Seasonality and incidental sinus abnormality reporting on MRI in an Australian climate*

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Rhinology 50: 320-325, 2012
DOI: 10.4193/Rhino11.270
***Received for publication:** December 29, 2011
Accepted: March 28, 2012

Summary

Background: Incidental sinus mucosal abnormalities on MRI are a common finding. This study aims to investigate seasonality and reporting of these findings.

Methodology: Prospective, cross-sectional study of adult patients presenting for neuro-radiological assessment using MRI. 173 patients were recruited over 'winter' and 'summer' collection periods (mean maximum temperature 14.5°C and 24.3°C, respectively). Patients were classified as symptomatic for rhinosinusitis according to the European Position Paper on Rhinosinusitis and Nasal Polyps 2007 definition. A modified Lund Mackay score was used to assess sinus pathology. Mucosal thickening of > 3mm was considered pathological. Radiologist reports were reviewed for mention of incidental sinus abnormalities.

Results: There was an incidental rate of 58.1% overall, with significantly more sinus abnormalities in winter. Sinus abnormalities were mentioned in 8.1% of radiologist reports, half of which were in asymptomatic patients. There were significantly more sinus abnormalities amongst symptomatic patients.

Conclusions: Incidental sinus changes on MRI are a common finding and are often reported on by radiologists. However, they bear little association with symptoms. Their prevalence is influenced by season and thus their significance is greater during cooler months. Specialist referral should be reserved for symptomatic patients that have failed medical therapy.

Key words: paranasal sinuses, Magnetic Resonance Imaging, incidental findings, air pollution, seasons

Introduction

Incidental sinus abnormalities have been demonstrated by a number of studies for both Computerised Tomography (CT) and Magnetic Resonance Imaging (MRI) [(1)]. Whilst MRI scans are not the first-line imaging modality for rhinosinusitis [(2)], they are commonly performed for other cranial indications and thus the paranasal sinuses are often imaged inadvertently. Incidental findings, especially when reported on, may result in referral to an ENT (Ear, Nose, and Throat) specialist for further management. The extent to which these incidental findings are reported on has not been characterized by the literature.

Prevalence rates of sinus mucosal abnormalities on MRI range from 25 to 63% [(3-9)]. This range of values is in part due to variations in study methodology and definitions for the 'asymptomatic' subject or the 'abnormal' scan. However, the influence of regional/seasonal climate variation and pollution levels should also be considered [(1)]. Possible explanations for radiological abnormalities in asymptomatic individuals include resolving URTI (Upper Respiratory Tract Infection), allergic inflammation or mucosal thickening related to the natural physiological nasal cycle [(7,10)]. Viral URTIs demonstrate seasonal variation. It has been hypothesized that the underlying reason for this seasonality is a change in air temperature, which acts to cool the nasal airway and impair host defences [(11)].
Limited attention has been given to the influence of air tem-

perature on prevalence rates of sinus abnormalities. Further, studies that have assessed seasonal variation have reported conflicting outcomes [3,8,12]. Variation in incidental MRI abnormalities with season has not been assessed in a warmer climate such as Melbourne. Consequently, this study aimed to investigate 1) radiologist reporting of incidental abnormalities and their relationship with symptoms 2) the prevalence of sinus abnormalities and symptoms across two distinct periods with regard to temperature, humidity and environmental pollution.

Materials and methods

Patients

The sample population was recruited from the MRI department at St Vincent's Hospital, Melbourne during both 'winter' (July/August) and 'summer' (November/ December) collection periods. Patients were prospectively included if they were over the age of 18 and undergoing an MRI for non-sinus related pathology. These indications included cranial, internal auditory meatus and orbital assessment. The Research Governance Unit granted formal ethical approval and all subjects gave written informed consent.

In total, 197 patients met inclusion criteria, whilst 3 declined to participate. Of the remaining participants, 22 were excluded. Within this group, 20 were excluded due to inadequate radiological visualisation of the paranasal sinuses or absent scans, one with a malignancy involving the sinuses and another who had undergone prior sinus surgery.

