NONINVASIVE POSITIVE PRESSURE VENTILATION AFTER CARDIAC SURGERY

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SUMMARY

Background: We have reported the results obtained by non-invasive positive pressure ventilation (NIPPV) applied to the patients who had an open heart surgery and suffered from respiratory failure after extubation due to various reasons.

Materials and Methods: We applied NIPPV support following severe respiratory deterioration in fifteen patients who underwent open heart surgery under cardiopulmonary bypass in our clinic between January 2000 and January 2001. Nine patients (60%) required NIPPV because of acute inflammation of underlying chronic obstructive pulmonary disease (COPD). Remaining six patients (40%) suffered from alveolar hypoventilation despite normal preoperative respiratory function. Despite NIPPV support (average 2 to 4 hours), five patients required reentubation due to respiratory failure defined as persistandt hypoxia, hypercapnia and hemodynamic instability. However, respiratory parameters improved significantly in 10 patients and reentubation was avoided.

Results: Ten patients who did not require reentubation were supported by NIPPV for average of 8±5 hours (range 3-18 hours). One patient (6.66%) died as a result of acute respiratory distress syndrome (ARDS) following aspiration pneumonia during the first week of postoperative period.

Conclusion: NIPPV which is less invasive when compared to endotracheal intubation can be life saving. Timely application of NIPPV also prevents possible complications of endotracheal intubation in the patients who suffered from respiratory failure that did not require immediate intubation after open heart surgery.

Key Words: Open Heart Surgery, Respiratory Failure, Non-invasive Ventilation.

ÖZET

Kardiyak Cerrahi Sonrası Noninvasiv Pozitif Basınçlı Ventilasyon

Giriş: Açık kalp cerrahisi geçiren ve extübyasyondan sonra çeşitli nedenlerle solunum sıkıntısı gelişen hastalarda, non-invaziv pozitif basınçlı ventilasyon (NIPPV) uygulaması ile elde ettiğimiz sonuçları bildirdik.

Maleryal ve Metoq: Kliniğimizde ocak-2000 ve ocak-2001arasında kardiyopulmoner bypass altında açık kalp ameliyatı geçiren ve yoğun bakım takibinde ekstübasyon sonrası solunum fonksiyonları ve parametreleri bozulan 15 hasta NIPPV desteği uyguladık. Bunlardan 5 tanesinde NIPPV 2-4 saat (ortalama 3±0.5) uygulanmasına rağmen sebat eden hipoksı, hiperkapni ve hemodinaminin bozulması nedeniyle reentübasyon yapıltı. Kalan 10 hastada ise NIPPV uygulanması ile hastaların solunum fonksiyonları düzeldi. Bunlarda reentübasyona gerek olmadığı bir hasta geç dönemde entübe oldu. Hastaların 9'u (60%) preoperatif KOAH'lı olup ekstübasyon sonrası akut alevlenme, 6 (%40) hasta ise preoperatif akciğer fonksiyonları normal olması rağmen ekstübasyon sonrası alveolar hipoventiilasyon nedeniyle NIPPV'na ihtiyaç duydu.

Sonuçlar: Entübasyona gerek kalmayan 10 hasta ortalama 3-18 saat (ortalama 8±5) arasında NIPPV desteginde kaldı. 1(6.66%) hasta aspirasyon pnömonisi nedeniyle postoperatif birinci haftada akut respiratuvar distress sendromu (ARDS) sonucu eksitus oldu.

Tartışma: Açık kalp cerrahisi sonrası acil entübasyonu gerektirmeyen solunum yetmezliği gelişen hasta gruplarında, endotrakeal entübasyona göre daha az invaziv olan NIPPV hayat kurtarıcı olmakta ve endotrakeal entübasyonun olası komplikasyonlarını önlemektedir.

Anahtar Kelimeler: Açık Kalp Cerrahisi, Solunum Yetmezliği, Non-invaziv Ventilasyon

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Although mechanical ventilation using endotracheal intubation is a life saving method in cases with respiratory failure, there has been a search of methods which will lead to sufficient respiration without intubation. With the application of positive pressure at different levels (BEEP UP) to inspiration and expiration using a total face mask or naso mask has reduced the necessity of endotracheal intubation(1). In recent years, non-invasive ventilation has been successfully used both in acute respiratory failure accompanied by alveolar hypoventilation(2,3). Thus, acute respiratory failure may improve using a less complicated noninvasive method. As a result, hospitalization period of patients is shortened and they are prevented from invasive ventilation complications.

