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The incidence of concha bullosa and the correlation with nasal septal deviation

A. Arvin Sazgar, J. Massah**, M. Sadeghi*, A. Bagheri*** and F. Rasool*****

*Department of Otolaryngology, Head and Neck Surgery, Faculty of Medicine, Tehran University of Medical Sciences; **Department of Mechanics of Agricultural Machinery, Abourayhan Campus, University of Tehran; ***Department of Maxillofacial Radiology, Faculty of Dentistry, Tehran University of Medical Sciences; ****Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran

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Abstract. *The incidence of concha bullosa and the correlation with nasal septal deviation. Objectives*: To analyse the incidence of concha bullosa and any aetiological correlation with nasal septal deviation.
Methodology: Paranasal sinus computerised tomography (CT) scans were made of 143 consecutive patients with sinonasal symptoms. Patients with altered anatomy (iatrogenic or pathological) were excluded and the remaining CT scans were analysed for the pneumatisation of the middle turbinate, septal deviation and the correlation between them.
Results: Sixty-three percent of patients had some types of septal deviation and 35% had unilateral or bilateral concha bullosa. Septal deviation was present in 9 out of 13 patients (69.2%) with large unilateral or dominant concha bullosa, 10 out of 24 (41.7%) with medium unilateral or dominant concha bullosa, and 12 out of 30 (40%) with small concha bullosa. There was a clear link between the presence of a unilateral concha, or a dominant concha (in bilateral concha), and the presence of nasal septal deviation ($P < 0.009$).
Conclusions: After the assessment of various sizes and shape of concha bullosa and the form of nasal septal deviation away from the dominant concha, we suggest that deviation is an indirect result of the presence of the concha. This hypothesis can be proved by reference to the laws of physics.

Introduction

Concha bullosa is an aeration of the middle turbinate and may be unilateral or bilateral. Less frequently, aeration of the superior turbinate can occur, whereas aeration of the inferior turbinate is infrequent. The air cavity in a concha bullosa is lined with the same epithelium as the rest of the sinonasal tract. The incidence of CT findings positive for concha bullosa varied from 14–53%[1-3] and the link between concha bullosa and ostiomeatal complex obstruction and sinusitis continues to be debated.[4-7] Nasal septal deviation is an asymmetric bowing of the nasal septum. Traumatic deviation or developmental abnormalities of the nasal septum can lead to significant nasal airway obstruction and cosmetic deformity.

The exact mechanism of turbinate aeration has not been elucidated. Nevertheless, it is believed that the airflow pattern of the nasal cavity plays an important role. Despite the results from other studies, we do not believe that septal deviation and concha bullosa are two anatomic variants found incidentally and concomitantly, even assuming that the space on the concave side of the nasal cavity in cases with septal deviation provokes the development of concha bullosa and increases the pneumatisation of the middle turbinate.[1-3,8]

The objective of this prospective study was to investigate the incidence of concha bullosa and septal deviation. At the same time, we wanted to evaluate the form and location of septal deviation in conjunction with concha bullosa and establish whether there was any causal relationship. Indeed, our aim was to evaluate the concha's effect on its medial side.

Materials and methods

Between July 2005 and July 2006, all patients aged above 16 years referred to our clinic for an evaluation of sinusitis underwent a CT scan of the paranasal sinuses using a standardised imaging protocol. We used a spiral CT scan (X series (2B201-166E), Toshiba whole-body X-ray CT-scanner), 400 mA and 120 kVp with 2 mm slice thickness and

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Table 1
Location of septal deviation in antero-posterior direction in paranasal sinus CT scans of 143 subjects

Location of deviation	Frequency	Percent
Without deviation	53	37.1
Anterior	24	16.8
Posterior	4	2.8
Middle	34	23.8
Middle and anterior	24	16.8
Anterior and posterior	1	0.7
Middle and posterior	3	2.1
Total	143	100.0

5 mm interval (2 mm in OMC region) in the axial and coronal planes. Nasal vasoconstrictors were not administered. After excluding patients with altered anatomy (iatrogenic or pathological), the remaining scans of 143 patients with normal anatomy were meticulously analysed for aeration of the middle turbinate and the form of any septal deviation. The analyses were reviewed by one otolaryngologist and one maxillofacial radiologist, and any differences in opinions were resolved by consensus. Concha bullosa was defined as being small, moderate and large respectively when 25%-50%, 51%-75%, and more than 75% of the vertical height (measured from superior to inferior in the coronal plane) of the middle turbinate was pneumatised. We defined nasal septal deviation as an asymmetric bowing of the nasal septum found in axial and coronal CT studies. Because a perfectly straight nasal septum is uncommon, we ignored minor deviations (a deviation angle of less than 10 degrees). The direction of the deviation was defined by the side of the convexity of the curvature. Vertical and horizontal deviation of the nasal septum was subjectively assessed as being absent, anterior, posterior, middle, anterior and posterior, middle and anterior, middle and posterior. We also evaluated the presence/absence of any nasal air channel between the medial aspect of the concha and the adjacent surface of the nasal septum.