Data collection

In total, 172 subjects were evaluated. Of these, 89 subjects were recruited during a 4-week 'winter' period and 83 during a 3-week 'summer' period. Structured interviews were performed on patients immediately prior to, or after, their scan regarding any sinus symptoms they had experienced in the week preceding their MRI scan. Interviews also included questions regarding a past history of allergic type sinonasal symptoms. Subjects were classified as symptomatic if their symptoms met the criteria for rhinosinusitis described in the European Position Paper on Rhinosinusitis and Nasal Polyps 2007 (EPOS 2007) [2] (Figure 1). The paranasal sinuses were then assessed on T2-weighted axial and coronal views using an adapted Lund Mackay scoring system by two investigators blinded to the subject's symptom status (ADR and CT).

The Lund Mackay radiological grading system [13] (Table 1) was chosen for its simplicity, widespread use and ease of application [14]. The Lund Mackay system was designed for CT [13] imaging but given that MRI does not adequately display the ostiomeatal complex, this aspect of the score was excluded. The authors acknowledge that the full Lund Mackay score (including ostiomeatal complex) has been applied to MRI in a recent trial [15]. In assessing incidental findings, only mucosal thickening of 3mm or more was considered abnormal as mild mucosal thickening (1 - 2mm), in particular of the ethmoids, has been thought to be insignificant or part of the physiological nasal cycle [7]. A Lund Mackay score of greater than zero constituted an abnormal scan. The radiologist report for each scan was reviewed independently and any mention of paranasal sinus disease was recorded. Daily temperature and humidity data was sourced from the Bureau of Meteorology database, whilst air pollution data was sourced from the Environmental Protection Agency Australia, for both collection periods. Environmental data was collected from 2 weeks prior to the first patient scan through to the day of the last patient's scan for each period. The reason for collecting data prior to the first patient scan was to account for the time taken for pathology and symptoms to develop under the influence of the environmental factors.

Statistical analysis

Data was analysed using Microsoft Excel 2008. Chi-square and paired t-tests were used with a level of significance of 5%.

Results

Of 172 patients, 63 were men and 109 were women. Ages ranged from 18 to 83 with a mean of 52. There was a participation rate of 98.5%. The overall prevalence of incidental findings within the sinuses, noted by the investigators, was 58.1%, whilst 33.7% of all patients had symptoms that met criteria for rhinosinusitis as per EPOS 2007 [2].

Amongst the symptomatic patients, there was a significantly higher prevalence of sinus abnormalities (64.4%) than in the asymptomatic patients (54.9%, $\chi 2 = 4.479$, df = 1, $p < 0.034$).

Environmental factors

Sinus abnormalities were further analysed according to seasonal factors. During the 'winter' sample, the mean maximum daily temp was 14.5°C and humidity 69%, in contrast to the 'summer' sample where the mean maximum temperature was 24.3°C and humidity 60% (Table 3).

NO_2 (nitrogen dioxide) and CO (carbon monoxide) levels were higher during the 'winter' period. NO_2 levels dropped from 0.9 to 0.4 parts per (pp) million, whilst CO levels moved from 27.7 to 18.8 pp billion, from winter to summer (Table 3).

Correspondingly, the prevalence of incidental findings was significantly greater in the winter sample (65.2%) than during the summer sample (50.6%, $\chi 2 = 7.795$, df = 1, $p < 0.005$) (Figure 2). There was no change in API (air particle index) observed across the two recruitment periods.

Symptoms

When considering the seasonal relationship to symptoms, a higher prevalence amongst symptomatic patients was only observed in the 'winter' period. During this season, 73.0% of the symptomatic patients had sinus abnormalities compared with 59.6% amongst the asymptomatic ($\chi 2 = 4.702$, df = 1, $p < 0.03$) (Figure 2). This contrasts with the 'summer' period where the prevalence amongst symptomatic and asymptomatic patients

Acute rhinosinusitis (ARS) is defined as:
Sudden onset of two or more symptoms, one of which should be either nasal blockage/congestion/obstruction or nasal discharge (anterior/posterior drip)
+/- facial pain/pressure,
+/- reduction or loss of smell;
for <12 weeks;
with symptom free intervals if the problem is recurrent

Figure 1. Research definition for acute rhinosinusitis according the European Position Paper for Sinusitis 2007 [2].

