

# Morphometric Analysis of Nasal Cavity in Neonates – A CT Study

## Análisis Morfométrico de la Cavidad Nasal en Neonatos: Un Estudio de TC

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**SUMMARY:** The nasal cavity in the newborn represents the initial part of the respiratory system, and its anatomical and functional integrity has a direct impact on respiratory function, especially during the first days of life when newborns breathe exclusively through their nose. The aim of this study was to analyze the morphometric parameters of the nasal cavity in newborns and to correlate it with gender, gestational age, and the side of the nasal cavity. Also, the correlation between these parameters and anthropometric measurements of the newborns, including birth weight (BW), body length (BL), head circumference (HC), and gestational age was analyzed. The study was conducted on a sample of 80 newborns (39 male and 41 female), of which 20 were preterm and 60 were term. Using head computed tomography (CT) scans, parameters of the anterior, middle, and posterior thirds of the nasal cavity were measured, and anthropometric data were obtained from the medical records. Statistically significant gender related differences were found in the anterior bony width (ABW) and anterior mucosal width (AMW). Gestational age was significantly associated with ABW, AMW, bony choanal aperture width (BCAW), and maximal vomer width (MVW). In relation to the side of the nasal cavity, a significant difference was found between right and left anterior mucosal widths (RAMW and LAMW). Also, ABW, AMW, and BCAW showed statistically significant correlations with BW, BL, HC, and gestational age. These results may contribute to a better understanding of the development of the nasal cavity in the neonatal period, as well as potential differences in anatomical structure between different groups of newborns.

**KEY WORDS:** Nasal cavity; Newborn; Morphometry; Computed tomography.

## INTRODUCTION

The nasal cavity is located in the midface, limited inferiorly by the hard palate, laterally by the maxillary sinuses and their medial walls, and superiorly by the nasal, ethmoid, and sphenoid bones. It includes the nasal septum, nasal mucosa, and nasal turbinates. The septum, oriented in the sagittal plane, divides the nasal cavity into two separate chambers.

Understanding the normal morphometric characteristics of the nasal cavity in newborns, both full-term and preterm is crucial for the timely diagnosis and differentiation of congenital anomalies such as choanal atresia, stenosis of the piriform aperture, and middle nasal stenosis. Morphometric analysis enables precise quantitative

assessment of the dimensions and shape of the nasal cavity, which is important in both normal and pathological conditions. Normal values for the piriform aperture in newborns and infants up to 6 months range from 8.8 mm to 17.2 mm. However, due to variability in the size of nasal structures depending on gestational age, knowledge of reference values for normal nasal cavity morphometry is necessary (Sahin-Yilmaz & Naclerio, 2011).

One of the more significant congenital malformations of this region is piriform aperture stenosis, which can imitate the symptoms of other obstructive conditions and require urgent diagnostic evaluation and therapeutic intervention. A piriform aperture width less than 8 mm is indicative for

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congenital stenosis. Despite the absence of precise data on nasal cavity morphometry in preterm newborns in the reviewed literature, it is known that preterm infants have an increased risk of respiratory problems due to underdeveloped airways (Manica *et al.*, 2009).

With the help of high-resolution computed tomography (CT) scans and precise morphometric analysis, clinicians can make an accurate diagnosis, distinguish between similar clinical presentations, and promptly choose the appropriate surgical or conservative treatment. This is especially important in infants under one year of age, whose anatomical structures are small and still developing, making measurement precision critically important. This can significantly contribute to improving diagnostic and therapeutic approaches in neonatology and pediatric otorhinolaryngology (Lowe *et al.*, 2000; Moosa *et al.*, 2005; Likus *et al.*, 2014; Pupovac *et al.*, 2020).

The aim of the study was to determine the morphometric parameters of the nasal cavity in newborns, and to correlate it with sex, gestational age, and the side of the nasal cavity. Also, to analyze the degree of correlation between these parameters and the anthropometric measurements of the newborns.

## MATERIAL AND METHOD

The study was designed as a retrospective analysis of CT scans of the nasal cavity in 80 newborns (neonates) aged 0-28 days, who were treated in the neonatal intensive care units and the department for full-term and preterm infants at the Institute for Child and Youth Health Care of Vojvodina, in Novi Sad, from January 1, 2017, to January 31, 2025.

