Clinical and laboratorial repercussions of the nasal continuous positive airway pressure in preterm newborns

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Abstract

Objective: to evaluate the efficacy and the problems associated with the use of nasal continuous positive airway pressure (CPAP).

Methods: ninety-six preterm newborns needing nasal CPAP either as initial ventilatory support or for weaning from mechanical ventilation were studied prospectively.

Results: the nasal CPAP was used in children weighing from 480 to 2450 g and with corrected gestational age of 24 to 39 weeks. It was indicated in cases of apnea (12.5%), hyaline membrane disease (32.3%), pneumonia (4.2%), transient tachypnea (22%), and weaning from mechanical ventilation (29%). The last indication was more frequent in children with lower weight (P<0.01). Median time in nasal CPAP was 60.3 hours. After the installation of nasal CPAP, there was a significant improvement in the respiratory distress, which was not shown in the blood gases. The percentage of children that were fed and presented nasal hyperemia, nasal bleeding, and abdominal distention was directly proportional to how long they had been in nasal CPAP. Children weighing ≤ 1000 g had higher incidence of abdominal distention (P<0.01), and those weighing between 1500 and 2500 g had higher difficulty in maintaining nasal CPAP (P=0.04). The treatment was successful in 37% of children weighing ≤ 1000 g, 59% of those weighing 1000 to 1500 g, and 83% of those weighing from 1500 to 2500 g.

Conclusions: Nasal CPAP is a good option for ventilatory assistance in preterm babies. It is a safe therapy in general, with topic complications; it does not prevent patients from being fed during its use. Furthermore, it was successful in 59% of the studied patients.


Introduction

The application of nasal CPAP during spontaneous breathing was first used in newborns in 1971 by Gregory et al.¹ for the treatment of hyaline membrane disease. CPAP was administrated through an endotracheal cannula or through a pressurized chamber placed around the patient’s head. With time, devices for CPAP administration were developed: a pressurized facial chamber, a mask able to ventilate mouth and nostrils, as well as nasal and nasopharyngeal devices.²-⁴

At first, the use of nasal CPAP was restricted to hyaline membrane disease. This was due to the fact that this technique can increase functional residual capacity, ventilation-perfusion ratio, and stabilize the thoracic cavity.¹,² After

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some time, it was recognized that these properties could be useful in other clinical situations, such as apnea, meconium aspiration syndrome, pneumonia, cardiopathies, ventilator weaning, in patients with respiratory distress due to diaphragm paralysis, bronchiolitis, and also in obstructive sleep apnea in older patients.6-8

In obstructive or mixed apnea, it is known that when CPAP stabilizes the thoracic cavity, it reduces the negative afferent neuronal impulse on the respiratory center,9 alters the respiratory effort through by acting on the Hering-Breuer’s reflex,10 and increases the patency of upper airways either by the activation of dilator muscles in this region or by passive opening of airways due to the positive pressure.11,12

In patients with meconium aspiration syndrome, CPAP, when applied with moderate pressure, reverses atelectasis and stabilizes collapsed terminal airways.13 There are no reports on CPAP in pneumonia cases in the literature, but it is possible to speculate that the distending continuous positive pressure opens the alveoli that collapsed as a result of the pneumonic process.

In patients cardiopathies with engorgement of pulmonary vessels and decrease of pulmonary compliance, in situations of postthoracotomy, CPAP reverts the decrease of functional residual capacity, a frequent finding in such cases.14

CPAP is used after extubation because when newborn is extubated, the vocal cords remain separated for some time, and this precludes the maintenance of the physiologic positive pressure, which contributes to lung expansion. Besides, the cough reflex is impaired, and tracheobronchial secretion is increased. Thus, newborn, especially preterm babies, faces the risk of developing respiratory distress, atelectasis, and apnea after the removal of the endotracheal catheter. The efficiency of nasal CPAP after extubation depends on the level of pressure created; in studies in which the pressure used was below 5 cmH2O, there was no difference between the use of nasal CPAP or oxygen halo.15

