Major inflammatory patterns of chronic sinonasal diseases and their accompanied anatomical variations; CT scan review

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ABSTRACT

Background: Because of wide use of Functional Endoscopic Sinus Surgery (FESS) technique in the recent years and basic role of coronal computed tomography (CT) scan in demonstrating the normal drainage route of para-nasal sinuses, identifying the major patterns of inflammatory sinonasal disease and accompanied anatomical variations is essential for appropriate preoperative surgical planning. In review of publisthed literature, there is no data on CT patterns of chronic inflammatory sinonasal disease and their accompained anatomical variations of nose and PNS in our local population.

Objectives: was to determine the frequency of CT patterns and variations in patients with sinonasal symptoms.

Methods: This was a cross sectional descriptive study conducted on 404 consecutive patients with clinical manifestations of chronic rhinosinusitis referred to radiology department of Alkindy teaching hospital. Coronal and if needed axial CT scan were taken from them. CT scans were reviewed and inflammatory patterns and accompanied anatomical variations were specified.

Results: Five major recurring patterns of inflammation including infundibular 23.76%, ostiomeatal unit (OMU) 21.78%, sphenoethmidal recess (SER) 7.92%, sinonasal polyposis 19.80% and sporadic 20.79% were seen. Special pattern was noted in 3.96% while normal CT examination was noted in 9.90%. The total percentage was more than 100% due to simultaneous occurance of more than one pattern in the same case. In 73.2% of cases accompanied anatomical variation including septal deviation (34%), concha bullosa (26%), Agger nasi cell (13%), giant bulla ethmoidalis (12%), Haller cell (8%), pneumatization of uncinate process (5%), paradoxic middle turbinate (4%), and Onodi cell (2%) were seen.

Conclusion: In this study, the concept of the major inflammatory patterns of sinonasal disease was introduced and their frequncies in our local poluplation were reported. By applying these patterns to the radiological report, more tailored and safe endoscopic sinus surgery could be possible.

Key words: Paranasal sinuses, chronic inflammatory sinusitis, CT

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Chronic rhinosinusitis is defined as inflammatory sinonasal disease lasting longer than 12 weeks [1]. It affects approximately 12.5% of people [2]. The purpose of radiological imaging in inflammatory lesions in the nasal cavity and paranasal sinuses is to confirm the diagnosis, characterise the extent and localisation of disease and describe anatomical variants in order to select patients that may benefit from sinus surgery. Computed tomography (CT) is regarded as the "gold standard" in the primary imaging of inflammatory sinonasal lesions [3, 4]. Endoscopic surgery has been increasingly utilized, requiring a meticulous assessment and a detailed description of both nasal and paranasal cavities structures [5]. The use of coronal CT scans prior to Functional Endoscopic Sinus Surgery (FESS) in order to map the sinonasal bony anatomy and pneumatisation variants and to evaluate the extent of disease is well documented [6-8]. In order to identify radiological patterns of sinonasal inflammatory disease and elucidate how these patterns would influence the surgical approval of FESS, Sonkens et al. [9] in 1991 reviewed 500 screening sinus CTs (SSCT). The group identified five CT patterns of inflammatory paranasal sinus disease, these include the infundibular (I), ostiomeatal unit (OMU) (II), sphenoethmoidal recess (SER) (III), sinonasal polyposis (IV), and the sporadic or unclassifiable (V) patterns. The first three of these patterns, the infundibular , OMU, and SER patterns, are related to obstruction of the mucociliary drainage routes of the paranasal sinuses. These obstructive patterns are responsible for the majority of inflammatory sinus disease [9]. In the normal population, only a few patients have more than one inflammatory pattern, while this phenomenon is common in patients with an underlying systemic disease as in cystic fibrosis patients [10]. Each inflammatory pattern as described by Sonkens et al. [9] can further be categorised into "routine" and "complex" surgical groups reflecting the anatomical

localisation, extent and technical considerations of surgical intervention, as well as the risk of surgical complications of the surgery required [9, 11]. Infundibular pattern, OMC pattern and sporadic pattern are classified as "routine" surgical group, while sinonasal polyposis and SER pattern are classified as "complex" surgical group. In the infundibular pattern, infundibulotomy alone or together with limited ethmoidectomy will usually be sufficient, while the OMC pattern often requires more extensive ethmoidectomy. The sporadic pattern, though classified as belonging to the routine surgical group, often requires tailored FESS if surgery is necessary. Sinonasal polyposis is grouped as complex because surgery may be extensive and located close to the lamina cribrosa and the anterior ethmoid artery, increasing the risk of CSF leakage and profuse bleeding. Furthermore, polyps that obscure surgical bony landmarks complicate surgery. The SER pattern is grouped as complex due to its posterior location, making it more difficult to reach safely with the endoscope [9].