Newborns who were referred for CT diagnostics due to suspected traumatic head injury, and who had no nasal breathing difficulties or any otorhinolaryngological or craniofacial malformations, were selected for morphometric analysis. Newborns with genetic disorders (e.g., Down syndrome), mental retardation, congenital defects or complexes of congenital anomalies (CHARGE syndrome, VATER association, Crouzon, Pfeiffer, or Apert syndromes), craniosynostosis, or hydrocephalus were excluded from the study.

The following data on newborns were obtained from medical records: sex, gestational age at birth, birth weight, birth length, and head circumference. On the CT head scans, 15 parameters were measured related to the width of the anterior, middle, and posterior thirds of the nasal cavity (Likus *et al.*, 2014).

The CT scans were performed using a spiral technique in the transverse plane with bone reconstruction in layers of 1.25 mm in thickness, in accordance with standard pediatric head imaging protocols. The obtained axial images were transferred to a workstation for analysis. The measurement plane was parallel to the Frankfurt plane (auriculo-orbital plane), and measurements were taken at the level of the floor of the nasal cavity.

Measured parameters (Figs. 1 and 2):

Anterior third of the nasal cavity:

- ABW - Anterior bony width between the two ridges extruding from the maxilla-pyiform aperture
- RABW - Right anterior bony width from the right maxillary ridge to the septal mucosa
- LABW - Left anterior bony width from the left maxillary ridge to the septal mucosa
- AMW - Anterior mucosal width between two mucosal edges extruding from the maxilla including the anterior airspace and the global thickness of the septum
- RAMW - Right anterior mucosal width between the lateral mucosa and the septal mucosa
- LAMW - Left anterior mucosal width between the lateral mucosa and the septal mucosa

Middle third of the nasal cavity:

- MMW - Minimal soft tissue width from the mucosa of one inferior turbinate to the other
- RMMW - Right minimal soft tissue width from the turbinal to the septal mucosa
- LMMW - Left minimal soft tissue width from the turbinal to the septal mucosa

Posterior third of the nasal cavity:

- BCAW - Bony choanal aperture width between both pterygoid processes-choanal aperture
- RPBW - Right posterior bony width between bone sidewall and septal mucosa
- LPBW - Left posterior bony width between bone sidewall and septal mucosa
- RPMW - Right posterior mucosal width between the lateral mucosa and the septal mucosa
- LPMW - Left posterior mucosal width between the lateral mucosa and the septal mucosa
- MVW - Maximal width of vomer

The statistical analysis of the obtained data was performed using the Statistical Package for Social Sciences-SPSS 21 program. The results are presented as parameters

of descriptive statistics: mean value ( $\bar{x}$ ) and standard deviation (SD). To determine differences between groups, Student's t-test was used. Correlations between parameters were analyzed using Pearson's correlation coefficient. A statistically significant difference was considered if  $p < 0.05$ .

The research was approved by the Ethics Committee of the Institute for Child and Youth Health Care of Vojvodina in Novi Sad (date 20.3.2025; decision number:1642).

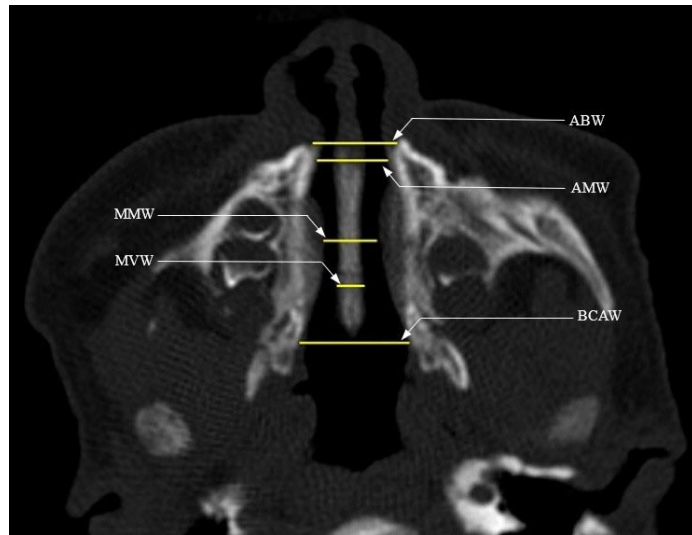


Fig. 1. Axial CT image normal nasal cavity in neonates. Measurements: anterior bony width (ABW), anterior mucosal width (AMW), minimal soft tissue (MMW), maximal width of vomer (MVW) and bony choanal aperture width (BCAW).

