Noninvasive Bi-Level Positive Airway Pressure Ventilation in Blunt Chest Trauma

Mai Mohammed Mahran a*, Rehab Said El-Kalla b, Ayman Abd EI khalek Sallam c, Mohamed Ahmed El Heniedy d and Hala Mohey El- deen EL- Gendy b

a Emergency Medicine & Traumatology Department, Faculty of Medicine, Tanta University, Tanta, Egypt.
b Anesthesia, Surgical Intensive Care, and Pain Management Department, Faculty of Medicine, Tanta University, Tanta, Egypt.
c Cardiothoracic Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt.
d Vascular Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt.

Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Chest injury was found to cause death in 20%–25% of multiple trauma patients. Thoracic trauma is, therefore, important in the overall management of multiple injury patients and may require a longer stay in the Intensive Care Unit (ICU) and use of mechanical ventilation.

Methods: This prospective randomized clinical study was in Emergency Intensive Care, Tanta University Hospitals. For, 88 adult patients with blunt chest injury. Patients were enrolled in this study aged ≥18 years old classified into two equal groups: Group I (Non-Invasive Mechanical Ventilation group) = 44 patient: Patients in this group received BIPAP. Group II (Control group=44 patient: Patients in this group have received high flow O2 by mask O2 without use of non-invasive mechanical ventilation. Data of collection were: the demographic data. Frequent arterial blood gas analysis of all patients every 6 hrs. Respiratory rate, Arterial blood pressure, Heart rate were
recorded: every 6 h. All Patients receive analgesia. Evaluate outcome: a-Primary outcome. Tracheal intubation, duration of ventilation. b-Secondary outcome. Mortality, ICU length stay. And Chest Trauma Scoring System. **Results:** Ten patients (22%) were intubated and mechanically ventilated in group I (BiPAP), with mean value of duration of ventilation 34.4 hrs. But at group II 16 patients (36%) were intubated and mechanically ventilated with mean value of duration of ventilation 34.12 hrs. ICU stay at group I (BiPAP) was statistically decrease of number of days when compared to group II (control), 6 days at group I and 12 days at group II. In this study no case of mortality was recorded with non-invasive ventilation, although three mortality cases were recorded with the control group. **Conclusion:** This study recommends the pre-emptive use of Non-Invasive Ventilation in the treatment for blunt chest injury in patients at risk for respiratory failure. Success of Non-Invasive Ventilation depends on improvement of hypercarbia and hypoxemia in patients impending respiratory failure due to reversible cause as blunt chest trauma with the expectation of a good outcome and avoidance of intubation.

**Keywords:** Blunt chest trauma; noninvasive bi-level positive airway pressure ventilation; respiratory failure; hypercarbia; hypoxemia.

### 1. INTRODUCTION

Blunt chest trauma may cause injury to the thoracic wall, pleura, lung parenchyma, airway structures, major vessels, heart and pericardium, diaphragm and other mediastinal structures [1]. Trauma-related mortality accounts for 9% of deaths in all age groups and most cases involve blunt injuries [2].

Chest trauma considered a major trauma so, in emergency department trauma management consists of a rapid primary survey, resuscitation, a more detailed secondary survey, and, finally, the initiation of definitive care [3].

Oxygen should be commenced with a mask for all patients who have sustained major trauma. A target oxygen saturation range of 94-98% should be maintained [4].

Noninvasive ventilation (NIV) refers to the administration of ventilatory support without using an invasive artificial airway (endotracheal tube or tracheostomy tube). NIV is rapidly gaining acceptance around the world as the preferred choice of treatment over invasive ventilation [5].

The (Non-invasive Positive Pressure Ventilation) NPPV is an appealing option for patients requiring ventilatory assistance with potentially reversible conditions when tracheal intubation is not immediately necessary. Noninvasive ventilation has been shown to improve preoxygenation prior to intubation when compared to standard methods of oxygen delivery [6].

