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Volumetric Analysis of the Paranasal Sinuses using CT among Chronic Sinusitis Conditions

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Abstract: ***The volume of air sinuses offers values that are more accurate and closest to their natural measurements and contributes to diagnosing sinus pathologies. The study aimed to compare paranasal sinus volumes of chronic rhinosinusitis patients to unaffected controls in Saudi Arabia using Computerized tomography scans (n=151), which processed by axial manual segmentation of the air sinuses using a 3D Slicer Program to construct a three dimensional (3D) volume model of each PAS bilaterally. The sample consisted of 50 normal controls and 101 patients with chronic sinusitis (73 males and 78 females, age ranging from 1 to 83 years). They were divided into two age groups :> 20 years (43) and<20 years (108). The result showed that: the commonly involved gender with sinuses pathologies was the female, with a 53.5% relative to male. The chronic sinusitis infected older ages (>20 years old) with a percent of 81.18% more than the younger one (<20 years old) with a percent of 18.81%. The commonly involved sinuses were the maxillary sinus, ethmoidal, frontal, and the sphenoidal sinuses. The mean bilateral maxillary and ethmoid sinus volumes in the chronic sinusitis patients were smaller than that in the normal or control group, also reveals that the mean bilateral frontal and sphenoid sinus volumes in the chronic sinusitis patients were similar to the normal or control group.***

Keywords: Paranasal Sinuses, chronic sinusitis, volumetric, CT.

1. Introduction

The Para-nasal 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 a small canal. They include the frontal, ethmoidal, maxillary, and sphenoid sinuses [1]. They develop as diverticula of the nasal cavity at the end of the third intrauterine month, maintaining communication via patent Ostia [2]. These out pouchings expand into the maxillary, sphenoid, frontal and ethmoid bones by the growth of the mucous membrane sacs. This may be regarded as primary pneumatization [3]. Various methods have been utilized in the literature to measure the volume of the PAS.

In the latest studies, volumes rendering techniques and three-dimensional (3D) reconstruction models have been developed [4-6]. 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 [5]. According to Lee et al., [7] 3D reconstructions from these CT images can yield a more precise form 3D morphology of the PAS. The literature reviewed reveals that the volume of air sinuses is the most important parameter that can establish its size. These normal values may be useful in diagnosing sinus pathologies [8]. There appears to be wide variation in paranasal sinus anatomy [8], [9], but the cause for these differences and their impact on sinonasal disease is unclear [10-12], and is frequently associated with chronic sinus disease [12]. This raises the relevant question of whether the relationship between sinus pneumatization and mucosal disease can be applied as a generalization. This remains incompletely resolved because paranasal sinus pneumatization has been difficult to quantify. The role of decreased paranasal sinus pneumatization in the development of CRS is also unclear. Kim et al. found that CRS patients had similar paranasal sinus pneumatization compared to healthy controls, although CF patients demonstrated impaired sinus development [13]. That study, however, was restricted to a volumetric and dimensional analysis of the maxillary sinus in children and adolescents age 4 to 17. There have been reports of decreased maxillary sinus volume in patients with CRS [14], [15]. These studies, however, did not measure the volumes of the other paranasal sinuses or did not find differences outside of the maxillary sinus.

This study aimed to compares paranasal sinus volumes of CRS patients to unaffected controls within a Saudi Arabia population using CT.

2. 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). 151 (73males, 78 females, aged 1 – 83 years). The sample consisted of 50 normal controls and 101 patients with chronic sinusitis. They were divided into two age groups :> 20years (n43) and<20 years (n108) [16].

All patients were attending Radiology Department Buraidah Central Hospital. KSA. All the patients underwent a complete medical history, head, and neck physical examination. The radiology consultant evaluated all CT scans, and patients were classified following evaluation by CT scan of the paranasal sinuses into two groups, Control Group (n=50): patients suffered from headache, facial pain, and epistaxis, but CT scans of their nasal cavity and paranasal sinus were within normal limits without inflammatory change. Chronic sinusitis Group (n=101): a patient with chronic sinusitis, CT scans who showed inflammatory changes in paranasal sinuses.

