Noinvasive Ventilation in Relapse of Acute Respiratory Failure outside ICU

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Citation

Abstract
The transfer of patients to the ICU from General Ward could be a frequent issue of major concern in many hospitals around the world. We assessed the effectiveness of NIMV protocol outside ICU in sub-group of patients with relapse of acute respiratory failure and determine the factors associated with ICU transfer.

Methods: Prospective observational study. A total of 525 patients were treated of acute respiratory failure during this period of three years study. (Of this 353 (67.2%) were managed with standard therapy and 46 (8.7%), presented with relapse and required NIMV outside ICU.

Results: The most frequent diagnoses were: COPD 22 (47.8%), CAP 13 (28.3%), CHF 5 (10.9%), Asthma 4 (8.7), Diffuse Interstitial Pulmonary Disease 2 (4.3%). Levels of IPAP were 13.5 ± 2.1 and EPAP 6.1 ± 0.8. Respiratory acidosis was the more frequent finding (82.6%). Transfer to the ICU 5 (10.9%), need for endotracheal intubation 3 (6.5%). 2 (4.3%) patients in the study died, and 44 (95.7%) patients alive. The variables associated with transfer to the ICU were: IPAP level (p=0.005), EPAP level (p=0.03), Antibiotic Regimen Changes (p=0.01), and elevated HR (p=0.04) and acid-base disorders (p=0.10). Cumulative survival at 13 months was 86% and in 36 months it was 73% by the Kaplan-Meier method.

Conclusions: We identified a sub-group of patients who can benefit from the early application of NIMV protocol outside ICU after the relapse of acute respiratory failure. However, a multi-centre study, that involves a greater number of patients with these characteristic could be required.

INTRODUCTION
Non-invasive mechanical ventilation (NIMV) has been shown to be an effective treatment for acute respiratory failure, (1,2,3,4,5). Most of the research on NIMV has been conducted in Intensive Care Unit (ICU) setting. Nevertheless, several studies found conclusive information about the role of NIMV outside ICU. Plant, et al (6), found difference in mortality (20%) in the standard treatment and 10% in the NIMV group (p<0.05), and they also showed in a subgroup of patients with arterial pH < 7.30, mortality results were higher than from the ICU.

Further studies have shown benefits from the early introduction of NIMV therapy in patients with arterial pH < 7.35 (7, 8). However, Keenan et al., found poor outcomes with this approach during early hospitalization period (9).

Several studies using NIMV outside ICU, had heterogeneous population that included patients with normal pH, compensated and uncompensated hypercapnic and some were hypoxemic (10, 11).

In most studies, emergency room patients with acute respiratory failure who are NIMV candidates, are either stabilized (12), and then transferred to the general ward. or treated in ICU. Indeed most studies that use NIMV outside ICU, do so because of lack of space in the ICU (10, 11, 16). However, the great majority of patients that come to emergency with acute respiratory failure are stabilized with standard treatment. Nevertheless a sub group of patients could appear relapse of the acute respiratory failure. Our hypothesis is that in this subgroup of patients NIMV protocol can be applied early avoiding the transfer of patients to ICU.

Our objectives are:
Primary: To evaluate if our NIMV protocol is effective in this group of patients. We consider transferring to the ICU (for monitoring, constant NIMV or endotracheal intubation), as indicator of failure.

Secondary: To determine the factors associated with failure in this subgroup of patients.
MATERIALS AND METHODS

PATIENTS

We included all patients that were admitted to Military Hospital in Guayaquil, Ecuador, between December 1st, 2004 and January 1st, 2007. Consent was obtained from the patients or their relatives if they were unable to do so. This study was approved by the Ethics Committees from “University of San Francisco de Quito” in Cumbaya, and Military Hospital in Guayaquil – Ecuador.

