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Research Article

VOLUMETRIC INDEXING OF PARANASAL SINUSES OF SAUDI SAMPLE DERIVED FROM COMPUTED TOMOGRAPHIC IMAGES

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Abstract

Volumetric of air sinuses contributes in diagnosis of sinus pathologies, and applied in forensic field. The aim of the study was to estimate the volumes of paranasal sinuses in Saudi Arabia Qassim region relative to right, left, gender and age in normal patients. Methodology as retrospective study based on CT images for a sample size of 24 males, 26 females. The volumes derived from summation of areas of the sinuses and multiplying by the slice thickness in axial plane of CT image, which is, depend on 3D Slicer Program. The results showed that: the volume of the maxillary air sinus was the largest and the sphenoid and frontal air sinuses were the smallest, and the mean volumes of maxillary, ethmoid, frontal and sphenoid were 13.1,4.6,3.4 and 3.4 cm respectively. The maximum volumes of paranasal air sinuses occurred at 21-25 years old for maxillary and sphenoid air sinuses, while the maximum volumes for the ethmoid and frontal air sinuses occurred at 16-20 years old. The air sinuses have significant proportional correlation (R2 = 82) with aging. The data revealed that the growth rates of the two sides were symmetrical for all sinuses except for the frontal air sinuses. Male sinuses volumes were greater than female in different age groups for all sinuses.

Keywords: PNS, Volumetric, Biodata, CT

INTRODUCTION

The paranasal sinuses are hollow, air-filled spaces located within the bones of the face and base of the skull surrounding the nasal cavity. There are four pairs of sinuses, each connected to the nasal cavity by small canal. They include the frontal, ethmoidal, maxillary and sphenoid sinuses (Juhl *et al.,* 1998). They develop as diverticulae of the nasal cavity at the end of the third intrauterine month, maintaining communication with it via patent ostia (Chang *et al.,* 2014). These out pouchings expand into the maxillary, sphenoid, frontal and ethmoid bones by growth of the mucous membrane sacs. This may be regarded as primary pneumatization (Scuderi *et al.,* 1993). Various methods have been utilized in the literature to measure the volume of the PAS. In the latest studies, volume rendering techniques and three-dimensional (3D) reconstruction models have been developed (Jun *et al.,* 2005; Apuhan *et al.,* 2011; Park *et al.,* 2010). Currently, CT imaging is the radiological technique of choice for analyzing the PAS, as the distinction between bone, mucosa and other soft tissue can be clearly defined (Apuhan *et al.,* 2011). The literature reviewed reveals that the volume of the air sinuses is the most important parameter that can establish its size and these normal values may be useful in the diagnosis of sinus pathologies, (Lee *et al.,* 2012) and in forensic identification of sex and ancestry (Fernandes, 2004). Therefore, evaluating volume and morphology in 3D of the PAS would theoretically be more accurate than closest estimates, offering values that are the best fit to their natural measurements (Apuhan *et al.,* 2011). This first step of deriving norms of the volumes for the PAS in populations, followed by determining the actual morphological types or categories, would enable comparison with existing types in comparable populations according to age, sex and population. Some studies have analyzed a few age categories that are too large, for example, Wolf *et al,* (1993) study divided their sample into four year age groups (1-4yrs; 4-8 yrs; 8-12yrs), (Karakas and Kavaklı, 2005) into five year age groups (1-5yrs; 6-10 yrs; 11-15yrs; 16-20 yrs) and Fernandez *et al,* (2000) into two large age cohorts (≤20 yrs and >20 yrs). Further, the development of the PAS for these studies has been limited to a maximum of 12 years (Wolf *et al.,* 1993), According to Adibelli *et al,* (2012) "normal paranasal air sinus development may continue into early adulthood". Furthermore, early adulthood according to anatomical textbooks is defined as 21 to 25 years of age, when all ossification and growth is complete (Moore and Dalley, 2018). In addition, Park et al, (Wolf *et al.,* 1993) further explain that few studies have illustrated the growth of the air sinuses for all age periods, particularly the growing period of 1 to 25 years. This study aimed to calculate volume of normal growth of the PAS from ages 1 to 83 years, and its relationship to age, sex, laterality and in a Saudi Arabia population.

