Prevalence of paranasal sinusitis in adults and its characteristics in smokers

tian yuxin[1], zhou huiqun[1], wang jingjing[1], fan liqiang[1], xue wenyue[1], liu yaoqian[1], li yongdong[1], yu dongzhen[1], zhengnong Chen[1], and yin shankai[1]

[1]Shanghai Jiao Tong University

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Abstract

Background: Paranasal sinusitis is frequently encountered in clinical practice. The application of imaging techniques has highlighted the high incidence of incidental sinus abnormalities. Additionally, the adverse impact of smoking on paranasal sinusitis has been verified; however, few studies have compared the characteristics of affected sinuses between non-smokers and smokers. This study aimed to assess the prevalence of paranasal sinusitis detected by magnetic resonance imaging (MRI) and determine its characteristics and affected sinuses in smokers. Methods: This cross-sectional study involved 4813 participants from two communities in Shanghai, China. Demographic data were recorded, and participants underwent a physical examination and head MRI. Logistic regression analysis was used to examine the relationship between smoking and paranasal sinusitis and the Cochran–Armitage test to analyze age-specific prevalence of paranasal sinusitis in smokers versus non-smokers. Results: Among the 4813 participants (2368 men, 2445 women; mean age, 53.0±10.1 years), the prevalence of paranasal sinusitis was 15.4 %, being higher in men (20.1 %) than in women (10.8 %; $p<0.001$). Paranasal sinusitis was significantly associated with smoking (adjusted OR=1.37, 95 % CI=1.10–1.70), and in smokers, it occurred most often in the maxillary sinus (19.1 %), followed by ethmoid (2.9 %), frontal (2.2 %), and sphenoid (1.8 %) sinuses. Conclusion: The prevalence of paranasal sinusitis was 15.4 % in Chinese adults aged 35–75 years. This gradually increased with age, reaching a peak at 55 years and stabilizing thereafter. In smokers, sinusitis occurred more often in the anterior nasal sinuses. (Clinical Trials. gov number: NCT00926172)

Introduction

Paranasal sinusitis refers to inflammation of the paranasal sinuses as a result of either infectious or noninfectious causes, and it is frequently encountered in clinical practice. Although paranasal sinusitis is not a life-threatening disease, it can have a substantial impact on health-related quality of life[1] and, concurrently, increase the personal and social economic burden due to the relatively high cost of treatment[2, 3].

On the one hand, according to previous studies, the prevalence and patterns of sinusitis may vary by region and population and may change with the course of time [4-7]. However, these studies diagnosed chronic rhinosinusitis (CRS) based on standardized surveys that may have introduced subjective bias to the results. Additionally, individuals with asymptomatic sinusitis are likely to be overlooked in such studies. On the other hand, many population-based studies have determined smoking to be an important independent risk factor for the development of CRS [8-10]. A recent study investigating 37 753 people in Korea found that, for every year of active smoking, the prevalence of self-reported CRS increases by 1.5 %[10]. However, few studies have compared the epidemiological and clinical characteristics of sinusitis between smokers and non-smokers. In addition, because smoking may cause symptoms that are similar to those of sinusitis, studying the relationship between smoking and sinusitis from the perspective of symptoms alone is challenging.

Meanwhile, with the application of imaging techniques, the high incidence of incidental findings of sinus abnormalities across all age groups has attracted attention [11-13]. A recent report described a case of asymptomatic sinusitis with a potential glomerulonephritis-related origin [14]. Previous studies have confirmed that imaging findings are significantly related to symptoms presented in patients with paranasal sinusitis[15-17]. Compared to computed tomography (CT), magnetic resonance imaging (MRI) does not use radiation and, additionally, does not overstage or overclassify patients with sinus disease[18]. Therefore, the clinical application of MRI could provide an ideal method for the objective detection of paranasal sinusitis in the general population.

We conducted a cross-sectional survey among individuals from two communities in Shanghai, China. This study aimed to provide objective and reliable data on the prevalence of paranasal sinusitis detected by MRI and to determine the effects of smoking on paranasal sinusitis in a large population.

Methods

Study population

This was a cross-sectional study performed at the Sixth People's Hospital Affiliated to Shanghai Jiao Tong University, Shanghai, China. The participants were randomly selected from two communities in districts with long-term stable populations (Pandongli and Jingfenglu), because the age and sex distribution data were similar to those of the 2007 Shanghai census. In brief, the study population consisted of participants aged between 35 and 75 years (n=4813) who underwent head MRI between June 2007 and June 2011. Exclusion criteria included participants who refused to take part in the study or were not adherent, as well as those who were not suitable for MRI, such as cases involving a pacemaker or metallic implant, the early stage of pregnancy, dentures, or claustrophobia. The study protocol was reviewed and approved by the ethics committee of the Sixth People's Hospital Affiliated to Shanghai Jiao Tong University. All participants provided informed consent prior to study enrollment [19].

