

Screening for sinus disease in patients with asthma: A computed tomography-controlled comparison of A-mode ultrasonography and standard radiography

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Background: *Paranasal sinus disease and bronchial asthma are frequently associated. Patients with asthma often have chronic inflammatory changes of the paranasal mucosa rather than acute bacterial sinusitis. Our aim was to compare the rankings of A-mode ultrasonography and standard radiography as routine screening procedures in the diagnostic workup of these patients.*

Methods: *We compared the evaluation of the maxillary sinuses by A-mode ultrasonography and standard radiographs. Computed tomography served as a gold standard in 19 patients with asthma who had no history of sinus surgery.*

Results: *Computed tomography showed at least some minimal mucosal thickening in any of the paranasal sinuses in 74% and of the maxillary sinuses in 61% of the patients. Compared with the results of computed tomography, plain-view radiography gave a specificity of 86.7% for the maxillary sinuses. Although all cases of severe mucosal thickening were detected, sensitivity for minimal mucosal hyperplasia was low, at 52.2%. In contrast, A-mode ultrasonography demonstrated a sensitivity of 70% but a specificity of only 22%.*

Conclusions: *Even symptom-free patients with asthma show a high prevalence of at least limited mucosal thickening in the paranasal sinuses. Acute sinusitis is not a common finding. A-mode ultrasonography does not allow sufficient evaluation of this mucosal hyperplasia and is therefore not suitable for initial screening in these patients. It may prove helpful as a follow-up in selected patients with known anatomic characteristics, however, especially when antral fluid is involved. For routine screening in patients with asthma, a conventional Waters' view radiograph should be used in conjunction with direct visualization of the ostial-meatal area by fiberoptic or rigid rhinoscopy. This combination provides information about the degree of mucosal hyperplasia as well as mucosal inflammation and secretion. (J ALLERGY CLIN IMMUNOL 1994;94:804-9.)*

Key words: Sinusitis, asthma, A-mode ultrasonography, computed tomography, Waters' view radiograph

Patients with asthma are known to have a high prevalence of sinus inflammation.^{1, 2} Various mechanisms, such as bacterial seeding of the lungs, reflex bronchospasm, and enhancement of partial β -adrenergic blockade, have been implicated as

Abbreviations used

CT: Computed tomography

US: A-mode ultrasonography

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mechanisms through which sinus disease can cause deterioration of asthma.^{3, 4} Although sinusitis was long considered to be caused primarily by infection, newer data suggest that the swelling of the paranasal mucosa and asthma are both manifestations of a common inflammatory process.^{5, 6}

Because of the possible therapeutic implications for a decrease in the severity of their

TABLE 1. Patient characteristics

Patient	Sex	Age (yr)	Current sinus symptoms	Respiratory disease	FEV ₁ (% predicted)	Sinuses with mucosal thickening on CT
1	M	31	None	Allergic rhinitis, extrinsic asthma	78	LM
2	F	53	None	Extrinsic asthma	81	E
3	M	55	None	Mixed-type asthma	70	RM, LM, FS, E
4	F	23	None	Mixed-type asthma (steroid dependent)	54	
5	F	33	Rhinorrhea	Intrinsic asthma	61	RM, LM
6	F	55	None	Mixed-type asthma	82	RM, LM
7	F	45	None	Mixed-type asthma (steroid dependent)	92	
8	M	47	None	Intrinsic asthma	102	RM, LM, E
9	F	26	Rhinorrhea	Allergic rhinitis, extrinsic asthma	90	LM
10	M	33	None	Mixed-type asthma	102	RM, LM, E, FS
11	F	53	None	Extrinsic asthma	113	RM, LM
12	M	30	None	Mixed-type asthma (steroid dependent)	84	RM, LM, E
13	F	57	None	Mixed-type asthma (steroid dependent)	27	RM
14	M	58	Olfactory loss	Intrinsic asthma (steroid dependent), aspirin sensitivity	93	RM, LM, E
15	F	39	None	Mixed-type asthma	88	
16	F	55	None	Intrinsic asthma (steroid dependent)	65	S
17	M	55	None	Intrinsic asthma (steroid dependent)	42	
18	M	58	None	Allergic rhinitis, mixed-type asthma	70	RM, LM, E, S
19	M	51	None	Intrinsic asthma	36	RM, LM, E

FEV₁, Forced expiratory volume in 1 second; M, male; LM, left maxillary sinus; F, female; E, ethmoid sinus; RM, right maxillary sinus; FS, frontal sinus; S, sphenoid sinus.

asthma, such as treatment with topical steroids, antibiotics, or endoscopic sinus surgery, it is important to diagnose concomitant sinus pathology in patients with asthma.^{7, 8} Standard radiography in different views has been the classic imaging method for the paranasal sinuses. It is fast, well standardized, and inexpensive. Although modern techniques such as computed tomography (CT) and nuclear magnetic resonance imaging obviously provide a much higher resolution, their use is limited by cost, availability, and, in the case of CT, the higher dose of radiation.⁹

The purpose of this study was to determine whether A-mode ultrasonography (US) is sufficiently sensitive and specific to replace standard radiography as a screening method for the type of sinus disease common in patients with asthma.

