Anatomical Variations of the Lateral Nasal Wall and Paranasal Sinuses: A CT Study for Endoscopic Sinus Surgery (ESS) in Thai Patients

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Computerized tomography (CT) of the paranasal sinuses is usually required prior to endoscopic sinus surgery. CT demonstrates both the extent of disease(s) and the anatomical variations that may predispose to rhinosinusitis and nearby vital structures that iatrogenic damage can be avoided. The authors retrospectively reviewed 88 CT scans of paranasal sinuses and orbits, performed at Srinagarind Hospital between January 1995 and February 1997. Only adult patients were included. The study showed the presence of frontal sinuses in 88% of cases (95%CI 82.3-92.5%), agger nasi cells in 92% (95%CI 87-95.6%), concha bullosa in 34% (95%CI 27.1-41.6%), Haller's cell in 24% (95%CI 17.8-30.9%), Onodi cell in 25% (95%CI 19.8-32.1%), dehiscence of the internal carotid artery in 10.2% (95%CI 6.2-15.7%) and the optic canal in the sphenoid sinus in 18.2% (95%CI 12.8-24.7%). The most common olfactory fossa was type II. Haller's cell was a coincident finding not a risk factor for maxillary rhinosinusitis. Concha bullosa was a non-statistically significant, risk factor for maxillary rhinosinustis.

Keywords: *Paranasal sinuses, Radiography, Computed tomography*

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With the increased use of endoscopy for the evaluation and surgical treatment of paranasal sinus diseases, attention is now directed toward the analysis of the lateral nasal wall and paranasal sinus anatomy. Computerized tomographic imaging (CT) of the paranasal sinuses (PNS) has become a widely accepted tool for assessing the PNS and providing a detailed anatomy of the lateral nasal wall; it is considered a prerequisite to endoscopic sinus surgery (ESS)[1-6]. Reports from various countries detail the prevalence and clinical significance of the anatomical variations of the lateral nasal wall and PNS found using CT scan[5,7-10]. In Thailand, for example, ESS has become the most popular approach for rhinosinusitis and nasal polyps, but to the authors' knowledge a report on the anatomical variations of the lateral nasal wall and PNS in Thai patients has not been published.

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This CT study aimed to determine the prevalence and clinical significance of the important bony anatomical variations of the lateral nasal wall and PNS in adult Thai patients for a baseline prior to ESS, and to assess the possible role of concha bullosa and Haller's cell in maxillary rhinosinusitis/ inflammation.

Material and Method

This was a descriptive study. The authors reviewed 88 coronal and axial CT scans of the PNS and orbit performed at Srinagarind Hospital between January 1995 and February 1997. The authors then included patients over 18 whose CT scan clearly demonstrated the anatomical variations of the lateral nasal wall and PNS, and excluded cases with nose/PNS tumors, fungal rhinosinusitis, mucocele and those who had had a previous nose/PNS surgery/injury.

CT scans were performed using the bone algorithm, a 3-mm interscan interval of the coronal view

for the anterior groups of PNS, a 5-mm section of the coronal view for the posterior PNS groups, and a 5-mm section of the axial view. Each CT scan was interpreted by an otolaryngologist (ST) and a radiologist (BN). Interpretation was by consensus, but if there was no agreement, a third investigator (NS) made the decisive interpretation.

The study parameters were age, sex, clinical diagnosis and radiographic findings, which comprised the site of sinus infection, the presence of frontal sinus, agger nasi cell, the types of olfactory fossa, concha bullosa, Haller's cell, Onodi cell, and the condition of the optic nerve and internal carotid artery in the sphenoid sinus (including the presence of accessory sphenoid septum and its attachment to vital structures).

Each CT scan was analyzed separately in half-heads and the results were reported as a percentage with 95% confidence intervals (CI). The data on concha bullosa and Haller's cell were also analyzed for their contribution to maxillary rhinosinusitis by considering the odds ratio (OR).

Results

The consecutive CT scans from 88 patients (48 females), separated into 176 sides were evaluated. The age ranged between 18 and 79 years (mean, 41). The clinical diagnosis (Table 1) from the records was re-classified according to the CT findings into the PNS rhinosinusitis/inflammation group (96 sides, mean age 38) and the PNS non-rhinosinusitis/non-inflammation group (80 sides, mean age 45). The anterior ethmoid sinus was the most common site of infection/inflammation followed by the maxillary, posterior ethmoid, frontal and sphenoid sinuses (Table 2).

