Prevalence of Anatomic Variation Demonstrated on Screening Sinus Computed Tomography and Clinical Correlation

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Screening sinus computed tomography (SCCT) of 133 patients performed from March 2003 to February 2004, were retrospectively reviewed, concerning anatomic variation at ostiomeatal unit (OMU) and nasal septal deviation. Six patterns of inflammatory sinus disease were designated: maxillary infundibulum, nasofrontal duct, OMU, sphenoethmoidal recess, polyposis and sporadic. The most common anatomic variation was concha bullosa (14.3%), followed by Haller cell (9.4%), large Agger nasi cell (7.9%) and paradoxical middle turbinate (5.3%). Nasal septal deviation was presented in 75 patients (56.4%). Inflammatory sinus disease was presented in 181 lateral nasal walls (68%) and maxillary infundibular pattern was the most common (33.1%). There was significant correlation between large Agger nasi cell and nasofrontal duct pattern ($p< 0.05$). The remaining anatomic variations and nasal septal deviation had no significant correlation to the inflammatory sinus disease.

Overall, the anatomic variation which can compromise the mucociliary drainage was frequently observed, however, only the large Agger nasi cell had significant correlation to the inflammatory sinus disease.

Keywords: *Anatomic variation, Screening sinus computed tomography*

J Med Assoc Thai 2005; 88(Suppl 4): S110-5
Full text. e-Journal: *http://www.medassocthai.org/journal*

The concept that inflammatory sinus disease results primarily from interference of mucociliary clearance due to compromise of the ostiomeatal channels of the individual sinus cavities is popular[1]. According to Harnsberger[2,3], six patterns of inflammatory sinus disease were designated: maxillary infundibular (pattern I), nasofrontal duct (pattern II), ostiomeatal unit (pattern III), sphenoethmoidal recess (pattern IV), sinonasal polyposis (pattern V) and sporadic or non-obstructive (pattern VI).

The reported prevalence of anatomic variations demonstrated on screening sinus CT widely varies among several groups of investigators. The difference may be due to anatomic definition, study population and method of analysis. Certain anatomic variations are thought to be predisposing factor for the development of sinus disease[4-7]. However, as reported by Earnwaker[8], the presence of anatomic variations, singly or in combination, does not constitute a disease state.

The purpose of the present study was to examine the prevalence of anatomic variation at anterior OMU which was demonstrated on screening sinus CT, and their clinical correlation. The specifically studied variations, included concha bullosa, Haller cell, paradoxical middle turbinate and Agger nasi cell and nasal septal deviation. The anatomic definition was based on those of Som.[1] Agger nasi cell is the most anterior ethmoid air cell, lying deep to the lacrimal bone and bordering the primary ostium or the floor of the frontal sinus. Since Agger nasi cell is present in nearly all patients, only the large Agger nasi cell is concerned in the present study. Nasal septal deviation is malalignment of component of adult nasal septum (septal carti-

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lage, perpendicular ethmoid plate and vomer). In the present study, only anterior curvature of nasal septum was recorded due to the intimate relationship with OMU.

Material and Method

Screening sinus CT of 148 patients performed from March 2003 to February 2004 were randomly selected and retrospectively reviewed by a 3rd year training resident of Radiology. Thirteen patients were excluded because previous sinonasal surgery, facial trauma, sinonasal neoplasm and younger age (<12 years old).[9] Age, sex and preliminary diagnosis at the time of imaging were recorded. Each lateral nasal walls of one patient was separately reviewed. Presence of concha bullosa, Haller cell, paradoxical middle turbinate, large Agger nasi cell and anterior curvature of nasal septal deviation was recorded. Any evidence of mucosal thickening detected on CT, was considered abnormal[1]. The pattern of inflammatory sinus disease was recorded. All 133 cases were reevaluated by experienced neuroradiologist, blinded to the original report.

Fifteen patients were scanned on a Sytec 4000 (GE medical system, Asia/Pacific) and thirty-seven patients were scanned on Somatom plus 4 (Siemens, Germany). Images were obtained by using a bone algorithm with 3-mm sequential scan from glabella to anterior clinoid process and 5-mm sequential scan from anterior clinoid processes to posterior clinoid processes[3,4,5,8]. Eighty-one patients were scanned on Sensation 4 (Siemens, Germany), using Kernell 70, with 4-mm sequential scan from glabella to posterior clinoid processes[10]. The scanner gantry was angled perpendicular to the hard palate. Data was acquired on coronal plane without the use of intravenous contrast material. All images were filmed (window width = 2000 HU and window level = 500 HU).

