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Nasal Anthropometry among Term and Preterm Indian Neonates- Does Size Matter?

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Abstract

Introduction: The binasal prongs are used in neonatal intensive care unit (NICU) to provide nasal Continuous Positive Airway Pressure (n-CPAP) in preterm neonates. A variable degree of nasal trauma is the most common complication of n-CPAP therapy. This can be reduced by use of appropriately sized binasal prongs that are customized to the anatomical measurements of noses. The aim was to estimate the nasal two-dimensional anthropometrical parameters among Indian neonates across different gestations; to compare between both sexes and between neonates with different intra uterine growth status and gestational ages.

Methods: Hundred and one neonates across different gestational ages (24 – 42 weeks) and intrauterine growth status who were admitted to the NICU of a tertiary teaching hospital were enrolled and grouped into five categories based on their gestational ages viz. 37 – 42 weeks, 34 – 36 weeks, 31 – 33 weeks, 28 – 30 weeks, and 24 – 27 weeks. Seven nasal and para-nasal measurements were taken (nostril width, nostril length, columella width, columella length, nose width, nose length and philtrum length) for each neonate using a vernier caliper.

Results: All anthropometrical measurements differed significantly across gestations especially between 37 - 42 and 24 - 27 wks ($p = 0.00$). Males differed from females only with respect to nostril width ($p = 0.032$). The measurements varied significantly when compared among small for gestational age, appropriate for gestational age and large for gestational age neonates.

Conclusions: The nasal parameters differed significantly among various GA and intra-uterine growth statuses, which should help design appropriate sizes of bi-nasal prongs.

Introduction

It is a well-known fact that respiratory distress syndrome (RDS) affects a significant proportion of preterm neonates[1] and is one of the major causes of neonatal mortality. Hence, the recent Neonatal Resuscitation Program (NRP) guidelines recommend a delivery room respiratory support in the form of Nasal Continuous Positive Airway Pressure (n-CPAP) which can provide a positive end-expiratory pressure of around 5 cm H_2O, for these vulnerable preterm babies.[2,3] The use of n-CPAP in these babies has been reported to lead to earlier transition in the delivery room area, lower mortality, lower rates of intraventricular hemorrhage and bronchopulmonary dysplasia as compared to use of mechanical ventilation directly.[4]

Various CPAP generators as well as nasal interfaces, have been innovated and improvised in the past. Diverse interface devices like nasopharyngeal tube, single nasal prongs, bi-nasal prongs, nasal cannula have been used to deliver n-CPAP in neonates however, each of these have their own merits and limitations. Short bi-nasal prongs are commonly used in recent times and have shown to have better respiratory outcomes in neonates with RDS as compared to use of nasopharyngeal or single nasal prongs.[5] The major and the most common complication of n-CPAP therapy in preterm neonates is the variable degree of nasal trauma.[6,7] Even though there is no recognized classification specifically addressing to the nasal trauma secondary to n-CPAP in neonates, the US National Pressure Ulcer Advisory Panel[8,9] guidelines for staging have been often used in most of the neonatal studies. This classification has attempted to grade nasal injury from early stage of non-blanchable erythema with intact skin to an advanced stage of necrosis, with full thickness skin loss. In a study using the above classification of nasal trauma in neonates on n-CPAP, 42.5% of neonates developed nasal trauma. 88.3% had stage I nasal trauma, 11% stage II trauma and 0.7% had stage III trauma.[9] A similar incidence (20 - 60%) with nasal septum being the commonest site for injury was reported by another study.[10] Fischer et al, in a large cohort of preterm with different gestational ages and weights, reported an increase in the relative risk of nasal injury when the gestational age was < 32 weeks, birth weight < 1500 grams, n-CPAP duration > 5 days and Neonatal Intensive Care Unit (NICU) stay was > 14 days.[9] The higher incidence of nasal trauma in smaller babies is most of the times attributed to the soft, fragile skin, ischemia prone underlying tissue and more importantly the ill-fitting, inappropriately sized binasal prongs.[6] The number of the injuries and their severity can be reduced if an appropriate size binasal prongs are used, that are customized to the anatomical measurements of the noses.