The absence of the frontal sinus was found in 21 sides (11.9%, 95%CI 7.5-17.7%), a unilateral absence in 9 patients (10.2%, 95%CI 4.8-18.5%) and a bilateral absence in 6 (6.8%, 95%CI 2.5-14.3%). The agger nasi (Fig. 1)cell was present in 162 sides (92%, 95%CI 87-95.6%), Haller's cell (Fig. 2) in 42 (23.9%, 95%CI 17.8-30.9%) and Onodi cell (Fig. 3) in 44 (25%, 95%CI 19.8-32.1%). The unilateral Haller's cell was found in 16 patients (18.2%, 95%CI 10.8-27.8%) and bilateral Haller's cell in 13 (14.8%, 95%CI 8.1-23.9%). The Onodi cell was found on only one side in 12 patients (13.6%, 95%CI 7.2-22.6%) and bilaterally in 16 (18.2%, 95%CI 10.8-27.8%). No significant association between Haller's cell and maxillary rhinosinusitis/inflammation was found (OR = 0.52 (95%OR 0.22-1.17)) (Table 3).

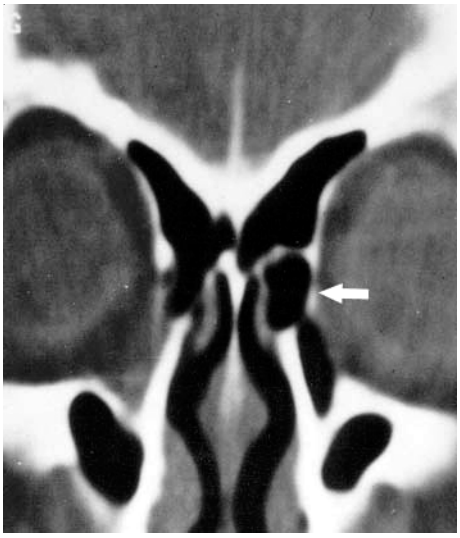

Fig. 1 CT paranasal sinus (CT PNS), coronal scan reveals agger nasi ,left side (white arrow)

Table 1. Clinical diagnosis of the patients

Clinical Diagnosis	Number of patients (cases)	Percentage
Rhinosinusitis	38	43.2
Nasal polyps	2	2.3
Chronic rhinitis	14	15.9
Orbital pathology	21	23.9
Others (headache, anosmia)	13	14.8
Total	88	100.0

Table 2. Sites of paranasal sinus inflammation (n = 176 sides)

Site of inflammation	Number (sides)	Percentage (95%CI) in total sides (n = 176)	Percentage (95%CI) in 96 sides (n = 96) (in those with PNS rhinosinusitis/inflammation)
Anterior ethmoid sinus	76	43.2 (35.8-50.8)	79.2 (69.7-86.8)
Maxillary sinus	70	39.8 (32.5-47.4)	72.9 (62.9-81.5)
Posterior ethmoid sinus	53	30.1 (23.4-37.5)	55.2 (44.7-65.4)
Frontal sinus	32	18.2 (12.8-24.7)	33.3 (24.0-43.7)
Sphenoid sinus	29	16.5 (11.3-22.8)	30.2 (21.3-40.4)
Total	260		

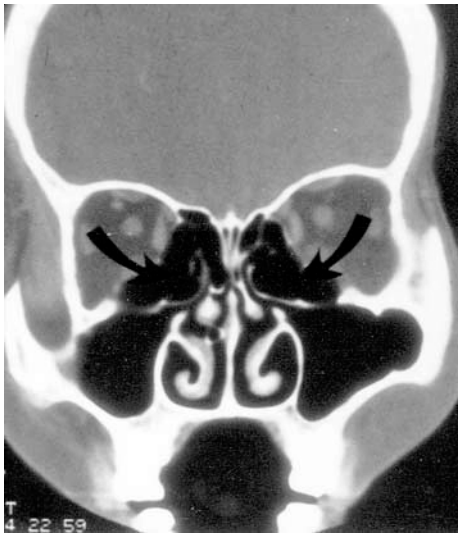

Fig. 2 CT PNS shows bilateral Haller cells (arrows)

