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Concha Bullosa and Other Sino-Nasal Variants:
Clinical and CT Correlation

Backgroud/Objectives: In recent years endoscopic sinus surgery has been established as a successful treatment of chronic sinusitis and more attention has been given to CT evaluation of the paranasal sinuses. Concha bullosa is defined as aeration of the middle turbinate. It is one of the most important anatomic variants that may cause inflammatory sinus disease by narrowing of the middle meatus. The incidence of concha bullosa has been reported from 4-80% in different studies.

The goal of this study is to determine the incidence of concha bullosa and a few other significant sinonasal anatomic variants in symptomatic patients and to correlate with the presence of inflammatory sinus disease as detected on CT.

Materials and Methods: Coronal CT scans of the sinuses were evaluated in 174 consecutive symptomatic patients. The symptoms included postnasal discharge and tenderness over the facial sinuses during the past two weeks prior to examination.

Results: The mean age of patients was 30.6 years (from 7 to 66 years); and there were 95 (54.6%) males and 79 (45.4%) females. Concha bullosa was present in 113 (64.9%) patients. It was bilateral in 45 (39.8%) and unilateral in 68 (60.2%) patients. In cases with unilateral concha bullosa, the left to right ratio was 1.7 to 1. Inflammatory disease of the sinuses was identified in 81 (71.7%) patients with concha bullosa and 35 (57.7%) patients without concha bullosa. The incidence of inflammatory disease of the sinuses was higher when there was coexistence of concha bullosa and deviation of the nasal septum. The most common symptom was headache (71.8%), and the least common was fever (27.9%). Tenderness over the frontal and maxillary sinuses, postnasal drip and fever were more common in patients with concha bullosa.

Conclusion: Concha bullosa is associated with higher incidence of inflammatory sinus disease. With simultaneous concha bullosa and nasal septal deviation, the incidence of inflammatory disease increases.

Keywords: Sinuses, Paranasal, Concha Bullosa, Computed Tomography.

Introduction

Sinusitis is not a new disease[1], but new methods are emerging for treatment of this old and common disease. In the past two decades endoscopic sinus surgery has proven to be a successful surgical technique for treatment of chronic recurrent inflammatory sinonasal disease.[2,3] Recently, evaluation of sinonasal anatomy and the extent of inflammatory disease by screening coronal CT have been given more importance.[4-7] Increasing attention is focused on the anatomic variations in this region.[5-7,9,13] Concha bullosa is one of the most important of these sinonasal anatomic variants that may cause inflammatory sinus disease by narrowing of the middle meatus.[3,6,20]

Most of the anatomic sinonasal variations occur along the lateral wall of the nasal cavity. All sinuses drain in this region, therefore, the anatomic variations hinder the normal mucociliary drainage. This, in turn, predisposes to inflammatory disease of the sinuses.[11] In addition to concha bullosa, other significant anatomic variants which play a role in this situation include: nasal septal deviation, septal spur, prominent ethmoid bulla, paradoxical turbinate, Haller cell, agger nasi cell, lateral or medial deviation of the uncinate process,

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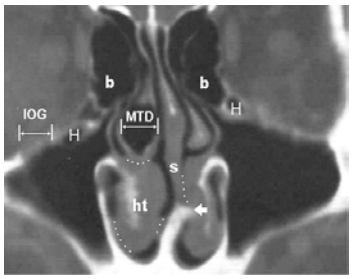

Figure.1 The measurement of the size of cuncha bullosa as maximum transeverse diameter (MTD). The transverse diameter of the inferior orbital groove (IOG) can be measured at the same coronal scan for comparison. There is also bilateral prominent ethmoidal bulla (b), Haller cell (H), and intranasal mucosal adhesion or synechia (dotted lines). Nasal septum (s) is deviated to left with a spure (arrow).

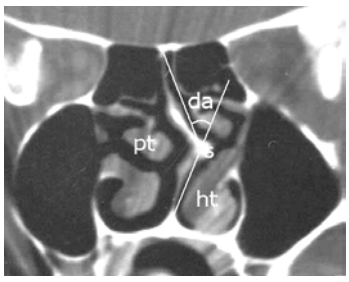

Figure 2. The measurement of the deviation angle (da). There is also septal spure (s), paradoxical turbinate (pt), and hypertrophied iferior turbinate (ht).

