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Prongs or Mask for Nasal Continuous Positive Airway Pressure in Neonates

Which One Is More Comfortable?

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ABSTRACT

Background: Nasal continuous positive airway pressure (NCPAP) is a common mode of respiratory support in neonatal intensive care units. Our objective was to compare whether NCPAP given with nasal prongs compared with a nasal mask reduces the pain scores in preterm infants with respiratory distress. **Methods:** Preterm infants on NCPAP due to respiratory distress were included in the study. All infants received NCPAP via the Infant Flow SiPAP. The COVERS pain scale was used to score the infants' pain. Each infant was studied alternating between nasal prongs and a nasal mask. Heart rate, respiratory rate, oxygen saturation, and transcutaneous CO_2 ($tcCO_2$) were monitored. Blood pressure and the infants' pain scores were determined every 30 minutes and the average of measurements was taken. **Results:** The median (interquartile range) values of pain scores, respiratory rates, oxygen saturations, $tcCO_2$ levels, and systolic blood pressures differed significantly and favored the nasal mask. **Conclusions:** This study demonstrates that continuous positive airway pressure via a nasal mask leads to a significant reduction in pain scores without altering the respiratory parameters of babies. On the basis of this study, it is possible to conclude that NCPAP applied via nasal mask may be a good alternative to NCPAP applied via nasal prongs.

Key Words: NCPAP, preterm infants, nasal mask, nasal prongs, pain

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Nasal continuous positive airway pressure (NCPAP) is a simple, low-cost, and noninvasive form of respiratory assistance that has been widely used to support spontaneously breathing infants.[1] Various interfaces for the delivery of continuous positive airway pressure (CPAP) exist, including prongs, nasal masks, nasal cannulas, and nasopharyngeal tubes.[2] The Infant Flow System (Vyaire, Mettawa, Illinois) is commonly used worldwide and has 2 different interface devices: a set of soft silicone nasal prongs and a nasal mask covering the nose with appropriate strapping and fixation.[3] Short binasal prongs have remained the standard of care for the delivery of NCPAP for years, with some limitations, including discomfort, pain, and septal deformities.[1,4–6] For effective delivery of NCPAP, tight-fitting binasal prongs are required to maintain a constant airway pressure. Tight fitting of the binasal prongs can cause damage to the nasal septum

and nasal flares, which can lead to pain and discomfort in infants.[7,8] Nasal masks are being increasingly used in recent years for delivering CPAP due to their ease of application.[1] Both interfaces may be associated with pressure loss, air leaks, and therefore intermittent hypoxia, which may occur during treatment.[9]

Pain is an important issue, especially for infants treated in the neonatal intensive care units (NICUs). It is well known that pain has short- and long-term consequences.[10,11] Pain and neonatal stress affect neurological development and long-term behavior.[12,13] In the short term, it has been widely reported that pain has a negative effect on some physiological parameters such as heart rate, respiration, oxygenation, and blood pressure.[14]

In this study, we aimed to assess whether NCPAP given with a nasal mask instead of nasal prongs would decrease pain scores and improve physiological parameters such as heart rate, respiratory rate, oxygen saturation, and blood pressure without deteriorating the infant's respiratory status. To the best of our knowledge, none of the previous studies have compared pain between nasal prongs and masks in infants during NCPAP.

PATIENTS AND METHODS

The study was conducted in the NICU at Marmara University Hospital. A crossover design that included within-participant comparison was used in the study. Preterm infants, who were less than 37 weeks of gestation at birth and receiving CPAP due to respiratory distress, were included. NCPAP was delivered via the Infant Flow SiPAP (IFS) (Vyaire, Mettawa, Illinois, USA). Exclusion criteria were infants with Apgar scores of 5 and less, hypotension requiring inotropic support, congenital heart disease, chromosomal abnormalities, major malformations, nasal deformities, and congenital airway abnormalities such as tracheoesophageal fistula and bilateral choanal atresia in infants on analgesics or sedation. Twenty-two preterm infants with respiratory distress were enrolled, and written informed consent was obtained from their parents.