Even though it is undoubtedly an important prerequisite to have the nasal sizes for development of the safe nasal interface sizes, there are few studies that look at the nasal anatomical parameters in Indian neonates of different gestations. Most of the prongs that are used in the Indian setup are based on the studies and sizes of the western babies. Our study aims to assess nasal parameters in neonates of different gestations for development of appropriate size binasal prongs.

Methods

This observational study was performed in the Neonatology Department of a tertiary care and teaching hospital of North India between January 2016 and April 2016. The study was approved by the ethical committee of the institution. All the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1964, as revised in 2000. All neonates born (live or stillbirth) were enrolled in the study within 72 hours of birth. The neonates who had any congenital malformation or facial dysmorphism of the nasal or para-nasal area were excluded from the study. It was pre-decided to measure at least five babies (male or female) in each gestational category for appropriate representation in each group. The gestational categories in which the measurements were taken were 24^{+1} - 27 completed weeks; 28^{+1} - 30 completed weeks; 31^{+1} - 33 completed weeks; 34^{+1} - 36 completed weeks and 37^{+1} - 42 completed weeks. A gestational assessment was done within 72 hours of birth using the New Expanded Ballard Score.[11] Based on Ghosh et al,[12] who reported the mean width of columella of term neonates as 2.5 mm with SD of 0.1, we calculated the sample size with a precision of 0.2 mm and confidence interval of 95% which came to 100 neonates. Candidates were enrolled after taking due informed consent from the parents or the primary caregiver. Baseline information including age in completed days, sex, and birth weight, appropriateness of growth for the estimated gestational age and date of birth were recorded. A Vernier caliper with a least count of 0.1 mm was used for measuring the various parameters. For this study, all the measurements were made by a Vernier caliper. The measurements were done using aseptic technique by an experienced paediatrician (Figures 1 & 2). Special care was taken to perform the same with all asepsis when the baby was quiet and sleeping. The mother was always with the baby when the measurements were taken. Each measurement was done at least thrice successively, and the mean of the measurements was finally recorded. Seven nasal and para-nasal parameters were measured (in mm), which were: (1) Nasal length ; measurement from the base of the nose to the tip of the nose (2) Nasal width (outer ala to ala distance) (3) Nostril length (Base of the nostril to the highest point) (4) Nostril width (The horizontal measurement from one side to other) (5) Columella length (The length from the base to the highest point on columella in the center) (6) Columella width (This was taken at the base of the columella) (7) Philtrum length (The length from the point of attachment of columella to the upper margin of the upper lip).

Figure 1. Measuring nasal width using vernier caliper

Figure 2. Measuring columellar width using vernier caliper

Measurements were statistically analyzed and tabulated. Arithmetic mean for each parameter in each group with standard deviations were calculated. One way analysis of variance (ANOVA) was used for comparing mean values of different groups; post hoc Tukey's HSD (Honestly significant difference) test was used to identify the significance of differences of mean among these groups and student t-test was used for comparing two groups with continuous variables. All the calculations / tests were performed with the help of SPSS 2.0. A p-value of < 0.05 was considered statistically significant.

Results

101 neonates were enrolled in the study from GA of 24 weeks till 42 weeks. Among the study group, 50.5% (51 / 101) were males. 23.76% (24 / 101) neonates were extremely low birth weight (ELBW), 24.75% (25 / 101) were very low birth weight (VLBW) and 28.71% (29 / 101) were low birth weight (LBW). Among all, 72.28% (73/101) were preterms.