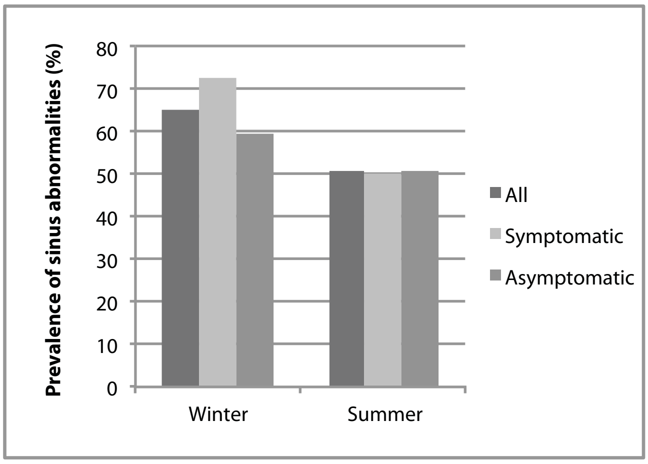

Figure 2. Prevalence of sinus abnormalities amongst symptomatic and asymptomatic across seasons.

was virtually identical, 50.0% and 50.8% respectively (Figure 2) ($\chi2 = 0.016$, df =1, $p < 0.898$). Accordingly, prevalence only varied significantly with season amongst symptomatic patients. There was no observed environmental influence on prevalence amongst the asymptomatic patients.

In contrast to the observed association between prevalence of sinus abnormalities and season, there was not a significant association between average Lund Mackay score and season. The average Lund Mackay score in 'winter' was 1.5 whilst that in 'summer' was 1.2 ($p < 0.178$). There was also not a significant difference in the average Lund Mackay score observed between symptomatic and asymptomatic patients, irrespective of season (Table 4).

Thirty-two subjects (18.6%) reported regularly suffering from allergic symptoms. The prevalence of sinus abnormalities in this group was 62.5%, which was not significantly different ($p < 0.54$) to the 57.1% amongst those who denied regular allergic symptoms.

Sinus abnormalities

The specific sinus abnormalities of rhinosinusitis that we observed included: sinus mucosal thickening, mucous retention cysts and polyps, and air fluid levels. Mucosal thickening (of > 3mm) represented the majority (84.6%) of sinus abnormalities observed, followed by mucous retention cysts seen in 21.5% of the patients observed and represented 40.7% of abnormalities seen (Table 5). There was no significant variation in the prevalence noted of mucous retention cysts across season, where 24.7% of patients had cysts or polyps in winter and 18.1% in summer ($\chi2 = 1.971$, df = 1, $p < 0.16$). The majority of those observed were in the maxillary sinuses, whilst 2 were in the sphenoid sinuses. In 14 of these 37 patients, the cyst or polyp was the only radiological pathology identified (Table 5). In contrast, all air fluid levels were observed in the presence of associated sinus mucosal thickening.

Discussion

The sensitivity of MRI to soft tissue changes makes the modality prone to identifying incidental sinus findings [5,16]. Incidental sinus abnormalities, if commented on by a radiologist in particular, can lead to referrals to an otolaryngologist for further evaluation or treatment despite a lack of symptoms. This study has characterised the frequency with which these abnormalities are reported on, demonstrating that 8.1% of these 'normal' patients were reported as having sinus abnormalities. Furthermore, there was no significant association with symptoms as half of these were in asymptomatic patients.

Whilst radiologists did report on sinus abnormalities in 14 of the 100 abnormal scans, 86 abnormal scans were not commented on. The decision to mention incidental sinus abnormalities by a radiologist is highly discretionary. Our impression is that many radiologists choose not to mention incidental changes because they understand that that these findings are common and do not correlate with symptoms or that the significance of sinus abnormalities is minimal in comparison to the patients other

Table 1. Lund Mackay radiological grading system [13] (adapted).