### 2. PATIENTS AND METHODS

A prospective randomized study was conducted in the Emergency Intensive Care, of Tanta University Hospital in Egypt. All patients underwent the standard procedures of the protocol.

This clinical study was conducted from the beginning of January 2018 to the end of December 2019 in Emergency Intensive Care, Tanta University Hospitals. For, 88 adult patients with blunt chest injury of both sexes.

The records of all patients were reviewed, and data were collected prospectively. Patients were randomly classified using closed envelops and a computer generated random numbers into two groups each group of 44 patients: Group I (Non Invasive Mechanical Ventilation group) =44 patient: Patients eligible in this group was received BiPAP as conventional ventilation. Patients in this group received BIPAP (ResMed). (Fig.1).

It was started using the bi-level positive airways pressure S/T (spontaneous triggered) mode via a properly fitted face mask, the head of the bed was raised to 30°–45° in order to minimize the risk of aspiration. Moreover, utilizing a disposable spacer was possible to reduce the pressure on the bridge of the patient's nose and to reduce dead space. The mask was fitted by head straps to avoid an excessively tight fit, the patients were not sedated in this group.

The initial inspiratory positive airway pressure (IPAP) was set at 12 cmH₂O, and the initial
expiratory positive airway pressure (EPAP) was set at 5 cm H2O. Back-up respiratory frequency was set at 12 breaths/min, according to clinical efficacy and patient tolerance. IPAP (inspiratory positive airway pressure) and EPAP (expiratory positive airway pressure) was raised by 2–3 cmH2O every 5 to 10 minutes.

Fraction of inspired oxygen (FiO2) was adjusted to maintain oxygen saturation (SpO2) more than 94%.

BiPAP was started intermittently and the IPAP/EPAP was decreased gradually. When the support pressure level (IPAP-EPAP) reaches ≤5 cmH2O, a weaning trial was done.

And Group II (Control group=44 patient: Patients in this group was received high flow O2 by mask O2 without use of non-invasive mechanical ventilation.

2.1 Measurements

Several measurements were collected including: demographic data demonstrated by age and sex of all patients who have been subjected to frequent arterial blood gas analysis every 6 hrs. As well as from admission to emergency ICU whatever patient on room air, oxygen mask, nasal cannula or BiPAP. Other measurements included respiratory rate, arterial blood pressure, heart rate recordings every 6 hours. Patients receive analgesia or not. In evaluation of the outcome, there was primary outcome; tracheal intubation, duration of ventilation. And a secondary outcome; mortality, ICU length stay. Moreover, there was a Chest Trauma Scoring System [7]. (Table -1) to evaluate trauma of patients.

Table 1. chest trauma scoring system

<table>
<thead>
<tr>
<th>Age score</th>
<th>Score</th>
<th>Rib score</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;45 y</td>
<td>1</td>
<td>&lt;3 RIBFX</td>
<td>1</td>
</tr>
<tr>
<td>45-65 y</td>
<td>2</td>
<td>3-5 RIBFX</td>
<td>2</td>
</tr>
<tr>
<td>&gt;65 y</td>
<td>3</td>
<td>&gt;5 RIBFX</td>
<td>3</td>
</tr>
<tr>
<td>Pulmonary contusion score</td>
<td>Bilateral RIBFX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td>Unilateral minor</td>
<td>1</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>Bilateral minor</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unilateral major</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral major</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Final score 2-12, Patients grouped as <5 and ≥5). RIBFX – Rib fractures

Fig. 1. second-generation BiPAP
2.2 Statistical Analysis

In this study, data were organized and tabulated. SPSS version 19 (Statistical Package for Social Studies) created by IBM, Illinois, Chicago, USA was used to statistically analyze the collected data. The level of significant was adopted at p < 0.05.

3. RESULTS

Present study included 88 patients. Age was ranged from 18 to 70 years and from 18 to 72 years with mean value 38±16.7 years and 34.4±13.5 years in groups I, II respectively. Male patients were 23 patients (52.2%) and 21 patients (47.7%) in groups I and II respectively. Female patients were 22 patients (50%) and 22 patients (50%) in groups I and II respectively.