Fig. 3 CT PNS presents Onodi cell (arrow)

Pneumatization of middle turbinate (MT) or concha bullosa (CB) (Fig. 4) was detected in 60 sides (34.1%, 95%CI 27.1-41.6%). The pneumatization of only the vertical lamella of the middle turbinate (lamellar type) was the most common type followed by true concha bullosa (extensive pneumatization of the entire middle turbinate) and the bulbous type (inferior bulbous portion of the middle turbinate), respectively (Table 4). Twenty-seven patients (30.7%, 95%CI 21.3-41.4%) had concha bullosa on only one side and 17 bilaterally (19.3%, 95%CI 11.7-29.1%). The association between concha bullosa and maxillary rhinosinusitis/inflammation was neither statistically nor clinically significant, OR = 1.01 (95%OR 0.51-2) (Table 5).

According Keros' classification (Table 6), olfactory fossa depth type II was most common followed by type III and type I, respectively. Most of the olfactory fossa were of the same type bilaterally. An asymmetrical depth of olfactory fossa was found in 27 patients (30.7%, 96%CI 21.3- 41.4%).

The bulging of the internal carotid artery into the sphenoid sinus was found in 57 sides (32.4%, 95%CI 25.5-39.8), unilateral in 15 patients (17%, 95%CI 9.9-26.6) and bilateral in 21 (24%, 95%CI 15.4-34.1%). The clinically bony dehiscence of its wall was found

Table 3. Relationship between Haller's cell and maxillary rhinosinusitis/inflammation

Haller's cell	Rhinosinusitis/ inflammation (sides)	Non-rhinosinusitis/ non-inflammation (sides)	Total
Presence	12	30	42
Absence	58	76	134
Total	70	106	176

Table 4. Pattern of middle turbinate pneumatization (n = 176)

Pattern of concha bullosa	Number	Percentage (95%CI)
No pneumatization	116	65.9 (58.4-72.9)
Lamellar type	34	19.3 (13.8-25.9)
True concha bullosa	22	12.5 (0.8-18.3)
Bulbous type	4	2.3 (0.6-5.7)
Total	176	100.0

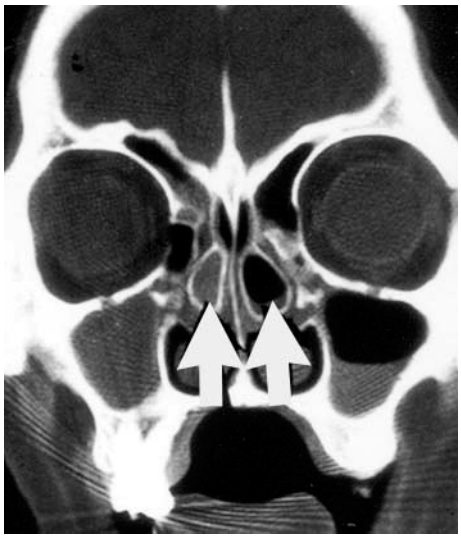

Fig. 4 CT PNS discloses bilateral concha bullosa (arrows)

Table 5. The association between maxillary rhinosinusitis/ inflammation and concha bullosa

Concha Bullosa	Rhinosinusitis/ inflammation (sides)	Non-rhinosinusitis/ non-inflammation (sides)	Total
Presence	24	36	60
Absence	46	70	116
Total	70	106	176

Table 6. Types of olfactory fossa

Types of olfactory fossa	Number (sides)	Percentage (95%CI)
Type I (1-3 mm in depth)	21	11.9 (7.5-17.7)
Type II (4-7 mm in depth)	121	68.8 (61.3-75.5)
Type III (≥ 8 mm in depth)	34	19.3 (13.8-25.9)
Total	176	100.0

in 18 sides (10.2%, 95%CI 6.2-15.7), unilateral in 4 patients (4.5%, 95%CI 1.3-11.2%) and bilateral in 7 (7.9%, 3.3-15.7%). The optic canals ran through the superior aspect of the sphenoid cavity or had the clinical bony dehiscence of the optic canal in 32 sides (18.2%, 95%CI 12.8-24.7), unilateral in 6 patients (6.8%, 95%CI 2.5-14.3%) and bilateral in 13 (14.8%, 95%CI 8.1-23.9%).