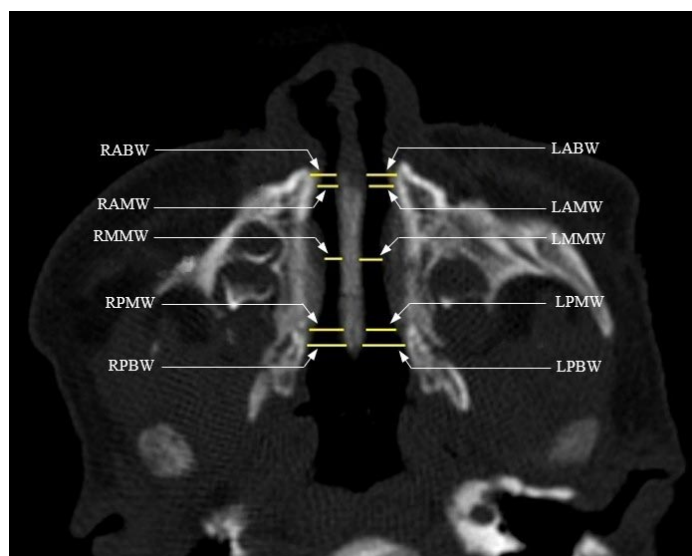


Fig. 2. Axial CT image normal nasal cavity in neonates. Measurements: right (RABW) and left (LABW) anterior bony width, right (RAMW) and left (LAMW) anterior mucosal width, right (RMMW) and left (LMMW) minimal soft tissue width, right (RPMW) and left (LPMW) posterior mucosal width and right (RPBW) and left (LPBW) posterior bony width.

## RESULTS

A total of 80 CT scans of newborns were analyzed, including 20 preterm newborns (born before the 35th gestational week) and 60 term newborns (born at or after the 35th gestational week). In relation to sex, there were 39 male and 41 female newborns. The average gestational age was 38.27 weeks. The average value of body weight (BW) was 3185 g, body length (BL) was 49.88 cm, and head circumference (HC) was 34 cm.

The average value of the width of the anterior part of the nasal cavity at the level of the piriform aperture (ABW) for all neonates was  $11.73 \pm 1.54$  mm, while the width of the posterior bony part at the level of the choanal opening (BCAW) was  $14.19 \pm 1.85$  mm. The width of the middle membranous part of the nasal cavity (MMW) was  $6.67 \pm 0.96$  mm. Average values of the other measured parameters in relation to gestational age and sex are presented in Table I.

By comparing the average values of the measured parameters of the nasal cavity between male and female newborns, a statistically significant difference was found for the parameters ABW and AMW. The female neonates had higher values. For the other parameters - MMW, BCAW and MVW - no statistically significant differences were found between the sexes.

By comparing the average values of the measured parameters of the nasal cavity between preterm and term newborns, a statistically significant difference was found for the parameters ABW, AMW, BCAW and MVW. Term neonates had higher values. For the MMW parameter, no statistically significant difference was found, indicating that gestational age does not influence this particular nasal cavity dimension (Table II).

Table III presents differences between the measured parameters of the nasal cavity in relation to the side, in all 80 neonates (including both sexes and both gestational age groups). A statistically significant difference was found between the right and left airway width between the mucosa of the lateral nasal wall and the nasal septum at the level of the piriform aperture (RAMW and LAMW).