Type of injuries were: Combined lung contusion with unilateral fracture ribs were found in 15 patients (34%) and 20 patients (45.4%) in group I and II respectively.

Combined lung contusion with bilateral fracture ribs were found in 10 patients (22.7%) and 12 patients (27.2%) in group I and II respectively.

Combined lung contusion with unilateral fracture ribs and pneumothorax were found in 6 patients (13.6%) and 6 patients (13.6%) in group I and II respectively.

Combined lung contusion with unilateral fracture ribs and hemopneumothorax were found in 3 patients (6.8%) and 9 patients (20.4%) in group I and II respectively. Combined unilateral fracture ribs with pneumothorax were found in 3 patients (6.81%) and 0 patients (0%) in group I and II respectively.

Bilateral fracture ribs were found in 7 patients (15.9%) and 0 patients (0%) in group I and II respectively as shown in (Fig.2).

Chest trauma scoring system was 6.31±2.74 and 6.61±2.13 in group I and II respectively. That there was statistically insignificant difference in Chest trauma scoring system in group I as compared to group II at all as shown in and (Fig.3).

PaCO\textsubscript{2} insignificantly decrease at group I when compared to group II at admission to ICU then 1\textsuperscript{st} 6 hrs, 12 hrs, 24 hrs and at 48 hours significantly decrease respectively. As shown in and (Fig. 4).
Fig. 3. Comparison of Chest trauma scoring system in the two studied groups

Fig. 4. Comparison of PaCO₂ at both groups

Table 2. Comparison for PaO₂ between the two groups

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>1st6hrs</th>
<th>12hrs</th>
<th>24hrs</th>
<th>48hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BiPAP</td>
<td>Mean</td>
<td>67.31</td>
<td>87.47</td>
<td>96.70</td>
<td>92.63</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>8.16</td>
<td>12.98</td>
<td>17.06</td>
<td>9.97</td>
</tr>
<tr>
<td>Control</td>
<td>Mean</td>
<td>75.83</td>
<td>64.72</td>
<td>81.68</td>
<td>93.25</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>41.79</td>
<td>9.09</td>
<td>18.57</td>
<td>8.58</td>
</tr>
<tr>
<td>T test</td>
<td></td>
<td>1.32</td>
<td>9.51</td>
<td>3.95</td>
<td>0.30</td>
</tr>
<tr>
<td>P value</td>
<td></td>
<td>0.191</td>
<td><strong>0.000</strong>*</td>
<td><strong>0.000</strong>*</td>
<td>0.758</td>
</tr>
</tbody>
</table>

Table 3. Primary outcome tracheal intubation, duration of ventilation

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td></td>
<td>10 (22%)</td>
<td>16 (36%)</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td></td>
<td>5 (11.3%)</td>
<td>6 (13.6%)</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
<td>2 (4.5%)</td>
<td>4 (9.09%)</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
<td>3 (6.81%)</td>
<td>2 (4.5%)</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td>0 (0%)</td>
<td>4 (9.09%)</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>34.4 ± 9.9</td>
<td>34.12 ± 9.2</td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>
PaO$_2$ insignificantly decrease at group I when compared to group II at admission to ICU then significant increase of PaO$_2$ at group I when compared to group II at 1st, 6hrs and 12hrs. Then insignificant increase of PaO$_2$ at group I and group II at 24hrs and 48hours respectively. As shown in Table 2.

At group I (44) patients receive analgesia, in the BiPAP group, pain control was achieved with fentanyl patch 75 mic and paracetamol infusion. In the control group (44) patients receive analgesia fentanyl patch 75 mic and paracetamol 10 mg/ml Solution for Infusion.

Also, (4) patients from control group added morphine sulphate 2mg to fentanyl patch 75 mic and paracetamol infusion to decrease pain threshold because they have multiple fractures added to chest trauma. There was statistically significantly difference between both groups. (P < 0.05).