The sphenoid sinus possessed only one true intersphenoidal septum in 42 cases (47.7%, 95%CI 36.9-58.6%), while the rest had an additional accessory septa. These septa were found to adhere to the internal carotid artery in 24 sides (13.6%, 95%CI 8.9-19.6%) or the optic nerve in 7 (14%, 95%CI 1.6-8%).

Discussion

This CT study in adult Thai patients who attended Srinagarind Hospital, Faculty of Medicine, Khon Kaen University, demonstrated the prevalence of anatomical variations of the lateral nasal wall, variations of PNS, sites of sinus infection/inflammation and conditions of the optic canal and the internal carotid artery vis- -vis the PNS.

In the present study and those of Bolger et al[6], Calhoun et al[7] and Kennedy et al,[11] the most common site of sinus infection/inflammation was the anterior ethmoid sinus. However Clement et al[12] and Lloyd et al[13] had a different finding (Table 7)[6,7,12,13]. The difference is perhaps an artifact of selection criteria. The patients included in the present study were those with or without nasal symptoms (compare Bolger et al[6] and Calhoun et al[7]) unlike the other studies that included CT PNS from only those patients with clinical or endoscopic signs of sinusitis or chronic nasal complaints[11-13].

The agger nasi cell, the most anterior extramural ethmoid cells, is located in the most anterosuperior aspect of the middle meatus, below the frontal sinus. Using coronal CT scan, this cell was detected in 92.1% comparable to Bolger et al 89% and Earwaker 96%[6,14]. The degree of pneumatization of the agger nasi cells may impede the drainage of the frontal sinus. This means that in treatment of a frontal sinusitis by functional endoscopic sinus surgery (FESS), the surgeon may have to remove this cell in order to create adequate drainage of the frontal sinus.

The most common type of olfactory fossa in the present study was type II (68.8%) followed by type III (19.3%) and type I (11.9%). The prevalence of each type of olfactory fossa was comparable to Keros' study[15].

The concha bullosa, an air cell within the middle turbinate, is usually an extension of the anterior ethmoid air cell[9]. The reported prevalence by gross anatomical study varied between 8 and 20%[16-18]; however, the prevalence by CT proved greater. In the present study the prevalence of concha bullosa, irrespective of the type, was 34.1% and the types of concha bullosa were comparable to the study by Earwaker[14]. The presence of concha bullosa may contribute to chronic or recurrent rhinosinusitis by compromising normal sinus drainage[2,7]. The

Table 7. Sites of sinus of inflammation/infection expressed in percentage

Sinus of infection/ inflammation	Kennedy et al[11]	Clement et al[12]	Lloyd et al[13]	Bolger et al[6]	Calhoun et al[7]	The present study
Anterior ethmoid sinus	78	35	63	78.2	84.3	79.2
Maxillary sinus	66	73	83	68.8	77.7	72.9
Frontal	34	19	57	30.5	38.6	33.3
Posterior ethmoid	31	13	60	32.2	36.6	55.2
Sphenoid sinus	16	13	49	22.3	25.4	30.2

present study demonstrated that the association between the presence of concha bullosa and maxillary rhinosinusitis was not statistically or clinically significant.

In the present study, the prevalence of Haller's cell, an ethmoidal air cell located beneath the floor of the orbit, was 23.8% (comparable to Earwaker)[14]. Stackpole et al[19] demonstrated a significant increase in maxillary sinus mucosal disease in patients with medium or large Haller's cells (45.8%) vs. those with small cells (28.9%) ($p < 0.05$). The present study, however, confirmed no such association. However, the present study did not take the size of Haller's cell into account. The relationships between the optic nerve and the internal carotid artery with posterior PNS, the posterior ethmoid and the sphenoid sinuses, is crucial information for the endoscopic sinus surgeon because these vital structures may be vulnerable and therefore get damaged during surgery leading to serious iatrogenic complications even death. The Onodi cell, the posterior-most ethmoid air cell into which the optic canal bulges into, was found in 25% of the total sides in the present study. This finding was much higher than other CT studies by DeLano et al[20], Driben et al[21] and Weinberger et al[22] where prevalence was between 3-7 percent. Compared with the endoscopic anatomical study by Thanaviratananich et al [23], the prevalence by CT study was much lower, 25% vs 60%. The study of Onodi cell by CT study was less sensitive than anatomical studies[21,22].

