Anatomic variations of the paranasal sinus area in pediatric chronic rhinosinusitis with nasal polyps

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Abstract

Abstract objectives: We aimed to report the prevalence of anatomic variations in Chinese pediatric patients with chronic rhinosinusitis with nasal polyps (CRSwNP) and to explore the correlation between anatomic variations and the extent of chronic sinusitis in children. Design: This retrospective study conducted between January 2018 and June 2020. Setting:This study involved children from the First Affiliated Hospital, Sun Yat-sen University and Guangzhou Women and Children's Medical Center. Participants: Participants included 50 children with CRSwNP. Main outcome measures: The diagnosis of CRSwNP was based on symptoms, endoscopy, and computed tomography examination according to European criteria on chronic rhinosinusitis. The presence of anatomical variations was determined, and its correlation with disease extension was analyzed. Results: Fifty children were included in the study. The anterior ethmoid sinus was the most commonly affected sinus in children, followed by the maxillary, posterior ethmoid, frontal, and sphenoid sinuses. Agger nasi cells were the most common anatomic variation in children sinus (96%), followed by inferior turbinate hypertrophy (60%), septal deviation (55.1%), concha bullosa (45.8%), Onodi cells (44.9%), Haller cells (38%), and paradoxical middle turbinate (4%). No significant correlation was found between anatomic variation and corresponding sinusitis hypertrophy and maxillary sinusitis ($P > 0.05$). Conclusions: Our results found no correlation between anatomic variations and sinusitis in pediatric CRSwNP. The occurrence of pediatric CRSwNP is as attributed more to immunological, infectious, or other factors rather than anatomic variations.

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hypertrophy (60%), septal deviation (55.1%), concha bullosa (45.8%), Onodi cells (44.9%), Haller cells (38%), and paradoxical middle turbinate (4%). No significant correlation was found between anatomic variation and corresponding sinusitis hypertrophy and maxillary sinusitis ($P > 0.05$).

Conclusions: Our results found no correlation between anatomic variations and sinusitis in pediatric CRSwNP. The occurrence of pediatric CRSwNP is as attributed more to immunological, infectious, or other factors rather than anatomic variations.

Keywords: Anatomic variations, Pediatric, Chronic rhinosinusitis with nasal polyps (CRSwNP), Computed tomography (CT)

Key points

- We found that the prevalence of anatomical variations in CRS children was far lower than that of our CRSwNP children by searching previous studies.
- The number of cases was small due to the very low prevalence of pediatric CRSwNP.
- Our results found no correlation between anatomic variations and sinusitis in pediatric CRSwNP.
- The occurrence of pediatric CRSwNP was largely attributed to immunological, infection, or other factors rather than anatomic variations

Data availability statement: All data relevant to the study are included in the article. All data are available upon reasonable request.

Introduction

Chronic rhinosinusitis (CRS) is a common health problem, affecting 5-12% of the whole population. It is often classified as chronic rhinosinusitis with nasal polyps (CRSwNP) and without nasal polyps (CRSsNP). CRSwNP is commonly found after the age of 20, with a prevalence of 2.7%. In the pediatric population, only 0.1% of the population was reported as CRSwNP despite that this number increases 40% in children with CF(Cystic fibrosis).[1,2,3,4]

The development of CRSwNP is often attributed to anatomic variation, viral or bacterial infection, and allergy. Agger nasi cells, Haller cells, paradoxical middle turbinate, and concha bullosa of the middle turbinate are common anatomic variations that may lead to rhinostenosis, increasing the risk of the development of CRS. [5,6,7] On the contrary, some studies have suggested that the presence of anatomic variations does not predispose individuals to CRS.

For the pediatric population, the study by Kim et al. showed a higher prevalence of anatomical variations in the pediatric CRS group than in the control group.[8] Contrary to Kim's study, Lusk reported that there was no relationship between CRS and anatomic variations.[9] As for pediatric CRSwNP, no studies have explored the correlation between nasal polyps and anatomical variations due to its low prevalence.

In this study, we aimed to report the prevalence of common anatomic variations in Chinese pediatric patients with CRSwNP and to analyze the relationship between anatomic variations and the extent of chronic sinusitis with nasal polyps in children.