All patients were examined on a multislice CT scanner (Toshiba Aquilion 64 CT scanner) according to the following parameters: slice thickness between 0.625 to 1.25mm, 120 kV, 230 - 280 mA, Collimator width 3 - 5 cm, Scan type-Helical full 1.0 sec, FOV: 25.0, Bone window (center 200 HU, width 1500 HU).

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 most accessible 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 were reconstructed. SLICER 3D then calculated the bilateral volumes (right and left sides) of each PAS from these 3D models. The volume of the PAS was determined and measured in cm^3 according to the SLICER 3D program.

3. Results and Discussion

Figure 1.shows the commonly involved gender with sinuses pathologies. It shows that the commonly involved gender with sinuses pathologies was the female, with 53.5% relative to males. Such high incidence among females could be ascribed to the fact that; women exposure to dust and smoking from home cleaning and cooking more than men, and these lead to allergic rhinitis, which is the causative factor in sinusitis. Another causative factor is rhinitis of pregnancy. Recent theories of sinusitis indicate that it often occurs as part of a spectrum of diseases that affect the respiratory tract and is often linked to asthma. Thus, Women are known to have higher prevalence and severity of asthma [17].

Timmanagouda [18] in which he found that the incidence percent among female was 65.4% relative to male (34.6%), has noticed the same results

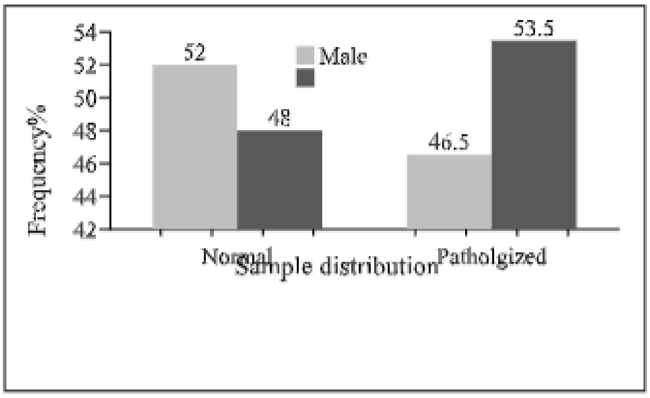

Figure 1: shows the commonly involved gender with sinuses pathologies.

Figure 2 shows the distribution of chronic sinusitis based on two age groups. In which it reveals that chronic sinusitis infected older ages (>20years old) more than a younger one (<20 years old). The high incidence among the adult age group could be ascribed to more expose to the environment, recurrent upper respiratory tract infections. The same result has been obtained by[19] Ologe and Olatunji said that these findings corroborate the findings by earlier workers and scribe the less common incidence in children to wide ostia and some of their sinuses are not fully developed. These factors could reduce the chances of sinus obstruction that could lead to sinusitis. Chan et al., [20], in a histopathologic study of children with chronic rhinosinusitis (CRS) compared to the sinus mucosa in pediatric and adult CRS, concluded that sinus mucosa of young children with CRS has less eosinophilic inflammation, basement membrane thickening, and mucus gland hyperplasia characteristic of adult CRS.