CPAP may cause local complications, such as nasal obstruction by edema, nasal bleeding, deformities, necrosis of the nasal septum, or even choanal stenosis. There may be pulmonary complications, such as pneumothorax, interstitial emphysema, pneumomediastinum, and pulmonary bronchodylsia. Yet, when compared to mechanical ventilation, CPAP presents a lower frequency of barotrauma.16

The application of CPAP, due to the increase in intrathoracic pressure, may lead to a decrease in secondary cardiac output, to a decrease in venous return, and to the induction of prostaglandin E, which has a negative inotropic action. CPAP may also increase pulmonary vascular resistance, since it increases the intra-alveolar pressure that compresses the vascular surface. However, these effects depend on the pressure applied, and, in situations where CPAP improves ventilation and oxygenation, pulmonary vascular resistance may even fall.14,17 The possibility of an increase in the incidence of intracranial hemorrhage with the use of CPAP has already been suggested. However, medical centers that use CPAP more freely, associated, when necessary, with minimum intermittent mechanical ventilation, do not report increased incidence of intracranial hemorrhage, volutrauma or pulmonary bronchodylsia.18-20

Intestinal gaseous distension due to the use of CPAP is not considered a complication, because of its benign character.21

Although there have been significant developments in neonatal ventilators during the two past decades, and despite the fact that CPAP is not used as frequently, some medical centers continue to use it and improve it as a strategy to fight pulmonary bronchodylsia and other damage resulting from endotracheal intubation. The neonatal intensive care unit (NICU) at Hospital das Clínicas de Ribeirão Preto, for example, still adopts CPAP as an alternative for respiratory support in preterm and term newborns.

The objective of the present work was to assess the repercussions of the application of nasal CPAP in preterm newborns at the NICU at Hospital das Clínicas de Ribeirão Preto, Brazil.

Methods

This is a prospective study including 113 preterm newborns weighing 2,500 g or less, with corrected gestational age equal to or below 40 weeks. We included all newborns requiring ventilation with CPAP as initial ventilatory support or during ventilator weaning, without facial malformations that could affect CPAP performance. One of the authors (MACR) had direct contact with all these children from August 1994 to August 1996. We excluded patients with less than 2 hours of observation and/or whose data were incomplete.

At birth, we collected information about Apgar scores at the 1st and 5th minutes, gestational age, weight, age at the moment of CPAP application, and indication for the use of CPAP based on clinical evolution and radiological report. Gestational age was compared using the Ballard22 or Capurro23 somatic methods, depending on the patient’s clinical status. Children were stratified into three weight categories, namely: 1,000 g or less, from 1,001 to 1,500 g, and from 1,501 to 2,500 g. Each stratum had to contain at least 30 children.

For the application of CPAP, we employed two types of double nasal catheters (Argyle, Sherwood Medical, St. Louis, MO, USA; and Hudson, Hudson RCI Temecula, CA, USA) brands. Both were used more than once if there were no alterations resulting from ethylene oxide sterilization.
CPAP was obtained using a neonatal ventilator as flow generator, connecting the patient’s gas outlet to a flask containing water and immersed at 5 cm. The liberated flow was enough to produce gas bubbles in the water of the flask connected to the patient’s expiratory route. The gas offered had the usual amount of oxygen, and it was warm and humid.

The indication for CPAP application was made by the medical team and depended on the underlying pathology. For children with problems such as pneumonia, newborn transitory tachypnea, and hyaline membrane disease, CPAP was applied when oxygen concentrations superior to 40% were necessary to maintain oxygen arterial tension over 50 mmHg, paCO₂ over 60 mmHg, and/or respiratory distress with a score of at least 3 on the Silverman-Andersen scale. If paCO₂ was maintained over 60 mmHg with concomitant fall of pH to <7.20 after 2 hours of CPAP, the patient was intubated (one of the failure criteria). For ventilator weaning, if the child had minimal ventilatory parameters (inspiratory pressure below 16, ventilator frequency below 20, peep below 4), and presented a good respiratory effort, s/he was extubated and submitted to nasal CPAP. In apnea cases, nasal CPAP was used when treatment with methylxanthines was not enough to change this status.

