 ml/kg predicted body weight and respiratory rate below 25 cycles/min.

Inspiratory triggering sensitivity (pressure triggering) was individually adjusted for each patient according to the degree of leakage allowed so as to prevent autocycling or ineffective efforts. Likewise, the expiratory trigger level was adjusted for each patient individually to obtain the highest tidal volume and the longest inspiratory time without inducing expiratory strain effort. A heated humidifier was used to avoid oronasal dryness.

NIV was considered a failure if any of the following could not be achieved: maintenance of PaO₂ more than 60 mmHg with FIO₂ of 0.5 or less, pH above 7.3, static or increase in PCO₂ less than 10 mmHg, hemodynamic stability (blood pressure <180 or >90), absence of frequent or malignant arrhythmia, maintenance of conscious level with an ability to protect the airway (coma or seizure), the ability to cough and clear copious tracheal secretions, and tolerance to the oronasal mask.

Weaning from noninvasive ventilation

After 2 days of NIV at least one trial of SBT on NIV with gradually increased duration was attempted each day. Complete removal of the NIV mask was done when the patient could breathe spontaneously on pressure support less than 5–7 cmH₂O for 3 h. Weaning was considered successful if reintubation or noninvasive ventilation was not required within 72 h of suspension of ventilation.

Measured outcome

Lung mechanics [auto-PEEP, static compliance, dynamic compliance, airway resistance (Raw)] as well as the spontaneous variables [respiratory rate, tidal volume, rapid shallow breathing index (RSBI), and negative inspiratory pressure (NIP)] were monitored

at three stages: on admission, before SBT, and after SBT. Spontaneous parameters were also monitored during the NIV trial. ABG monitoring was performed after beginning each ventilatory phase and after changing the ventilatory setting using a Radiometer ABL 800 Flex (Radiometer Medical ApS, Åkandevvej 21, Brønshøj, Denmark). During NIV it was done at the beginning and after 1 and 4 h, and when indicated.

Our primary outcome was failure of NIV shift, whereas secondary outcomes included mortality, length of ICU and hospital stay, VAP, and other complications of NIV.

VAP was defined as the presence of a new and persistent (>48 h) lung infiltrate on chest radiography combined with at least two of the following: fever, peripheral leukocyte count higher than 10 000 cells/mm³, and endotracheal secretion obtained by suctioning from the lower respiratory tract in which a Gram stain showed one or more types of bacteria.

Statistical analysis

IBM SPSS statistics (version 19.0, IBM Corporation, Armonk, New York, USA) was used for data analysis. Data were expressed as mean±SD for quantitative parametric measures, and the following tests were performed: comparison between the mean of two independent groups for parametric data using the Student *t*-test, comparison between two independent groups for nonparametric data using the Wilcoxon Rank Sum test, comparison between more than two patient groups for parametric data using analysis of variance, and diagnostic validity test including sensitivity, specificity, and efficacy. The receiver operating characteristic curve was constructed to obtain the most sensitive and specific cutoff for each technique. To evaluate the most discriminating markers between the compared groups, area under the curve (AUC) can also be calculated. Multiregression analysis was used to search for a panel (independents parameters) that can predict the target parameter (dependent variable). Using stepwise multiregression analysis, parameters among these panels could be ranked according to their sensitivity to discriminate. *P* values less than 0.05 were considered statistically significant.

Results

Before enrollment in the study, out of the 46 patients, 12 (26%) were subjected to the initial NIV trial during the acute phase but failed, whereas 34 (74%) patients required urgent intubation on admission.

Out of 46 patients, only 30 patients failed the initial SBT and were enrolled in the study after fulfilling the inclusion criteria. “Patients were then extubated and shifted to NIV to continue weaning”.

Out of the 30 patients, 21 (70%) passed the NIV trial and were successfully weaned off NIV. In contrast, nine (30%) patients failed the transition to NIV and were reintubated and invasively ventilated (Fig. 1).