These data were recorded in the patient's individual data sheet. The findings were analysed using SPSS statistical software, and correlations were compared with chi-square testing where applicable.

Results

The mean age of the patients was 35.3 years (range 16-75). There were 69 male (48%) and 74 female (52%) patients. Of the 143 patients, 90 (62.9%) had nasal septal deviation: 40 (28%) had convexity to the right, 45 (31.5%) had convexity to the left, and 5 (3.5%) had biconvex nasal septal deviation. We also assessed the shape of the deviation in three approximately equal sections (Table 1). The middle turbinate is located roughly adjacent to the middle part of the septum.

Concha bullosa was found in 50 (35%) cases, of which 17 (11.9%) were bilateral and 33 (23.1%) unilateral. Of the 33 patients, seventeen cases had concha bullosa on the right side, and sixteen cases had concha bullosa on the left side. Of the 67 concha (50 patients), 13 were large (in 11 patients), 24 were moderate (in 23 patients), and 30 were small (in 24 patients). Of the 17 bilateral concha, 2 were large-large, 1 was medium-medium, 6 were small-small, 2 were large-medium, 3 were large-small, and 3 were medium-small.

The correlation between a unilateral or dominant concha and contralateral nasal septal deviation was significant ($P = 0.009$). In patients with a unilateral or dominant concha and nasal septal deviation, the association of septal deviation was greater in patients with medium or large concha than in those with small concha. The association between concha bullosa and septal deviation was 9 out of 13 (69.2%) in patients with large unilateral or dominant concha bullosa, 10 out of 24 (41.7%) in those with medium unilateral or dominant concha bullosa, and 12 out of 30 (40%) in small concha bullosa. Septal deviation was found in 59 cases without aeration of the middle turbinate. The septum was approximately straight in one patient with large-large concha and in one with large-medium concha. A complete air channel between the medial aspect of the concha and the adjacent surface of the nasal septum was detected in 46 cases with concha bullosa.

Discussion

There are some studies dealing with the incidence of middle turbinate pneumatisation and also the correlation between septal deviation and concha bullosa.[1-3,9] However, to date, no exact causal relationship has been established. It has been shown on the basis of CT images that, in general, the

Figure 1
In this patient, the concha and nasal septum are in contact with each other.

Figure 2
The nasal septum fits tightly round the shape of concha bullosa with preservation of the air channel between them.

Figure 3
In this patient the septum not only deviates to the right side but also is thinner just next to the concha.

incidence of concha bullosa varies between 13.0% and 53.6% in adults[3-11] and between 5% and 10% in children.[12-14] Like other studies, we found a statistically significant relationship between unilateral concha bullosa and nasal septal deviation ($p<0.009$).[1-3,6,8] We also found that the association with septal deviation was greater in patients with large concha than in those with medium or small concha.

Can the "e vacuo" theory, as postulated by Stammberger, thoroughly explain the creation of concha bullosa preceded by unfilled space to the concave side of a septal deviation? We suggest another hypothesis: not all people with a septal deviation necessarily have concha bullosa (59 cases in this study), while almost all cases with dominant or large concha bullosa definitely have sepal deviation, especially near the site of the concha. We found arguments that conformed with another study[3]: there was often maintenance of the nasal air channel between the medial aspect of the concha and the adjacent surface of the nasal septum (92% in the present study) but it seems the shape of the nasal septum next to the concha bullosa is moulded by the irregularity of concha's surface

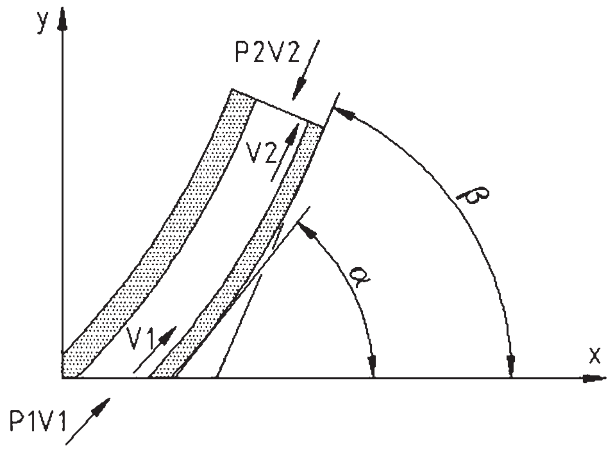

Figure 4
In a gutter-like nasal cavity, the force exerted by the inlet fluid on the gutter walls is P_1V_1 and the force exerted by the fluid on the gutter is P_2V_2 (product of fluid pressure by fluid velocity).

(Figures 1,2). The septum not only deviates to the opposite side but is also often thinner and deformed just next to the concha (Figure 3).

A subtle investigation shows that the match between the shape and location of a septal deviation on the one hand and the concha bullosa on the other represents a causal relationship between the gradual growth of a concha and the creation of a septal deviation. This hypothesis can be proved by reference to the laws of physics. It should be pointed out that these relationships are valid for incompressible fluid, whereas respiratory airflows are compressible. The effects of the forces of respiratory airflows on the respiratory tract occur over years. The compressibility of the air has therefore been disregarded.

