Nasal Fossae Dimensions in the Neonate and Young Infant

A Computed Tomographic Scan Study

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Objective: To determine normal values in the size of nasal fossae to better delineate the concept of nasal stenosis in young infants with nasal obstruction and without choanal atresia.

Design: Case series.

Setting: Referral center.

Patients: Consecutive sample of 62 infants (aged 0 to 6 months) with no craniofacial anomalies who underwent conventional axial computed tomography scans for a neurologic disorder.

Intervention: From computer-stored images, the slices taken at the level of the nasal fossae floor and those just above were examined. The length and 10 measurements of the width of the nasal fossae were used to determine normal values.

Results: Most measurements, even the length of the nasal fossae, were positively correlated to the age of the patient ($R = .44$). In the age 0 to 2 months group, the median length was 29.35 mm (range, 21.3-40.4 mm). It was 31.5 mm in the age 4 to 6 months group (range, 25.3-36.9 mm). The anterior bony aperture seems to be the most accurate distance for the assessment of neonatal nasal fossae stenosis. Its median width was 13.5 mm (range, 8.8-17.2 mm). Large variations characterized the dimensions of the middle nasal fossae and the choanae: median values were 7.6 mm (range, 4.9-13.5 mm) and 14.3 mm (range, 10.8-19.0 mm), respectively.

Conclusions: This study defined the normal range of variation for the main dimensions of the nasal fossae in the horizontal plane. These can be used as a basis for determining nasal stenosis in cases of neonatal obstruction.


NEONATES ARE obligate nasal breathers. Nasal obstruction can be a major cause of dyspnea as well as being associated with feeding difficulties, recurrent aspiration, colic, sleep problems, and cyanotic attacks. When complete obstruction occurs, it can be life threatening, and if left untreated it can lead to developmental delay and obstructive sleep apnea with its cardiac and general sequelae.

During the last decade, computed tomography (CT) has become the standard technique for diagnosing and assessing the condition of a neonate with choanal atresia because the abnormal bony and membranous deformities can be readily seen on CT images.$^{1,4}$ However, less has been published about the neonate with nasal obstruction but without choanal atresia (NOWCA).$^5$ Edema of the nasal mucosa, narrow transverse width of the bony nose, choanal stenosis, and adenoid tissue obstruction of the choanae can all cause airway obstruction similar in severity to the respiratory impairment of choanal atresia. Usually, NOWCA presents with snoring and oral respiration between 3 to 6 weeks after birth. Other symptoms include rhinorrhea, labored breathing, cyanosis, feeding difficulties, dysphagia, and sleep disturbances. It tends to resolve slowly with time, and normal respiration returns by age 6 months.$^5$ This diagnosis can be easily missed because affected infants do not usually have any associated congenital anomalies and because the onset of symptoms may be several weeks after birth.$^5$ Treatment depends on identifying the site and etiology of the nasal obstruction; surgical widening of the bony nasal vault or choanae is not necessary.$^5$

To evaluate infants with NOWCA, the normal values of the nasal fossae are required. In 1985, Slovis et al$^4$ studied 66 CT scans of children with normal choanae and showed that the bony distance between the lateral wall of the nasal cavity and the vomer, ie the choanal airspace, in the new-
born was 0.67 cm and increased in size with age at a rate of 0.027 cm per year to age 20 years. In 1996, Corsten et al. reviewed the CT scans of 56 infants up to age 1 year with and without nasal obstruction. Their analysis showed that of the 4 dimensions used (maximal anterior bony diameter, diameter of the choanal aperture, minimal soft tissue diameter, and maximal width of the nasal septum), only the maximal posterior bony diameter showed significant differences between normal and nasally obstructed infants. In 1997, Sweeney et al. examined 28 patients between the ages of 2 and 13 years and reinforced that a linear relationship exists between the age and average choanal size with the choanae enlarging at a mean rate ± SD of 0.28 ± 0.09 mm per year. They highlighted that there is no significant difference between the average choanal size in children with and without nasal obstruction and that the size of the choanal air space cannot be used to predict the presence of nasal obstructive symptoms in children between the ages of 2 and 13 years.

Our study aimed to determine normal values in the size of nasal fossae in infants younger than 6 months to help define and diagnose NOWCA in young infants.