MATERIALS AND METHODS

This prospective correlational descriptive clinical study was done in Buraidah Central Hospital. Data was collected in the period from (1.8.2017) to (1.1.2020). A total of 50 patients.26 patients were females while the 24 were males and their ages were ranged from 1 to 83 years old. The inclusion criteria were the following: a) images without observable signs of abnormal pathological processes of the paranasal air sinuses; b) slice thickness <1.25mm) non-distorted images. Growth of the air sinuses was compared with age, sex and laterality. The age period was arranged as stipulated in similar studies by Fernandez *et al.* (2000) as following 1-5; 6-10; 11-15; 16-20; 21-25; >25.

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The DICOM images of the patients were then transferred and viewed on a personal computer (lenovo, 64bit, Intel core i3, 4GB RAM). The images of each patient were of slice thicknesses between 0.625 to 1.25mm in the axial plane, and were imported to SLICER 3D (www.slicer.org). SLICER 3D also allowed for viewing of the DICOM images in the three different planes viz. axial, sagittal and coronal. The axial view was selected as the most convenient and easiest method to trace axial contours of the sinuses for further analysis. Once each sinus was manually segmentally traced (per slice) from the floor to roof, the 3D models of each paranasal air sinus was reconstructed. SLICER 3D then calculated the bilateral volumes (right and left sides) of each PAS from these 3D models. Volumes of the PAS were determined and measured in cm^3 according to the SLICER 3D program.

RESULTS AND DISCUSSION

Figure 1: Shows the mean volume in cm3 for paranasal sinuses (PAS). It revealed that: the largest sinuses were the maxillary air sinus (13.1 cm3) followed by ethmoid air sinuses (4.6 cm3) and the rest sinuses were smaller. In comparison with previous studies; Park *et al.* (2010) found same result while Rennie *et al.* (2017) agreed that maxillary sinuses were the largest but the one was not as the current result. And they ordered as follows: maxillary air sinus [8727.3 mm3 (R); 8849.5 mm3 (L)]; frontal air sinus [3605.0 mm3 (R); 4029.9 mm3 (L)]; ethmoid air sinus [3558.2 mm3 (R); 3512.7 mm3 (L)] and sphenoid air sinus [3243.7 mm3 (R); 3396.0 mm3 (L)], concluded that the mean bilateral volume for the maxillary air sinus was the largest and the sphenoid air sinus was the smallest.

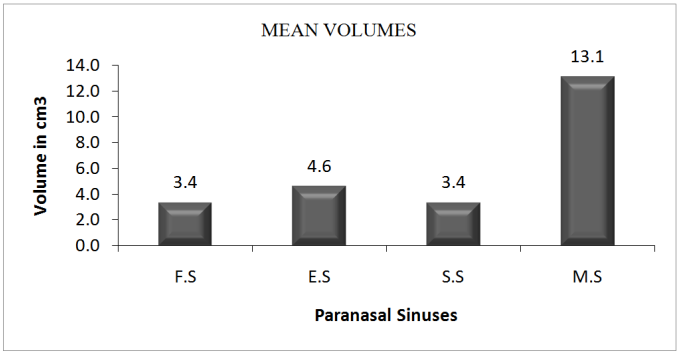

Figure 1. Shows the mean volume in cm3 for paranasal sinuses (PAS)