Data collection

The recording of demographic information, physical examination (including height, weight, and blood pressure), and head MRI were performed during a single interview. The following general information was obtained: age, sex, height, weight, body mass index (BMI), smoking (defined as having smoked >100 cigarettes in a lifetime), alcohol consumption (defined as consuming >30 g of alcohol per week for one year or longer), hypertension, diabetes, hyperlipidemia, stroke, coronary heart disease, myocardial infarction, and arrhythmia [19].

Paranasal sinusitis

The MRI signals in the frontal, maxillary, and sphenoid sinuses were classified as follows [20]:

0. Absence of signal: normal 1. Visible illumination of the sinus mucosa, although <5 mm: normal 2. Thickening of the mucosal membrane [?]5 mm, although occupying less than 50 % of the cross-section of the sinus: pathological 3. The mucosa occupies more than 50 % of the cross-sectional area, although the sinus still contains some air: pathological 4. Total sinus opacification or fluid level: pathological 5. Polyp or retention cyst: a lesion with rounded edges surrounded by air: pathological 6. Other: anatomic abnormalities presumed to be attributable to previous nasal or sinus surgery: pathological

The MRI signals in the ethmoid sinuses were classified as follows[20]:

0. Absence of signal: normal 1. Minimal or moderate sinus opacification: normal 4. Marked or total sinus opacification: pathological

Paranasal sinusitis was defined as the presence of abnormal findings in at least one of the paranasal sinuses detected by head MRI.

MRI protocol and image analyses

Head MRI studies were performed on a 3.0 T system (Achieva X-Series, Philips Medical Systems, OH, USA) and T2-weighted images were used for the screening of paranasal sinusitis. All T2-weighted images were obtained in the axial plane, although, if necessary, sagittal or coronal images were also obtained. The images were analyzed independently by three observers, with more than 5 years of work experience in neuroradiology, who were unaware of the participants' information or the study's purpose.

Statistical analyses

Statistical analyses were performed using SPSS 25.0 (IBM Corp., Armonk, NY, USA). In the univariate analyses, the chi-squared test was used to compare categorical variables, while Student's t-test was used for continuous variables. Logistic regression analysis was used to assess the risk factors for paranasal sinusitis. Additionally, the Cochran–Armitage trend test of SAS 9.4 (SAS Institute, Cary, NC, USA) was used to analyze the age-specific prevalence of paranasal sinusitis in smokers and non-smokers. A p-value <0.05 was considered statistically significant for all analyses.

Results

Among the 4813 participants who were investigated (2368 men and 2445 women; mean age, 53.1 ± 10.1 years), paranasal sinusitis was diagnosed in 740 (15.4 %). Table 1 shows the characteristics of the study participants with and without paranasal sinusitis. The data show that sex was significantly associated with the presence of paranasal sinusitis, together with age, BMI, alcohol consumption, stroke, smoking, and hypertension.

Logistic regression analysis was performed to examine the risk factors associated with paranasal sinusitis (Table 2). When adjusted for age and sex (Model A), alcohol consumption and hypertension were not significantly associated with paranasal sinusitis. The final model (Model B) adjusted for all the factors that were found to be statistically significant in the univariate analysis, including age, sex, BMI, smoking, alcohol consumption, hypertension, and stroke—only smoking was significantly associated with the prevalence of paranasal sinusitis.

The age-specific prevalence of paranasal sinusitis in smokers and non-smokers is shown in Table 3. For all age groups, the prevalence was higher in smokers than in non-smokers (Figure 1). The prevalence of paranasal sinusitis significantly increased with age in non-smoking individuals, whereas no significant age-specific difference was found among smokers (trend test, non-smokers $p<0.001$; smokers $p=0.499$).

Table 4 shows a comparison of the prevalence of sinusitis affecting different regions between smokers and non-smokers; the anterior nasal sinuses were more often affected in smokers than in non-smokers, while no significant difference was found regarding the sphenoid sinus. Among the total study population, maxillary sinusitis was the most prevalent (13.4 %) while the prevalence was 19.1 % in smokers and 11.7 % in non-smokers.