The comparison of nasal measurements among different gestational age groups using one way ANOVA is shown in Table 1. On comparison of the five gestational groups, the estimated p values were highly significant for all the parameters. Post hoc analysis for nostril width revealed significant difference between 37 - 42 weeks group and 28 - 30 weeks group (p = 0.0052) and between 37 - 42 weeks and 24 - 27 weeks group (p = 0.008). For nostril length post hoc analysis revealed significance only for difference in measurements between 37 - 42 weeks and 24 - 27 weeks (p = 0.0273). With respect to columella width, the difference was significant when compared among the groups: 37 - 42 weeks vs 28 - 30 weeks (p = 0.0000); 37 - 42 weeks vs 24 - 27 weeks (p = 0.0000); 34 - 36 weeks vs 28 - 30 weeks (p = 0.0272); 34 - 36 weeks vs 24 - 27 weeks (p = 0.0001) and 31 - 33 weeks vs 24 - 27 weeks (p = 0.0101). For columella length post hoc analysis revealed significant difference for 37 - 42 weeks vs 34 - 36 weeks (p = 0.0057); 37 - 42 weeks vs 31 - 33 weeks (p = 0.0062); 37 - 42 weeks vs 28 - 30 weeks (p = 0.0005); 37 - 42 weeks vs 24 - 27 weeks (p = 0.0000) and 31 - 33 weeks vs 24 - 27 weeks (p = 0.0442). For nose width the difference among groups were significant except for 34 - 36 weeks vs 31 - 33 weeks and 28 - 30 weeks vs 24 - 27 weeks. For nose length, post hoc analysis revealed significant difference among all groups except 34 - 36 weeks vs 31 - 33 weeks and 28 – 30 weeks vs 24 - 27 weeks. Philtrum length showed significant difference only between 37 - 42 weeks vs 28 - 30 weeks (p = 0.0343) and 37 - 42 weeks vs 24 – 27 weeks (p = 0.0239).

Table 1. Comparison of parameters among different gestational groups [mean (mm) ± S.D.]

Gestational age (wks) n (%)	Nostril width	Nostril length	Columella width	Columella length	Nose width	Nose length	Philtrum length
42 – 37 N = 28 (27.72)	1.77 ± 5.68	0 ± 3.77	0.35 ± 4.11	1.77 ± 8.02	1.06 ± 20.71	1.77 ± 17.36	2.12 ± 7.89
36 – 34 N = 21 (20.79)	0 ± 4.74	1.06 ± 3.29	0.707 ± 3.67	0.707 ± 7	2.12 ± 18.14	1.41 ± 15.45	0 ± 7.52
31 – 33 N = 22 (21.78)	2.47 ± 4.77	1.06 ± 3.68	0.70 ± 3.36	0 ± 7.02	1.41 ± 16.84	1.06 ± 14.45	1.06 ± 7.52
30 – 28 N = 23 (22.78)	0.35 ± 4.17	0.71 ± 3.6	0 ± 3.22	0 ± 6.83	2.12 ± 15.07	0.71 ± 13.22	0.35 ± 6.87
27 – 24 N = 7 (6.93)	0.71 ± 3.5	0 ± 2.79	0 ± 2.64	0 ± 5.79	0 ± 14.28	0.35 ± 12.07	0 ± 6.29
p-value (ANOVA)	0.000	0.005	0.000	0.000	0.000	0.000	0.001

S.D. – Standard deviation; ANOVA: - Analysis of Variance.

The comparison of the parameters between both sexes using independent student t-test (Table 2), did not show any significant difference except nostril width (p = 0.032).

Table 2. Comparison of parameters between both sexes [mean (mm) ± SDs

Sex	Nostril width	Nostril length	Columella width	Columella length	Nose width	Nose length	Philtrum length
Male (n = 51)	0.941 ± 4.99	0.636 ± 3.66	0.668 ± 3.56	0.997 ± 7.23	2.690 ± 17.62	1.992 ± 15.13	1.202 ± 7.53
Female (n = 50)	0.913 ± 4.59	0.776 ± 3.43	0.523 ± 3.54	0.821 ± 7.10	2.637 ± 17.59	2.274 ± 14.91	1.051 ± 7.25
p-value (Independent t test)	0.032	0.111	0.875	0.492	0.959	0.610	0.217

Table 3 depicts the comparison of nasal parameters among neonates with different growth status using one way ANOVA. On comparison of the three groups, the p values for nose width (0.000), columella width (0.01) and philtrum length (0.004) were found to be significant. Post hoc analysis revealed significant difference between AGA and SGA (p=0.0193) for columella width; between AGA vs LGA (p = 0.0004) and SGA vs LGA (p = 0.0000) for nose width and between AGA vs LGA (p = 0.0030) and SGA vs LGA (p = 0.0051) for philtrum length.

Table 3. Comparison of parameters among neonates with different growth status [mean (mm) ± S.D.]