Multislice CT is currently the imaging modality of choice for evaluating PNS and adjacent structures. Such a method has been increasingly utilized in the assessment of anatomical variations, allowing their accurate identification with high anatomical details. Although the role of anatomical variations of osteomeatal complex in the etiology of sinonasal disease is controversial [12] but knowledge of these variations in every patient is critical in the preoperative evaluation for endoscopic surgery [13-16]. The frequency of these variations may differ among the different ethnic groups [17].

The most common pneumatisation variants from the anterior ethmoid cells are concha bullosa (pneumatisation of the middle turbinate), pneumatisation below the orbital floor and adjacent to the maxillary ostium, termed infraorbital cells or Haller cells, and agger nasi cells (pneumatisation of the most the anterior part of the maxillary bone). The importance of these pneumatisation variants is their close relation to the mucociliary drainage routes [13,18]. The most common pneumatisation variants from the posterior ethmoid cells are posterior ethmoid cells that continue posteriorly into the sphenoid bone either laterally or superiorly to the sphenoid sinus, termed sphenoethmoid or Onodi cells [19]. The aim of this study was to determine the frequency of major inflammatory patterns and accompanied anatomical variations in patients with chronic inflammatory sinonasal disease.

patients*:* This was a cross sectional descriptive study conducted on 404 consecutive patients with clinical manifestations of chronic rhinosinusitis referred to radiology department of Alkindy teaching hospital / Baghdad-Iraq and done in the period from April 2014 and April 2015.

The study included all patients who referred to radiology department with clinical diagnosis of chronic rhinosinusitis irrespective of socio-economic status. Patients with history of previous sinus surgery, invasive sinonasal mucosal disease or facial trauma were excluded from this study.

CT examination carried out using Siemens 64 multislice scan unit. Coronal sinus CT was applied as a standard view in most cases. Patients who were not compatable with or not tolerate the coronal examination such as those patient who were young children, had tracheostomy sites, had severe cervical arthropathy, had exccesive dental amalgam fillings or had short neck, thin section contagious axial images with coronal reconstruction were performed. Also direct axial images were applied to complement the coronal scans when severe disease in the sphenoid and posterior ethmoid sinuses was present.

CT scans were taken mainly in bone and intermediate windows and if soft tissue masses except polyposis were suspected, soft tissue windows were taken too. The used KVp was 120 and mA was 200. Window width range was 2000-2500 HU while window center range was 100-300 HU. The scan extent was from the posterior margins of sphenoid sinus to anterior margins of frontal sinus with 5mm section slice thickness done for posterior half and 3mm for anterior half to insure optimal visualization of the OMU. Intravenous contrast was not used.

CT scans were prospectively reviewed by single radiologist to confirm the recurrent inflammatory patterns of sinunasal disease and to delinate their frequency. Five patterns of sinonasal inflammation according to Sonkens reference view were in consideration. Typial radiological features of each pattern were ascertained and the relationship of the patterns to the known mucociliary drainage routes was assessed. The infindibular pattern (I) was designated when isolated maxillary inflammation due to isilateral obstruction of the maxillary ostium and/or the ethmoid infundibulum was identified (Fig.1). The OMU pattern (II) was designated when inflammatory disease within the ipsilateral maxillary, anterior ethmoid and frontal sinuses was identified (Fig. 2). The designated SER pattern (III) was applied when obstruction was present posteriorly within the region of the SER, resulting in sphenoid and posterior ethmoid sinusitis (Fig. 3) . The sinonasal polyposis pattern (IV) was designated when the nasal cavity and paranasal sinuses were filled by polypoid soft tissue densities (Fig. 4) . The sporadic or unclassified pattern (V) was specified for cases that did not fit into the obstructive patterns (I-III), and did not demonstrate

evidence of polyposis. So this pattern was designated to include retension cysts, mucoceles, and mild moucosal thickening without coexistent OMU or SER obstruction (Fig. 5).