Results

One hundred and thirty-three cases (266 lateral nasal walls) composed 71 males (53.4%) and 62 females (46.6%). Age ranged from 13 to 76 years old (mean, 40 years old). Clinical diagnosis of 116 cases (87.2%) was sinusitis and of 17 cases (12.8%) was nasal polyposis. Eighty-two lateral nasal walls (30.9% 82/266) had concerning anatomic variations. Isolated anatomic variation was commonly seen (67 (67/82) lateral nasal walls, 81.7%). Fourteeen lateral nasal walls (17.1%, 14/82) had 2 variations and one wall had 3 variatioins (1.2%).

Concha bullosae were presented in 38 lateral nasal walls (14.3%, 38/266), Haller cells were presented in 25 lateral nasal walls (9.4%, 25/266), large Agger nasi cells were presented in 21 lateral nasal walls (7.9%, 21/266) and the paradoxical middle turbinates were presented in 14 lateral nasal walls (5.3%, 14/266). The most common anatomic variation was concha bullosa. Nasal septal deviation occurred in 75 cases (56.4%, 75/133). One hundred and eighty-one lateral nasal walls (68%, 181/266) showed evidence of inflammatory sinus disease. The most common was pattern I (88 walls, 33.1%, 181/266), followed by pattern II (68 walls, 25.6%, 68/266), pattern III (65 walls, 24.4%, 65/266), pattern IV (28 walls, 10.5%, 28/266), pattern V (53 walls, 19.9%, 53/

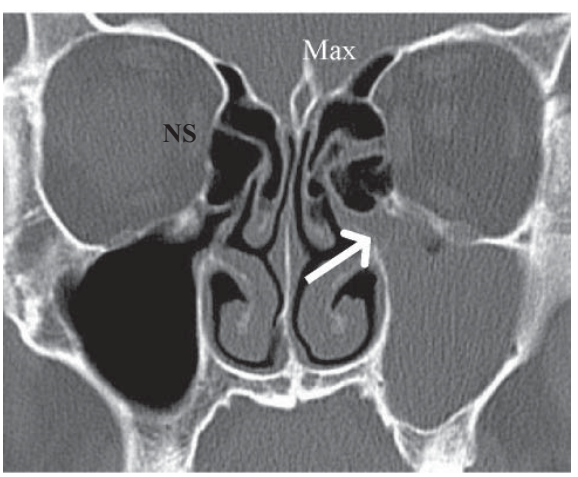

Fig. 1 Coronal CT scan shows opacification of left maxillary infundibulum and ipsilateral maxillary sinus (pattern I: maxillary infundibulum)

Fig. 2 Coronal CT scan shows opacification of left nasofrontal duct in conjunction with partial opacification of ipsilateral frontal sinus (pattern II: nasofrontal duct)

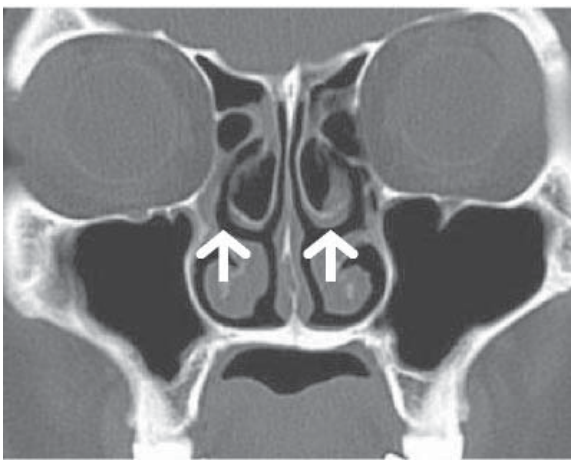

Fig. 3 Coronal CT scan shows pneumatization of bulbous segment of middle turbinate bones bilaterally (concha bullosa)