SELECTION CRITERIA

We selected patients who presented with signs of acute respiratory failure at the emergency room (RR >25 (breath for minute) use of accessory muscles, bronchospasm), and after being partially stabilized (RR < 25 rpm, PaCO2 < 45 - 50 mmHg with normal arterial pH) with a standard treatment protocol (supplemental oxygen, bronchodilator therapy with albuterol plus ipatropium bromide, intravenously and corticosteroids were subsequently transferred to the general ward, and who later on deteriorate during early hospitalization period, fulfilling therefore inclusion criteria for NIMV treatment protocol. (RR > 25 rpm, pH < 7.35 and PaCO2 > 45 mmHg).

To avoid the possible influence of Nosocomial Pneumonia (13) in relapse of acute respiratory failure, we considered only patients during the first 48 hours of hospital stay.

During hospitalization, a changes of antibiotic regimen were based on isolation of a specific pathogen on cultures, antibiotic’s susceptibility pattern and presence of indicators of clinical deterioration defined as (new pulmonary infiltrate in chest X-ray;

(CRX). White cell count (x109/L) (WCC) increase >50% from baseline, persistent fever, and increased heart rate >20% from baseline)

Basal acid-base status was recorded prior to the initiation of NIMV protocol (14), by means of Arterial Blood Gases measurement.

STANDARD HOSPITALIZATION THERAPY

All patients received supplemental Oxygen (< 3 liters for minutes to avoid oxygen-induced hypercapnic), Bronchodilator therapy (200mcg Albuterol/36mcg + Ipatropium Bromide every 2-4 hours) with a metered-dose inhaler with a spacer, Corticosteroid (100mg Hydrocortisone IV every 6 hours), and antibiotics at the discretion of the staff pulmonologist (Ampicillin/Sublactam or Piperacillin/Clavulanate plus a Fluoroquinolone).

NIMV PROTOCOL

We use a BIPAP S (Duet System with Autotrack, manufactured by Respironics Murrysville Inc., Pennsylvania, USA), and a VPAP S/T A manufactured by RESMED.

The spontaneous IPAP and EPAP levels were initially set to 12cm H2O and 6cm H2O, respectively.

Two types of interface devices were used: the Respironics Comfort Full Mask (manufactured by Respironics Murrysville Inc., Pennsylvania, USA), and the Mirage Full Face series II or Ultra Mirage series III (manufactured by Resmed).

NIMV therapy was given first on an initial non - interrupted 6 hours period that was strictly monitored by a Respiratory Technician, an NIMV – Trained Medical Resident, or by the Attending Physician; and after NIMV therapy was given in an alternating form of 3 hours duration, every 3 hours; following the tolerance of the patient and monitored by a Respiratory Technician or the head Nurse. Weaning was initiated after correct stabilization of clinical parameters. We pursued this protocol as long as the patient’s tolerability allow it.

EXCLUSION CRITERIA FOR NIMV

Patients were excluded if they presented hemodynamic instability, excessive airway secretions, if they appear uncooperative or agitated, unable to use the interface device, or if they have had recent upper airway surgery, or received NIMV with a “do not resuscitate” order.

NIMV WITHDRAWAL

Clinical stability was defined as: 1) RR <25rpm 2) HR <100bpm and 3) a compensated arterial pH with SaO2 (%) >90% at room air or with low flow oxygen (< 3 liters for minutes)

MEASUREMENTS

Arterial blood gases measurements were done before admission to general ward, and before initiation and during NIMV therapy. Mask’s complications such as excessive discomfort, nasal ulcer, gastric distention, and claustrophobia were also recorded.

OUTCOMES

The primary outcome was effectiveness of NIMV Protocol,
defined as necessity of transference to UCI for appropriate monitoring.

Secondary outcomes were: hospitalization days, percentage of patients needing endotracheal intubation, and death.

**STATISTICAL ANALYSIS**

All data was expressed as means ± standard deviations for continual variables, and percentages for nominal ones. Each variable was analyzed independently to look for any association with the event defined as failure (transfer to ICU). The t-test for independent samples was used for data with a normal Gaussian distribution and similar variance (determined via variance homogeneity test or Levene’s test).

A non-parametric test (chi square and Fisher’s exact test) was used for data with non-normal distribution and for nominal variables. A p-value of <0.05 was considered statistically significant. Independent variables that had a p-value of <0.15 on the univariate analysis was considered in the multiple logistic regression analysis.