**PATIENTS, MATERIALS, AND METHODS**

This study was carried out at Hôpital Saint-Vincent-de-Paul, a pediatric university hospital in Paris, France. Between February 1994 and February 1996, all infants younger than 6 months who received a conventional axial cerebral CT scan for a neurologic disorder were eligible for the study. The exclusion criteria included any infants with craniofacial malformations and substantial developmental delay. From computer-stored images, 1 slice taken at the level of the nasal fossa floor and 2 just above were evaluated. The lowest slice showing the choanal airspace was chosen for analysis.

The following 11 dimensions of the nasal fossa were assessed using calipers to evaluate the anterior, middle-third, and posterior widths and the total length on CT images: (1) length from the pyriform aperture to the posterior end of the vomer; (2) anterior bony width between the 2 ridges extruding from the maxilla; (3) anterior mucosal width on the same line between the 2 mucosal edges, including the anterior airspace and the global thickness of the septum; (4) right pyriform aperture mucosal width from the lateral mucosa to the septal mucosa; (5) left pyriform aperture mucosal width, also from the lateral mucosa to the septal mucosa; (6) minimal soft tissue width at the middle third of the nasal fossae, from the mucosa of one inferior turbinate to the other; (7) right minimal middle mucosal width from the turbinal to the septal mucosa; (8) left minimal middle mucosal width from the turbinal to the septal mucosa; (9) width of the bony choanal aperture between both pterygoid processes; (10) right choanal airspace; and (11) left choanal airspace. At this level, the mucosal edge cannot be differentiated from the bony limit (Figure 1).

All these width measurements were made along axes perpendicular to the length. Moreover, measurement of the length of the nasal fossae was made as a calibration procedure. The measurements were recorded with the infant’s age (corrected in cases of pre-maturity), sex, and the reason for the original CT scan.

For each category, the statistical study included the calculation of the mean, the SD, and the minimal and maximal values. For most categories, a scattergram (bivariate plot procedure) was used and the regression line shown. For each age, the bound variance was calculated and figured on the graphs as 2 lines parallel to the regression line at a distance of 2 SDs. Differences between sexes were analyzed by the Mann-Whitney U test.

![Figure 1. Measurement of the bony anterior width (1) and length (2) on the computed tomographic scan, using calipers.](image1)

![Figure 2. Measurement of the mucosal anterior width (1) and bony posterior width (2).](image2)

![Figure 3. Measurement of the middle mucosal width (1).](image3)
RESULTS

The study included 62 consecutive infants, 0 to 6 months of age, who met the above criteria. There were 33 male infants and 29 female infants. Their ages ranged from 3 days to 6 months (mean age, 2.5 months; median, 2.05 months). The indications for the CT scan were seizures, bradycardia, acute neonatal distress, deficiency in motility of a limb, meningitis, and routine evaluation after valve and skull trauma.

MEASUREMENTS

The following observations were made: (1) There is a significant correlation between the length of the nasal fossae and increasing age. (2) The width of the anterior bony aperture significantly increases with age. There is a slight difference in relation to sex; male infants have an insignificantly larger aperture. (3) The anterior mucosal aperture is also larger in male than female infants but the increase in size with age is less pronounced and not significant. (4) At the level of the middle nasal fossae, the width of the nasal airway does not correlate with age. There is a larger variation in males than in females. (5) At the posterior level, there is a slight correlation with age and a slightly larger size in females than in males, but this is not significant. (6) The differences between the posterior (choanal) measurements and the right and left widths of the nasal fossae and increasing age.

Figure 4. Scattergrams of the main dimensions of the nasal fossae according to the age of the infants. For each of the 5 graphs, the middle line represents the regression curve, and the lines above and below this curve represent 2-SD limits. The individual data points are coded by sex.

Length of the Nasal Fossae

R = 0.445

Mucosal Anterior Width

R = 0.230

Bony Anterior Width

R = 0.616

Bony Posterior Width

R = 0.288

Middle Mucosal Width

R = 0.024

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fossae illustrate the variation in the size and axis of the vomer. These observations and data are further illustrated and outlined in Figure 1, Figure 2, Figure 3, and Figure 4 and in the Table.