Ten patients (22%) were intubated and mechanically ventilated in group I (BiPAP), with mean value of duration of ventilation 34.4 hrs. But at group II 16 patients (36%) were intubated and mechanically ventilated with mean value of duration of ventilation 34.12 hrs. As shown in Table 3.

ICU stay at group I (BiPAP) was statistically decrease of number of days when compared to group II (control). 6 days at group I and 12 days at group II.

In this study no case of mortality was recorded with non-invasive ventilation, although three mortality cases were recorded with the control group.

4. DISCUSSION

Chest injury is the second leading cause of death in blunt trauma victims after brain injury and mortality has reached 25 per cent in some studies. Rib fractures are the most frequent physical manifestation of severe blunt chest injury [8].

Noninvasive ventilation (NIV) is frequently used in patients with acute respiratory failure and its success is dependent on the underlying cause of the condition [9].

patients mostly benefit from a short period of Noninvasive ventilation (NIV) to avoid progressive respiratory deterioration associated with falling vital capacity, increasing chest wall deformity, and decreasing ventilatory efficiency [10].

The study was conducted on 88 patients divided equally into two groups. Group I (BiPAP group) and group II (control group).

In this study the pre-emptive use of noninvasive mechanical ventilation was compared (BiPAP) bi-level positive airway pressure and high flow oxygen mask in patient with blunt chest injury The timing of initiation of NIV starting few hours after hospital admission.

In agreement with this results Prunet B et al. (2019) [11] Eligibility criteria for inclusion were as follows: severe blunt chest trauma, with an injury severity score (ISS) of >15, and a thorax abbreviated injury score (AIS) >3; pulmonary contusion of>10% of the total lung volume, documented by admission computed tomographic scan; need for tracheal intubation and mechanical ventilation for at least the first 48 h post trauma.

Also, Piastra M et al (2019) [12] The effectiveness of NPPV was demonstrated by an improvement in the PaO2, an increase in the tidal volume and a decrease in the respiratory rate.

The rate of failure of NIV in patients with blunt chest trauma in our study was very close to the rates reported by Antonelli M. et al (2017) [13] and colleagues showed in a randomized multicenter study that NIV was able to enhance oxygenation and avoid intubation in 54 % of ARDS patients.

Schreiber A et al (2018) [14] NPPV, as compared to high-flow nasal oxygen, could reduce the intubation rate in patients with severe chest trauma-related hypoxemia.

In addition, Xiouchaki N et al (2005) [15], several patients had bilateral lung injuries and were more likely to require intubation and prolonged mechanical ventilation. Within 24 h after starting NPPV, four patients required ETI.

Moreover, a recent meta-analysis that the number of patients reporting on NIMV in patients with ARDS is very limited and that the results of these studies suggest that these patients were
unlikely to have important added outcome benefits from NIMV.

The overall intubation rate in the NIMV group was 48%, and the overall mortality rate was 35%. However, patient selection widely differed among the studies, and none of these studies included trauma associated ARDS.

The strength of this current study is its prospective nature. We were able to obtain acceptable results and qualify BiPAP, in those critically ill patients who complaining of respiratory failure due to chest trauma.

Limitation of the study: There were several limitations in the present study, one of them was the smaller size of the sample, single-center study, the short period of follow up for the patients, and exclusion of certain conditions.

5. CONCLUSION

This study recommends the pre-emptive use of Non-Invasive Ventilation in the treatment for blunt chest injury in patients at risk for respiratory failure. Success of Non -Invasive Ventilation depends on improvement of hypercarbia and hypoxemia in patients impending respiratory failure due to reversible cause as blunt chest trauma with the expectation of a good outcome and avoidance of intubation.

CONSENT

An informed written consent were taken from each patient or from the relatives after full explanation of benefits and risks. Privacy of all patient data was granted and there was code number for every patient file that includes all investigations.

ETHICAL APPROVAL

Approval provided by the institutional ethical committee. Faculty of Medicine, Tanta University.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES


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