In the study, all infants received NCPAP via the IFS with a positive end-expiratory pressure level of 6 cm H_2O, which was increased stepwise to 8 cm H_2O depending on the severity of respiratory distress. The fractional inspired oxygen concentration (Fio_2) was adjusted to maintain oxygen saturation within a target range (Spo_2: 90%-94%), according to the protocol of the unit adopted from the European Consensus Guidelines.[15] The COVERS pain scale was used to score the infant's pain and has the clinical advantage of being universally applicable to all infants, regardless of their age. This includes infants who are premature, very low birth weight, intubated, or those who require mechanical ventilation.[16,17] This scale is a valid pain scale that can be used in a clinical setting to assess pain in newborns and infants and contains 6 categories of assessment: crying, oxygen requirements, vital signs, expression, resting, and signaling distress. Each infant was studied for 2 subsequent 3-hour periods, alternating between nasal prongs and a nasal mask. We did not use hydrocolloid dressing in infants to ensure standardization during the study period. Measurements were recorded 15 minutes after switching from one device to the other. During the study period, heart rate, respiratory rate, oxygen saturation (Philips IntelliVue MX550, Boblingen, Germany), and transcutaneous CO_2 ($tcCO_2$) (Sentec-TcM, Lincoln, USA) were monitored. A blood gas analysis was performed at the end of each study period before switching from one interface to the other. Blood pressure and the infants' pain scores were determined every 30 minutes (at the 30th, 60th, 90th, 120th, 150th, and 180th minutes) after switching from one interface to the other, and the average of 6 measurements was taken. The total study time was 6 hours for each infant. The primary objective was to compare the nasal mask with the nasal prongs in terms of the infants' comfort and pain. The secondary objectives were to evaluate changes in oxygen requirements, respiratory rate, heart rate, $tcCO_2$, blood pressure, and blood gas analyses. This study was approved by the Regional Committee on Biomedical Research Ethics.

Descriptive analyses were presented using medians and interquartile ranges (IQRs). The Wilcoxon test was used to compare median values of measurements between nasal prongs and nasal mask. A P value of less than .05 was considered statistically significant.

RESULTS

The study included 22 preterm infants with a mean gestational age of 28.9 ± 3.2 (23-35) weeks, mean postnatal age of 21.5 ± 4.8 (14-32) days, and a mean birth weight of 1176 ± 732 (545-2145) g. Ninety-five percent of the infants were born by cesarean delivery, and 63% of them were male. The indications for NCPAP were respiratory distress syndrome ($n = 4$) and bronchopulmonary dysplasia ($n = 18$). Twelve infants (54%) were born after an unremarkable prenatal history. One infant was born to a mother with gestational diabetes mellitus (4%), 6 were born to preeclamptic mothers (27%), and 2 were born to mothers with gestational hypertension (8%). The mother of the smallest preterm (small for gestational age) infant had a history of preeclampsia. Two mothers were treated for urinary tract infection in the third trimester of pregnancy. The demographic characteristics of the patients are shown in Table 1.

Table 1. Demographic features of the study group

Male/female, *n*	14/8
Gestational age, wk	28.9 (23-35)
Postnatal age, d	21.5 (14-32)
Birth weight, g	1176 (545-2145)
Antenatal steroids, *n* (%)	10 (45)

The median (IQR) values for pain scores, respiratory and heart rates, oxygen saturations, $tcCO_2$, systolic and diastolic blood pressures, and blood gas analyses are compared in Table 2. A statistically significant difference was found for the pain score, respiratory rate, oxygen saturation, $tcCO_2$, and systolic blood pressure favoring the nasal mask. There were no statistically significant differences in heart rate, diastolic blood pressure, or pH and Pco_2 in blood gas analysis between the 2 groups. No nasal trauma was observed in any infant during the study period.

Table 2. Comparison of the median (IQR) values of pain scores and other clinical parameters

	Median (IQR)	*P*[a]
Pain score P	3 (1.0)	<.001
Pain score M	2.3 (1.0)	
Heart rate P, beats/min	149 (21.5)	.426
Heart rate M, beats/min	149 (26.4)	
Respiratory rate P, breaths/min	49 (7.4)	.020
Respiratory rate M, breaths/min	48 (11.2)	
Oxygen saturation P, %	97.5 (2.8)	.035
Oxygen saturation M, %	97.9 (2.5)	
Systolic blood pressure P, mm Hg	65 (8.7)	.001
Systolic blood pressure M, mm Hg	65 (8.2)	
Diastolic blood pressure P, mm Hg	37.9 (9.7)	.204
Diastolic blood pressure M, mm Hg	37.7(6.5)	
Transcutaneous CO_2 P, mm Hg	43.8 (7.3)	.003
Transcutaneous CO_2 M, mm Hg	41 (5.5)	
pH P	7.35 (0.06)	.895
pH M	7.35 (0.06)	
Pco_2 P, mm Hg	43 (8.4)	.073
Pco_2 M, mm Hg	39.5 (8.5)	

Abbreviations: IQR, interquartile range; M, mask; P, prongs.
[a]Wilcoxon signed rank test.