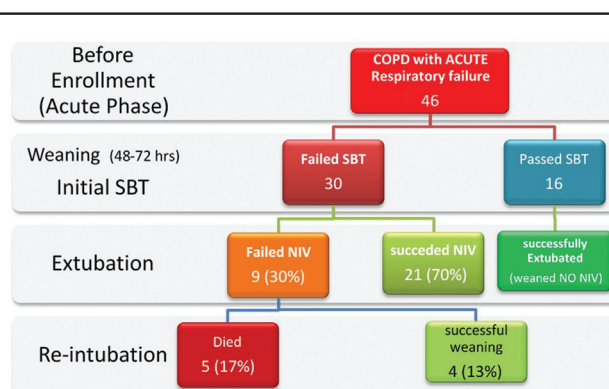
The difference in patients’ demographics and types of organism on sputum culture between the two groups (failed and passed NIV shift) are shown in Tables 1 and 2.

With regard to lung mechanics and ABG on admission, the NIV–failed group had a significantly higher admission auto-PEEP (5.44±0.53 vs. 3.91±0.10; *P*<0.001) and RSBI (202.22±21.48 vs. 175.19±20.74; *P*<0.05) and significantly lower static compliance (19.89±2.76 vs. 23.21±4.50; *P*<0.05) and NIP (7.22±1.79 vs. 11.86±2.08; *P*<0.001). In contrast, no significant differences were observed between the two groups regarding the other admission parameters – dynamic compliance and airway resistance – or any of the ABG parameters.

Multiple regression analysis revealed that admission RSBI and NIP were the strongest predictors of failure of early extubation and shift to NIV (*P*<0.05 and <0.001, respectively).

Using receiver operating characteristic curve for lung mechanics, a cutoff value for NIP of 9 cmH₂O had an

Figure 1



Enrollment and outcome of our patients. As shown in the figure, 46 consecutive COPD patients were mechanically ventilated for acute hypercapnic respiratory failure. After 48–72 h all patients received an initial SBT. Sixteen patients passed the trial and were successfully extubated, and 30 patients failed the SBT and were shifted to NIV. Twenty-one patients were successfully weaned, whereas nine patients failed and were reintubated. Out of the reintubated patients, only four patients could be successfully weaned conventionally, whereas five patients died during the ventilation course. COPD, chronic obstructive pulmonary disease; NIV, noninvasive ventilation; SBT, spontaneous breathing trial.

Table 1 Comparison of patients' characteristics on admission, between those who passed and those who failed noninvasive ventilation

Parameters	Passed NIV (n=21) [n (%)]	Failed NIV (n=9) [n (%)]	P value
Sex			
Female [7 (23.33%)]	6 (28.6)	1 (11.1)	>0.05
Male [23 (76.67%)]	15 (71.4)	8 (88.9)	
Age (years) (mean±SD)	63.67±7.76	63.56±11.19	>0.05
BMI (mean±SD)	29.05±3.19	25.89±5.30	>0.05
Smoking index (mean±SD)	839.48±340.99	887.50±241.65	>0.05
APACHE IV score (mean±SD)	68.10±8.86	72.78±13.59	>0.05
SAPS II score (mean±SD)	39.52±6.85	37.00±9.49	>0.05
Glasgow coma scale (mean±SD)	8.95±2.40	9.44±3.47	>0.05
History of COPD (years) (mean±SD)	5.62±1.36	5.00±1.80	>0.05
Diabetes mellitus [n (%)]	3 (14.3)	3 (33.3)	>0.05
Hypertension [n (%)]	11 (52.4)	7 (77.8)	>0.05
Ischemic heart disease [n (%)]	1 (4.8)	4 (44.4)	<0.05
Atrial fibrillation [n (%)]	3 (14.3)	0	>0.05
Renal impairment [n (%)]	1 (4.8)	0	>0.05
Cerebrovascular stroke [n (%)]	2 (9.5)	1 (11.1)	>0.05
HX of hospitalization past 3 months [n (%)]	13 (61.9)	9 (100)	<0.05
Previous ICU admission [n (%)]	9 (42.8)	4 (44.4)	>0.05
HX of previous MV [n (%)]	2 (9.5)	3 (33.3)	>0.05

APACHE, Acute Physiology and Chronic Health Evaluation; Hx, history; MV, mechanical ventilation; NIV, noninvasive ventilation; SAPS, simplified acute physiology score.