Normal anatomy enables newborns to feed and swallow while the nasolaryngeal airway remains patent. The neonatal larynx is at the higher C4 position and does not descend to the normal adult level of C6 or C7 until puberty. In addition, the angle between the glos- tis and the epiglottis is acute, resulting in a larynx that is tilted anteriorly and downward, causing the epiglot- tis to fall back readily into the laryngeal inlet. At rest, the epiglottic cartilage lies in contact with the soft palate. Oral respiration occurs only when the neonate is crying. Mouth breathing becomes learned behavior within the first 2 to 5 months of life, but prior to this time any compromise of the nasal passages can be life threatening.

In neonates, nasal resistance is very high compared with the resistance of the remainder of the airway, accounting for as much as 49% of total airway resistance. In addition, small degrees of obstruction can substantially affect airflow patency as the resistance to airflow is inversely proportional to the fourth power of the diameter of the tube through which it flows.

Anterior nasal pyriform aperture stenosis is rare and caused by bony overgrowth of the nasal process of the maxilla. This occurs at the narrowest part of the nasal airway, small changes in cross-sectional area dramatically increase airflow resistance. While the diagnosis is easy to make because there is no air-filled space on the CT image, minor forms may be underestimated.

For the assessment of choanal stenosis, the criteria of Derkay and Grundfast were based on (1) radiographic evidence of posterior choanal narrowing (a smaller than 6-mm opening); (2) difficulty in passing a 6F feeding catheter through the nose into the nasopharynx a distance of at least 32 mm; and (3) endo- scenic verification of anatomical narrowing by direct inspection. Surgical widening of the bony nasal vault or choanae, however, is not necessary. Conservative management includes nasopharyngeal airways, topical steroids, home monitoring, and parental cardiopulmonary resuscitation training.

In the literature, the sizes of choanae in neonates and of the middle nasal fossae in 2- to 3-year-old children have been published. The importance of the nasal pyriform aperture in young infants has been stressed. However, little data regarding the entire nasal fossae in neonates and young infants have been reported, and in this age group, NOWCA is not a rare condition. In many cases, a simple medical therapy ensures prompt relief of symptoms, but some severe cases require surgical management. In those circumstances, stenosis of the pyri- form aperture is seldom found on CT scan. In newborns with stuffy noses, congenital stenosis of the nasal fossae should be considered, although this diagnosis is difficult to make from a CT scan. Contact between a turbi- nate and the septum is not a diagnostic criterion because some degree of local contact (and even a synchia) can occur without any substantial compromise of the airflow.

Precise measurements of the nasal airway are needed at every site from the pyriform aperture to the choanae. Although anatomical studies have been performed on the skull, only the bony structures have been studied, and only at 3 sites: the pyriform aperture, the middle turbinate, and the choana. Also, few neo- nates were included in this study. Nonetheless, there are substantial similarities between our measurements and those in that anatomical study. Realistically, the only practical way to assess nasal fossae measurements in neonates is by CT scan. Moreover, it is the investi- gation of choice for the diagnosis of any nasal obstruction in patients of this age.

Our results confirm that the width of the nasal fos- sae increases with age. However, the posterior and especially the anterior widths increase more rapidly than the width of the middle nasal fossae. This may be owing to the role of the mucosa covering the inferior turbinate that enlarges in the first few months of life. This may also be owing to the technique of measurement. A CT scan is not a reliable tool for a precise assessment of mucosal depth along the airway. This is why the middle nasal fos- sae width is so widely distributed in this series.

Conversely, this study highlights the sites that grow with age during the first 6 months: the pyriform aper- ture and the choanal lumen. These bony limits are more precise, and their distribution is correlated with age. For each measurement at these sites, the range of normal values is assessed in the 0- to 6-month age group. Thus, from the anterior pyriform aperture to the choanal airspace, most sites of potential obstruction now can be precisely compared with those of normal infants. In cases of in- fants with a stuffy nose but without a space-occupying mass, the radiologist and the otolaryngologist are now able to diagnose the site of a possible nasal stenosis. This
should help to determine the etiology of a lot of unknown causes of nasal obstruction in young infants.

**CONCLUSION**

This study establishes the normal range of variation for the main dimensions of the nasal fossa in the horizontal plane in infants younger than 6 months. These may be used as a base for the determination of nasal stenosis in cases of neonatal obstruction.

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