CPAP was assessed in terms of its efficiency and frequency of associated morbidity. The therapeutic efficiency was assessed through the evolution of respiratory frequency, cardiac frequency, Silverman-Andersen scale, and gasometry data measured before CPAP installation and after 2, 24, and 48 hours. The Silverman-Andersen scale is based on the presence of expiratory moaning, nasal flange beat, intercostal and xiphoid appendix retractions, and thoracoabdominal synchrony, with scores from 0 (good) to 2 (poor) for each of the items. For intubated newborns, the Silverman-Andersen scale was assessed only 2, 24, and 48 hours after the application of CPAP, since the scale has its efficacy affected if the patient is on mechanical ventilation. Gasometry data were assessed through the analysis of blood coming from the umbilical, peripheral or capillary arteries, obtained through a heel stick. Oxygen saturation and paO₂ were not considered in the study, since the obtained samples consisted of either preductal, postductal, or, sometimes, capillary blood, making it impossible to analyze the data as one single unit.

The treatment was considered successful when CPAP was interrupted due to clinical improvement, with the patient being placed on oxygen halo or open-air breathing, with no need for intermittent mechanical ventilation during 72 hours after weaning from nasal CPAP. We considered nasal CPAP to have failed when the child was not able to maintain stability due to consecutive apneas, exaggerated respiratory effort accompanied by an increase in the cardiac frequency, progressive increase in the need for O₂, increase in blood pCO₂ to more than 60 mmHg, with concomitant fall of blood pH to less than 7.20.

As for the problems associated with CPAP, we analyzed the placement of the device, time receiving CPAP, as well as morbidities associated with nasal CPAP: bleeding, hyperemia and/or nasal septum necrosis, pneumothorax, pneumomediastinum, interstitial emphysema, abdominal distension, and the newborn’s capacity to receive gastroenteric feeds. Placement was assessed by the number of times the catheters came out of the nostrils, corrected for 24 hours. The assessment of these morbidities was always performed by the same investigator (MACR), who examined the newborns daily, evaluated medical records, and analyzed x-rays with the help of an experienced neonatal radiologist.

Some of the patients who used nasal CPAP eventually died. In such cases, in addition to the parameters mentioned above, we evaluated age at death, cause of death, and the temporal relation of death with the use of nasal CPAP.

The present protocol was approved by the Ethics Committee at Hospital das Clínicas de Ribeirão Preto.

For the statistical analysis, we initially evaluated the normality of the distribution of variables with the Kolmogorov-Smirnov test. Except for weight, no other variable presented normal distribution, and therefore, variables were analyzed through non-parametric statistical tests.

In the comparison of continuous quantitative variables between two independent samples, such as gestational age, corrected gestational age, number of times the catheter came out of the nostrils, and time receiving CPAP, we applied the Mann-Whitney method. We used Kruskal-Wallis’ analysis for the comparison of continuous quantitative variables between more than two independent samples, such as time of permanence and comparison between the several weight categories.

The analysis of two dependent variables was performed through the Wilcoxon method. For more than two dependent samples, such as the comparison of the values before, 2, 24, and 48 hours after CPAP, we applied Friedman’s two-way method for the analysis of variance, with K dependent samples.

The comparison between two independent qualitative samples was performed using the chi-square test (Fisher’s exact test). This test was applied to the assessment of Apgar score, pathology that led to the installation of CPAP, and morbimortality associated with CPAP. The estimates were carried out using The Statistical Package for the Social Sciences (SPSS) 5.01 (SPSS Incorporation, 1992). The accepted level of significance for all tests was 5%.