Methods

Patient and public involvement

This was a retrospective study, which enrolled 50 children with CRSwNP who consecutively underwent functional endoscopic sinus surgery in A hospital, and B hospital from January 2018 to June 2020. The study approved by the local Ethics Committee ([2016]096) without patient consent for publication.We followed the RECORD-PE guidelines for collecting the data. The Children who had consistent symptoms (> 3 months), such as purulent nasal discharges, coughs, headaches, and stuffy noses, even after maximum conservative treatment, including medication and nasal irrigation, were diagnosed with chronic sinusitis with nasal polyps based on a European position paper on chronic rhinosinusitis 2020. All patients received 3-4 courses antibiotic therapy, and nasal steroids spray prior to function endoscopic sinus surgery (FESS).

All CT scans were performed using the Philips Brilliance IDT 64 slice or iCT 256 slice scanner (Brilliance 64, Philips Healthcare, Cleveland, OH, USA) and stored using a picture archiving and communication system (Carestream PACS, Carestream Health, Inc. Rochester, NY, USA). Sinus CTs were reviewed by an investigator masked to the patients' clinical condition. The presence of sinusitis (right and left frontal, ethmoid, maxillary, and sphenoid) and anatomic variations: deviated nasal septum, concha bullosa, Kuhn (frontoethmoidal), Haller (infraorbital), and Onodi (sphenoethmoidal) cells were evaluated according to the European Position Paper on the Anatomical Terminology of the nasal cavity by two senior otolaryngologists.

The Chi-square test and Pearson correlation coefficient were used for the statistical analysis. A P- value < 0.05 was accepted as statistically significant.

Results

Study subjects

Fifty children (aged 12.2 $\pm$ 3.0 years) were included in the study. Table 1 summarizes the demographic characteristics of the enrolled children. In total, 38 cases of NP (76%) were located in the middle meatus, 11 cases of NP (22%) were located in the maxillary sinus, and one NP (2%) was located in the sphenoid sinus.

Incidence of sinusitis in CRSwNP according to location

The anterior ethmoid sinus was most commonly involved in the sinus, followed by the maxillary (Fig. 1a), ethmoid (Fig. 1b,c), frontal (Fig. 1d), and sphenoid sinuses (Fig. 1e) (Table 2). We also found that most sinusitis occurred bilaterally (Table 2).

Incidence of anatomic variations in CRSwNP

Agger nasi cells (Fig. 2a) were the most common anatomic variation (96%), followed by inferior turbinate hypertrophy (60%) (Fig. 2b), septal deviation (55.1%) (Fig. 2c), concha bullosa (45.8%) (Fig. 2d), Onodi cells (44.9%) (Fig. 2e), Haller cells (38%) (Fig. 2f), and paradoxical middle turbinate (4%) (Fig. 2g) (Table 2). All patients had at least one type of anatomic variation. When the patients were divided into 6- 12 and 13-18 age groups, we found that the incidence of septal deviation and concha bullosa was significantly higher in the 13-18 age group, whereas other anatomic variations had no difference according to age.

Correlation between the occurrence of sinusitis and anatomic variations

No significant correlation was found between agger nasi cells and frontal sinusitis ($P > 0.05$) (Table 3). No significant correlation was found between maxillary sinusitis and Haller cell ($P > 0.05$) (Table 4). No significant correlation was found between maxillary sinusitis and concha bullosa ($P > 0.05$) (Table 4). No significant correlation was found between inferior turbinate hypertrophy and maxillary sinusitis ($P > 0.05$) (Table 4).

Discussion

CRSwNP is known to have a great impact on pediatric patients and often needs surgical intervention. The knowledge of anatomic variations has great significance in the treatment of CRSwNP. However, most previous studies concentrated on pediatric CRS due to the very low prevalence of CRSwNP.

For pediatric CRS, the prevalence of involved sinus has been inconsistent. The incidence of maxillary sinusitis ranged from 51-89%; anterior ethmoid sinusitis, from 15-85%; posterior ethmoid sinusitis, from 16-57%; frontal sinusitis, from 2-63%; and sphenoid sinusitis, from 13-37%.[10,11,12] Most studies suggested that the maxillary sinus was the most commonly involved sinus in pediatric CRS.[10] In our study, the incidence of sinusitis was significantly higher compared with previous data on CRS reported by Mohannad, [13,] implying that CRSwNP was the one disease entity with more severe inflammation compared with CRS.