Comparing the anterior, middle, and posterior thirds of the nasal cavity, a statistically significant difference was found between the bony and membranous anterior parts of the nasal cavity - ABW

Table I. Average values of the measured parameters of the nasal cavity in relation to sex and gestational age.

|                                          | Neonates          |                |                |                  |                 |
|------------------------------------------|-------------------|----------------|----------------|------------------|-----------------|
|                                          | preterm<br>(n=20) | term<br>(n=60) | male<br>(n=39) | female<br>(n=41) | total<br>(n=80) |
|                                          | x±SD              | x±SD           | x±SD           | x±SD             | x±SD            |
| Anterior third of the nasal cavity (mm)  |                   |                |                |                  |                 |
| ABW                                      | 10.8±1.08         | 12.05±1.55     | 11.37±1.34     | 12.12±1.65       | 11.73±1.54      |
| RABW                                     | 4.02±0.94         | 4.56±1.34      | 4.17±1.31      | 4.68±1.17        | 4.42±1.26       |
| LABW                                     | 3.91±0.83         | 4.36±1.06      | 3.86±0.87      | 4.65±1.02        | 4.24±1.02       |
| AMW                                      | 7.68±1.07         | 8.85±1.20      | 8.28±1.13      | 8.83±1.36        | 8.54±1.26       |
| RAMW                                     | 2.38±0.56         | 2.93±1.02      | 2.56±0.89      | 3.04±0.96        | 2.79±0.95       |
| LAMW                                     | 2.3±0.63          | 2.58±0.89      | 2.21±0.66      | 2.84±0.89        | 2.51±0.83       |
| Middle third of the nasal cavity (mm)    |                   |                |                |                  |                 |
| MMW                                      | 6.51±0.64         | 6.73±1.04      | 6.70±0.99      | 6.63±0.92        | 6.67±0.96       |
| RMMW                                     | 1.86±0.52         | 1.90±0.74      | 1.84±0.76      | 1.94±0.60        | 1.89±0.69       |
| LMMW                                     | 1.78±0.44         | 1.80±0.60      | 1.76±0.65      | 1.84±0.46        | 1.79±0.57       |
| Posterior third of the nasal cavity (mm) |                   |                |                |                  |                 |
| BCAW                                     | 12.95±1.82        | 14.63±1.66     | 14.31±1.56     | 14.07±2.12       | 14.19±1.85      |
| RPBW                                     | 5.27±0.79         | 5.84±0.99      | 5.75±0.81      | 5.64±1.13        | 5.70±0.97       |
| LPBW                                     | 5.22±1.01         | 5.79±1.04      | 5.72±1.00      | 5.56±1.11        | 5.64±1.06       |
| RPMW                                     | 3.65±0.65         | 4.28±0.95      | 4.28±0.86      | 3.94±0.95        | 4.11±0.92       |
| LPMW                                     | 3.69±0.88         | 4.25±0.95      | 4.21±0.94      | 4.00±0.98        | 4.11±0.96       |
| MVW                                      | 3.78±0.58         | 4.39±0.71      | 4.32±0.61      | 4.16±0.84        | 4.24±0.73       |

Table II. Differences between the measured parameters of the nasal cavity in relation to sex and gestational age.

| Parameter | sex    |              | gestational age |              |
|-----------|--------|--------------|-----------------|--------------|
|           | t      | p            | t               | p            |
| ABW       | -2.265 | <b>0.026</b> | -3.387          | <b>0.001</b> |
| AMW       | -1.987 | <b>0.050</b> | -3.938          | <b>0.001</b> |
| MMW       | 0.321  | 0.749        | -0.915          | 0.363        |
| BCAW      | 0.593  | 0.555        | -3.910          | <b>0.001</b> |
| MVW       | 0.985  | 0.327        | -3.534          | <b>0.001</b> |

Table III. Differences between the measured parameters of the nasal cavity in relation to the side.

| Paired groups | t     | p            |
|---------------|-------|--------------|
| RABW- LABW    | 1.230 | 0.222        |
| RAMW- LAMW    | 2.388 | <b>0.019</b> |
| RMMW- LMMW    | 0.896 | 0.373        |
| RPBW- LPBW    | 0.668 | 0.506        |
| RPMW- LPMW    | 0.082 | 0.935        |

and AMW (t=21.146; p<0.001). A statistically significant difference was also found between the anterior bony part and the middle membranous part - ABW and MMW (t=24.555; p<0.001), as well as between the anterior and posterior bony parts of the nasal cavity - ABW and BCAW (t = -12.325; p<0.001).

Correlation analysis was conducted to assess the relationship between morphometric parameters of the nasal cavity (ABW, AMW, MMW, BCAW) and general

anthropometric measurements in newborns, including BW, BL, HC, and gestational age.