Sinus	Left	Right
Frontal (0,1,2)		
Maxillary (0,1,2)		
Anterior ethmoids (0,1,2)		
Posterior ethmoids (0,1,2)		
Sphenoid (0,1,2)		
Total (/20)		
O = no abnormality		
1= partial opacification (mucosal thickening*, mucous retention cyst/polyp, air fluid level)		
2 = total opacification		

* Mucosal thickening > 3 mm

Table 2. Reporting of incidental sinus abnormalities.

Number of scans	172
Number of scans with reported abnormalities	14
Reported abnormality [1]	
Thickening	7
Paranasal sinus disease	5
Mucous retention cyst/polyp	4
Air fluid level	1

[1] Greater than one abnormality may have been reported per patient

Table 3. Environmental data for the 'winter' and 'summer' periods.

Mean daily averages	Winter	Summer	Significance
Maximum temperature (°C) [1]	14.54	24.30	$p < 3 \times 10^{-19}$
Humidity (%) [1]	69.05	60	$p < 0.001$
CO (ppm) [2]	0.92	0.44	$p < 2 \times 10^{-6}$
NO2 (ppb) [2]	27.67	18.76	$p < 2 \times 10^{-5}$
API – Air particle index (Bscat) [2]	0.91	0.72	$p < 0.12$

1 Data provided by the Bureau of Meteorology, Australia

2 Data provided by the Environmental Protection Agency, Australia

Table 4. Mean Lund Mackay scores (adapted) across season.

	Winter	Summer	Significance
Symptomatic	1.80	1.11	$p < 0.087$
Asymptomatic	1.26	1.24	$p < 0.477$
Significance	$p < 0.1$	$p < 0.403$	

Table 5. Observed abnormalities as a proportion of total abnormalities.

Sinus abnormality	Percentage
Mucosal thickening	84.6
Mucous retention cyst/polyp	40.7
Mucous retention cyst/polyp only	15.4
Air fluid level	5.5

medical issues. However, as we have shown, this decision is not universal.

The significance of incidental changes and their reporting is likely to be greatest in climates and seasons that experience a higher prevalence of sinus abnormalities. Importantly, we have identified a significantly higher prevalence during cooler months in Melbourne, Australia. Whether this can be extrapolated to regional differences in climate is more difficult to determine, given great inter-study variability in methodology and definitions for the symptomatic patient and the abnormal scan [1]. Assessing the influence of temperature variation within the same study removes the influence of these variables. Few other studies have addressed this and their findings are conflicting.

Tarp et al., [8] prospectively investigated patients in Denmark across all four seasons and found a higher prevalence during the winter period but did not restrict observations with relation to symptom status. The findings of our study are consistent with those of Tarp et al., [8] in that there was a significantly higher prevalence of sinus abnormalities in cooler months.
In contrast, Cooke et al., [3] evaluated 350 patients in Scotland and saw no relationship between incidence and the month of the year. However, they did not assess more broadly between seasons. Havas et al. [12] prospectively investigated 666 patients using CT and saw no seasonal variation. This study was conducted in Sydney in 1988, where winter was 4.2°C warmer than in our study and the temperature range only 5.1°C across the two collection periods. Sinus abnormalities in our study were more prevalent in symptomatic patients during 'winter.' However, during 'summer' they were almost equivalent. It is possible that Havas et al., [12] did not observe a difference due to the warmer winter and lesser seasonal temperature variation in Sydney. Notably, seasonal variation in sinus abnormalities was only observed in symptomatic patients. We propose that this is in part due to the seasonality of viral URTIs. Eccles et al., [11] hypothesized that viral URTIs exhibit seasonality due to the influence of temperature on host defenses, where cooling of the nasal airway impairs mucociliary clearance and the phagocytic activity of leukocytes. The lower prevalence of sinus abnormalities in the summer group could thus be explained by a lower prevalence of URTIs in summer, as suggested by Lim et al. [1]