The frequencies of anatomical variations in CRS varied in different studies. Al-Qudah[13] and Kim[14]reported that the Agger nasi cell was the most common anatomical variation,[13,14] followed by septal deviation, Haller cell, concha bullosa, paradoxical middle turbinate, and Onodi cell. In van der Veken's study[15], anatomic

variations in 196 CRS children were determined as concha bullosa in 8%, Haller's cell in 3%, and septal deformity in 46% of the children. The study by April et al.[16] found that the incidence of anatomic variations in CRS children was 19% of the concha, 18% of Haller's cell, 13% of septal deformity, 7% of the paradoxical middle turbinate. The study by Balak et al. [17] found concha bullosa in 28%, septal deviation in 23%, over pneumatized ethmoidal bulla in 17%, Haller's cell in 14%, paradoxical middle turbinate in 9%, and uncinate process variations in 9% of CRS children. In our study, Agger nasi cells were found in 96% of cases, followed by inferior turbinate hypertrophy, septal deviation, concha bullosa, Onodi cells, Haller cells, and paradoxical middle turbinate, which was significantly higher compared with previous data on pediatric CRS.

When the population was divided into 6-12 and 13-18 age groups, we found that septal deviation and concha bullosa were more common in the older children group. Previous studies also showed that the prevalence of septal deviation and Concha bullosa increased with age.

Despite the high prevalence of anatomic variations in CRSwNP, we found no correlation between anatomic variation and the corresponding onset of sinusitis. Consistently, Al-Qudah[13] and Kim[14] showed no correlation between rhinosinusitis and anatomical variations in pediatric chronic rhinosinusitis.

Our study had the following limitations. First, the number of cases was small due to the very low prevalence of pediatric CRSwNP. Second, the lack of CRS and normal control weakened our conclusion. However, we found that the prevalence of anatomical variations in CRS children was far lower than that of our CRSwNP children by searching previous studies. Third, the direct correlation between NP and anatomical variations needs further exploration.

Thus, our results found no correlation between anatomic variations and sinusitis in pediatric CRSwNP. The occurrence of pediatric CRSwNP was largely attributed to immunological, infection, or other factors rather than anatomic variations. Therefore, surgery for pediatric CRSwNP should concentrate on the removal of the polyp and pathological tissue. The removal of anatomic variations should be avoided to reduce the possibility of abnormal facial bony growth.

References

1. Settipane GA. Epidemiology of nasal polyps. Allergy Asthma Proc. 1996;17(5):231-236.

2. Weber SA, Ferrari GF. Incidence and evolution of nasal polyps in children and adolescents with cystic fibrosis. Braz J Otorhinolaryngol. 2008;74(1):16-20.

3. Cuyle JP. Follow up of endoscopic sinus surgery on children with cystic fibrosis. Arch Otolaryngol Head Neck Surg. 1992;118(5):505-506.

4. Bolt RJ, de Vries N, Middelweerd RJ. Endoscopic sinus surgery for nasal polyps in children: results. Rhinology. 1995;33(3):148-151.

5. HamilosDL. Pediatric chronic rhinosinusitis. Am J Rhinol Allergy 2015;29(6):414–20. https://doi.org/10.2500/ajra.2015.29.4238.

6. Kabaalioglu N, Uygur K, Yasan H, Kabaalioglu A, Dogru H. The correlation between computed tomography findings of the paranasal sinuses and the symptoms of acute sinusitis. Kulak Burun Bogaz Ihtis Derg. 2003;11(2):39–45.

7. Jones NS, Strobl A, Holland I. A study of the CT findings in 100 patients with rhinosinusitis and 100 controls. Clin Otolaryngol Allied Sci. 1997;22(1):47–51.

8. Kim HJ, Friedman EM, Sulek M, Duncan NO, McCluggage C. Paranasal sinus developmentin chronic sinusitis, cystic fibrosis, and normal comparison population: a computerized tomography correlation study. Am J Rhinol 1997; / 11: / 275?81.

9. Lusk RP, McAlister B, Fouley A. Anatomic variation in pediatric chronic sinusitis. Otolaryngol Clin North Am 1996; / 29: / 75?91.

10. April MM, Zinreich SJ, Baroody FM, Naclerio RM. Coronal CT scan abnormalities in children with chronic sinusitis. Laryngoscope 1993; / 103: / 985?90.

11. Sivasli E, Sirikci A, Bayazyt YA, Erbagci H, Bayram M. Anatomic variations of the paranasal sinus area in pediatric patients with chronic sinusitis. Surg Radiol Anat 2002; / 24: / 400?5.

12. Willner A, Choi SS, Vezina LG, Lazar RH. Intranasal anatomic variations in pediatric sinusitis. Am J Rhinol 1997; / 11: / 355?60.