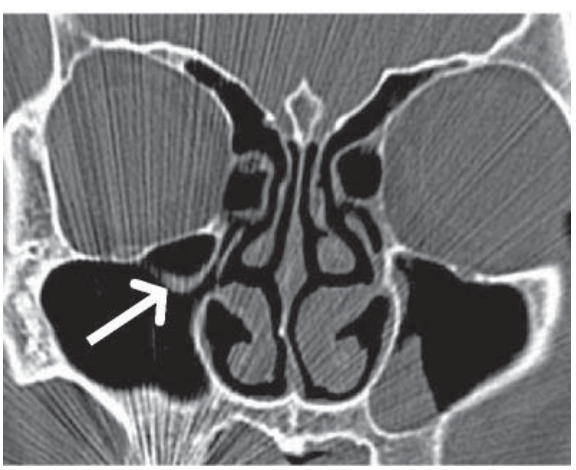

Fig. 4 Coronal CT scan shows pneumatized ethmoid air cell that projects along the medial roof of right maxillary sinus and most inferior portion of lamina papyracea, below the ethmoid bulla and lateral to the uncinate process (Haller cell)

266) and pattern VI (35 walls, 13.2%, 35/266). Combined pattern was common. Ten lateral nasal walls from 55 lateral nasal walls which had pattern III of inflammatory sinus disease, had associated concha bullosa. Nine lateral nasal walls from 88 lateral nasal walls which had pattern I of inflammatory sinus disease had associated Haller cells. Both concha bullosa and Haller cell have no significant correlation with inflammatory sinus disease ($p>0.05$). Ten lateral nasal walls from 68 lateral nasal walls which showed pattern II of inflammatory sinus disease, had associated large Agger nasi cell . There was significant correlation between large Agger nasi cell and pattern II of inflammatory sinus

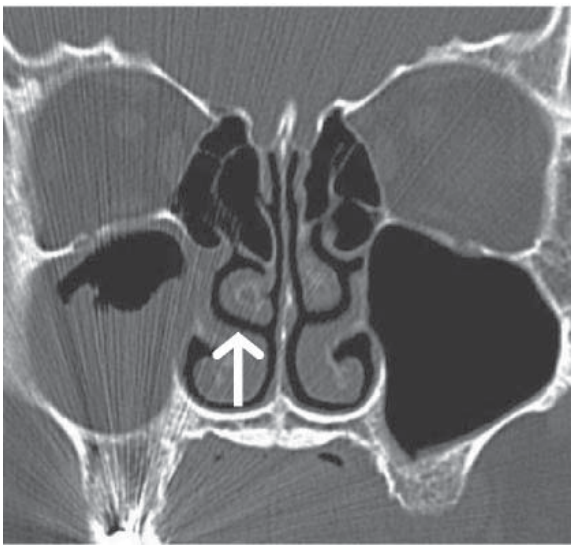

Fig. 5 Coronal CT scan shows lateral projection of major curvature of right middle turbinate (paradoxical middle turbinate). There is air-fluid level in right maxillary sinus

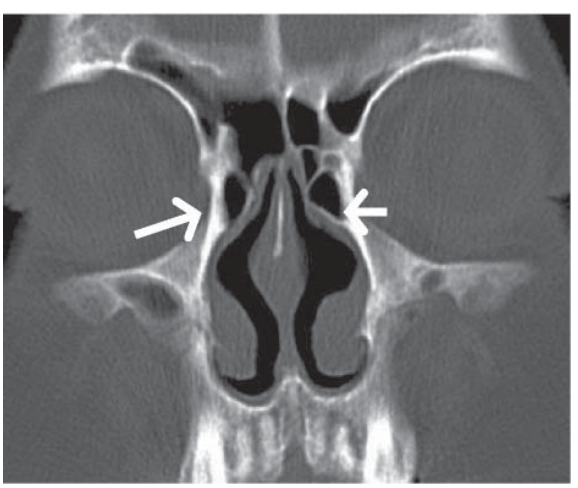

Fig. 6 Coronal CT scan shows bilateral anterior ethmoid air cells lying deep to lacrimal bone and bordering floor of frontal sinuses (Agger nasi cell)

disease ($p<0.05$). All lateral nasal walls with paradoxical middle turbinates had no associated ostiomeatal pattern of inflammatory sinus disease.