DISCUSSION

NCPAP is a noninvasive form of respiratory support that provides positive pressure to the airways of spontaneously breathing infants throughout the respiratory cycle. NCPAP is a simple and effective therapy for respiratory distress in infants. It can be delivered via a nasopharyngeal tube, nasal cannula, nasal prong, or nasal mask.[2,3] Prongs and nasal masks are the most commonly used interfaces to deliver NCPAP to infants.[18]

We hypothesized that using NCPAP with nasal mask, as opposed to nasal prongs, would reduce the pain score and increase the comfort of the infants without altering their respiratory status. The IFS device is widely used in NICUs to deliver NCPAP to both preterm and term infants. The device can administer NCPAP using short binasal prongs and nasal masks (Viasys Healthcare) available in 3 sizes (small, medium, and large).[19]

In randomized controlled trials, both prongs and masks were found to be equally effective in delivering NCPAP.[5,6,18–20] In these studies, no statistical significance was found between CPAP failure[5,6,19–21]; even lower oxygen and surfactant requirements[5] and lower intubation and mechanical ventilation rates[19] were found in the nasal mask group. There were no differences in secondary outcomes, such as differences in the rates of pneumothorax, severe cranial ultrasonographic abnormalities, oxygen therapy at 36 weeks' corrected gestational age, or death before hospital discharge.[19] A systematic review and meta-analysis compared the safety and efficacy of NCPAP delivered via nasal masks versus binasal prongs, including 7 randomized controlled trials and a total of 722 infants. Among all infants, the use of nasal masks decreased the rate of NCPAP failure within 72 hours of treatment initiation, and among a subgroup of infants requiring NCPAP for "step-up" therapy only, the use of a nasal mask decreased the incidence of moderate to severe bronchopulmonary dysplasia and the need for surfactant therapy.[18] In our study, we found that $tcCO_2$ levels, respiratory rate, and systolic blood pressure were lower and oxygen saturation levels were higher in preterm infants in the nasal mask group than in the nasal prong group. These findings show that delivering NCPAP with a nasal mask does not have a negative effect on ventilation and oxygenation.

Nasal trauma during CPAP is one of the most important concerns and can lead to severe injury in some infants. Nasal mask has been used to decrease the risk of nasal trauma, while supporting ventilation. A systematic review published in 2018 compared NCPAP failure and nasal trauma in preterm infants who received NCPAP via a nasal mask versus binasal prongs and found that the use of a nasal mask reduces the risk of moderate to severe nasal injury.[21] In some studies, nasal

trauma was significantly lower in the mask group,[5,6,22] while in others, no statistically significant difference was found.[19,20,23] During the study period, we did not observe any nasal trauma or injury in any of the infants, similar to studies reported in the literature.[19,20,23]

Newborns and infants often undergo numerous procedures during hospitalization, some of which can be painful.[16] However, pain in infants is often underrecognized and undertreated in NICUs,[16,24] which can have long-term effects on their pain response.[14,25] Therefore, it is important for clinicians to regularly assess and manage pain to avoid excessive exposure. CPAP cannulas can also cause pain, especially when they are not properly placed in the nostrils. We assumed that nasal mask could be more comfortable alternative as it may cause less trauma when properly placed. Several validated and reliable pain scales exist to measure acute pain in term and preterm neonates.[25] The COVERS scale has both concurrent and construct validity and can be used in clinical settings to assess pain in newborns and infants. Compared with other previously validated pain scales, the COVERS scale has the clinical advantage of being universally applicable to all neonates, regardless of their age or physiological state.[16,17] In our study, we found that there was a statistically significant difference in favor of nasal mask in terms of the pain scores (median [IQR]: 3 [1], 2.3 [1]; $P < .001$) and thus nasal mask led to a reduction in pain scores. These findings suggest that using a nasal mask provides better comfort and less pain, in addition to positive effects on ventilation and oxygenation.

Our study has several limitations, including the fact that it was not a randomized controlled study and blinding could not be performed. Another limitation is the small sample size and short study period. Findings could have been strengthened by combining several different study periods or conducting a longer study period. We recommend that these approaches be considered in future studies.

In conclusion, our study demonstrates that CPAP via a nasal mask leads to a significant reduction in pain scores and improves physiological variables such as respiratory rates and oxygen saturations without altering the infants' respiratory status. Nasal masks provide greater comfort and less pain to patients and, therefore, may improve their tolerance to NCPAP. On the basis of this study, it is possible to conclude that NCPAP applied via nasal mask is a good alternative to NCPAP applied via nasal prongs.

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