Discussion

The present study investigated the prevalence of paranasal sinusitis, diagnosed using MRI, among a community population from Shanghai, China. Additionally, the epidemiological and clinical characteristics of sinusitis between smokers and non-smokers were investigated. Overall, the prevalence of paranasal sinusitis was found to be 15.4 % in adults aged 35–75 years. This prevalence increased concurrently with age, from 12.6 % (35–44 years) to 16.5 % (55–75 years); a peak was reached at 55 years, stabilizing thereafter. The Cochran–Armitage trend test further showed that there was a positive correlation between age and paranasal sinusitis in non-smokers, while the prevalence in smokers remained consistently high, at more than 20 % in each age group. Moreover, it was found that paranasal sinusitis more often involved the anterior nasal sinuses in smokers than in non-smokers.

In China, the first large-scale investigation concerning the epidemiology of CRS was reported in 2015. This investigation estimated a CRS prevalence of 8.0 % in the entire population and 8.2 % among adults aged 15–75 years [21], which was lower than the prevalence noted in the present study. This difference may be explained as follows: The previous study diagnosed CRS based on the results from a standardized questionnaire, whereas this study employed MRI for this purpose. The former method of diagnosis may result in some patients with unobvious symptoms being overlooked, while the latter is not able to distinguish the course or type of sinusitis effectively. Havas et al. reported abnormal CT and MRI findings of the paranasal sinuses in asymptomatic adults to be as high as 42.5 % [13]. Kim et al. further confirmed that the prevalence and risk factors of CRS differed rather substantially when using different criteria, even in the same population[22]. Because of this difference, the investigation from 2015 may have underestimated the prevalence.

Compared to other studies that diagnosed paranasal sinusitis by means of MRI, the prevalence noted in our study was lower than that noted in studies from Denmark (31.7 %) [20], Japan (33.8 %)[23], and Norway (66 %) [12]. We believe that this variation could be due to the use of different diagnostic criteria and research techniques. Additionally, the prevalence of paranasal sinusitis is influenced by climate and race, being more likely to occur in colder climates and in people who are white [24-26]. That said, in Japan, a Lund–Mackay score [?]4 was classified as an MRI abnormality that was suspected as sinusitis, whereas in Norway, opacifications that indicated mucosal thickenings, polyps, retention cysts, or fluid were recorded when measuring >1 mm. In our study, however, mucosal thickening of [?]5 mm was used as an indication of paranasal sinusitis, as per the Danish diagnostic criteria. By choosing a relatively high cut-off value, challenges regarding overdiagnosis due to the high sensitivity of MRI can be overcome, ensuring more accurate findings [20].

Among all the participants in this study, 49.2 % were men. We found that men were approximately 86 % more likely to have paranasal sinusitis than women (adjusted OR = 1.86, 95 % CI = 1.54–2.24), which is consistent with the results of studies from Asia [21, 23, 27]. However, some surveys from developed Western countries found that women were at a higher risk of developing paranasal sinusitis[6, 9, 28]. This discrepancy may be related to differences in the living habits and level of awareness of paranasal sinusitis between populations from Eastern and Western countries.

At present, the relationship between the prevalence of paranasal sinusitis and age is somewhat controversial. In a previous study, Chen et al. found that the prevalence of CRS in Canadians older than 12 years increased with age, reaching a plateau after the age of 60 years[28]. Additionally, Hirsch et al. found that the prevalence of CRS peaked at 15.9 % between the ages of 50 and 59 years, subsequently dropping to 6.8 % after age 69 [24], while Shi et al. found a higher prevalence in individuals aged 15–34 years[21]. In our study, we found that the overall prevalence of paranasal sinusitis in adults aged 35–75 years increased with age, reaching a peak at 55 years of age and stabilizing thereafter. The prevalence of paranasal sinusitis was found to have a strong positive correlation with age, particularly among non-smokers. This may be related to certain changes in the nasal anatomy and physiology that occurs with aging, such as reduced mucosal blood flow and impaired mucociliary function [29].

It is well known that smoking is closely related to respiratory diseases. Literature shows that tobacco smoke can adversely affect sinonasal mucociliary clearance, innate immune function, and olfactory mucosal metaplasia [8]. Several clinical studies have confirmed that there is a correlation between smoking and paranasal sinusitis in the Asian population [8, 10, 30]. Our research confirmed these findings, in that smoking is one of the significant independent risk factors in the development of paranasal sinusitis.