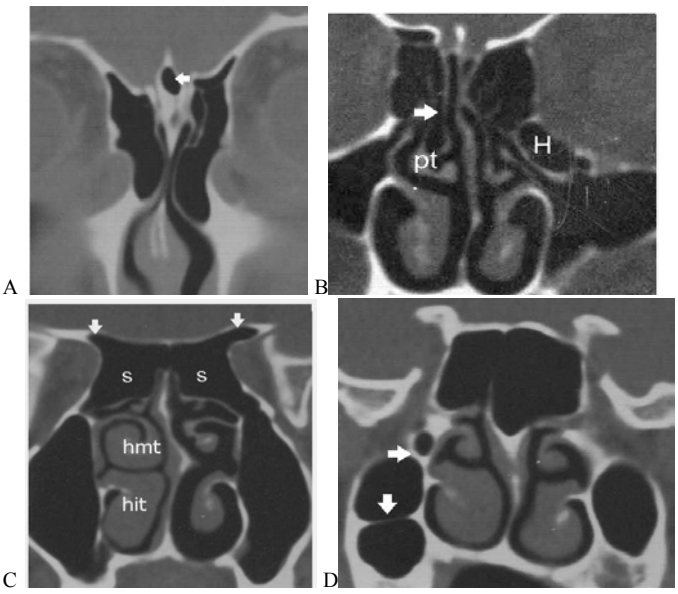

Figure 3. Sinonasal anatomic variants. A. Aeration of crista galli. B. The right middle turbinate has paradoxical curve (pt) and the perpendicular portion or stem of turbinate is aerated (stem type concha bullosa, arrow). A Haller cell is seen on left side (H). C.Sphenoid sinuses (s) are hyperaerated and both anterior clinoid processes are pneumatized (arrows). There is also unilateral hypertrophy of middle turbinate (hmt) and inferior turbinate (hit) on right side. D.Two intermaxillary septa are seen in right maxillary sinus (arrows).

hypertrophy of the middle turbinate, and synechia or intranasal mucosal adhesion (figs. 1-3).[5,6,9-15]

The incidence of concha bullosa has been reported to be 4-80% in different studies, in different populations and with different definitions. [8, 9, 13, 17, 20, 21] Some authors have defined concha bullosa as complete or near complete aeration of the middle turbinate[20], while others have considered it as any visible air cell in the middle turbinate.[8] In this study we keep in with the latter definition, recording the size of concha bullosa as the maximum transverse diameter on the coronal scans (Fig. 1). Our goal was to determine the incidence of concha bullosa and other significant sinonasal anatomic variations in coronal CT scans and to correlate with the inflammatory sinus diseases.

Materials and Methods

Coronal sinus CT scans of 174 consecutive symptomatic patients were reviewed for concha bullosa and other sinonasal anatomic variations associated with inflammatory diseases of the paranasal sinuses. These patients were referred for evaluation of acute and chronic inflammatory sinus disease. The patients with sinonasal tumors and trauma were excluded from the study.

The patients were asked about symptoms such as headache, nasal stuffiness, nasal discharge and fever during the two weeks prior to examination. They were also examined for postnasal drip and tenderness over the facial sinuses. The signs and symptoms of possible extension of sinus inflammation to ears or eyes were also searched.

All CT scans were performed by General Electric CT 9800 scanner. Although prone position has been recommended for performing CT of the sinuses in coronal plane (chin up position),[4,6-8,17] our patients were positioned in supine with the head hyperextended (head hanging position) since patients were more comfortable in this position. The gantry was perpendicular or near perpendicular to the hard palate. Contiguous thin slices were performed from sphenoid sinuses in the back to frontal sinuses. Scanning parameters included 3 mm slice thickness, 3mm table incrementation, 2 seconds scanning time, 125 kVp and 200 mAs. In all cases, we preferred direct coronal images (even with artifact from dental amalgam) to reformatted coronal images obtained from the axial data. The field of view was confined to the sinonasal area for optimal visualization. Bone and soft tissues were best visualized by filming on a window width of 1500-2000 HU and window level of 200-300 HU. Additional soft-tissue images on a window width of approximately 400 and a window level of 100 were obtained in most patients.