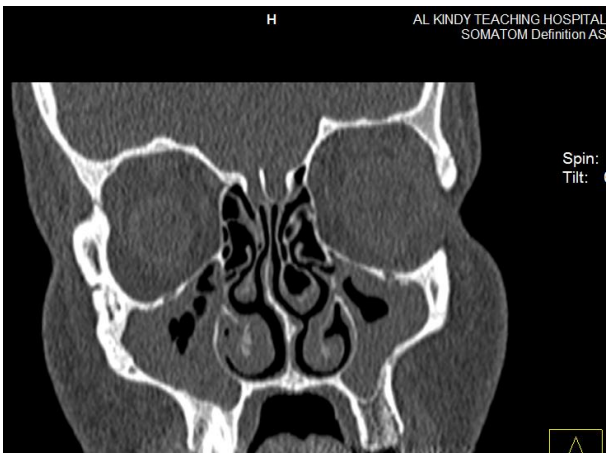

Fig. 1. Coronal CT shows bilateral infundibular inflammatory pattern involving the bilateral maxillary sinus ostium and the antrum Note left choncha bullosa and left deviated nasal septum.

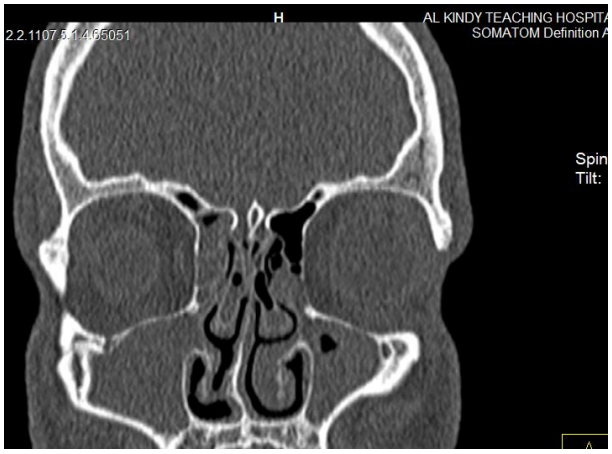

Fig. 2. Coronal CT shows inflammation involving the right ostiomeatal unit which consists of the frontal recess anterior ethmoid cells ethmoid infundibulum and maxillary sinus Note the infundibular pattern on the right involving the right maxillary sinus.

Fig. 3. Coronal CT. Sinonasal inflammatory disease of spheno-ethmoid recess (SER) pattern. Left sphenoid sinusitis due to mucosal thickening in the SER.

Fig. 4. Coronal CT. Sinonasal inflammatory disease of polyposis pattern. Polypoid soft tissue masses are filling the nasal cavities, maxillary and ethmoid sinuses. Note bulging of the sinus walls with loss of bony sinus architecture and broadening of the ethmoid infundibulum bilaterally

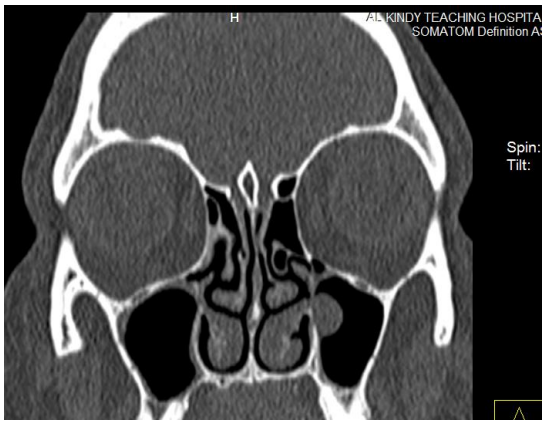

Fig. 5. Coronal CT. Sinonasal inflammatory disease of sporadic pattern in a patient with retention cyst in the left maxillary sinus .

Where possible, specific causal factors were delinated, including anatomical varients.

The ethical and Scientific considerations: Approvals of the local ethical and scientific committees were obtained before study-onset.

Results.

The sample of this study consisted of 404 patients with their age range from birth to 69 years (mean 36 years), 51.5% of them were females and 48.5% were male with a female: male ratio of 1.1:1. The age group (30-39) years showed the highest number of patients (134 patients, 33.1%).

Patients with chronic sinonasal inflammatory conditions were grouped radiologically into 5 major patterns, the infundibular pattern (I) was the most frequent and noted in 96 patients (23.76%), the osteomeatal unit pattern (II) was noted in 88 patients (21.78%), the sphenoethmidal recess pattern (III) was noted in 32 patients (7.92%), the sinonasal polyposis pattern (IV) was noted in 80 patients (19.80%), and the sporadic pattern (V) was noted in 84 patients (20.79%). Other patients are either show normal scans who were 40 patients (9.90%) or grouped as a special pattern since their CT findings do not fit into any of the above 5 major inflammatory patterns and they comprised 3.96% of the study sample. These patterns were seen solely or as a combinations and so total percent was more than 100% (Fig. 6).