The location of paranasal sinusitis differs depending on its etiology. In contrast to the abundant literature regarding the correlation between smoking and paranasal sinusitis, there are relatively few studies assessing its most prevalent location. Interestingly, we found that in smokers, paranasal sinusitis more commonly occurs in the anterior nasal sinuses than in non-smokers, where it occurs most often in the maxillary sinus, followed by the ethmoid, frontal, and sphenoid sinuses. In smokers, the most common sites of sinusitis were found to be the maxillary sinus, followed by the sphenoid, frontal, and ethmoid sinuses. Kjaergaard et al. demonstrated that smokers have lower nasal cavity volumes and smaller minimum cross-sectional areas, achieve lower peak nasal inspiratory flow rates, and have a lower decongestive capacity of the nasal mucosa [31]. Hence, we speculate that these nasal changes brought about by smoking are more likely to affect the mucociliary clearance movement and ventilation of the anterior nasal sinuses that open in the middle nasal passage. More research is needed to support this hypothesis.

Limitations

Several limitations of the present study should be mentioned. Firstly, paranasal sinusitis was diagnosed by

MRI, which lacks a description of the patient's subjective symptoms. Although patients with asymptomatic sinusitis can be overlooked, there is the additional possibility of overdiagnosis due to the sensitivity of MRI. Furthermore, we could not distinguish between acute and chronic sinusitis. Future studies should evaluate the prevalence of paranasal sinusitis in the general population using a combination of MRI and/or CT and the relevant symptoms. Secondly, CT is superior to MRI for the examination of anatomical bone variations, which is an important risk factor for paranasal sinusitis[32]. Lastly, paranasal sinusitis in children is also a common problem [33]; however, our research participants were limited to individuals aged 35–75 years due to factors such as cooperation. Therefore, the findings may not be applicable to the general population.

Conclusion

In conclusion, this study found that the overall prevalence of paranasal sinusitis in Chinese adults aged 35–75 years is 15.4 %. The major risk factors for paranasal sinusitis include age, sex, and smoking. In non-smokers, the prevalence of paranasal sinusitis increases with age, while in smokers, sinusitis more often involves the anterior nasal sinuses. These results may facilitate the understanding of the epidemiology of paranasal sinusitis detected by MRI and prove valuable in the prevention and treatment of paranasal sinusitis.

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Tables

Table 1. Characteristics of the study participants

Characteristic	Total (n=4813)	Paranasal sinusitis	Paranasal sinusitis	p-value
		Yes (n=740)	No (n=4073)	
Mean age, years (SD)	53.1 (10.1)	54.1 (10)	52.9 (10.1)	0.002*
Male/Female, n/n	2368/2445	475/265	1893/2180	<0.001*
Mean body mass index, kg/m^2 (SD)	23.6 (3.0)	23.9 (3.1)	23.6 (3.0)	0.011*
Smoking, n (%)$^+$	1056 (21.9)	238 (32.2)	818 (20.1)	<0.001*
Alcohol consumption, n (%)$^{++}$	614 (12.8)	12 (17.0)	488 (12.0)	<0.001*
Hypertension, n (%)	1205 (25.0)	212 (28.6)	993 (24.4)	0.014*
Diabetes, n (%)	346 (7.2)	59 (8.0)	287 (7.0)	0.369
Hyperlipidemia, n (%)	378 (7.9)	67 (9.1)	311 (7.6)	0.187
Stroke, n (%)	141 (3.0)	31 (4.2)	31 (4.2)	0.027*
Coronary heart disease, n (%)	103 (2.1)	21 (2.8)	82 (2.0)	0.154
Myocardial infarction, n (%)	17 (0.4)	5 (0.7)	12 (0.3)	0.108
Arrhythmia, n (%)	90 (1.9)	18 (2.4)	72 (1.8)	0.219

*p<0.05, comparison between participants with and without paranasal sinusitis +Smoked >100 cigarettes in a lifetime ++C

Table 2: Logistic regression analysis of risk factors associated with paranasal sinusitis

Risk factor	Crude	Crude	Model A	Model A	Model B	Model B
	OR (95 % CI)	p-value	OR (95 % CI)	p-value	OR (95 % CI)	p-value
Age (increase of 10 years)	1.11 (1.03–1.20)	0.007	1.12 (1.04–1.21)	0.005$^+$	1.09 (1.01–1.18)	0.036
Male	2.06 (1.76–2.43)	<0.001	2.07 (1.76–2.44)	<0.001^{++}	1.86 (1.54–2.24)	<0.001