Nineteen lateral nasal walls from 65 lateral nasal walls which had pattern III of inflammatory sinus disease, had associated nasal septal deviation. No significant correlation between nasal septal deviation and pattern III of inflammatory sinus disease was identified ($p>0.05$). Thirty-one lateral nasal walls from 53 lateral nasal walls which had pattern V of inflammatory sinus disease, had associated nasal septal deviation. No sig-

Table 1. Reported Prevalence of Anatomic Variations

Authors	Variations				
	Concha bullosa	Haller cell	Paradoxical MT	Agger nasi cell	Nasal septal deviation
Zinreich et al[10]	36%	10%	15%	nearly all	21%
Bolger[4]	(15.7%) 53%	45.1%	26.1%	98.5%	18.8%
Lloyd[7]	14%	2%	17%	3%	-
Scribano et al[11]	67%	24%	-	-	-
Yousem[12]	34-53%	10-45%	-	-	-
Joe[6]	15%	-	3%	-	-
Earnwaker[8]	31% (bulb)	20%	17%	98.5%	55%
The present study	14.3%	9.4%	5.3%	7.9%	56.4%

MT = middle turbinate

nificant correlation between nasal septal deviation and pattern V of inflammatory sinus disease was identified ($p>0.05$).

Discussion

Concha bullosa: The reported prevalence of concha bullosa varies widely among investigators. This may be due to factors such as differences in criteria for pneumatization, differences in study population and sensitivity of method of analysis. In study of Bolger[4], true concha bullosa was referred to extensive turbinate pneumatization that encroaches into the middle meatus and his true concha bullosa was noted in 15.7% of cases. Lloyd[6] reported it in 14% of cases. Joe[7] documented concha bullosa by intraoperative nasal endoscopy in 15% of cases. Earnwaker[8] reported middle turbinate pneumatization in 35.3% of turbinates and 12% of which had associated distorted turbinate. In the present study, concha bullosa was observed in 14.3% of cases and also it was the most common variation. Bolger[4] compared patients undergoing CT scan for chronic sinus complaints with patients undergoing scan for nonsinus reasons, pneumatization of the inferior bulbous portion of the middle turbinate was noted in 35.3% compared to 13.9%. Lloyd[6] concluded that only concha bullosa was shown to be associated with the presence of increased infection in the sinuses. Calhoun[5] demonstrated a significant association between concha bullosa and anterior ethmoid disease, but not with ostiomeatal complex disease. However, in the present study, there was no statistically significance between concha bullosa and OMU pattern of inflammatory sinus disease ($p>0.05$).

Haller cell: In the present study, Haller cells were found in 9.4% of cases. Zinreich[10] reported it in 10% of cases. However, using the same criteria, Bolger reported it in 45.1% of cases. Lloyd[7] reported it in 2% of cases. Earnwaker[8] reported it in 20% of cases. Bolger[4] described the possible reasons for this discrepancy as a consequence of difference in interpretation of Haller cell, sample study or in the technique of CT scanning. Bolger[4] also suggested that a narrow window setting often fails to delineate Haller cell. The latter reason did not affect the present study since the authors filmed on intermediate window setting. If there was any doubt about bony detail, the authors adjusted the images manually from saved data to optimally display the detail.

Although its proximity to the natural ostium of the maxillary sinus, Bolger[4], Lloyd[7], Zinreich[10] and Earnwaker[8] found no significant correlation between Haller cell and chronic sinus disease. In the present study, there was no significant correlation between Haller cell and maxillary infundibular pattern of inflammatory sinus disease ($p>0.05$).

Paradoxical middle turbinate: In the present study, the reported prevalence of paradoxical middle turbinate was 5.3%, lower than Calhoun[5] (12%), Lloyd (17%) and Bolger[4] (26.1%). This might be due to, the authors being concerned only with paradoxical curve affecting the middle meatus. The paradoxical curve of posterior portion of middle turbinate was not recorded in the present study. This variation may block the entrance to the middle meatus, however, no studies related it to sinus disease. In the present study, there was also no significant correlation between it and the ostiomeatal pattern of inflammatory sinus disease.