Results

Out of the 113 original patients, 17 were excluded from the study for having received CPAP for less than 2 hours or because their data were incomplete.
The main characteristics of the 96 children evaluated, as well as the reasons that led to the installation of nasal CPAP appear in Table 1. We studied preterm children with birth weight between 480 and 2,450 g, gestational age between 24 and 36 weeks, and corrected gestational age between 24 and 39 weeks. Most of children presented an Apgar score below 7 at the 1st minute; smaller children presented this feature more often (P<0.01). The recovery of preterm children, measured by Apgar score at the 5th minute, was 75% among those who were born weighing less than 1,500 g, and 90% among those who were born weighing between 1,501 and 2,500 g; these differences were not statistically significant.

The indication of CPAP for apnea, hyaline membrane disease, pneumonia, and newborn transitory tachypnea was similar in the weight groups we analyzed. The smaller the child was, the more frequent the use of CPAP as a support to respiratory weaning (P<0.01). Despite the tendency to longer periods of permanence in CPAP among smaller children, this difference did not reach statistical significance.

We investigated if the use of new or reused catheters would influence the incidence of hyperemia or nasal bleeding. We could not verify any statistical difference among the catheters either in terms of nasal hyperemia (P=0.22) or nasal bleeding (P=0.56). Based on this finding, we considered those children who received new and recycled catheters as one only group.

Clinical and gasometric repercussions of the application of nasal CPAP are shown in Table 2. For every weight stratum, after nasal CPAP installation, we verified a statistically significant increase in the respiratory difficulty assessed by SAB. Taking respiratory frequency or cardiac frequency as the only parameter, we did not verify any significant difference between the groups, except for the weight category between 1,001 and 1,500 g, which showed a statistically significant decrease in respiratory frequency.

We did not observe any differences before and after the application of nasal CPAP in terms of blood gas parameters. It was detected that 22 patients presented pCO2 higher or equal to 60 mmHg at some during the study. Fourteen of these patients initiated CPAP with pCO2 higher than 60 mmHg, and in three of them, this value remained the same for 2 hours after CPAP installation, with the need for endotracheal intubation in two cases. The maximum value of previous pCO2 found in the study was 77. Endotracheal intubation was not required in this page, since the patient presented clinical and gasometric improvement, with a decrease in Silverman-Andersen score and pCO2 values considered normal after 2, 24, and 48 hours.

Table 1 - Main characteristics of the studied population: weight at birth, gestational age, corrected gestational age at the moment of CPAP application, Apgar scores, indications and period of permanence in CPAP. Numbers are expressed as median, minimum, and maximum values, or number of children, and percentage in weight category

<table>
<thead>
<tr>
<th>Weight categories</th>
<th>≤ 1,000g</th>
<th>1,000g — 1,500g</th>
<th>1,500g — 2,500g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children</td>
<td>32</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>Weight (g)</td>
<td>847 (480-1,000)</td>
<td>1,275 (1,020-1,500)</td>
<td>1,890 (1,580-2,450)</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>30+6/7 (24-35)</td>
<td>32+4/7 (29-35)</td>
<td>34 (31-36)</td>
</tr>
<tr>
<td>Corrected gestational age (weeks)</td>
<td>31+1/7 (24-39)</td>
<td>32+4/7 (30-39)</td>
<td>34 (32-39)</td>
</tr>
<tr>
<td>Apgar score 1st minute &lt;7</td>
<td>26 (84%)†</td>
<td>20 (59%)</td>
<td>12 (57%)</td>
</tr>
<tr>
<td>Apgar score 5th minute &lt;7</td>
<td>8 (25%)</td>
<td>8 (24%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Apnea</td>
<td>5 (16%)</td>
<td>3 (9%)</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>Hyaline membrane</td>
<td>8 (25%)</td>
<td>13 (38%)</td>
<td>10 (33%)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0</td>
<td>1 (3%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>NTT§</td>
<td>5 (16%)</td>
<td>6 (18%)</td>
<td>10 (33%)</td>
</tr>
<tr>
<td>Ventilator weaning</td>
<td>14 (44%)‡</td>
<td>11 (32%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>CPAP period (hours)</td>
<td>51 (4-240)</td>
<td>41 (2-190)</td>
<td>33 (2.5-120)</td>
</tr>
</tbody>
</table>

