COMPARISON OF HAEMODYNAMIC EFFECTS OF NONINVASIVE VENTILATION DELIVERED VIA RESQGARD AND CPAP BOUSSIGNAC MASKS

EWELINA GASZYŃSKA¹, KRZYSZTOF ROGUSZKA², MICHAŁ STANKIEWICZ-RUDNICKI¹, ANDRZEJ WIECZOREK³, TOMASZ GASZYŃSKI²

Department of Hygiene and Health Promotion¹
Kierownik: prof. dr hab. F. Szatko
Department of Emergency Medicine and Disaster Medicine²
Kierownik: dr hab. T. Gaszyński
Department of Anesthesiology and Intensive Therapy³
Kierownik: prof. dr hab. W. Gaszyński
Medical University in Łódź

Noninvasive ventilation (NIV) is a technique of mechanical ventilation which does not require invasive airway management, i.e. intubation or tracheostomy. In emergency medicine Continuous Positive Airway Pressure (CPAP) is used often. A new method of NIV is Impedance Threshold Device (ITD). Breathing through an ITD is utilized to raise blood pressure in hypotensive patients.

**Aim of the study** was to compare haemodynamic effects of NIV ITD and NIV CPAP.

**Material and methods.** This study involved a group of 25 healthy volunteers. NIV was performed using ResQGARD ITD and CPAP Boussignac. Ventilation time was 25 minutes for each mask in each participant. Every three minutes parameters were collected: SpO₂, BP and HR. There was a one hour interval in between ventilation with each mask. CPAP pressure was set at a level of 8 cm H₂O and the mean inspiratory resistance of the ITD was 7 cm H₂O. Collected parameters were subjected to ANOVA statistical analysis.

**Results.** Absolute comparison of BP, HR and SpO₂ values did not reveal statistically significant differences between the masks. However considering blood pressure levels at entry, ventilation through an ITD significantly raised BP. Ventilation with NIV CPAP did not change significantly BP.

**Conclusion.** Ventilation through an ITD device significantly improve haemodynamic function, whereas CPAP ventilation had no significant effect on it.

**Key words:** mechanical ventilation, haemodynamic CPAP, Impedance Threshold Device

Noninvasive ventilation (NIV) is a technique of mechanical ventilation which does not require invasive airway management, i.e. intubation or tracheostomy. There are various clinical indications for this ventilation modality, e.g. in the course of weaning off mechanical ventilator. However, it is in emergency medicine that noninvasive ventilation plays a very significant role. It makes it possible to avoid intubation in patients who maintain airway patency on their own and breathe spontaneously but suffer from severely compromised gas exchange. Noninvasive ventilation techniques include Continuous Positive Airway Pressure (CPAP) and Biphasic Positive Airway Pressure (BiPAP). A new application of noninvasive mechanical ventilation has emerged in the form of Impedance Threshold Device (ITD). Breathing through an ITD is utilized to raise blood pressure in patients hypotensive due to different reasons, e.g. shock, orthostatic hypotension etc.

The aim of this study was to compare haemodynamic effects of two different modes of noninvasive ventilation- through an ITD and CPAP.
MATERIAL AND METHODS

After obtaining the Local University Ethics Committee approval (RNN/96/13/KB) the study involved a group of 25 healthy volunteers. We employed two different types of masks for NIV: ResQGARD ITD (mask No1) by Advanced Circulatory Systems INC, USA and CPAP Boussignac (mask No2) by Vygon, France. Ventilation time was 25 minutes for each mask in each participant. Every three minutes during ventilation a set of vital parameters was measured including SpO₂, SBP, DBP and HR. There was a one hour interval in between ventilation with each mask. CPAP pressure was set at a level of 8 cm H₂O and the mean inspiratory resistance of the ITD, as stated by the manufacturer, is 7 cm H₂O. Negative inspiratory pressure is thus augmented by this value. Collected parameters were subjected to ANOVA statistical analysis.

RESULTS

Demographic data of the experimental group are shown in tab. 1.