**FOLLOW UP**

All patients were evaluated for outpatient survival rate within a 36-month period of home follow-up. The Kaplan-Meier method (15) was used to determine survival rate outside the hospital.

**RESULTS**

A total of 525 patients were treated for acute respiratory failure, during this period 353 (67.2%) were managed with standard therapy of whom 46 (8.7%), had relapse of acute respiratory failure and required NIMV outside ICU Figure 1

**Figure 1**

Picture 1: Show. Patients taken care in Emergency Room with Acute Respiratory Failure.

The mean age was 72.8 ± 14.1 years, 26 (56.5%) were men and 20 (43.5%) were women. Previous NIMV events were 0.09 ± 0.2 events. Mean time from admission to NIMV treatment initiation was 1.5 ± 0.5 d. The number of previous admissions in the last three years was 0.8 ± 0.9 admissions.

The most frequent diagnoses were: 1) Chronic obstructive pulmonary disease (COPD) 22 (47.8%); 2) Community acquired pneumonia (CAP) 13 (28.3%); 3) Congestive Heart Failure 5 (10.9%); 4) Asthma 4 (8.7%); 5) Diffuse Interstitial Pulmonary Disease 2 (4.3%). Mean levels of IPAP were 13.5 ± 2.1 and for EPAP 6.1 ± 0.8. The frequency of acid-base disorders were: 1) Acute Respiratory Acidosis 26 (56.5%); 2) Chronic Uncompensated Respiratory Acidosis 12 (26.1%); 3) Compensated Metabolic Acidosis 3 (6.5%); 4) Metabolic Acidosis with Uncompensated Respiratory Alkalosis 1 (2.2%) and 5) Compensated Metabolic Alkalosis 1 (2.2%).

Patient’s CRX showed compromise of 1 quadrant in 12 (26.1%), 2 quadrants in 17 (37%), 3 quadrants in 3 (6.5%); and no compromise was observed in 14 (30.4%).

Patient conditions requiring NIMV were: 1) Hypercapnic with raised respiratory effort 36 (78.3%); 2) respiratory effort 8 (17.4%), and 3) Hypercapnic 2 (4.3%). Changes in antibiotic regimen were made in 6 patients (13%) and no change was made in 40 (87%).

Mean NIMV therapy duration was 4.7 ± 1.9 d. Mean hospitalization length was 6.3 ± 1.9 d. 43 (93.5%) patients remained in the general ward, while the final events 5 (10.9%) patients were transferred to the ICU. Endotracheal intubation was required in 3 patients (6.5%) while 43 patients (93.5%) did not. Two (4.3%) patients in the study died, leaving 44 (95.7%) patients alive. (see table 1).
Noinvasive Ventilation in Relapse of Acute Respiratory Failure outside ICU

Figure 2
Table 1 shows the characteristics of the study population:

<table>
<thead>
<tr>
<th>CHARACTERISTIC OF STUDY POPULATION</th>
<th>Mean (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOE (years)</td>
<td>72.8 ± 14.1</td>
</tr>
<tr>
<td>SEX (MEN/WOMEN)</td>
<td>25 (56.5%)/20 (43.5%)</td>
</tr>
<tr>
<td>Previous NIMV events</td>
<td>0.09 ± 0.2</td>
</tr>
<tr>
<td>Time from admissions to beginning of NIMV (days)</td>
<td>1.5 ± 0.5</td>
</tr>
<tr>
<td>Previous admissions in the last 3 years</td>
<td>0.8 ± 0.9</td>
</tr>
</tbody>
</table>

DIAGNOSES

<table>
<thead>
<tr>
<th>Disease</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD</td>
<td>22</td>
<td>47.8%</td>
</tr>
<tr>
<td>Community acquired pneumonia</td>
<td>13</td>
<td>28.3%</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>5</td>
<td>10.5%</td>
</tr>
<tr>
<td>Bronchial Asthma</td>
<td>4</td>
<td>8.7%</td>
</tr>
<tr>
<td>Diffuse Intestinal Pulmonary Disease</td>
<td>2</td>
<td>4.3%</td>
</tr>
</tbody>
</table>