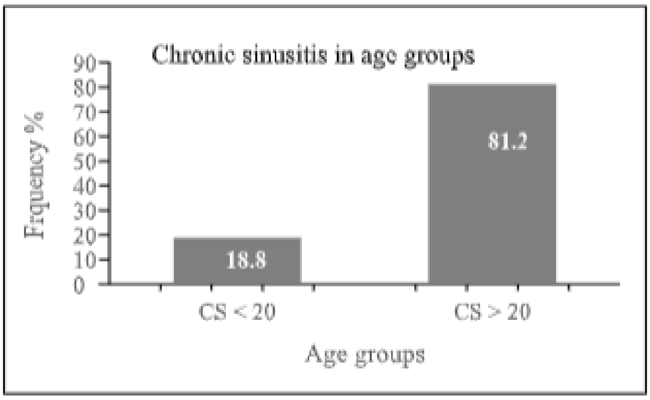

Figure 2: Shows the distribution of chronic sinusitis based on age groups

Figure 3 (a-b) shows the involved paranasal with chronic sinusitis among age groups. All age groups reveal that the commonly involved sinuses were the maxillary sinuses, followed by ethmoid sinuses. For maxillary sinuses, this result could be a scribe to the anatomical location of the frontal, ethmoidal, and the sphenoidal sinuses are witch anatomically located above the nasal cavities. Therefore, their drainage into the nasal cavity is assisted by gravity, especially when their openings are not obstructed by disease so that changes or alterations in the aforementioned paranasal sinuses may initially be subtle and not radiologically evident until it becomes extensive with blockage of sinus openings. On the other hand, poor anatomical position drainage predisposes the maxillary sinus to stagnation of secretions and infection more than any other paranasal sinus [21]. Other investigators in Nigeria have reported 47.5%-80.4% maxillary sinus involvement [22]. They all agreed that maxillary sinusitis is much commoner than sinusitis of the other paranasal sinuses. On the other hand, several studies found that; ethmoid sinuses were the commonly involved sinuses because of the obstruction of the osteomeatal complex, which is located within the ethmoidal sinuses and this obstruction due to mucosal inflammation [23-24].

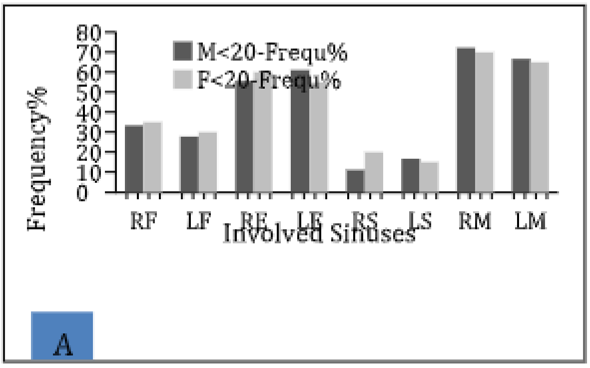

Figure 3 (A): Shows the involved paranasal with chronic sinusitis related to age and gender

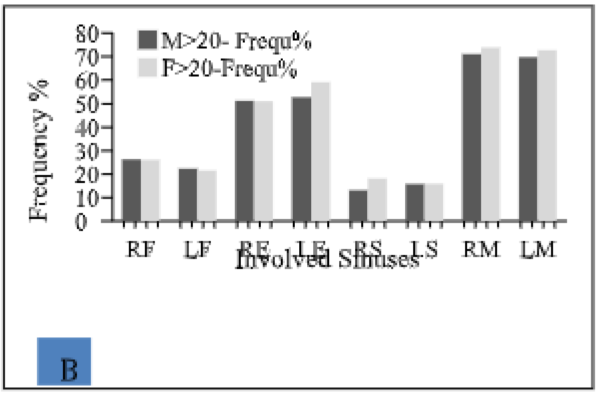

Figure 3 (B): Shows the involved paranasal with chronic sinusitis related to age and gender

Figure 4.4 (C-F) shows the comparison between the control group and chronic sinusitis group related to age and gender; It reveals that; the mean bilateral maxillary and ethmoid sinus volumes in the chronic sinusitis patients were smaller than that in the normal or control group, also reveals that the mean bilateral frontal and sphenoid sinus volumes in the chronic sinusitis patients were similar to the normal or control group, this result could be ascribe to more inflammatory changes in maxillary and ethmoid sinuses (more involvement to chronic sinusitis, more than 50%) and little or less inflammatory changes in the frontal and sphenoid sinuses (little involvement to chronic sinusitis, less than 50%) figure 3(a-b). Similar results have been noticed by Kim et al. [15] in which they found that; the mean volume of the maxillary sinuses was 22.5 ± 4.4 cm3 in the normal group and 20.0 ± 4.1 cm3 in the CRS group in longstanding pediatric chronic rhinosinusitis. Bilal et al., [25] found that the left-side maxillary sinus, sphenoid sinus, and frontal sinus pneumatization in the patients with nasal polyposis were smaller than those of the control group were, and he scribed that to genetic pneumatization and environmental factors. On the other hand, Ikeda [26] scribed the reduction in volume to the narrowing of the ethmoid infundibulum and middle meatus by inflammation of the ostiomeatal complex and by various bony anatomic variations in the nasal cavity, leading to impaired pneumatization of the maxillary sinus.