Table 1. Demographic data of the experimental group.
Values are mean and standard deviation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>40.2 SD 10.8 lat</td>
</tr>
<tr>
<td>Body weight</td>
<td>80.2 SD 9.3 kg</td>
</tr>
<tr>
<td>Height</td>
<td>175.5 SD 7.2 cm</td>
</tr>
<tr>
<td>Sex (F/M)</td>
<td>4/21</td>
</tr>
</tbody>
</table>

Absolute comparison of blood pressure, HR and SpO₂ values did not reveal statistically significant differences between the involved masks. However considering blood pressure levels at entry, ventilation through an ITD (mask No1) significantly raised both systolic and diastolic blood pressure. CPAP ventilation (mask No2) had no effect on haemodynamic parameters. Mean values of haemodynamic parameters are shown in tab. 2.

Table 2. Mean values of haemodynamic parameters.
Values are mean and standard deviation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maska 1</th>
<th>Maska 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure</td>
<td>135 SD 9.5</td>
<td>130 SD 7.8</td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td>77.5 SD 7.3</td>
<td>76.6 SD 6.2</td>
</tr>
</tbody>
</table>

DISCUSSION

CPAP is a noninvasive ventilation mode which enhances gas exchange in such clinical conditions as both cardiogenic and noncardiogenic pulmonary edema, asthma or COPD.
exacerbations caused by respiratory infections without the need to use invasive methods such as intubation and positive end-expiratory pressure ventilation. CPAP ventilation is indicated in posttraumatic (lung contusion) and postoperative (atelectasis especially following upper abdominal surgeries) gas exchange disorders, pulmonary edema and pneumonia. The underlying principle of CPAP ventilation is oxygenation improvement due to the following factors: increasing functional residual capacity (FRC), reduction of respiratory work as a result of continuous gas flow in ventilation circuit which facilitates inspiration, prevention of small airway collapse thanks to continuous positive pressure in the pleural cavity, recruiting atelectatic alveoli, reduction of alveolar shunts and normalization of the ventilation/perfusion ratio.

Haemodynamic effects of this ventilation mode are usually insignificant but in particular cases may influence patient condition. Studies conducted so far on haemodynamic effects of CPAP ventilation in emergency medicine revealed that this ventilation mode has no significant influence on blood pressure despite reducing preload and afterload through increased pulmonary and mediastinal pressure (1). The same observations follow from our study. Conversely, breathing through an ITD raises blood pressure as a result of increased venous return, stroke volume and cardiac output. Increased venous return is a consequence of negative airway pressure augmentation followed by negative mediastinal transmural pressure. In our study mean blood pressure increase for ITD mask was 7.3 mm Hg and was significantly higher compared with CPAP mask. This result is about two times lower than that obtained by Pantazopoulos et al. (3) and Smith et al. (4) – 15 and 12 mm Hg respectively.

Our study was conducted in a group of healthy individuals, whereas Pantazopoulos et al. examined a group of hypotensive patients. Mean blood pressure rise in these two studies may be different as a consequence of this. However, the effects of noninvasive ventilation in both groups are comparable and both studies reveal the same trend in haemodynamic changes. Convertino and Ryan made the same observations examining healthy volunteers (5, 6, 7).

The advantages of ITD ventilation include efficacy, easy and fast application, noninvasiveness and the fact that it takes advantage of physiological mechanisms to improve haemodynamic functions without pharmacological treatment. In their studies both Pantazopoulos (3) and Smith (4) confirmed the efficacy of ventilation through an ITD in hypotensive patients in emergency medicine. The principle of ITD ventilation is the augmentation of intrathoracic vacuum during inspiration which enhances venous return and cardiac output. This way, thanks to the application of Impedance Threshold Device, blood pressure is increased. ITD ventilation is utilized in hypotension defined as systolic blood pressure below 90 mm Hg, mean blood pressure below 60 mm Hg or a drop in these parameters by more than 40 mm Hg. It is used in cases of hypovolaemic, septic or neurogenic shock, orthostatic hypotonia, dehydration, anaphylaxis, drug overdose, intoxication, in trauma or dialysis patients. Patient discomfort, a disadvantage of this ventilation technique, was also reported by participants of our study. Compared with CPAP mask patient discomfort was more pronounced for ITD mask.

**CONCLUSION**

Ventilation through an ITD device significantly improve haemodynamic function, whereas CPAP ventilation had no significant effect on it.