The analysis showed statistically significant positive correlations between most of the measured parameters of the nasal cavity and anthropometric measurements:

- ABW showed a moderately positive statistically significant correlation with BW (r=0.359, p<0.001), BL (r=0.267, p=0.016), HC (r=0.359, p<0.001), and gestational age (r=0.389, p<0.001).
- AMW also showed a statistically significant correlation with BW (r=0.318, p=0.004), BL (r=0.301, p=0.006), HC (r=0.310, p=0.005), and gestational age (r=0.463, p<0.001).
- MMW did not show a statistically significant correlation with any of the examined anthropometric measurements (BW: r=0.206, p=0.064; BL: r=0.147, p=0.190; HC: r=0.117, p=0.299; gestational age: r=0.049, p=0.666).
- BCAW showed the strongest positive and statistically significant correlations compared to the other parameters, particularly with HC (r=0.525, p<0.001), BL (r=0.492, p<0.001), gestational age (r=0.476, p<0.001), and BW (r=0.449, p<0.001).

The results obtained indicate that the parameters of the anterior and posterior third of the nasal cavity, and in particular BCAW, show a stronger correlation with the general growth parameters of newborns. In contrast, the parameter of the middle third of the nasal cavity MMW did not show a statistically significant correlation with the examined anthropometric measurements.

## DISCUSSION

The nasal cavity in newborn represents the initial part of the respiratory system, and its anatomical and functional integrity has a direct impact on respiratory function, especially during the first days of life when newborns breathe exclusively through their nose. Therefore, knowledge of the normal values of morphometric parameters of the nasal cavity is of great importance in diagnosing pathological conditions and congenital anomalies.

This study revealed similarities and differences with previous studies that examined the morphometric characteristics of the nasal cavity in newborns. In this study, the average value of the width of the anterior part of the nasal cavity at the level of the piriform aperture (ABW) was  $11.73 \pm 1.54$  mm, while the width of the posterior bony part at the level of the choanal opening (BCAW) was  $14.19 \pm 1.85$  mm. The width of the middle membranous part of the nasal cavity (MMW) was  $6.67 \pm 0.96$  mm.

Belden *et al.* (1999), analyzed the width of the piriform aperture in children across three age groups: 0-3 months (average width 13.4 mm), 4-6 months (average width 14.9 mm), and 10-12 months (average width 15.6 mm). These authors showed that the width of the nasal cavity increases with the age of the child. The measurement results of the examined parameters in this study were lower than the values reported for the same age group in their study. For the 0-3 month age group, the width was  $14.874 \pm 1.62$  mm.

Lee *et al.* (2001) measured the width of the piriform aperture in children younger than 4 months using three-dimensional computed tomography (3D-CT) imaging. They indicated the usefulness of CT imaging of the anterior part of the nasal cavity, particularly for preoperative and postoperative evaluation in children. However, some authors point out that when interpreting the results of nasal cavity dimensions, especially its width, the mucosa covering the bony structures must also be taken into account. The presence of mucosa of varying thickness can influence the measured diameter of certain parameters.

In the study by Likus *et al.* (2016), which included 180 healthy newborns and young children, no statistically significant differences in measurements were found between sexes. However, in some previous studies, such as the one conducted by Contencin *et al.* (1999), variations in nasal cavity dimensions between male and female newborns were noted. In this study, statistically significant differences between male and female newborns were found only for the parameters ABW and AMW. The study by Djupesland & Lyholm (1998), showed that the size of the nasal cavity

airspace did not depend on sex, but a statistically significant positive correlation was observed with head circumference, which is similar to our findings, where a positive correlation was found between almost all examined parameters and anthropometric measurements.

Regarding the differences between term and preterm newborns, the results showed that almost all nasal cavity dimensions (ABW, AMW, BCAW, MVW) were statistically significantly different between the two groups. These results suggest that gestational age has a significant influence on the morphometric characteristics of the nasal cavity, with preterm newborns showing smaller nasal cavity dimensions compared to term newborns. These differences are consistent with previous studies suggesting that preterm infants may have reduced growth and development of certain body structures, including the nasal cavity, due to shorter gestational age. A 2021 study from India showed significant differences in nasal cavity morphometric parameters among newborns of different gestational ages, with larger dimensions in infants with higher gestational ages (Jain *et al.*, 2022).