EQUIPMENT USED

- BiPAP S DUET LX SYSTEM (RESPIRONICS) with AUTOTrak: 43 (93.5%)
- VPAP ST-4 (RESMED): 3 (6.5%)

VENTILATOR MODE

- BiPAP S: 48 (97.9%)
- CPAP: 1 (2.2%)

Levels EPAP (cmH2O): 5.15 ± 0.94, Range (5 - 10)
Levels IPAP (cmH2O): 13.5 ± 2.15, Range (11 - 18)

ACID BASE DISORDERS

- Acute respiratory acidosis: 20 (55.5%)
- Chronic uncompensated respiratory acidosis: 12 (25.1%)
- Compensated metabolic alkalosis: 2 (4.3%)
- Metabolic acidosis plus uncompensated respiratory alkalosis: 6 (12.2%)
- Metabolic acidosis plus uncompensated respiratory acidosis: 1 (2.2%)
- Compensated metabolic alkalosis: 1 (2.2%)

STATUS REQUIRING NIMV

- Hypercapnia plus respiratory effort: 36 (78.3%)
- Respiratory effort: 8 (17.4%)
- Hypercapnia: 2 (4.3%)

CHANGES IN ANTIBIOTIC REGIMEN

- NO: 40 (87.7%)
- YES: 9 (19.3%)

CHEST X-RAY

- Normal: 14 (30.4%)
- 1 quadrant: 12 (25.1%)
- 2 quadrant: 17 (37.2%)
- 3 quadrant: 3 (6.5%)

DAYS NIMV: 4.78 ± 1.93, Range (2 - 10)
DAYS HOSPITALIZATION: 6.39 ± 1.9, Range (3 - 12)

FINAL OUTCOMES

- Transfer to the ICU
  - NO: 44 (95.7%)
  - YES: 2 (4.3%)
- Endotracheal intubation
  - NO: 43 (93.5%)
  - YES: 3 (6.5%)
- Mortality
  - NO: 44 (95.7%)
  - YES: 2 (4.3%)

Data are presented as numbers and percentages unless otherwise specified.
NIMV, No Invasive Mechanical Ventilation; IPAP, Inspiratory Positive Airway Pressure; Airway EPAP, Expiratory Positive Pressure.

respiratory failure in emergency room, 12 hours, 24 hours and at the beginning of NIMV. See Tables 2

Figure 3
Tables 2. Diagnosis, characteristics and 46 consecutive patients receiving NIMV outside the intensive care unit.

![Image of Tables 2](image_url)

The variables associated with transfer to the ICU in the univariate analysis were (See table 3 and 4): IPAP level (p=0.005), EPAP level (p=0.03), Antibiotic Regimen Changes (p=0.01), and elevated HR (p=0.04) and acid-base disorders (p=0, 10)
DISCUSSION
This study shows a clear benefit with early implementation of the NIMV protocol in this subgroup of patients (8.7%) who presented acute respiratory failure relapse outside ICU. With this therapy, 41 (89.1%) patients were managed and did not require ICU transfer. Of the 5 (10.9%) patients which had to be transferred to the ICU, 2 (4.3%) subsequently died.

In our study we identified a sub-group of patients who after an initial improvement with standard treatment, their make relapse of the acute respiratory failure.

Of the 353 (67.2%) patients with standard therapy alone 46 (8.7%) required NIMV outside ICU. Although our patients were hypercapnic (PCO$_2$ 49.7 ± 9.8 and 7.38±0.03 at 24 hours) in the emergency room, it does not constitute an indication for the beginning of NIMV. Keenan, et al. (9) demonstrated that the use of NIMV in patients with hypercapnic and a compensated pH of 7.40, is poorly tolerated. In Keenan’s study, 2 (7.4%) out of 27 patients with standard treatment failed.