In the present study, the optic canal was found to traverse, or had bony dehiscence, the sphenoid sinuses in 18.2% of cases. The endoscopic sinus surgeon should take this high prevalence into account during surgery. Delano et al[20] demonstrated that the optic canal ran through the sphenoid sinus in 6% and there were bone dehiscences over the optic nerve in 24% of cases. The prevalence of bulging of the internal carotid artery into the sphenoid sinus and bony dehiscence were quite high, 32.4 and 10.2 percent of cases, respectively.

Conclusions

This CT study in adult Thai patients demonstrated the prevalence of anatomical variations of the lateral nasal wall, PNS, the condition of the optic canal and the sphenoid sinuses, all of which Thai endoscopic sinus surgeons should be aware of during operations. These variations might not be the same as the CT studies done among Western populations.

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ความแปรปรวนของผนังด้านข้างจมูกและโพรงอากาศข้างจมูก: การศึกษา ทางภาพรังสี คอมพิวเตอร์ สำหรับการผ่าตัดไซนัสด้วยการใช้กล้องในผู้ป่วยคนไทย

เบญจพร นิตินาวาการ, สงวนศักดิ์ ธนาวิรัตนานิจ, นิลุมล สง่าศิลป์

ก่อนรักษาผู้ป่วยด้วยการส่องกล้องผ่าตัดโพรงอากาศข้างจมูกมีความจำเป็นต้องตรวจผู้ป่วยด้วยการทำเอกซเรย์คอมพิวเตอร์ ภาพที่ได้จากกการตรวจเอกซเรย์คอมพิวเตอร์นั้น จะบอกขอบเขตของโรค และแสดงถึงความแปรปรวนของกายวิภาคที่ส่งเสริมให้เกิดไซนัสอักเสบ และอวัยวะข้างเคียงที่สำคัญ เพื่อแพทย์ผู้ผ่าตัดจะได้ระมัดระวัง และหลีกเลี่ยงผลแทรกซ้อนที่อาจจะเกิดขึ้นจากการผ่าตัด ผู้วิจัยได้ทำการศึกษาย้อนหลัง ภาพถ่ายรังสีคอมพิวเตอร์ของไซนัสในผู้ป่วยผู้ใหญ่จำนวน 88 คนที่มารับการรักษาในโรงพยาบาลศรีนครินทร์ ระหว่างเดือนมกราคม พ.ศ. 2538 และเดือนกุมภาพันธ์ พ.ศ. 2540 ผลของการศึกษาพบว่ามีไซนัสฟรอนทัลร้อยละ 88 (ค่าความเชื่อมั่นที่ร้อยละ 95, 82.3-92.5), agger nasi cell ร้อยละ 92 (ค่าความเชื่อมั่นที่ร้อยละ 95, 87-95.6), concha bullosa ร้อยละ 34 (ค่าความเชื่อมั่นที่ร้อยละ 95, 27.1-41.6), Haller's cell ร้อยละ 24 (ค่าความเชื่อมั่นที่ร้อยละ 95, 17.8-30.9), Onodi cell ร้อยละ 25 (ค่าความเชื่อมั่นที่ร้อยละ 95, 19.8-32.1), ไม่มีกระดูก ที่หุ้มหลอดเลือดแดง อินเทอร์นัลคาโรติด บางส่วนในบริเวณไซนัสสฟีนอยด์ร้อยละ10.2 (ค่าความเชื่อมั่นที่ร้อยละ 95, 6.2-15.7), ไม่มีกระดูก ที่หุ้มท่อเส้นประสาทตา (optic canal) บางส่วนในบริเวณไซนัสสฟีนอยด์ร้อยละ 18.2 (ค่าความเชื่อมั่นที่ร้อยละ 95 ค่าความเชื่อมั่นที่ร้อยละ 95, 12.8-24.7), ความลึกของ olfactory fossa พบว่าส่วนมากเป็นชนิดที่ 2 พบว่า Haller's cell หรือ concha bullosa ไม่มีสัมพันธ์หรือ เสี่ยงต่อการเกิด การอักเสบของไซนัสแมกซิลลารี (maxillary rhinosinusitis)