Agger nasi cell: The reported prevalence in different series ranges widely from 2% (Lloyd[7]) to 98.5% (Bolger[4]), corresponding to varying anatomic definitions. Earnwaker[8] described the Agger nasi cells as those lying anterior to the upper end of the nasolacrimal duct. Zinreich[10] noted the presence of the Agger nasi cell in nearly all patients and pointed out

that the Agger nasi cell is the air chamber below the frontal sinus which extends to the frontal recess superiorly, reaches the lacrimal fossa inferolaterally, and is anterolaterally arched by the nasal bones. In the present study and according to Som[1], Agger nasi cell is present in nearly all patients. The authors recorded only the large Agger nasi cells which encroached the anterior portion of the middle meatus and found it in 7.9% of cases. The intimate relationship of this cell to the lacrimal bone readily explains the finding of epiphora in select patients with sinus disease[13]. Additionally, the Agger nasi cell can be an important factor in selected cases of frontal sinusitis. In the present study, the authors revealed significant correlation between nasofrontal duct pattern of inflammatory sinus disease ($p<0.05$).

Nasal septal deviation: Nasal septal deviation was common in the present study. The reported prevalence in the literature ranges from 18.8% (Bolger[4]) to 96.9% (Takanishi[14]) due to differing criteria for the degree and morphologic features of septal deviation. Takanishi[14] defined any arching of the nasal septum as septal deviation and yielded the prevalence of 96.9%. Whereas Calhoun[5] defined nasal septal deviation when the septum impinged on adjacent structures and yielded the prevalence of 40%. With similar definition, Earnwaker[8] yielded prevalence of 44%. In the present study, according to Som[1] again, any deformity of the nasal septum is referred to septal deviation, however, the authors recorded only curvation of the anterior portion of the septum. Calhoun[5] reported the significant relationship between septal deviation and ostiomeatal complex disease. In the present study, there was no significant correlation between nasal septal deviation and OMU pattern of inflammatory sinus disease ($p>0.05$).

Conclusion

The anatomic variations which can compromise the mucociliary drainage are frequently observed and the most common is concha bullosa. However, only a large Agger nasi cell significantly leads to nasofrontal duct pattern (pattern II) of inflammatory sinus disease. The presence of remaining anatomic variations (concha bullosa, Haller cell and paradoxical middle turbinate) as well as nasal septal deviation, does not provide a major role for inflammatory sinus disease.

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ความชุกของความหลากหลายทางกายวิภาคศาสตร์ของ paranasal sinus ที่ตรวจพบจากเอกซเรย์คอมพิวเตอร์และความสัมพันธ์ทางคลินิก

สุกัลยา เลิศล้ำ, บุษกร วชิรานุภาพ

ผลการตรวจ paranasal sinus ด้วยเครื่องเอกซเรย์คอมพิวเตอร์ของผู้ป่วย 133 ราย ระหว่างเดือนมีนาคม พ.ศ. 2546 ถึงเดือนกุมภาพันธ์ พ.ศ. 2547 ได้รับการทบทวนเกี่ยวกับความหลากหลายทางกายวิภาคศาสตร์ พบว่า concha bullosa เป็นความหลากหลายทางกายวิภาคศาสตร์ที่พบบ่อยสุด (14.3%), พบรองลงมาเป็น Haller cell (9.4%), Agger nasi cell ที่มีขนาดใหญ่ (7.9%), และ paradoxical middle turbinate (5.3%) nasal septal deviation พบในผู้ป่วย 75 ราย (56.4%) พบการอักเสบในไซนัส 181 ข้าง (68%) และ maxillary infundibular เป็นรูปแบบที่พบมากที่สุด (33.1%) มีเพียง Agger nasi cell ที่มีขนาดใหญ่ที่มีความสัมพันธ์กับไซนัสอักเสบรูปแบบ nasofrontal ($p<0.05$) สำหรับconcha bullosa, Haller cell, paradoxical middle turbinate และ nasal septal deviation ไม่พบว่ามีความสัมพันธ์กับการเกิดไซนัสอักเสบ

โดยสรุปความหลากหลายทางกายวิภาคศาสตร์ของ paranasal sinus ที่สามารถทำให้การระบายสิ่งคัดหลั่งของ paranasal sinus ไม่สะดวกนั้นพบได้บ่อย แต่เฉพาะ Agger nasi cell ที่มีขนาดใหญ่เท่านั้นที่สัมพันธ์กับการเกิดไซนัสอักเสบ