† P<0.01  ‡ When CPAP is applied  § Newborn transitory tachypnea
Morbidities were analyzed in terms of two aspects: weight group and period of permanence in nasal CPAP. When the patients were analyzed according to the period of permanence in nasal CPAP, we detected that the percentage of children with nasal hyperemia, nasal bleeding, abdominal distension and who were fed was higher for longer periods of nasal CPAP application. The number of times the catheter came out of the nostrils per a given time unit was not associated with the period of permanence in nasal CPAP. These data are presented in Table 3. Fortunately, during the study, we did not detect any child with nasal septum necrosis, pneumothorax, pneumomediastinum, or interstitial emphysema.

Analyzing these same parameters in terms of weight group, we found differences that reached statistical significance only for abdominal distension and for the number of times the catheter came out of the nostrils, as shown in Table 4. Smaller children (less than or equal to 1,000 g) presented a higher incidence of abdominal distension, and children weighing between 1,501 and 2,500 g presented more difficulty to remain adequately connected to the double nasal catheter.

Table 5 presents the frequency of CPAP interruption due to clinical improvement, without returning to intermittent mechanical ventilation in the ensuing 72 hours. The comparisons between the weight groups according to the underlying pathology was compromised by the small number of children in each segment. However, taking the height/weight strata as a whole, it is possible to observe that the success of nasal CPAP is directly proportional to the child’s weight.
Table 4 - Intercurrences in preterm newborns after nasal CPAP application, according to the weight at birth

<table>
<thead>
<tr>
<th>Weight categories</th>
<th>≤ 1,000g</th>
<th>1,000g—1,500g</th>
<th>1,500g—2,500g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children</td>
<td>32</td>
<td>34</td>
<td>30</td>
</tr>
<tr>
<td>Nasal hyperemia</td>
<td>9 (28%)</td>
<td>11 (34%)</td>
<td>12 (40%)</td>
</tr>
<tr>
<td>Nasal bleeding</td>
<td>14 (44%)</td>
<td>7 (21%)</td>
<td>7 (23%)</td>
</tr>
<tr>
<td>CON</td>
<td>0.25 (0-0.58)</td>
<td>0.19 (0-1.8)</td>
<td>1.15 (0-2.78)†</td>
</tr>
<tr>
<td>Abdominal distension</td>
<td>11 (34%)</td>
<td>3 (9%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Feeding</td>
<td>18 (56%)</td>
<td>16 (47%)</td>
<td>11 (37%)</td>
</tr>
</tbody>
</table>

CON= catheter out of nostrils for 24 hrs. Expressed as median values and percentiles 25 and 75.

‡ P<0.01; * P=0.04

Table 6 shows the characteristics of the newborns who died. Two babies (gemelar C- C’s twin) died when they were very close to CPAP weaning. These patients were clinically well, but suddenly developed a hemorrhagic process.

Discussion

The characteristics of the studied population are shown in Table 1. As predicted, there was great variability in weight (between 480 and 2,450 g). For this reason, almost all analyses were performed by in terms of height/weight strata.

The Apgar scores at the 1st minute were low in 84% of the patients with less than 1,000 g. Apgar values at the 5th minute, for the three weight categories, were higher than or equal to 7 in most of the children, indicating that the children analyzed in the study were not significantly compromised in the postdelivery period. Indication for nasal CPAP was similar between the groups, except for its application after extubation, which was more frequent among smaller children. This is in agreement with the literature.15

As for the period of permanence in nasal CPAP, shown in Table 1, despite the apparent tendency to a more prolonged use among smaller children, there were no differences between the three weight categories from a statistical point of view. The average period of permanence in CPAP, considering all the patients, was 60.3 hours. Published studies describe a great variability for the period of permanence in nasal CPAP, with averages between 48 and 124 hours; some children remain on CPAP for several weeks.18,25