The seasonal variation in symptomatic patients may also be due to an exaggerated response in those with chronic rhinosinusitis through increased sensitivity of their paranasal sinus mucosa. Both chronic rhinosinusitis and nasal polyps show elevated cytokine expression and increased numbers and activation of T cells [17,18]. Consequently, this may make them more susceptible to climatic and environmental factors.
Aside from temperature and humidity, air pollutants may also be a contributing factor to the greater prevalence of sinus abnormalities observed during the winter period. Spannhake et al., [19] assessed the in vitro effects of the air pollutants, NO2 and O3 and noted an up-regulation of the epithelial cell cytokine response in the presence of rhinovirus infection. Bhattacharyya observed a positive correlation between air pollutants (CO, NO2, API) and sinusitis presentation over a 10-year period [20]. Although our environmental data presented in Table 3 suggest higher levels of CO and NO2 during the 'winter' period, we cannot comment upon the relative contributions made by air temperature and air pollution towards sinus changes. As our study assessed only one winter and one summer period, further studies may wish to obtain more longitudinal data to assess any correlation between environmental factors and symptom presentation.
Having minimized the influence of 'symptom producing' URTIs by observing a summer sample, there still remains an incidental rate. Notably an incidental rate that is almost equivalent for both symptomatic and asymptomatic subjects. When searching for factors that might generate this rate, we considered the physiological nasal cycle, polyps, and mucous retention cysts. These are factors that less commonly produce symptoms. Studies investigating mucous retention cysts have identified an incidence of 12.4% to 35.6% [21-23]. Interestingly, Kanagalingam et al., [22] identified a rate of 35.6% amongst a normal population (i.e. ophthalmic patients without nasal complaints), compared with 22% observed amongst patients with chronic rhinosinusitis by Harar et al., [23]. This supports the assertion that mucous retention cysts are not likely a manifestation of nasal disease. Amongst our cohort, 21.5% had mucous retention cysts or polyps and there was no significant variation of these across season. In almost half of these patients, the cyst or polyp was the only observed pathology within the sinuses. Thus, in addition to temperature dependent URTIs, mucous retention cysts and polyps contribute to the high prevalence of incidental sinus abnormalities. The Lund Mackay score incorporates these features as pathological but we have observed that they are in part responsible for the incidental Lund Mackay score seen in the general population [24]. Furthermore, it has been found that there is no relationship between persistent ostiomeatal complex obstruction and the development of mucous retention cysts [21]. Only opportunely located medial maxillary sinus mucous retention cysts are likely to obstruct the ostiomeatal complex. Therefore, very few contribute to the development of a local sinusitis.
In contrast to the findings we observed across season, Bhattacharyya observed a positive correlation between annual temperature and symptoms of sinusitis using the American National Health Interview Survey but did not incorporate imaging [25]. These contrasting findings are likely explained by the fact that our study assessed temperature variation across season within a given year, rather than annual temperature variation across years.

In conclusion, incidental sinus abnormalities are a common finding on MRI. Our study suggests that they are seen in 58.1% of subjects presenting for non-ENT conditions and in 54.9% of those who are asymptomatic for rhinosinusitis. However, although they are frequently reported upon by radiologists (8.1% of scans in our series), their mention bears little relationship to symptoms. We noted that differences in prevalence are seasonal and may be due to variation in climatic and environmental factors including air temperature, humidity and air pollutants, even in the relatively 'warm' Australian climate.
At cooler temperatures (14.5°C), incidental sinus abnormalities were more prevalent amongst patients with symptoms of rhinosinusitis. However, this association was lost during summer (24.3°C), where the milieu of contributing factors is likely to be

different. We hypothesize that temperature dependent URTIs are a potential culprit for the higher prevalence observed in cooler temperatures.

Future studies may wish to investigate the prevalence and variation of the incidental rate in hot or tropical climates. In these environments, we hypothesise that the prevalence and seasonal variation may be less significant. These findings reinforce the importance of a thorough symptom evaluation, examination and trial of medical therapy by primary practitioners prior to referral for specialist evaluation in the presence of sinus abnormalities on MRI. Additionally, if radiologists include incidental findings within their report, they should highlight the need to correlate imaging findings with the clinical scenario in view of the poor correlation with symptoms.

Acknowledgements

The authors would like to thank the staff of St Vincent's Hospital MRI department for their great assistance with the study. There was no funding required for this project, all contributions were voluntary.

Authorship contribution

AdR: project design, data collection, data analysis, writer; NT: project supervision; CT: data collection; SO'L: manuscript editing; PM: project design, project supervision, manuscript editing.

Conflict of interest

None declared.

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