We considered concha bullosa as any visible pneumatization of the middle turbinate. The size of each concha bullosa was recorded as the maximum transverse diameter in coronal scans (Fig. 1). A concha bullosa of the same size may have different effect in patients with different body size (eg. children vs. adults). So we compared the transverse diameter of concha bullosa with the transverse

diameter of the inferior orbital groove (IOG), as an internal reference, in the same coronal CT slice and recorded as the ratio of the transverse diameter of the concha bullosa to the inferior orbital groove. The inferior orbital groove was visible in almost all patients mostly in the same coronal image that concha bullosa was visible.

Any retention fluid, mucous retention cyst, and air/fluid level in the sinuses, mucosal thickening, complete or near complete opaque sinuses or ostiomeatal complex were considered as inflammatory sinonasal disease. Marked intranasal mucosal contact was considered as synechia.

The nasal septal deviation angle was measured as the angle between the point of deviation with the superior and inferior junctions of the nasal septum with the roof and floor of the nasal cavity (Fig. 2). In cases of s-shaped deviation of the septum both angles produced between septal alignment superior and inferior to the deviation points were measured, but the deviation pointing to the ostiomeatal complex (effective deviation) or the greater deviation (dominant deviation) was considered as the main deviation angle. Because a perfectly straight nasal septum is uncommon, we ignored minor deviations, especially those with gentle curves. We considered a deviation angle of less than 10 degrees as non-significant. Giant or prominent ethmoid bullae were evaluated subjectively when this air cell was protruded to the ostiomeatal complex. Hypoplasic frontal sinus was considered when the maximum superolateral extension of this air cavity was less than one-third of the length of the superior orbital rim. Hypoplastic maxillary sinus was considered when the floor of the sinus was higher than the floor of the nasal cavity. Hypoplastic sphenoid sinus was considered subjectively when this air cavity had abnormally a small size. Conversely, extensive pneumatization of this sinus considered when anterior clinoid processes, dorsum sellae or base of the pterygoid processes were aerated.

Results

In this study, 174 patients with symptoms of inflammatory sinonasal disease were evaluated by CT. The mean age of the patients was 30.6 years (from 7 to 66 years). Twenty-one patients (12.1%) had previous sinonasal surgery.

More than one-third of the patients (36.5%) were 15-24 years old and about three-forth (73.5%) were 15-44 years old. There were 95 (54.6%) males and 79 (45.4%) females.

Concha bullosa was seen in 113 (64.9%) patients. In this group, there were 57 males and 56 females. By considering male to female ratio in all patients this means higher incidence of concha bullosa in females (70.9% of all females in comparison to 60.0% of all males). The mean age of patients who had concha bullosa was 30.3 years, ranging from 8 to 63 years with no marked difference between patients with or without the condition. Concha bullosa was bilateral in 45 (39.8%). In patients with unilateral concha bullosa left to right ratio was 1.7 to 1. Ectopic air cell (or bulla) in the superior turbinate was seen in 9 (5.2%) and in the inferior turbinate in 2 (1.1%). A single case had bullae in his superior, middle, and inferior turbinates (Fig. 4).

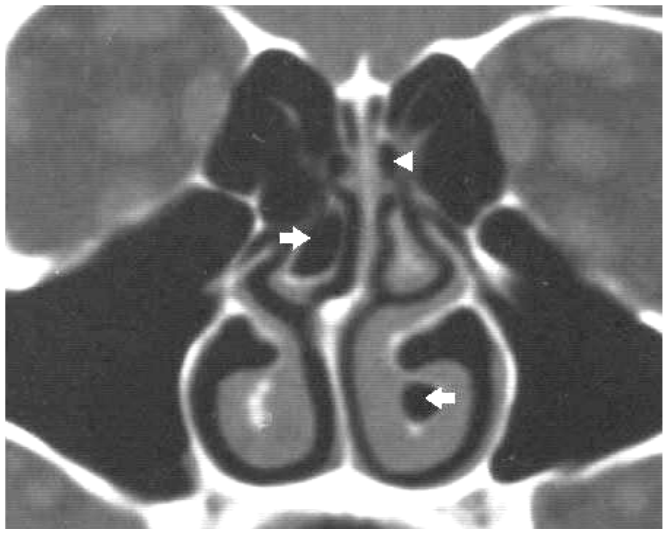

Figure.4 Concha bullosa in right middle turbinate (arrow). There is also ectopic air cells (buula) in left inferior turbinate (arrow) and left superior turbinate (arrow head).