The results in Figures (2 a-d) showing that: the air sinuses' growth have proportional increment correlation with ageing, and varied dependent on age groups. For frontal sinuses (Fig. 2-a), the graph show that frontal sinuses had strong correlation (R2 = 0.8) with age, showing rapid continues increasing in growth, reaching the maximum by 16-20 years of age followed by a plateau thereafter. Several previous studies agreed with the current result with different maximum volumes that sinuses were reached and varied as follow; reaching maximum volume at 19 years of age (Park *et al.,* 2010), over 20 years of age (Fernandez *et al.,* 2000), between 21-25 years of age (Karakas and Kavaklı, 2005), and over 25 years of age (Rennie *et al.,* 2017). For maxillary sinuses (Fig. 2-b) the graph showed that: maxillary sinuses gradually increase in growth and reaching a maximum by 21-25 years of age followed by a plateau thereafter. Three studies agreed with the current result with different maximum volumes that sinuses were reached and varied as follow as follow; over 20 years of age (Fernandez *et al.,* 2000), between 21-25 years of age (Karakas and Kavaklı, 2005) and over 25 years of age (Rennie *et al.,* 2017). In comparison between the current study and the previous studies; we can conclude that, both frontal and maxillary sinuses reaching maximum growth in 20 years old followed by a plateau thereafter, or continuing in growth over 20 years old, and these results supported by Jun et al, 2005 and Tatlisumak *et al.* (2008). For ethmoid sinuses (Fig. 2-c), the graph showed that: there was gradual increase in growth reaching a maximum by 16 to 20 years old and then decreased. Relative to literature, Rennie *et al.* (2017) showed that: ethmoid sinuses had strongest correlation with age, and continues rapid increasing in growth reaching a maximum by 16 to 18 years of age followed by a plateau thereafter. While Fernandez *et al.* (2000) got same result with a maximum by 11 to 15 years of age, and then decreased. For sphenoid sinuses (Fig. 2-d), show that sphenoid sinuses had strongest correlation with age, and has a rapid continuing increment growth as ageing to reach the maximum by 21 to 25 years old then decreased. Compared with this result; Rennie *et al.* (2017) agreed that sphenoid sinuses increase gradually with ageing (1-9 years) and peaking at 16 to 18 years old. On the other hand Fernandez *et al.* (2000) got same results for sphenoid sinuses correlation with ageing but reaching the maximum by 11 to 15 years old, and then decreased. Also, Karakas and Kavaklı, (2005) showed same result related to sphenoid sinuses correlation with ageing however the maximum growth occurred by 21 to 25 years of age and then decreased.

In comparison between the current study and the previous ones; the researchers could conclude that: both ethmoid and sphenoid sinuses reaching maximum growth by 15-25 years old and decreased thereafter. Also, the current study agree with the result obtained by Takahashi (Takahashi, 1984); in view of growth relation with ageing where they ascribed such type of growth to resorption type that develop between osseous walls of both frontal & sphenoid sinuses and however Rennie *et al.* (2017) disagreed with the above argument and suggestions and further they ascribed the similarity between ethmoid and sphenoid sinuses to their common origin and as well got strengthen by (Spaeth *et al.,* 1997). The graphs (Fig. 2-b, c, & d) showed symmetrical sides growth relative to ageing except for the frontal air sinuses (Fig. 2-a), in which the left air sinus appears to grow at a faster rate than the right side in the period from16 to 20 years old. similar result have been noticed by Rennie *et al.* (2017) with exception for the frontal and sphenoid air sinuses. However, Ariji *et al.* (1996) stated that: no significant differences concerning sides growth. While in this realm Amusa *et al.* (2011) highlighted a significant difference concerning sides growth where the left and right frontal sinuses develop independently and attributed such phenomena to unequal reabsorption of diploe during sinuses development. Also, for the justification of growth variation in sinuses, Koertvelyessy (1972) ascribed to environmental factors such as coldness. Since all sinuses have increasing growth versus aging up to an average of 21 years old and the observed change for frontal sinuses between right and left sides after 15 years; the other factor considers to be study for frontal sinuses is the gender. Based in (Fig. 3) the frontal sinuses have been obviously derived depending on gender to left frontal sinuses for both genders as greater than right frontal sinuses for both gender; however, the left frontal sinuses for male was the bigger one and each sinus as left (male/ female) and right (male/female) running in parallel. This result supported by Rennie *et al.* (2017)