In our institution, the decision of where to initiate the NIMV protocol, either in the emergency room, the ICU or the general ward, relies solely in the decision of the staff pneumonologist.- ICU. This is because our group has reached the sufficient expertise in applying the NIMV protocol. It has been well demonstrated that a unit’s skills in NIMV are greatly improved only after a completion of a
“learning curve” (16)

Paus-Jenssen, et al. (17) studied 75 subjects treated with NIMV. The results showed that 1/4 (41%) of NIMV therapies were started outside ICU. Nevertheless, they did not specify the use of a standardized NIMV protocol. An 18% of patients received NIMV because of shortness of breath.

Viñay Maheshwari et al. (18) showed that 82% of NIMV therapies were started in the general ward. and that in 75% of patients, NIMV could be maintained with favorable response. Also, the use of a NIMV protocol was associated with a better outcome (56% vs. 43.5%). Cabrini L, et al. (19) showed that under the supervision of a Medical Emergency Team, the NIMV could be applied in a wide variety of settings, outside the ICU,

A 56.5% of our patients had acute respiratory acidosis as the primary arterial blood gases disorder. This data is consistent with Farha et al. (20) findings, which reported 58.82% of cases with primary respiratory acidosis.

In this study we showed that the patients with COPD, the values of PCO2 were high, in spite of the partial normalization of pH, PaO2, Sato2%, RR in the first 24 hours. Of equal way our patients with CAP showed high values of PCO2

Some authors (3, 21) have demonstrated that NIMV in CAP can be useful under certain conditions, especially in hypercapnic patients. Nevertheless, other studies have demonstrated that patients with pure hypoxic respiratory failure have lower response rates (22, 23). Even though, improvements is seen due to mechanical development (interface devices, equipment and techniques) (24, 25), there is not sufficient evidence to recommend NIMV in patients with pure hypoxic respiratory failure, uncompensated metabolic acidosis with hypoxemia or severe shock (26, 27)

Our study showed that the increasing level of IPAP is factor associated a failure. Patients with IPAP levels of ≥ 18cm H2O had higher probabilities of being transferred to the ICU. Even if changes in IPAP level are related to those on PaCO2, this single variable is not a predictor of outcome. (29). IPAP levels are linked to the RR, exhaled minute volume, PaCO2 levels, bronchospasm persistency and patient comfort levels. Another factor associated a failure was the HR. Patients who had tachyarrhythmias should be managed and controlled with continued monitoring in the ICU.

We also found that basic acid disturbance was factor associated with transference to UCI, metabolic acidosis, shock and hypoxaemia have high probability of failure to the NIMV and therefore its must be always made in the UCI

In the multivariate analysis we found that the appropriateness antibiotic use and IPAP pressure levels were factors associated with the transfer of the patient to the ICU. However our model will be unstable, evidenced by estimated OR by its extremely wide CI.(29). However, a multi-centre study that involves a greater number of patients with these characteristic could be required.

Limitations in our study are:

1. It’s a monocentric, observational study that can not represent the actual NIMV management in other hospitalization areas.

2. Due to a small sample size, we did not consider the relationship that may have subsisted between baseline co-morbidities or diseases (diabetes mellitus, cancer, hypothyroidism), and antibiotic therapy failure and/or mortality.

3. Since NIMV is a standard treatment for uncompensated hypercapnic respiratory failure, a control group wasn’t included.

On the other hand, in this study the NIMV protocol applied to certain patients showed advantages over others outside ICU, because of:

1. Availability of beads in the ICU was not an issue.

2. Patients were included to NIMV protocol only after they have had experienced respiratory failure posterior to partial stabilization with a standard treatment. Therefore, we tried to minimize the superimposed effect of conventional BIPAP therapy in respiratory insufficiency.

3. Finally the relapse of acute respiratory insufficiency outside ICU, constitutes a fact that there is to have it in account in sub-groups of patients with respiratory pathologies in which the early intervention with NIMV would be indicated

Based in these results, we consider that an NIMV protocol (administered by a well trained group of health care providers and physicians) applied early outside UCI in patients. with worsened respiratory failure, after the application of a standard treatment, could be used successfully, avoiding
transferring of the patients to ICU.

References


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