Table 2 Comparisons between patients who passed and those who failed noninvasive ventilation on admission regarding positive sputum culture

Organisms	Passed NIV (n=21) [n (%)]	Failed NIV (n=9) [n (%)]	P value
<i>Hemophilus</i>	3 (14.3)	0	
<i>Morexilla</i>	4 (9)	0	
<i>Streptococcus</i>	7 (33.3)	0	
<i>Staphylococcus</i>	2 (9.5)	1 (11.1)	
Normal flora	5 (23.8)	0	0.001
<i>Klebsella</i>	0	3 (33.3)	
<i>Acenitobacter</i>	0	2 (22.2)	
<i>Pseudomonas</i>	0	2 (22.2)	
MRSA	0	1 (11.1)	

MRSA, methicillin-resistant *Staphylococcus aureus*; NIV, noninvasive ventilation.

efficacy of 93% (sensitivity 90%, specificity 100%, negative pressure 81, positive pressure 100, and AUC 0.952). Similarly, a cutoff value of 4 for auto-PEEP of 4 cmH₂O showed an overall efficacy of 83.3% (sensitivity 76%, specificity 100%, negative pressure 64.3, positive pressure 100, and AUC of 0.952), whereas static compliance (20 cmH₂O) and RSBI (182) showed lower values.

Lung mechanics and arterial blood gases were remeasured just before SBT. The successful group showed significant differences in all lung mechanics for early shifting to NIV. However, none of the ABG ventilation parameters (pH, PCO₂, or HCO₃) showed any significant difference (Table 3).

Multiple regression analysis revealed that Raw and NIP just before SBT were the strongest predictors

of success of early extubation and shift to NIV ($P<0.05$ and <0.001 , respectively).

With regard to the rate of decline in the successful group versus the failed NIV group from admission to just before the SBT, only Raw and compliance were significantly higher in the successful group compared with the failed group. None of the other parameters (RSBI, auto-PEEP, and NIP) revealed a significant change. Static compliance was 0.93 ± 0.30 versus 0.40 ± 0.23 ml/cmH₂O ($P<0.001$), dynamic compliance was 1.26 ± 0.59 versus 0.41 ± 0.23 ml/cmH₂O ($P<0.001$), Raw was -0.36 ± 0.12 versus -0.16 ± 0.11 cmH₂O/l/s ($P<0.001$), RSBI was -0.31 ± 0.08 versus -0.31 ± 0.08 breaths/min/ml ($P>0.05$), auto-PEEP was 0.24 ± 0.14 versus 0.16 ± 0.19 cmH₂O ($P>0.05$), and NIP was 1.04 ± 0.37 vs. 1.20 ± 0.56 cmH₂O ($P>0.05$) in the successful and the failed group, respectively (Fig. 2).

Table 3 Comparison of patients who passed and those who failed the noninvasive ventilation regarding the lung mechanics and arterial blood gases before spontaneous breathing trial

Parameter	Mean±SD			
	Passed NIV (n=21)		Failed NIV (n=9)	
	On admission		Before the SBT	
RSBI (breaths/min/ml)	175.19±20.74	202.22±21.48	119.33±8.29	139.67±14.55
<i>P</i>		<0.05		<0.001
Auto-PEEP (cmH ₂ O)	3.91±0.10	5.44±0.53	2.91±0.77	4.56±0.73
<i>P</i>		<0.001		<0.001
<i>C</i> _{stat} (ml/cmH ₂ O)	23.21±4.50	19.89±2.76	44.24±8.88	27.89±6.15
<i>P</i>		<0.05		<0.001
<i>C</i> _{dyn} (ml/cmH ₂ O)	13.24±3.08	13.33±3.08	29.00±6.48	18.44±3.43
<i>P</i>		>0.05		<0.001
Raw (cmH ₂ O/l/s)	15.33±2.54	14.44±1.94	9.69±1.66	12.11±1.62
<i>P</i>		>0.05		<0.001
NIP (cmH ₂ O)	11.86±2.08	7.22±1.79	23.57±2.14	15.11±1.45
<i>P</i>		<0.001		<0.001
pH	7.23±0.06	7.27±0.05	7.40±0.03	7.41±0.03
<i>P</i>		>0.05		>0.05
PCO ₂	77.11±14.01	73.54±11.70	50.93±7.64	50.07±3.82
<i>P</i>		>0.05		>0.05
HCO ₃	31.77±5.37	32.03±2.55	30.6±3.9	31.02±1.86
<i>P</i>		>0.05		>0.05

Auto-PEEP, autopositive end-expiratory pressure; *C*_{dyn}, dynamic compliance; *C*_{stat}, static compliance; NIP, negative inspiratory pressure; NIV, noninvasive ventilation; P0.1, negative pressure in first 100 ms; RAW, airway resistance; RSBI, rapid shallow breathing index; SBT, spontaneous breathing trial.