The location of concha bullosa in the middle turbinate was different. Some were in the vertical portion or "stem" of the middle turbinate, some in the inferior or bulbous portion of middle turbinate, and finally some in the entire of the middle turbinate. The average of the maximum transverse diameter of concha bullosa was 5.6 mm (1 to 17 mm) (table 1). In comparison with the transverse diameter of the inferior orbital groove (IOG), the size of concha bullosa varied from 0.3 to four times larger than IOG. Many patients with concha bullosa had additional sinonasal anatomic variations. The overall incidence of these variations was higher in patients who had concha bullosa than patients without it (table 2).

Another common important variant, nasal septal deviation was seen in 109 (62.6%). In this group, there were 59 males (62.6% of all males) and 50 females (63.3% of all females) with no sex predominance. The deviated septums were pointing to the right in 56 (51.4%), to the left in 46 (42.2%), and to both sides (s-shaped septum) in 7 (6.4%). Simultaneous septal spur was seen in 38 (34.9% of

Transverse diameter	Nomber	Percentage
< = 4mm	68	43.0%
5-8mm	70	44.3%
9-12mm	11	7.0%
> = 13 mm	9	5.7%
Total	158	100.0%

TABLE 1. Size of conchae bullosae as maximum transverse diameter.

Deviation angle (degrees)	Nomber	Percentage
< = 14	*13*	*11.9%*
15-24	*54*	*49.5%*
25-34	*31*	*28.4%*
35-44	*5*	*4.6%*
> = 45	*6*	*5.5%*
Total	*109*	*100.0%*

TABLE 3. The severity of septal deviations as deviation angle

Anatomic variant	Concha Bullosa			Osteomeatal Disease		
	Present (113)	Absent (61)	All (174)	Present (117)	Absent (57)	All (174)
Septal deviation	76(67.3%)	23(54.1%)	109(62.6%)	*72(61.5%)*	*37(64.9%)*	*109(62.6%)*
Septal spur	31(27.4%)	11(18.0%)	42(24.1%)	*27(23.1%)*	*15(26.3%)*	*42(24.1%)*
Haller cell	16(14.2%)	10(16.4%)	26(14.9%)	*17(14.5%)*	*4(7.0%)*	*26(14.9%)*
Paradox turbinate	5(4.4%)	3(4.9%)	8(4.6%)	*6(5.1%)*	*2(3.5%)*	*8(4.6%)*
Giant ethmoid bulla	29(25.7%)	11(18.0%)	40(23.0%)	*29(24.8%)*	*11(19.3%)*	*40(23.0%)*
Prominent middle turbinate	13(11.5%)	6(9.8%)	19(10.9%)	*16(13.7%)*	*3(5.3%)*	*19(10.9%)*
Prominent inferior turbinate	54(47.8%)	20(32.8%)	74(42.5%)	*46(39.3%)*	*28(49.1%)*	*74(42.5%)*
Hyperaerated sphenoid	23(20.4%)	6(9.8%)	29(16.7%)	*22(18.8%)*	*7(12.3%)*	*29(16.7%)*
Aerated crista galli	8(7.1%)	4(6.6%)	12(6.7%)	-	-	-
Intermaxillary septa	7(6.2%)	5(8.2%)	12(6.7%)	*7(6.0%)*	*5(8.9%)*	*12(6.7%)*
Hypoplasic sinuses	24(21.2%)	14(23.0%)	38(21.8%)	*26(22.2%)*	*10(17.5%)*	*38(21.8%)*

TABLE 2. The incidence of anatomic variants in patients with and without concha bullosa and Osteomeatal sinus disease.

deviated septums). The spurs were almost always at the point of deviation; only two spurs were seen inferior to deviation points and another two were seen without septal deviation. Mean deviation angle was 24.6 degrees (range; 10 to 56 degrees) Mean deviation angle to the right was 23.2 and to the left was 26.4 degrees (table 3).

Increased density in ostiomeatal unit or inflammatory disease in the sinuses were identified in 117 (67.2%). The remainder of CT scans were normal. Inflammatory disease was seen in 81 of 113 patients with concha bullosa (71.7%) and 35 of 61 patients without concha bullosa (57.7%). There was no correlation between nasal septal deviation with the incidence of inflammatory changes in paranasal sinuses, but this incidence was higher in "severe" septal deviation (deviation angle ≥ 25 degrees) in comparison with "mild" septal deviations (deviation angle < 25 degrees). Furthermore the incidence of inflammatory disease was higher in patients with simultaneous occurrence of concha bullosa and septal deviation than patients with concha bullosa alone (without septal deviation) (table 4).