Growth Status n(%)	Nostril width	Nostril length	Columella width	Columella length	Nose width	Nose length	Philtrum length
(AGA) N = 71 (70.29)	0.996 ± 4.76	0.751 ± 3.58	0.609 ± 3.63	0.981 ± 7.22	2.617 ± 17.66	2.235 ± 15.06	0.904 ± 7.31
(SGA) N = 25 (24.75)	0.777 ± 4.70	0.612 ± 3.40	0.523 ± 3.26	0.645 ± 6.90	1.947 ± 16.54	1.719 ± 14.54	1.061 ± 7.30
(LGA) N = 5 (4.96)	0.447 ± 5.70	0.671 ± 3.70	0.274 ± 3.80	0.758 ± 7.70	0.822 ± 22.10	1.475 ± 16.90	2.761 ± 9.00
p-value (ANOVA)	0.083	0.481	0.01	0.080	0.000	0.073	0.004

S.D. – Standard deviation; ANOVA: - Analysis of Variance.

Discussion

The present study is an attempt to determine the basal values for various nasal parameters in different gestational age groups of the local population of neonates belonging to the north-western part of India. The study suggests that, as the gestation progresses, all the seven parameters assessed increase and values differ significantly between the gestation groups more so in the first and the last categories (37 - 42 weeks and below 28 weeks). JS et al[13]published a cross sectional study in 2019 on discrepancy in physical dimensions of nose and CPAP interface in 32 preterm neonates from 26^{+0} - 34^{+6} weeks gestation. The various anthropometric measurements were done using 3D photogrammetry. The measurements were observed to increase as weight of neonates' weight increased.

On comparison of male and female participants of the study, it was found that nostril width differs significantly between the two groups, being larger in males. This finding was comparable to the study done by Khandekar et al,[14] who reported mean nasal widths as 15.5 mm and 14.5 mm in male and female neonates respectively. They also found that mean columellar height in term neonates was 4.2 mm in male babies and 4.1 mm in females. Mean columellar width was 4.5 mm in male neonates and 4.4 mm in females. No comparison of means was done to assess whether the two groups differ with respect to the parameters assessed. Also, preterm babies were not a part of this study. Our study found lesser mean columellar width but larger columellar length and nasal width values compared to their study. Our study also noted no significant difference in measured parameters (except nostril width) between male and female babies.

Ghosh A et al[12] studied craniofacial anthropometric measurements of 1860 term neonates (1060 normal birth weight and 800 low birth weight) of Northeastern India and reported that there was significant difference In measurements of nose length, Columella width, and length and width of philtrum between males and females with male neonates having higher measurements. But preterm neonates were not included in this study. Our study did not find such statistically significant difference between the two sexes except for nostril width. This could probably be attributed to lesser sample size. In another study done by Agnihotri et al[15] for assessment of craniofacial anthropometry in infants and newborns, it was found that philtrum length differs in male and female neonates with p-value less than 0.05 while no such difference was found in the present study. Preterm neonates were again not a part of this study. Wong et al[16] assessed comparability of 3D digital photogrammetric images and direct methods and found them to be comparable on validity and reliability for craniofacial assessment.

A comparison among AGA, SGA and LGA groups, showed that columella width, nose width and philtrum length differ significantly between the three groups being the largest in LGA babies and the smallest in SGA babies. These would be an important data looking at the proportion of the SGA babies in the Indian population, as the current interfaces available are mainly derived from AGA preterm population. When we analyzed our data and applied post hoc (Tukey's HSD) after ANOVA, we found significant difference in nostril width and length; columellar width and length in the categories of GA < 28 weeks; 31 - 33 and ≥ 37 weeks.

The nomograms of the nasal and the paranasal parameters of the Indian babies of different gestation would be vital data to develop the indigenous (Indian), novel and customized nasal prongs for the Indian babies, translating into lesser nasal injury and better outcomes. The variation in the measurements between different gestation categories would be important to develop the minimum range of the nasal prongs that can fit most of the Indian neonates, this minimum range would add to reduction in the running cost in the widely existent constraint settings. Although our study is an important study for the nasal anthropometry among Indian neonates, one major limitation is lesser number (n = 7) of extremely preterm infants available for enrollment.

Conclusions

Post-hoc HSD suggests the use of at-least three different sizes of nasal prongs in Indian neonates (< 28 weeks; 31 - 33 and ≥ 37 weeks). Larger and multicentric studies are required before this can be put into use for manufacturing customized nasal prongs for Indian neonates.

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