Outcome of noninvasive ventilation

The success rate of early shift to NIV was 70%. None of the patients died by the time of hospital discharge. In contrast, nine (30%) patients failed the trial, of whom four (13%) were weaned successfully by means of invasive ventilation, and five (17%) died during invasive ventilation (Fig. 1).

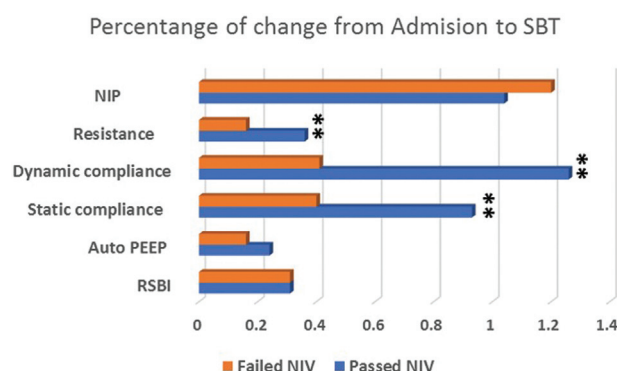
Our results also showed an increased incidence of tracheostomy and VAP in the failed group; the increased incidence of skin abrasion in the successful group was insignificant, as shown in Table 4.

Finally, the failure group showed a significant increase in total ventilatory period compared with the successful group (400.89±183.83 vs. 170.43±30.37 h; *P*<0.05), length of ICU stay (18.14±7.75 vs. 10.22±1.28 days; *P*<0.05) and length of hospital stay (18.37±7.71 vs. 11.95±1.36 days *P*<0.05).

Discussion

Main findings

In COPD patients with acute respiratory failure, early shift to NIV after 48–72 h succeeded in the case of 21 (70%) patients. For optimal patient selection and timing of shift to NIV, lung mechanics rather than ABG both at the time of admission and before SBT could predict success. NIP with RSBI on admission and with RAW before the

Figure 2

Percentage of improvement of different mechanics from admission to SBT. As shown there is significant improvement in airway resistance and compliance (static and dynamic compliance), mild but insignificant improvement in the auto-PEEP, and no improvement in RSBI and NIP. Auto-PEEP, autopositive end-expiratory pressure; NIP, negative inspiratory pressure; RSBI, rapid shallow breathing index; SBT, spontaneous breathing trial.

SBT were the most predictive of success. Using this approach, the hospital and intensive care unit stay was shorter and the incidence of nosocomial pneumonia and tracheostomy was lower in the successful group.

Shifting to noninvasive ventilation

This study shows that after an initial SBT, performed after 48–72 h of invasive ventilation, 35% of patients

Table 4 Comparisons between patients who passed and those who failed noninvasive ventilation regarding morbidity

Parameters	Passed NIV (n=21) [n (%)]	Failed NIV (n=9) [n (%)]	P value
Skin abrasion			
Mild	9 (42.9)	1 (11.1)	>0.05
Moderate	4 (19)	1 (11.1)	
Tracheostomy	0	4 (44.4)	0.001
VAP	0	8 (88.8)	<0.001

NIV, noninvasive ventilation; VAP, ventilator-associated pneumonia.

could be successfully weaned. Importantly, 70% of patients who failed the initial SBT could be successfully weaned by shifting to NIV as a step-down from invasive ventilation. Only 19.5% of the patients admitted with AHRF failed both the SBT and NIV, of whom more than half were never weaned by any other method and died.

The weaning process has been stratified into simple, difficult, and prolonged weaning based on the number of trials of SBT and number of days before success of the trial [18]. The use of NIV to facilitate the weaning process has been implemented in the last two decades, where it was initially applied after long periods of invasive ventilation, or after extubation failure [4,9,10,19,20]. Interestingly, in the recent BTS/IC guidelines, it is preferred over tracheostomy for weaning [21]. Later NIV was applied after shorter periods (48–72 h) in several studies including predominantly or exclusively patients with COPD in randomized controlled trials. Almost all studies found NIV superior to invasive weaning [22–25]. Because of the observed success, it was not surprising to find NIV suggested for all patients who failed the SBT. Our protocol was proposed on this basis [18].