We have shown that NIPPV is an effective method for postoperatively developing respiratory failure in patients who have had open heart surgery.

**MATERIALS AND METHODS:**

Fifteen patients who had open heart surgery between January 2000-January 2001 and developed acute respiratory failure after extubation during intensive care follow-up period were supported by NIPPV.

The average age of patients was 55±7 (between 48-62), whereas 9 patients (60%) were of COPD. Eight patients (53.3%) had isolated coronary artery bypass grafting (CABG) operation, one had (6.66%) mitral valve replacement (MVR) and one had (6.66%) (whose preoperative lung functions were normal) CABG+ mitral ring annuloplasty operation. One of the patient with COPD was operated on, left aorta-renal saphenous bypass, due to renal arterial stenosis three months before CABG operation. There was no comorbid factor except for COPD in the other patients.

All the patients were given general anaesthesia and the average operation duration was 140±35 minutes. All of them were extubated postoperatively for 12±4 hours on average. They were ventilated in the mode of pressure control ventilation during the postoperative period. The patients were extubated in case of FiO₂=0.4 and PEEP≤5cmH₂O, PaO₂>70mmHg and PaCO₂<50 mmHg, SaO₂<90, PaO₂<70mmHg, PaCO₂>50 mmHg during the weaning period, perspiration, breathing the spontaneous speed of which is greater (> than 20 breath/minute, agitation or a decrease in consciousness level, an increase in heart beating more than 20%, a change in blood pressure more than 20%, a decrease in cardiac output greater than 30% or lack of ventricular arrhythmias.

The patients were supported by NIPPV (FiO₂=0.4) 4±2 hours (on average) after extubation due to dispne, takipne, SaO₂<90, PaCO₂>50 mmHg, PaO₂<70mmHg and respiratory asidose.

Five patients (33.3%) couldn’t recover from respiratory failure although they were supported by NIPPV for 3±0.5 hours on average and they were re-entubated. In the remaining ten patients (66.7%) such a treatment was kept being given for 8±5 hours on average when NIPPV worked.

During the respiratory deterioration period of patients, the hemodynamic parameters (cardiac index, central venous pressure, pulmonary arterial pressure and systemic arterial pressure) were at normal levels (Table-1). For all of the patients the following requirements were considered to give them NIPPV support; a) intact bulbar function accompanied by coughing reflex, b) minimal secretion, c) hemodynamic stability, d) functional gastrointestinal system, e) spontaneous respiration of the patient, f) cardiac arrhythmias lack of ischemia, g) adaptation of the patient to non-invasive ventilation.

NIPPV was applied through non-invasive ventilation mode of ESPIRT (Respinoricios PIN V-1000 SN VS 3001274) ventilation and a total face mask. Inspiratory positive airway pressure (IPAP) was between 12-16 cmH₂O on average, where as expiratory airway pressure (EPAP) was 4-7 cmH₂O. IPAP and EPAP were optimized according to the patients tolerance and to keep tidal volume as 8-10 ml/kg.
Arterial blood gas sampling was obtained through a 18-gauge plastic cannula placed in the radial artery and mixed venous sampling through 7F, three lumen Swan-Ganz catheter (Edwards Swan-Ganz Baxter Healthcare Corp, Irvine, CA), pH, PaCO₂ and PaO₂ levels were examined in the blood samplings. Pulmonary gas change parameters were recorded (Table-2) just as soon as the patient suffered from respiratory failure, in the fifteenth and thirtieth minutes of NIPPV support and one hour after weaning from NIPPV support.

After 3-18 hours (8±5 on average) the patients were not provided with non-invasive ventilation when PaO₂ >70 mmHg, PaCO₂ <50 mmHg, SaO₂ >90 and when there was tachypnea and consequently their inspiratory and expiratory pressure support was decreased.