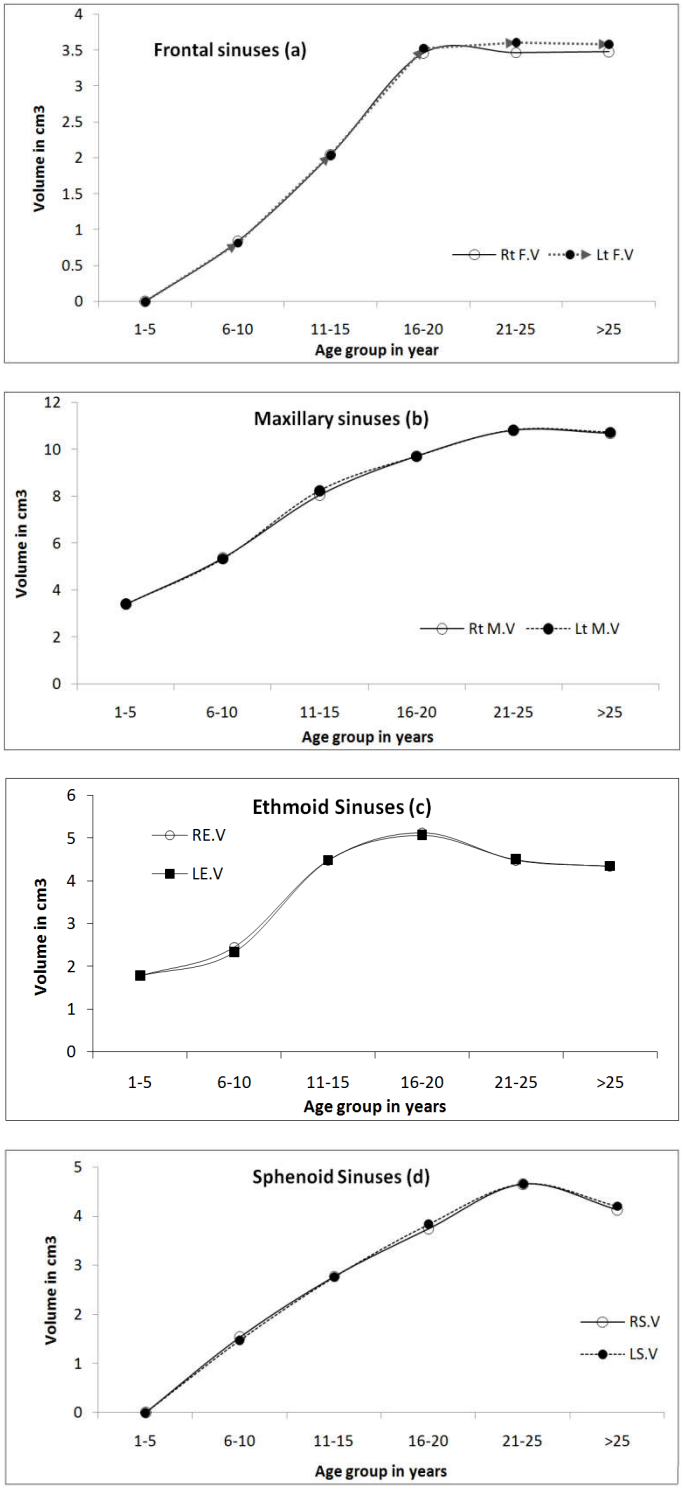

Fig 2 a-d. Show the comparison of the growth of the paranasal air sinuses according to age groups

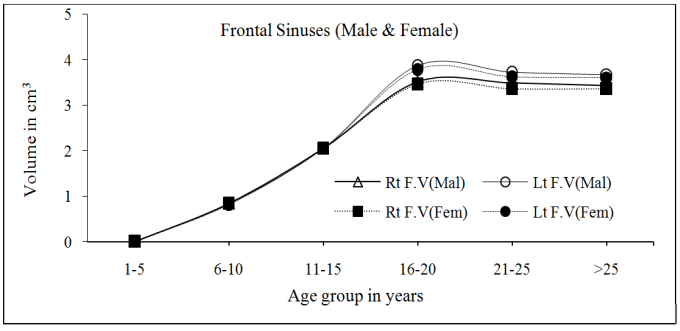

Figure 3. Shows the volume of frontal sinuses versus age group relative to genders

Conclusion

PSA showing strong correlation (R2 = 0.8) growth relative to ageing from 1-5 years up to 11-15 years as superimposed type of graph, then the variation started after the age of 16 years old and as well divided into two anatomical sides as simultaneous right sinuses and simultaneous left sinuses in view of growth correlated with ageing and gender.

REFERENCES

Adibelli, Z.H., Songu, M., Adibelli, H. 2011. Paranasal sinus development in children: A magnetic resonance imaging analysis. *American journal of rhinology & allergy,* 25(1):30-5.