Predictors of success of noninvasive ventilation

Our results have shown that lung mechanics, rather than ABG, are predictors of successful extubation and early shifting to NIV. This was found throughout the whole ventilator course starting from admission to SBT, suggesting that the deranged mechanics, specifically pulmonary hyperinflation, are the primary abnormality that should be pursued. The increased RAW and resultant increased intrinsic PEEP would reduce the pressure-generating capacity of the muscles. After triggering, the overinflated lungs result in smaller volumes and less alveoli sharing in the gas-exchange process. Ultimately, the resultant muscle fatigue and altered gas exchange are responsible for weaning failure. Such load/capacity imbalance may manifest as high RSBI and low NIP. In this respect, our study showed that admission RSBI and NIP are the two most independent predictors of success/failure of weaning.

In the setting of dynamic hyperinflation, NIV with PEEP can counteract intrinsic PEEP by making it easier to trigger the ventilator. Specifically, applied PEEP decreases the work of breathing and reduces the elevated inspiratory trigger threshold load. [26,27]. Therefore, the success of early shift to NIV in our study probably relied on the ability of NIV to prevent the underlying pathophysiologic mechanism of weaning failure. However, higher pressures required on NIV may be difficult to achieve. Hence, the decrease in RAW was the most independent predictor of success before SBT. It is important to note that the significant decline of RAW (with secondary improvement in dynamic compliance) was the cornerstone for the improvement of the mechanics, by helping the decline of air-trapping and improving compliance, thus explaining the success of early transition to NIV.

Such improvements did not similarly appear with auto-PEEP. This could be attributed to the fact that the higher the airway resistance, the less accurate the auto-PEEP measurement (the more underestimated it is). But with the improvement in resistance, more of the hidden auto-PEEP appeared in the measurements; therefore, there seemed to be no statistically significant difference. However, to confirm this finding, this can vividly appear in the corresponding improvement of compliance measurement after alleviation of air-trapping.

The present study is the first to pursue the lung mechanics that can predict the success/failure of early extubation and shift to NIV, whether it be on admission or before SBT, to avoid the risk of premature extubation and determine the optimum time for weaning/extubation.

Noninvasive ventilation and prevention of infection

Our study has shown that early shift to NIV after failure of SBT was associated with a lower incidence of nosocomial pneumonia and shorter length of hospital and ICU stay. Torres *et al.* [28] initially found that invasive ventilation for more than 3 days in patients with COPD was significantly associated with an increased risk for nosocomial pneumonia. This

finding has been confirmed by other investigators, where NIV has been shown to significantly decrease the incidence of pneumonia [10,29]. In fact, pulmonary infection window control was suggested as an indicator for early shifting to NIV, regardless of the outcome of the SBT, to prevent the development of VAP [11,12]. The presence of the endotracheal tube can predispose to the development of pneumonia by impairing cough and mucociliary clearance as contaminated secretions often accumulate above the cuff and leaks around it or because bacterial binding to the surface of bronchial epithelium is increased.

Our study has a few limitations. This is a noncontrolled study conducted on a small group of hypercapnic COPD patients. However, the aim of the study was to find predictors for early shift rather than the feasibility of early shift, which has been previously evaluated. Further randomized controlled trials studies may be needed to confirm that mechanics other than ABG or other physiologic variables are the important predictors that should be investigated. Furthermore, it must be noted that there are inherent pitfalls in measurements of certain mechanics – for example, RAW and compliance – which could be affected by a variety of factors, such as retained secretions, bronchospasm, apparatus resistance, tissue edema, and body posture. Also, measurements of auto-PEEP are approximations, and all are somewhat lower than the actual values existing within the lung. The high levels of regional hyperinflation can remain behind closed airways, sealed completely by mucus plugs, preventing all further discharge of trapped gas.

Conclusion

In COPD patients with acute hypercapnic respiratory failure, early shifting to NIV after failure of SBT may be a successful bridge to weaning. To this end, lung mechanics are better predictors for success than ABG, in which improving airway resistance is the most important predictor.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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