Table 5 - Number of children with successful nasal CPAP treatment according to weight category and underlying pathology

<table>
<thead>
<tr>
<th>Weight categories</th>
<th>≤ 1,000g</th>
<th>1,000g—1,500g</th>
<th>1,500g—2,500g</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyaline membrane</td>
<td>2 (25%)</td>
<td>6 (46%)</td>
<td>7 (70%)</td>
<td>15 (48%)</td>
</tr>
<tr>
<td>NTT</td>
<td>4 (80%)</td>
<td>4 (67%)</td>
<td>10 (100%)</td>
<td>18 (86%)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>0</td>
<td>0</td>
<td>2 (67%)</td>
<td>2 (50%)</td>
</tr>
<tr>
<td>Apnea</td>
<td>2 (50%)</td>
<td>3 (100%)</td>
<td>3 (75%)</td>
<td>8 (73%)</td>
</tr>
<tr>
<td>Ventilator weaning</td>
<td>4 (27%)</td>
<td>7 (64%)</td>
<td>3 (100%)</td>
<td>14 (48%)</td>
</tr>
<tr>
<td>Total</td>
<td>12 (37%)</td>
<td>20 (59%)</td>
<td>25 (83%)</td>
<td>57 (59%)†</td>
</tr>
</tbody>
</table>

* p<0.01
The immediate impact of nasal CPAP was assessed through the Silverman-Andersen score, presented in Table 2. We detected an expressive decrease in the Silverman-Andersen score in all weight categories as soon as 2 hours after the installation of CPAP. The improvement continued to be significant until 48 hours. These data clearly show the immediate benefic effects of nasal CPAP on the assessed group. However, differently from other previous reports, an improvement was not detected in blood gases. This happened because the initial status of the studied children was fair, and also because the medical team avoided this situation. However, when we specifically analyzed the evolution of children who presented pCO₂ higher than or equal to 60 mmHg during parts of the treatment, we were able to see the impact of the treatment. Among the 14 children who initiated CPAP with a high pCO₂, only two maintained elevated pCO₂ 2 hours after CPAP installation, which determined tracheal intubation. CO₂ is a gas that quickly spreads from the blood to the alveolar gas, and therefore the increase in alveolar ventilation decreases PA CO₂ and proportionally decreases Pa CO₂. CPAP increases alveolar ventilation and CO₂ exchange when there is atelectasis or decrease in pulmonary volume. Airway distending pressure re-expands collapsed alveoli, and keeps open those that would collapse, thus increasing the gaseous exchange surface.²⁶ In patients with very low weight (<1,000 g) the extremely compliant thoracic cavity tends to collapse during expiration, when the diaphragm descends; this results in low stream volume even in those patients who do not present surfactant deficiency. CPAP application in this situation may correct these physiologic abnormalities, and promote increased gaseous exchange.¹⁴

The comparison between the use of new and reused catheters was performed due to the lack of resources in many Brazilian institutions, which often results in the re-utilization of materials in order to cut costs. Although no differences were detected, it must be stressed that we restricted the employment of reused catheters, disposing of those that were hardened by the sterilization process with ethylene oxide.

As for topical complications, nostril hyperemia, the first sign of tissue aggression, was a very frequent finding. It was directly correlated with the period on CPAP (Table 3), but not with the child’s size (Table 4). After 48 hours on nasal CPAP, about half of the children presented this complication.

Similarly to hyperemia, the presence of nasal bleeding was directly proportional to the period on CPAP (Table 3). Although we observed that smaller children were affected more frequently (Table 4), it did not reach statistical significance (P=0.08). Practically half of the children presented bleeding after 48 hours on CPAP, and 29% of all children presented this complication during the study. We did not find any comment on the incidence of hyperemia and nasal bleeding related to the use of CPAP in the literature, but the data obtained in the present study are doubtlessly a reason for concern.