When fluid comes into contact with a fixed plate, the direction of its movement will change and will follow the curvature of the plate. As a result, the force of the fluid will be applied to the plate. Frictional and gravitational forces have been disregarded here. In a gutter-like nasal cavity, force is exerted by the inlet fluid on the gutter walls (Figure 4). As shown

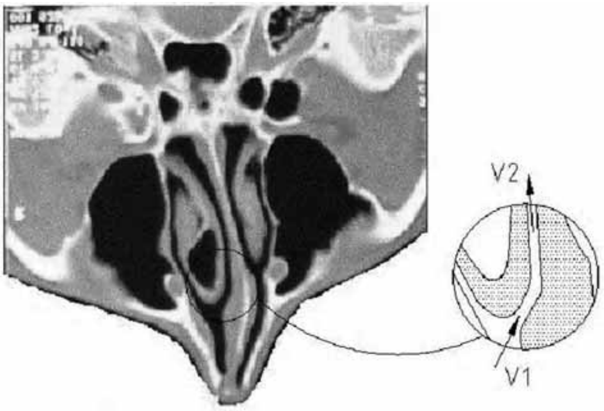

Figure 5
The velocity of the inlet air to the gutter is V_1 and the outlet air velocity is V_2.

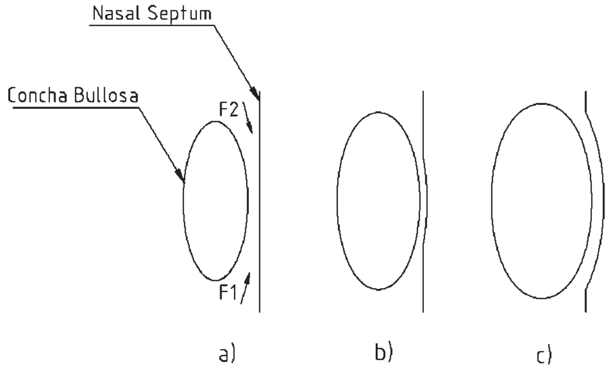

Figure 6
The shape of the nasal septum is changed in proportion to the growth of the concha bullosa.

Figure 7
In this patient, we see bilateral large concha bullosa next to a straight septum (note the preservation of the air channels).

in Figure 5, the velocity of the inlet fluid to the gutter is V_1 and the outlet fluid velocity is V_2. It is obvious that the smaller the cross-sectional area of the gutter outlet, the greater the difference will be between V_1 and V_2. An increase in the difference between these two velocities results in larger forces being exerted by the air on the walls of the nasal cavity (Figure 5).[15]

The following equation represents this force:

$$F = \varrho Q (V_2 - V_1)$$

Where Q is the rate of flow of the fluid and ϱ is the specific gravity of the fluid. When walls are equally solid, this force will affect the weaker wall. Figure 6 shows how air passes through a nasal cavity with one flat side and one ellipsoid side. It is clear that, given equal wall solidity, the ellipsoid plate (concha bullosa) will be more resistant to the external forces than the flat plate (septum).

As shown in Figure 6a, at the beginning, force is applied by the air on the flat and ellipsoid surfaces (Figure 6). Given the geometric structure of the ellipsoid surface, the force has a greater effect on the flat surface and changes its shape. The shape of the wall with less curvature and a weaker geometric structure will be changed. As the ellipsoid structure grows, the distances between concha and septum decreases, resulting in a proportional increase in the velocity of the fluid (respiratory air), in turn increasing the force.

$$A_1 V_1 = A_2 V_2$$

Where A_1 and A_2 is the cross-sectional area at the inlet and outlet points in the nasal cavity.[15] Figures 6b and 6c show the change in the shape of the nasal septum in proportion to the growth of the concha bullosa as a result of the forces discussed here. After a number of years have passed, the changed shape of concha bullosa leaves its impression on the nasal septum.

The "e vacuo" hypothesis cannot explain many features of the formation of concha bullosa formation, such as the creation of bilateral medium to large concha bullosa alongside a straight septum (two cases in our study). However, this feature can be explained by reference to the vectors of total fluid forces on both sides of the nasal septum (Figure 7).

Conclusion

In conclusion, it can be stated that the airflow through the different parts of the nose depends on the length and cross-sectional area of the airway and the pressure gradient across the nose. The expansion of the concha bullosa gradually reduces the space between middle turbinate and nasal septum and the increase in the obstruction results in a corresponding increase in the pressure required to generate a certain flow. Given the geometric structure, more pressure will be exerted on the nasal septum, which will gradually deviate. This process causes the nasal septum to fit tightly round the shape of concha bullosa, with the preservation of the air channel between them.

We think that, in future, there should be studies of the incidence of nasal septum and the correlation of deviation with concha bullosa in different age groups.

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M. Sadeghi, M.D.
Tehran University of Medical Sciences
Faculty of Medicine
Department of Otolaryngology, Head and Neck Surgery
Dr. Gharib Ave
Keshavarz Bld.
Tehran, Iran
Tel.: +98-21-66932288
Fax: +98-21-66932288
E-mail: Sadeghih@sina.tums.ac.ir