Table-1: Pulmonary gas change parameters in patients with acute respiratory failure and supported:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>NIPPV-15</th>
<th>NIPPV-30</th>
<th>Post-NIPPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO₂, mm-Hg</td>
<td>50±6</td>
<td>58±9</td>
<td>62±8</td>
<td>66±9</td>
</tr>
<tr>
<td>SaO₂-Hb,%</td>
<td>79±8</td>
<td>85±6</td>
<td>84±4</td>
<td>89±3</td>
</tr>
<tr>
<td>PaCO₂, mm-Hg</td>
<td>66±10</td>
<td>59±10</td>
<td>56±8</td>
<td>55±6</td>
</tr>
<tr>
<td>PHa</td>
<td>7.32±0.05</td>
<td>7.41±0.06</td>
<td>7.41±0.05</td>
<td>7.42±0.04</td>
</tr>
<tr>
<td>PVO₂, mm-Hg</td>
<td>38±3</td>
<td>43±3</td>
<td>45±4</td>
<td>47±3</td>
</tr>
</tbody>
</table>

PaO₂=arterial oxygen tension; SaO₂-Hb,%=arterial oxygen saturation; PaCO₂= arterial carbon dioxide tension; PHa=arterial pH; PVO₂=mixed venous oxygen saturation.

Pulmonary Gas Change

Arterial blood gas sampling was obtained through a 18-gauge plastic cannula placed in the radial artery and mixed venous sampling through 7F, three lumen Swan-Ganz catheter (Edwards Swan-Ganz Baxter Healthcare Corp, Irvine, CA), pH, PaCO₂ and PaO₂ levels were examined in the blood samplings. Pulmonary gas change parameters were recorded (Table-2) just as soon as the patient suffered from respiratory failure, in the fifteenth and thirtieth minutes of NIPPV support and one hour after weaning from NIPPV support.

After 3-18 hours (8±5 on average) the patients were not provided with non-invasive ventilation when PaO₂ >70 mmHg, PaCO₂ <50 mmHg, SaO₂ >90 and when there was tachypnea and consequently their inspiratory and expiratory pressure support was decreased.

Table-2: Hemodynamic values in patients given NIPPV treatment due to acute respiratory failure:

<table>
<thead>
<tr>
<th>Hemodinamik değerler</th>
<th>Hasta (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac index(L/min/m²)</td>
<td>2.2±0.2</td>
</tr>
<tr>
<td>Central venous pressure (mm-Hg)</td>
<td>8±2</td>
</tr>
<tr>
<td>Pulmonary capillary wedge pressure (mm-Hg)</td>
<td>13±2</td>
</tr>
<tr>
<td>Systemic vascular resistance(dyn/sec/m²)</td>
<td>1430±120</td>
</tr>
<tr>
<td>Pulmonary vascular resistance(dyn/sec/m²)</td>
<td>130±25</td>
</tr>
<tr>
<td>Heart Rate (beat/min.)</td>
<td>90±5</td>
</tr>
</tbody>
</table>

Table-3: Pulmonary gas change parameters in five patients re-entubated after NIPPV ventilation support:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>NIPPV</th>
<th>IPPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaO₂, mm-Hg</td>
<td>52±5</td>
<td>57±6</td>
<td>75±7</td>
</tr>
<tr>
<td>SaO₂-Hb,%</td>
<td>75±7</td>
<td>83±5</td>
<td>90±3</td>
</tr>
<tr>
<td>PaCO₂, mm-Hg</td>
<td>67±9</td>
<td>60±9</td>
<td>48±6</td>
</tr>
<tr>
<td>PHa</td>
<td>7.31±0.06</td>
<td>7.40±0.06</td>
<td>7.43±0.04</td>
</tr>
<tr>
<td>PVO₂, mm-Hg</td>
<td>38±3</td>
<td>42±3</td>
<td>50±3</td>
</tr>
</tbody>
</table>

PaO₂=arterial oxygen tension; SaO₂-Hb,%=arterial oxygen saturation; PaCO₂= arterial carbon dioxide tension; PHa=arterial pH; PVO₂=mixed venous oxygen saturation.
RESULTS

Ten patients tolerated non-invasive positive pressure ventilation well. Treatment of non-invasive ventilation lasted 3-18 hours (8±5 on average). The patients who had difficulty in getting rid of tracheobronchial secretion were aspirated using nasotracheal method. The patients who met the weaning criteria were not given non-invasive ventilation any more.

One out of 10 patients was given pressure support ventilation treatment, providing him with orotracheal entubation due to aspiration and acute respiratory depression. The patient died in the first week of postoperative period due to aspirational pneumonia, ARDS and multi organ failure.