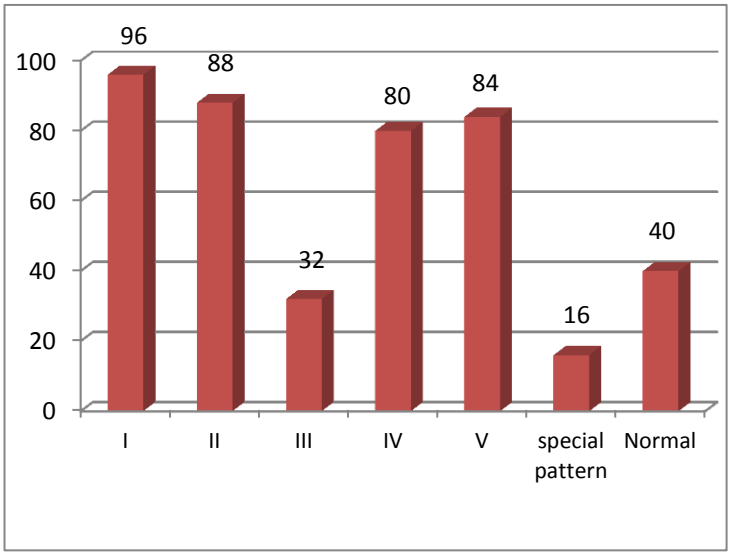

Fig. 6. Distribution of patients according to the CT patterns of chronic sinusitis Regarding the sporadic or unclassified pattern (V) which was specified for cases that did not fit into the obstructive patterns (I-III), mild mucosal thickening without coexistent OMU or SER obstruction comprise 52% , retention cysts 38% and mucocele 10% (Fig. 7).

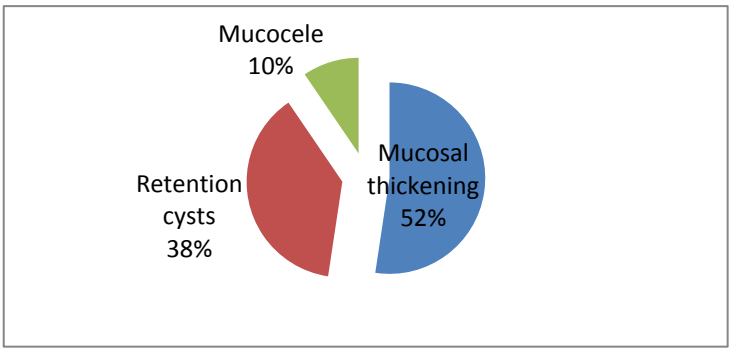

Fig. 7. Pie chart show the distribution of patients of sporadic pattern according to the specific pathology.

The most frequent sinus involved in patients with sinusitis was maxillary sinus. Most patients with sinusitis had a combination of sinuses involved (Fig. 8).

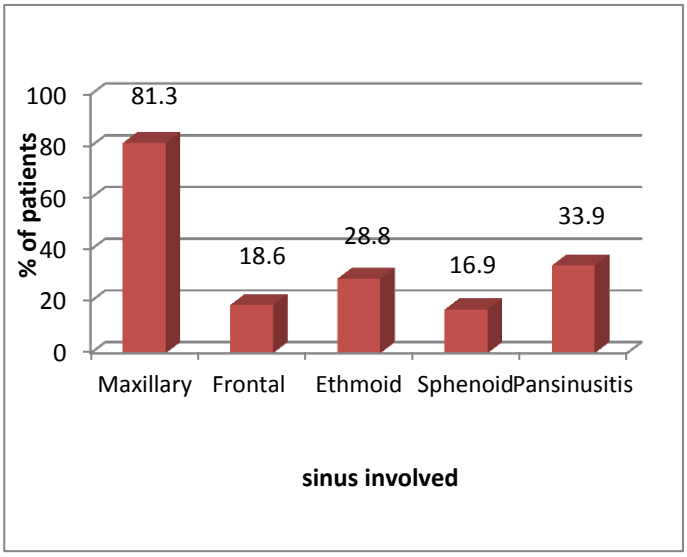

Fig. 8. The distribution of patients according to the sinus involved whether in isolation or in combination The most commonly encountered anatomical variation in this study was the nasal septal deviation 34% while the less commonly encountered was Onodi cells 2%. Some cases had more than one variant (Table 1).