Risk factor	Crude	Crude	Model A	Model A	Model B	Model B
BMI (increase of 1 unit)	1.23 (1.05–1.44)	0.011	1.20 (1.03–1.41)	0.022	1.13 (0.93–1.36)	0.214
Smoking	1.89 (1.59–2.24)	<0.001	1.35 (1.11–1.65)	0.003	1.37 (1.10–1.70)	0.004
Alcohol consumption	1.51 (1.22–1.87)	<0.001	1.09 (0.87–1.36)	0.461	0.90 (0.70–1.16)	0.414
Hypertension	1.25 (1.05–1.48)	0.014	1.19 (0.99–1.43)	0.060	1.13 (0.93–1.36)	0.214
Stroke	1.58 (1.05–2.37)	0.028	1.56 (1.03–2.36)	0.037	1.40 (0.92–2.14)	0.117

Model A: adjusted for age and sex. Model B: adjusted for all factors

+Adjusted for sex; ++Adjusted for age

OR = odds ratio, CI = confidence interval, BMI = body mass index

Table 3. Age-specific prevalence of paranasal sinusitis in smokers and non-smokers

Age (years)	Total	Total	Total	Non-smokers	Non-smokers	Non-smokers	Smokers	Smokers	Sm
	Investigated, n	Paranasal sinusitis Participants, n	Paranasal sinusitis Proportion (95 % CI)	Investigated, n	Paranasal sinusitis Participants, n	Paranasal sinusitis Proportion (95 % CI)	Investigated, n	Paranasal sinusitis Participants, n	Pa sin Pr (95
Total	4813	740	15.4 (14.4–16.4)	3757	502	13.4 (12.3–14.5)	1056	238	22. (20 25.
35–44	1214	153	12.6 (10.7–14.5)	1021	112	11.0 (9.1–12.9)	193	41	21. (15 27.
45–54	1797	287	16.0 (14.3–17.7)	1323	182	13.8 (11.9–15.6)	474	105	22. (18 25.
55–64	1066	176	16.5 (14.3–18.7)	812	116	14.3 (11.9–16.7)	254	60	23. (18 28.
65–75	736	124	16.5 (14.1–19.6)	601	92	15.3 (12.4–18.2)	135	32	23. (16 30.
p-value of trend+	—	—	0.007	—	—	<0.001	—	—	0.4

+Calculated using the Cochran–Armitage trend test

CI = confidence interval

Table 4. Prevalence of sinusitis in different locations according to smoking status

	Total (n=4813)	Smoking	Smoking	p-value
		Yes (n=1056)	No (n=3757)	
Maxillary sinusitis, n (%)	643 (13.4)	202 (19.1)	441 (11.7)	<0.001*
Ethmoid sinusitis, n (%)	69 (1.4)	31 (2.9)	38 (1.0)	<0.001*

	Total (n=4813)	Smoking	Smoking	p-value
Frontal sinusitis, n (%)	70 (1.5)	23 (2.2)	47 (1.3)	0.026*
Sphenoiditis, n (%)	78 (1.6)	19 (1.8)	59 (1.6)	0.603

*p<0.05, comparison between smokers and non-smokers

Figure 1 .

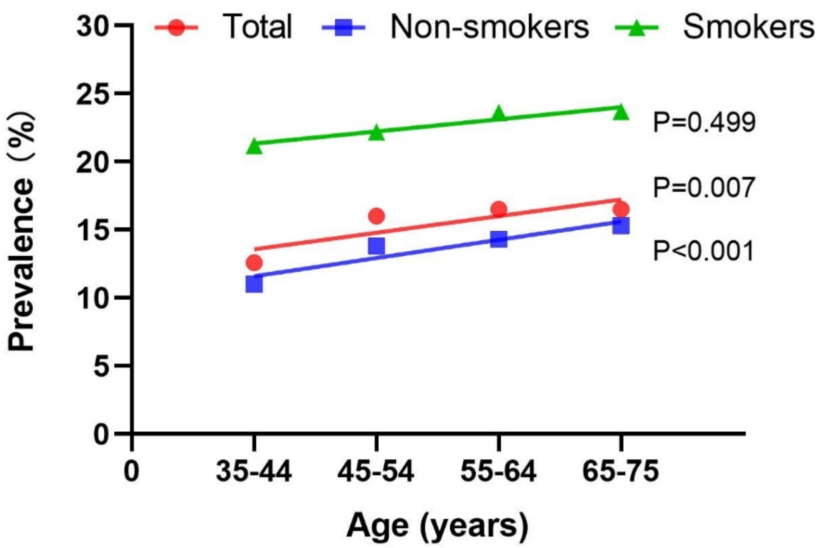

Figure Legends

Figure 1 . Age-specific prevalence of paranasal sinusitis in smokers and non-smokers. (P = p-value of the Cochran–Armitage trend test)