Nasal septum necrosis did not occur in the patients in this study. Fortunately, this serious complication of CPAP is not frequently described in literature. The few cases described generally involve preterms with very low weight.¹⁸,²⁷ Topical complications may be minimized with the use of some basic measures. Nasal catheters must be

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### Table 6 - Main characteristics of preterm newborns who eventually died after treatment with nasal CPAP

<table>
<thead>
<tr>
<th>Newborns</th>
<th>Weight at birth (g)</th>
<th>Gestational age (weeks)</th>
<th>Age at CPAP beginning</th>
<th>CPAP period</th>
<th>Age at death</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAVS</td>
<td>480</td>
<td>24</td>
<td>9 h</td>
<td>39 h</td>
<td>48 h</td>
<td>Generalized hemorrhage</td>
</tr>
<tr>
<td>AA</td>
<td>880</td>
<td>32+5/7</td>
<td>61 h</td>
<td>4 h</td>
<td>15 d</td>
<td>Pneumonia</td>
</tr>
<tr>
<td>JCP</td>
<td>1000</td>
<td>30</td>
<td>82 h</td>
<td>78 h</td>
<td>63 d</td>
<td>BDP† + pneumonia</td>
</tr>
<tr>
<td>LCS</td>
<td>1120</td>
<td>32</td>
<td>25 day</td>
<td>120 h</td>
<td>9 m</td>
<td>BDP + cardiac failure</td>
</tr>
<tr>
<td>JLG (gene C)</td>
<td>690</td>
<td>31</td>
<td>2 h</td>
<td>28 h</td>
<td>33 h</td>
<td>Pulmonary and CNS‡ hemorrhage</td>
</tr>
<tr>
<td>RMM</td>
<td>1490</td>
<td>32</td>
<td>2 h</td>
<td>30 h</td>
<td>8 d</td>
<td>Enteroocolitis + pneumonia</td>
</tr>
<tr>
<td>ACO</td>
<td>980</td>
<td>31</td>
<td>36 h</td>
<td>48 h</td>
<td>5 d</td>
<td>Pulmonary hemorrhage</td>
</tr>
<tr>
<td>MAO</td>
<td>620</td>
<td>25</td>
<td>40 min</td>
<td>24 h</td>
<td>44 h</td>
<td>Pulmonary hemorrhage</td>
</tr>
</tbody>
</table>

† Pulmonary bronchodyplasia ‡ Central nervous system
made of soft material and with an adequate size, according to the patient’s nostril. Both big catheters, which compress nostrils, and those that are too small, and therefore hard to fix, traumatize nostrils. It is important that we constantly watch the skin of the nasal region searching for signs of irritation, and we should also frequently verify the catheter position. It is fundamental that the gas flow administrated to the patient be warm and rather wet. This measure helps to control the formation of secretion, making these fluids more liquid and, therefore, more easily removable. When promoting the humectation of gases, the condensed water inside the circuit must be cleared in order to avoid an increase in breathing resistance.

The fixation of the catheter to the nostrils must also be discussed. Doubtlessly, it is an important factor for treatment success. As already discussed, the excessive mobility of the catheter in relation to the nostrils causes trauma to the skin and the mucosa. Besides, the frequency in which catheters come out of the nostrils leads to fluctuations in the oxygen supply and in the continuous distending pressure offered, and, consequently, it may destabilize the patient. We evaluated the fitness of the fixation system based on the number of times the catheter was spontaneously displaced per a given time unit. The incidence catheter displacement did not present any correlation with the period of nasal CPAP application (Table 3), but it varied according to the child’s size (Table 4). The bigger and more mature the newborn, the higher the possibility of motion, and the harder the maintenance of the catheter in the right position. A way to solve the problem of variation in oxygen tension when the catheter is displaced is maintaining children in an environment with the same concentration of oxygen offered by the CPAP system.