Table 1 : Frequency of anatomical and pneumatization variants in this study.

Variant	Percent
Septal deviation	34%
Chonca bullosa	26%
Agar nasi cell	13%
Giant ethmoida bulla	12%
Haller cell	8 %
Pnematization of uncinate process	5%
Paradoxic middle turbinate	4%
Onodi cells	2%

Discussion: CT is regarded the best non invasive diagnostic imaging for PNS diseases because it offers excellent delination of the bony anatomy and extent of sinus disease and serves as a road map during surgical procedures. In this study, coronal CT was applied as a standered view because it correlates with the surgical approach. The coronal plane optimally shows the ostiometal unit, the relationship of the brain, ethmoid roof and the orbit to the paranasal sinuses. Axial CT was applied when the patient was unable to maintain prone position or in cases of severe disease involving the sphenoid and posterior ethmoid sinuses as axial plane can be helpful in displaying the position of the internal carotid arteries and optic nerves with respect to the bony margins of the posterior ethmoid and sphenoid sinuses.

In this study, the five major patterns including infundibular, OMU, ESR, polyposis and sporadic were seen in 23.76%, 21.78%, 7.92%, 19.80%, and 20.79% respectively. Normal CT examination was present in 9.90%. Some cases showed pathology not fitted into any of the 5 major patterns and specified as a special pattern and compromise 3.96% of the study sample. The total of all percentages was greater than 100% due to simultaneous occurrence of more than one pattern in some patients. Sonkens at al. [9] in 1991 reviewed 500 screening sinus CT scans for FESS candidates and identified five CT patterns of inflammatory paranasal sinus disease. When comparing the frequency of different patterns in our local population with the caucasion population in Sonkens et al series, the results were close except for higher incidence in the polyposis pattern in our population which may be attributed to geographic and ethnic factors as there were many studies revealled that the mechanism and etiology of nasal polyposis may be different in Asian population in contrast to Caucasian population as the neutrophil- predominant polyps accounts for 50 % in Asian population in contrast with Caucasian where 80-90% of polyps are eosinophilic [20-22]. Naimi et al.[23] in 2006 reviewed 200 coronal CT scans of FESS candidates in Iran and reported higher frequency for SER pattern in comparison to current study results (24% versus 7.92%) and this may be attributed to that Naimi's study was on a group of patients with severe complaints who were candidates for surgery not just those who were symptomatic as in this study and therefore no normal CT percentages included in his study.

This study showed that the most frequent sinus involved in patients with chronic sinusitis was the maxillary sinus and this may be attributed to its prominent exposure to the environment and the anatomy that allows drainage of the cavity. It is either involved alone as in infundibular or sporadic patterns or in combination with other sinuses as in OMU and polyposis patterns.

In this study, different frequency of the anatomical and pneumatization variants compared to previous reports of Caucasian, Asian and Japanese races were noted (Table 2). Genetic and environmental factors seem to be the best explanation for these variations. Differences in the used anatomic difinition of these varients in reporting prevalence may play role in these variations.

Table 2: Reported incidence of sinonasal anatomical variations in different ethnic population.

Author & Country	DNS	CB	BE	AN	PMT	PUP	HC	ON
Ear wak	44%	55 %	89 %	96%	17 %	-	20%	-

er (Australia) [24]								
Naimi et al (Iran) [23]	40%	24%	8%	8%	4%	6%	12%	2%
Pérez et al (Spain) [25]	58.2%	24.5%	-	-	10%	nil	45%	10.9%
Mohammed et al(Pakistan) [26]	26%	18.2%	-	-	14.3%	5.2%	9.1%	7.8%
Mazza D etal (Italy) [27]	-	29%	-		11%	5%	5%	9%
Tonai etal (Japan) [28]	-	28%	-	-	25%	-	36%	-
Current study	34%	26%	12%	13%	4%	5%	8%	2%

DNS: Deviated nasal septum. CB: Choncha bullosa. BE: Bulla ethmoidalis. AN: Aggar nasi. PMT: Paradoxical middle turbinate. PUP: Pneumatized uncinate process. HC: Haller cell. ON: Onodi cell.

Conclusion: In this study, more characterization of the concept of inflammatory sinonasal disease patterns had been introduced as well as the common anatomical and pneumatization variants. The frequency of these major radiological patterns in our local population was reported and their accompained anatomical and pneumatization varients were delinated. By applying these patterns to the radiological report, CT scan will offer a detailed road map of relevant surgical anatomy and pathology for the endoscopic surgeon and consequently will improve patient care and surgical result.

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