Amusa, Y., Eziyi, J., Akinlade, O., Famurewa, O., Adewole, S., Nwoha, P., et al. 2011. Volumetric measurements and anatomical variants of paranasal sinuses of Africans (Nigerians) using dry crania. *International journal of medicine and medical sciences,* 3(10):399-03.

Apuhan, T., Yıldırım, Y.S., Özaslan, H. 2011. The developmental relation between adenoid tissue and paranasal sinus volumes in 3-dimensional computed tomography assessment. *Otolaryngology--Head and Neck Surgery,* 144(6):964-71.

Ariji, Y., Ariji, E., Yoshiura, K., Kanda, S. 1996. Computed tomographic indices for maxillary sinus size in comparison with the sinus volume. *Dentomaxillofacial Radiology,* 25(1):19-24.

Chang CC, Incaudo GA, Gershwin ME. 2014. Diseases of the sinuses: a comprehensive textbook of diagnosis and treatment: Springer.

Fernandes, C. 2004. Volumetric analysis of maxillary sinuses of Zulu and European crania by helical, multislice computed tomography. *The Journal of laryngology and otology,* 118(11):877.

Fernandez, J.S., Escuredo, J.A., Del Rey, A.S., Montoya, F.S. 2000. Morphometric study of the paranasal sinuses in normal and pathological conditions. *Actaoto-laryngologica,* 120(2):273-8.

Juhl, J., Crummy, A.B. and Kuhlman, J. 1998. Paul and Juhl's. Essentials of radiologic imaging. 7th ed. Philadelphia: Lippincott-Raven.

Jun, B.C., Song, S.W., Park, C.S., Lee, D.H., Cho, K.J., Cho, J.H. 2005. The analysis of maxillary sinus aeration according to aging process; volume assessment by 3-dimensional reconstruction by high-resolutional CT scanning. *Otolaryngology—Head and Neck Surgery,* 132(3):429-34.

Karakas, S., Kavaklı, A. 2005. Morphometric examination of the paranasal sinuses and mastoid air cells using computed tomography. *Annals of Saudi medicine,* 25(1):41-5.

Koertvelyessy, T. 1972. Relationships between the frontal sinus and climatic conditions: a skeletal approach to cold adaptation. *American journal of physical anthropology,* 37(2):161-72.

Lee, D.H., Shin, J.H., Lee, D.C. 2012. Three-dimensional morphometric analysis of paranasal sinuses and mastoid air cell system using computed tomography in pediatric population. *International journal of pediatric otorhinolaryngology,* 76(11):1642-6.

Moore, K.L., Dalley, A.F. 2018. Clinically oriented anatomy: Wolterskluwerindia Pvt Ltd.

Park, I.H, Song, J.S, Choi, H., Kim, T.H., Hoon, S., Lee, S.H., et al. 2010. Volumetric study in the development of

paranasal sinuses by CT imaging in Asian: a pilot study. *International journal of pediatric otorhinolaryngology,* 74(12):1347-50.

Rennie, C.O., Haffajee, M.R., Satyapal, K.S. 2017. Development of the paranasal air sinuses in a South African Population utilising three dimensional (3D) reconstructed models. *Eur j anat.,* 21(3):197-209.

Scuderi, A.J., Harnsberger, H.R., Boyer, R.S. 1993. Pneumatization of the paranasal sinuses: normal features of importance to the accurate interpretation of CT scans and MR images. *AJR American journal of roentgenology,* 160(5):1101-4.

Spaeth, J., Krügelstein, U., Schlöndorff, G. 1997. The paranasal sinuses in CT-imaging: development from birth to age 25. *International journal of pediatric otorhinolaryngology,* 39(1):25-40.

Takahashi, R. 1984. The formation of the human paranasal sinuses. *ActaOto-Laryngologica*, 97(sup408):1-28.

Tatlisumak, E., Ovali, G.Y., Asirdizer, M., Aslan, A., Ozyurt, B., Bayindir, P. et al. 2008. CT study on morphometry of frontal sinus. Clinical Anatomy: The Official Journal of the American Association of Clinical Anatomists and the *British Association of Clinical Anatomists,* 21(4):287-93.

Wolf, G., Anderhuber, W., Kuhn, F. 1993. Development of the paranasal sinuses in children: implications for paranasal sinus surgery. *Annals of Otology, Rhinology & Laryngology,* 102(9):705-11.

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