13. Al-QudahM.The relationship between anatomical variations of the sino-nasal region and chronic sinusitis extension in children. Int J Pediatr Otorhinolaryngol. 2008;72(6):817–21.

14. Kim HJ, JungCho M, Lee JW, Tae Kim Y, Kahng H, Sung Kim H,

et al. The relationship between anatomic variations of paranasal sinuses and chronic sinusitis in children. Acta Otolaryngol. 2006;126(10):1067–72.

15. van der Veken PJ, Clement PA, Buisseret T, Desprechins B, Kaufman L, Derde MP. CT-scan study of the incidence of sinus involvement and nasal anatomic variations in 196 children. Rhinology 1990;28:177-84.

16. April MM, Zinreich SJ, Baroody FM, Naclerio RM. Coronal CT scan abnormalities in children with chronic sinusitis. Laryngoscope 1993;103:985-90.

17. Baflak S, Karaman CZ, Metin KK, Kunt T. Anatomical differences of paranasal sinuses in children with chronic sinusitis. Turkish Arch Otolaryngol 1998; 36:116-21.

18 van der Veken PJ, Clement PA, Buisseret T, Desprechins B, Kaufman L, Derde MP. CT-scan study of the incidence of sinus involvement and nasal anatomic variations in 196 children. Rhinology 1990; / 28: / 177?84

Tables 1 Demographic and clinical data of children with CRSwNP

Characteristics
Sex ratio (male:female)
Age (year)
Times of FESS
1 2 3 4
Smoking history
Allergic rhinitis
Asthma Blood eosinophils percent (%) Blood eosinophils count Symptom score CT score Sides of NP Unilateral Bilateral

The data was presented with mean±standard error.

CRSwNP, chronic rhinosinusitis with nasal polyps

FESS, Functional endoscopic sinus surgery

Table 2 Incidence of sinusitis in CRSwNP according to location and Incidence of anatomic variations in CRSwNP

Sinusitis	Sinusitis	Left	Left	Left	Right	Bilateral	Total	T
Maxillary	Maxillary	6(12%)	6(12%)	6(12%)	6(12%)	37(74%)	49(98%)	4
Anterior ethmoid	Anterior ethmoid	3(6%)	3(6%)	3(6%)	4(8%)	43(86%)	50(100%)	5
Posterior ethmoid	Posterior ethmoid	3(6%)	3(6%)	3(6%)	5(10%)	38(76%)	46(92%)	4
Sphenoid	Sphenoid	5(10%)	5(10%)	5(10%)	3(6%)	26(52%)	34(68%)	3
Frontal	Frontal	2(4%)	2(4%)	2(4%)	6(12%)	31(62%)	39(78%)	3

Sinusitis	Sinusitis	Left	Left	Left	Right	Bilateral	Total	T
Variations	Variations	Right	Left	Left	Bilateral	Total	Total	T
Agger nasi cell	Agger nasi cell	2(4.00%)	1(2.00%)	1(2.00%)	45(90.00%)	48(96.00%)	48(96.00%)	4
Septal deviation	Septal deviation	0(0.00%)	27(55.10%)	27(55.10%)	0(0.00%)	27(55.10%)		
Haller cell	Haller cell	6(12.00%)	7(14.00%)	7(14.00%)	6(12.00%)	19(38.00%)	19(38.00%)	1
Concha bullosa	Concha bullosa	2(4.17%)	5(10.42%)	5(10.42%)	15(31.25%)	22(45.83%)	22(45.83%)	2
Inferior TH	Inferior TH	6(12.00%)	11(22.00%)	11(22.00%)	13(26.00%)	30(60.00%)	30(60.00%)	3
Paradoxical MT	Paradoxical MT	0(0.00%)	1(2.00%)	1(2.00%)	1(2.00%)	2(4.00%)	2(4.00%)	2
Onodi cell	Onodi cell	0(0.00%)	22(44.90%)	22(44.90%)	0(0.00%)	22(44.90%)	22(44.90%)	2

TH, Turbinate Hypertrophy. MT, Middle Turbinate.