The occurrence of abdominal distension among newborns submitted to nasal CPAP has been emphasized in the literature. The radiological finding described is dilatation of intestinal loops. It is, though, different from necrotizing enterocolitis, because of the absence of wall thickening, intestinal pneumatosis or air leakage from the loops. This benign distension occurs mainly among immature newborns, and happens because these children do not have the enough intestinal motility to eliminate the air swallowed during the use of nasal CPAP. In the present study, the longer the period of permanence on CPAP was (Table 3), the higher the incidence of abdominal distension. Among children weighing 1,000 g or less (34%), the incidence of abdominal distension was also higher (Table 4). In the literature, this event is reported in up to 83% of the children weighing less than 1,000 g on nasal CPAP.

The presence of benign abdominal distension does not prevent patients from being fed enterally. However, it is important that we closely watch these children’s tolerance. In the present study, the frequency with which newborns received milk depended on the period s/he they had been on CPAP. Those who on CPAP for a longer period presented a higher probability of initiating feeding: after 48 hours on nasal CPAP, 77% of the patients were fed (Table 3).

We did not verify the occurrence of pneumothorax, pneumomediastinum, or interstitial emphysema during the study. However, is should be stressed that the standardized expiratory pressure for the project was at 5 cm of water, which must have contributed to this result.

The success of nasal CPAP was related to newborn weight. While there was a recovery rate of 83% among children weighing more than 1,500 g, the failure rate was higher than the recovery rate among patients weighing less than 1,000 g (Table 5). However, until very recently, the use of nasal CPAP was not considered in such small children. Considering the problem from a more optimistic perspective, we may say that, in less than one-third of the children weighing less than 1,000 g (37%), and in 59% of those weighing between 1,000 and 1,500 g, nasal CPAP successfully prevented endotracheal intubation.

The success CPAP also depended on the disorder. The highest efficiency rate reported was in the treatment of newborn transitory tachypnea (86%); the worst rate (48%), occurred in the treatment of hyaline membrane and on ventilator weaning. We may question why patients with newborn transitory tachypnea required CPAP, especially those weighing more than 1,500 g. All the patients diagnosed with newborn transitory tachypnea presented respiratory distress or elevated pCO2, which justified ventilatory support in addition to oxygen nasal catheter. From a radiological point of view, these patients presented characteristics of newborn transitory tachypnea, but we cannot rule out the idea that they also had a slight dysfunction in the surfactant system. The absence of phosphatidylglycerol has been described in the amniotic fluid of patients with this disorder.

As for hyaline membrane disease, if the patients were divided into two groups, one weighing 1,500 g or less, and the other weighing more than 1,500 g, the recovery frequency with CPAP would be 38% and 70%, respectively. Bassiouny et al., studying 44 patients with an average weight of 1,410 ± 400 g and hyaline membrane disease, obtained 61% of success with nasal CPAP. In cases of nasal CPAP indicated because of hyaline membrane disease, the age in which CPAP was initiated would be an important factor for the success of the procedure, but this did not differ between the present study (7 hours with variation of 5 minutes to 60 hours in patients weighing 1500 g or more) and that of Bassiouny et al. (6 hours with variation of 18 minutes to 70 hours).

Concerning ventilator weaning, the frequency of success in the present study was smaller than that described in the literature (27% vs. 76%) for patients weighing less than 1,000 g, and for patients weighing 1,500 g or less (64% vs. 84%). The reason for intubation and the period of intubation before CPAP differed in the analyzed studies.
The deaths observed in the present study occurred in the population weighing less than 1,500 g, and they were not directly related to nasal CPAP (Table 6), but resulted from complications due to the child’s immaturity.

In conclusion, nasal CPAP is a good alternative for ventilatory support in preterm children. It may be applied independently of the child’s weight, since 34% of children weighing 1,000 g or less had their respiratory problems solved with CPAP. However, it is more efficient in larger children. CPAP has proved to be a safe treatment, with topical complications, related the duration of the procedure. In addition, it does not prevent children from receiving enteric feeds. However, it is important to stress that constant and rigorous monitoring is required, not only for early detection of topical and barotrauma complications, but also, when necessary, to start mechanical ventilation.

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References