In addition to concha bullosa, Haller cells, prominent ethmoid bullae, prominent middle turbinate, paradoxical middle turbinate, and hypoplasic sinuses were more common in patients with inflammatory disease depicted on CT scans than patients without inflammatory disease (table 2). The first four of these variants are suspected to narrow the ostiomeatal complex [5,6,9-1]. It is believed that hypoplasic maxillary sinuses with a long attenuated infundibulum are frequently responsible for isolated maxillary sinus disease, especially in children.

In 86 patients who participated in physical examination, the results of examination for postnasal drip, tenderness over facial sinuses and signs or symptoms of extension of inflammatory process to ears or eyes and the incidence of symptoms of inflammatory sinus disease during the last two weeks prior to performing CT were evaluated . The most common symptom was headache that occurred in 70 (81.4%) patients, and the least common was fever that occurred in 24 (27.9%) patients. Otorrhea, otalgia, or tenderness over the mastoid bones were present in 24 (27.9%). There were no cases of intraorbital extension of sinusitis. Tenderness over the frontal and maxillary sinuses, postnasal drip and fever were more common in patients with concha bullosa.

Tenderness over the facial sinuses was present in 40 of 86 patients (46.5%). We compared the results of this clinical test with CT appearances of corresponding sinuses for the existence or absence of inflammatory disease . The results were different in frontal and maxillary sinuses, in which tenderness over maxillary sinuses seemed to be a more reliable sign of inflammatory disease (positive predictive value of 0.76), but the absence of tenderness had poor correlation with disease-free sinuses (negative predictive value of 0.43). Conversely, in frontal sinuses tenderness was not a reliable sign of inflammatory disease on CT (positive predictive value of 0.42), but the absence of tenderness over frontal

		Ostiomeatal Disease	
		Present	Absent
Septal Deviation (SD)	Present	72(66.1%)	37(33.9%)
	Absent	45(69.2%)	20(39.8%)
Deviation severity	Mild (< 25 deg.)	40(61.5%)	25(38.5%)
	Severe (>=25 deg.)	32(72.1%)	12(27.9%)
Concha bullosa	Without SD	26(66.6%)	13(33.3%)
	With SD	*54(73.7%)*	*20(26.2%)*

TABLE 4. Ostiomeatal or sinus disease and septal deviaton.

sinuses had correlation with normal sinuses (negative predictive value of 0.75).

Discussion

Concha bullosa is one of the most common sinonasal anatomical variants that frequently is associated with inflammatory sinus disease. This ectopic air cell is lined with the same epithelium as the rest of the nasal cavity and thus can be affected by the same inflammatory disorder experienced in paranasal sinuses.[6,8,19] Concha bullosa is best diagnosed by coronal CT, which provides the otolaryngologist with the most accurate information for possible therapeutic decisions.[7,8,13]

The incidence of concha bullosa has been reported from 4-80% in different studies on different populations and by different definitions of concha bullosa.[8,9,13,17,20,21] Ritter found an incidence of concha bullosa (in all patients with and without sinusitis) of only 4-12%.[21] Bolger et al. described "true" concha bullosa as pneumatization of the entire middle turbinate with a frequency of 16%. They found that the incidence of all types of concha bullosa was 78%. [20] Babbel and Harnsberger reported an incidence of 14% in 500 CT examinations of symptomatic patients. [17] Zinreich defined concha bullosa as any visible pneumatization of middle turbinate and reported an incidence of 34%.[8] In this study, we are concordant with the recent definition, but we found an incidence of 64.9%. We recorded the size of concha bullosa as the maximum transverse diameter in coronal scans (Fig. 1). Sixty-five of all 158 conchae bullosae (43.0%) had a maximum transverse diameter of less than 5 mm (table 1).

Calhon et al. found that concha bullosa was more common in patients with sinus disease and statistically related to anterior ethmoid disease.[16]In contrast, Zinreich reported that the overall incidence of ostiomeatal disease in symptomatic patients was identical whether patients did or did not have a concha bullosa.[8] It seems that concha bullosa, especially the large ones, can obstruct ostiomeatal complex and cause inflammatory disease. We found higher incidence of sinus disease in patients who have a concha bullosa. This was true in most of the other anatomic variants around the ostiomeatal complex.

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