By analyzing the differences between the right and left nasal cavity parameters (RABW-LABW, RAMW-LAMW, RMMW-LMMW, RPBW-LPBW, RPMW-LPMW), the results showed statistically significant differences only for the width of the breathing space between the membranous part in the region of the piriform foramen (RAMW-LAMW), while the other parameters did not show a significant difference. This suggests that right-left asymmetries in the nasal cavity are minimal, although small but statistically significant variations can occur, such as in RAMW and LAMW. Likus *et al.* (2016), did not report significant side differences in nasal cavity dimensions in newborns, while some previous studies have noted more minor variations in the dimensions of the nasal cavity between the right and left sides.

No reviewed literature was found that explored the association between nasal cavity morphometric parameters and body weight, length, or gestational age, which can certainly affect measurement results. Therefore, we suggest further research that will include this aspect. Also, few studies focus on preterm newborns, and in neonatology and pediatric otorhinolaryngology, knowledge of normal values of the nasal cavity in newborns with extremely low birth weight is crucial for diagnosing congenital anomalies and guiding further therapeutic approaches (Slovic *et al.*, 1985; Corsten *et al.*, 1996; Aslan *et al.*, 2009; Reeves *et al.*, 2013; Dzhanuzakov *et al.*, 2025).

## CONCLUSION

The results of this study provide significant insights into the differences in morphometric characteristics of the nasal cavity in newborns depending on sex, gestational age and side. Statistically significant differences by sex were found for the parameters ABW and AMW, while significant differences were also found for the parameters ABW, AMW, BCaw, and MVW in relation to gestational age. In relation to the side of the nasal cavity, a significant difference was found between RAMW and LAMW. Also, among the examined parameters, ABW, AMW, and BCaw showed statistically significant correlations with body weight, body length, head circumference and gestational age. These results may contribute to a better understanding of the development of the nasal cavity in the neonatal period, as well as potential differences in anatomical structure between different groups of newborns.

**PRITINA, M.; PUPOVAC, N.; KLJAJIC, V.; SPASOJEVIC, S.; VUCINIC, N.; TRAJKOVIC, V. & STANKOVIC, K.** Análisis morfométrico de la cavidad nasal en neonatos: Un estudio de TC.  
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**RESUMEN:** La cavidad nasal del recién nacido representa la parte inicial del sistema respiratorio, y su integridad anatómica y funcional tiene un impacto directo en la función respiratoria, especialmente durante los primeros días de vida, cuando los recién nacidos respiran exclusivamente por la nariz. El objetivo de este estudio fue analizar los parámetros morfométricos de la cavidad nasal en recién nacidos y correlacionarlos con el sexo, la edad gestacional y el lado de la cavidad nasal. Además, se analizó la correlación entre estos parámetros y las mediciones antropométricas de los recién nacidos, incluyendo peso al nacer (PN), longitud corporal (LC), circunferencia de la cabeza (CC) y edad gestacional. El estudio se realizó en una muestra de 80 recién nacidos (39 hombres y 41 mujeres), de los cuales 20 fueron prematuros y 60 de término. Utilizando tomografías computarizadas (TC) de la cabeza, se midieron los parámetros de los tercios anterior, medio y posterior de la cavidad nasal, y se obtuvieron datos antropométricos de los registros médicos. Se encontraron diferencias estadísticamente significativas relacionadas con el sexo en el ancho óseo anterior (AOA) y el ancho de la mucosa anterior (AMA). La edad gestacional se asoció significativamente con el AOA, el AMA, el ancho de la abertura coanal ósea (ACO) y el ancho máximo del vómer (AMV). En relación con el lado de la cavidad nasal, se encontró una diferencia significativa entre los anchos de la mucosa anterior derecha e izquierda (AOAD y el AOAI). Además, el ancho corporal anterior, el ancho de la mucosa anterior y el ancho de la abertura coanal ósea, mostraron correlaciones estadísticamente significativas con el peso al nacer, la longitud corporal, el perímetro cefálico y la edad gestacional. Estos resultados podrían contribuir a una mejor comprensión del desarrollo de la cavidad nasal en el período neonatal, así como a las posibles diferencias en la estructura anatómica entre diferentes grupos de recién nacidos.

**PALABRAS CLAVE:** Cavidad nasal; Recién nacido; Morfometría; Tomografía computarizada.

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