Sedation was ensured by 1-2 mg midazolam in three patients who had aggitational suffering during non-invasive ventilation treatment. Sternum separation caused by positive pressure ventilation was observed in two patients (20%) and they had sternal revision operations for 7-9 days on average. Anaesthesical agents that had immediate effects were used in sternum revision, those patients were extubated on the operating table and there was no postoperative respiratory difficulty. NIPPV lengthened the duration of ICU 2±1.5 days on average. Those patients stayed in ICU for 3±0.5 days on average.

Five patients were re-entubated after 3±0.5 hours on average. Four of those patients were with COPD and one of them suffered from postoperative myocard infarction. Blood gas levels of those patients before and after NIPPV are presented in table-3. Four (80%) of the five patients re-entubated were extubated after 4±2 days on average. These four patients stayed in ICU for 6±2.4 days on average. One patient (20%) could not be extubated for ten days, thus tracheostomy was applied.

DISCUSSION

The primary treatment of acute respiratory failure has been mechanical ventilation support using endotracheal entubation for many decades. Endotracheal entubation likely to have complications such as upper respiratory system trauma, barotrauma and nasochomial infection. Non-invasive ventilation applied to specially selected groups of patients have more advantages than invasive ventilation does. However, there may be some problems limiting the treatment such as patient adaptation, atalectasy and facial ulcers cused by mask pressure (4).

The followings are acute respiratory failure conditions under which non-invasive ventilation can be used; acute respiratory asidose where there is no need for immediate entubation, respiratory distress, co-operation on patient’s side, hemodynamic stability, lack of active cardiac arrhythmia or that of ischemia, without active upper gastrointestinal system hemorrhage, intact upper respiratory system and without acute facial trauma (5-8).

In many studies, use of NIPPV in patients with respiratory failure caused by various neuromuscular diseases, deformities in thoracic wall, COPD and control anomalies in central respiration has been detected. The diseases for which NIPPV is used during treatment of acute an chronic respiratory failure may be listed as follows; thoracic wall deformities, neuromuscular diseases, central alveolar hypoventilation, bronchiectasy, COPD, tumor fibrosis, pneumonia, ARDS, cardiogenic pulmonary oedema, postoperative complications, cardiac failure, failure in patients with difficulty in termsof weaning from extubation and obstructive sleeping apnea (9-11).

NIPPV prevents artificial respiratory complications, provides flexibility in the beginning and termination of mechanical ventilation, lessens the need for sedation, protects the airway swallowing and speech mechanisms, lessens the need for invasive monitorization and enables us to give patients early mobilization. The disadvantages of NIPPV is that it can not be used in patients with aspiratory risk or excessive secretion, loss of preventive airway reflex and upper airway obstruction and those who require
entubation, it might not be effective in acute respiratory failure with severe hypoxemia, it may lead to distension of stomach, some lesions on the skin, facial ache, sense of drying in the nose, eye irritation (conjunctivity), clostrophobia, sleep disorders and mask leakage (12,13).

NIPPV should not be used in patients who must not be resuscitated or who cannot be cooperative, and in cases where secretions cannot be removed, and systolic blood pressure is lower than 90 mmHg or where severe asidose, shock, arrhythmias that cannot be controlled and obstruction of upper respiratory system is observed (9,14).

NIPPV is an attractive alternative to entubation in acute and chronic study style. If NIPPV fails, then, entubation may be applied. If there is no unsuitable condition to NIPPV in patients, it is perfect choice for the clinician in terms of adaptation of patient with the ventilator (15,16).

It is such an unusual complication that patients who have had open heart surgery may suffer from respiratory failure in ICU after extubation. In many of those patients there are different risk factors such as COPD and excessive weight, most commonly respiration depending on cardiac complications (17-19).

We have succeeded in prevention of re-entubation at a rate of 60% in fifteen patients underwent open heart surgery in our clinic and who suffered open heart surgery in our clinic and who suffered from respiratory failure by using NIPPV.

We have also shown that NIPPV is an alternative treatment which may be easily applied to patients, where respiratory failure developed after open heart surgery and not required immediate entubation and it may eliminate the need of re-entubation in suitable patient groups. NIPPV; decrease the risk of complications of a more invasive method endotracheal entubation.
REFERENCES