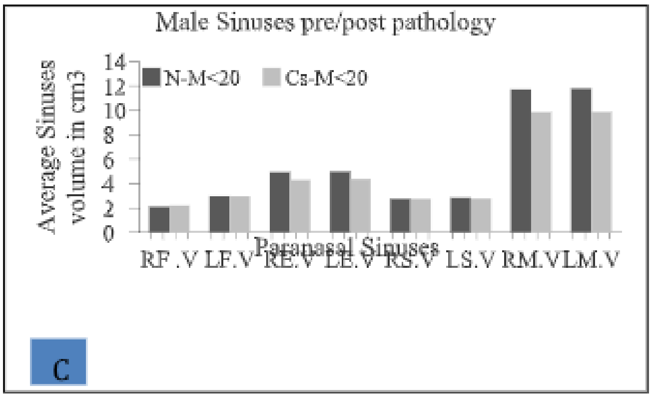

Figure 4.4 (C): shows the comparison between control group and chronic sinusitis group related to age and gender

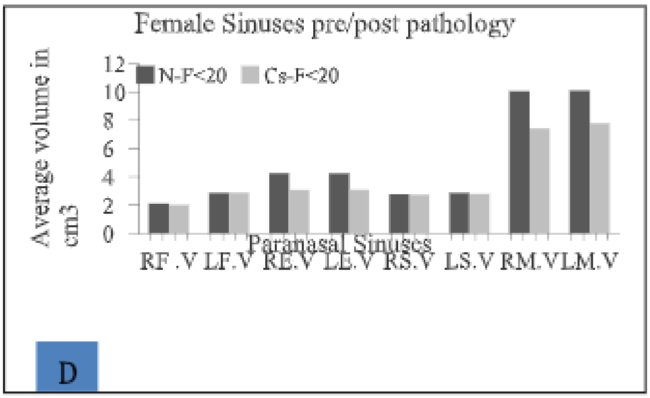

Figure 4.4 (D): shows the comparison between control group and chronic sinusitis group related to age and gender

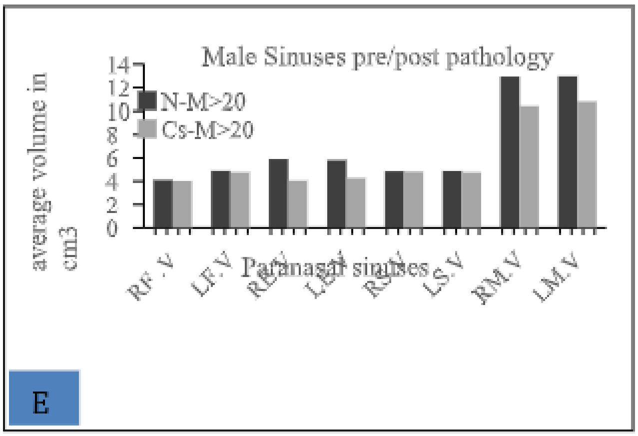

Figure 4.4 (E): shows the comparison between control group and chronic sinusitis group related to age and gender.

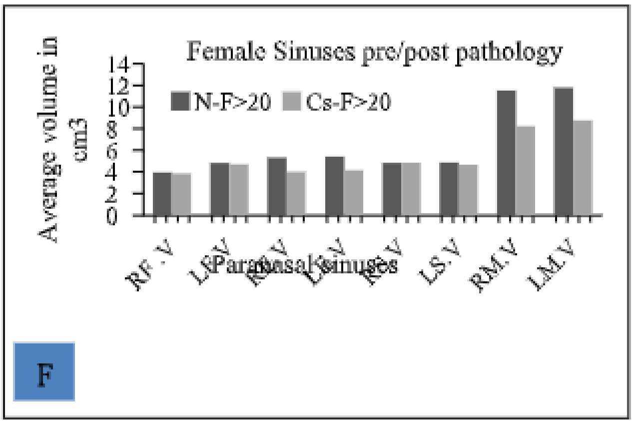

Figure 4.4 (F): shows the comparison between control group and chronic sinusitis group related to age and gender

4. Conclusion

CT Volumetric analysis of paranasal sinuses between normal and pathological condition provide us with real action of pathological changes. Chronic sinusitis disease affects the growth of sinus volumes at different ages. Inflammatory changes decrease the sinuses volume rely on the widespread of the disease, so maxillary and ethmoid sinuses were reduced, therefore. More research and studies are needed to determine the percentage of the sinus opacification that lead to sinus volume decreasing.

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