Table 3 Relationship between agger nasi cells and frontal sinusitis

	Right agger nasi cell	Right agger nasi cell	
Right frontal sinusitis	Absent	Present	Total
Absent	1(2%)	12(24%)	13(26%)
Present	2(4%)	35(70%)	37(74%)
Total	3(6%)	47(94%)	50(100%)
	Left agger nasi cell	Left agger nasi cell	
Left frontal sinusitis	Absent	Present	Total
Absent	1(2%)	16(32%)	17(34%)
Present	3(6%)	30(60%)	33(66%)
Total	4(8%)	46(92%)	50(100%)

Table 4 Relationship among Haller cell,concha bullosa, inferior turbinate hypertrophy and maxillary sinusitis

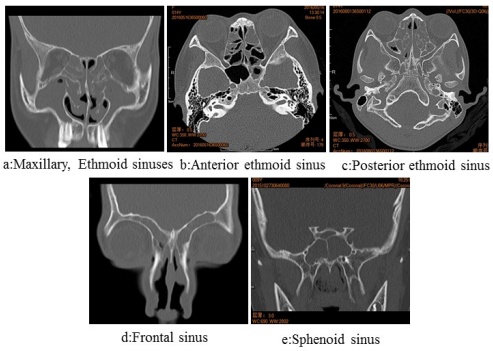
		Right Haller cell	Right Haller cell	Right Haller cell
Right maxillary sinusitis	Right maxillary sinusitis	Absent	Absent	Present
Absent	Absent	7(14%)	7(14%)	0(0%)
Present	Present	31(62%)	31(62%)	12(24%)
Total	Total	38(76%)	38(76%)	12(24%)
		Left Haller cell	Left Haller cell	Left Haller cell
Left maxillary sinusitis	Left maxillary sinusitis	Absent	Absent	Present
Absent	Absent	6(12%)	6(12%)	1(2%)
Present	Present	31(62%)	31(62%)	12(24%)
Total	Total	37(74%)	37(74%)	13(26%)
	Right concha bullosa	Right concha bullosa	Right concha bullosa	Right concha bullosa
Right maxillary sinusitis	Absent	Absent	Present	Present
Absent	3(6%)	3(6%)	4(8%)	4(8%)
Present	30(60%)	30(60%)	13(26%)	13(26%)
Total	33(66%)	33(66%)	17(34%)	17(34%)
	Left concha bullosa	Left concha bullosa	Left concha bullosa	Left concha bullosa
Left maxillary sinusitis	Absent	Absent	Present	Present
Absent	4(8%)	4(8%)	3(6%)	3(6%)
Present	26(52%)	26(52%)	17(34%)	17(34%)
Total	30(60%)	30(60%)	20(40%)	20(40%)

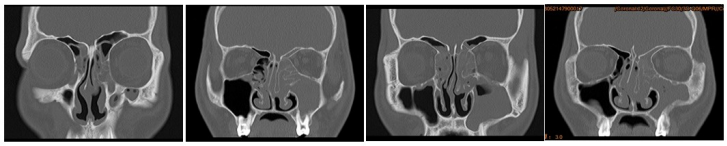
	Right inferior turbinate hypertrophy	Right inferior turbinate hypertrophy	Right inferior turb
Right maxillary sinusitis	Absent	Present	Total
Absent	4(8%)	3(6%)	7(14%)
Present	27(54%)	16(32%)	43(86%)
Total	31(62%)	19(38%)	50(100%)
	Left inferior turbinate hypertrophy	Left inferior turbinate hypertrophy	Left inferior turbi
Left maxillary sinusitis	Absent	Present	Total
Absent	2(4%)	5(10%)	7(14%)
Present	24(48%)	19(38%)	43(86%)
Total	26(52%)	24(48%)	50(100%)

Figure legend:

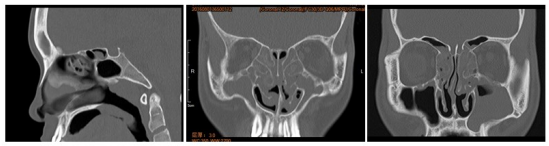
Fig.1. The sinusitis occurs in maxillary, anterior, posterior ethmoid, frontal and sphenoid sinuses: a: maxillary, ethemoid sinuses; b: anterior ethmoid sinuses; c: posterior ethmoid sinuses; d: frontal sinus; e: sphenoid sinues

Fig.2. Anatomic variations in pediatric chronic rhinosinusitis:a: agger nasi cells; b: bilateral inferior turbinate hypertrophy; c: septal deviation>3mm; d: concha bullosa ; e: Onodi cells; f: Haller cells ; g: paradoxical middle turbinate





a:Agger nasi cell b:Inferior turbinate hypertrophy c:Septal deviation d:Concha bullosa



e:Onodi cell f:Haller cell g:Paradoxical middle turbinate