Previous studies have not applied a sufficient gold standard to the evaluation of US.

METHODS

Patient selection

Nineteen consecutive and otherwise unselected adult patients (10 women and nine men, age range 23 to 58 years) with a history of bronchial asthma and without previous sinus surgery who were admitted to the Hochgebirgsklinik Davos-Wolfgang served as study subjects. Each patient signed an informed consent form that was approved by the ethical committee of the Hochgebirgsklinik Davos-Wolfgang.

All patients were questioned for symptoms of sinus pain, headache, cough, and rhinorrhea. Of the 19 patients, only three (15.8%) reported current symptoms when asked whether they had rhinorrhea (postnasal drip), "sinus headache," or hyposmia.

TABLE II. Results of standard radiography and US of the maxillary sinuses compared with CT standard

	TP	TN	FN	FP	Sensitivity (%)	Specificity (%)
Plain-view radiography	12	13	11	2	52.2	86.7
US	14	4	6	14	70	22.2

TP, True positive; TN, true negative; FP, false positive; FN, false negative.

Lung function analysis showed a range of 27% to 113% of predicted forced expiratory volume in 1 second. Of the 19 patients, 13 had atopic asthma and six showed no allergic component. Of the latter group, one patient had a history of aspirin sensitivity. Seven patients were on regimens of systemic steroids at admission (Table I).

Standard radiography

Occipitomental (Waters') and occipitofrontal (Caldwell) views of the paranasal sinuses were performed for all patients. These radiographs were interpreted by one experienced chest physician, who was not provided with any historical or clinical information. The evaluation was done separately for each side, so that in total 38 maxillary sinuses were studied. Positive radiographic examination criteria were more than 2 mm of mucosal thickening, any degree of opacification, or air fluid levels. The criterion of 2 mm for the detection of mucosal thickening was used to allow direct comparison with CT.

A-mode ultrasound

US was performed with a 3.5 MHz pencil probe on a computer-assisted US unit (Homoth HNO Diagnostik Center; Hamburg, Germany) on every patient by one otolaryngology specialist who also had no knowledge of the patients' history or symptoms. Each maxillary sinus was traced from a cranial to a caudal position, and two readings were recorded as printouts for each side. Mucosal thickening was diagnosed when the signal after the peak of the initial echo was wider than 5 mm.

Computed tomography

All patients received an axial CT series of the paranasal sinuses from the hard palate to the top of the frontal sinus, with a slice thickness of 3 mm and table incrementation of 6 mm to minimize radiation dose to the orbitae and also to allow best evaluation of the anterior wall of the maxillary sinuses, the principle region accessible by US. These were interpreted by an experienced radiologist who did not have access to the clinical findings. Mucosal thickening was interpreted as mucosal lining wider than 2 mm.

Statistical analysis

With CT as the reference, we calculated sensitivity and specificity for US and plain-view radiography as

follows: Sensitivity = $TP/(TP + FN)$ and Specificity = $TN/(TN + FP)$, where TP is true positive, TN is true negative, FP is false positive, and FN is false negative.

RESULTS

By CT, some degree of mucosal thickening in the maxillary sinuses was found in 23 of the 38 maxillary sinuses examined (60.5%). If all paranasal sinuses were considered, 14 of the 19 patients (73.7%) had at least minimal mucosal thickening in at least one sinus region. With respect to the maxillary sinuses, there was a tendency toward more severe involvement of the basal regions, possibly representing a negative effect of gravity on sinus clearance. No patients had acute sinusitis with significant effusions in the maxillary antrum.

Results of plain-view radiography were regarded as pathologic in 12 of the 23 sinuses that showed mucosal thickening on CT, representing a sensitivity of 52.2%. Two suspected lateral mucosal thickenings were false positive. Overall specificity of plain view radiography for detection of thickening of the mucosa of the maxillary sinuses was 86.7%.

US was interpreted as showing mucosal thickening of the anterior sinus wall in 28 of the 38 sinuses, yielding an overall sensitivity of 70%. A high rate of false-positive results, however, reduced the specificity to 22.2% (Table II).

DISCUSSION

Although the importance of evaluating the sinuses in patients with asthma is well documented,^{1, 2, 4, 10} we have to deal with two major problems: (1) What exactly is "sinusitis" in patients with asthma? (2) How do we screen for it? In adult patients with asthma, a more common finding than acute sinusitis is marked mucosal thickening, also characterized as chronic hyperplastic sinusitis; this is sometimes seen in combination with nasal polyps, which may cause few or no symptoms.^{5, 11} The histopathologic similarity of

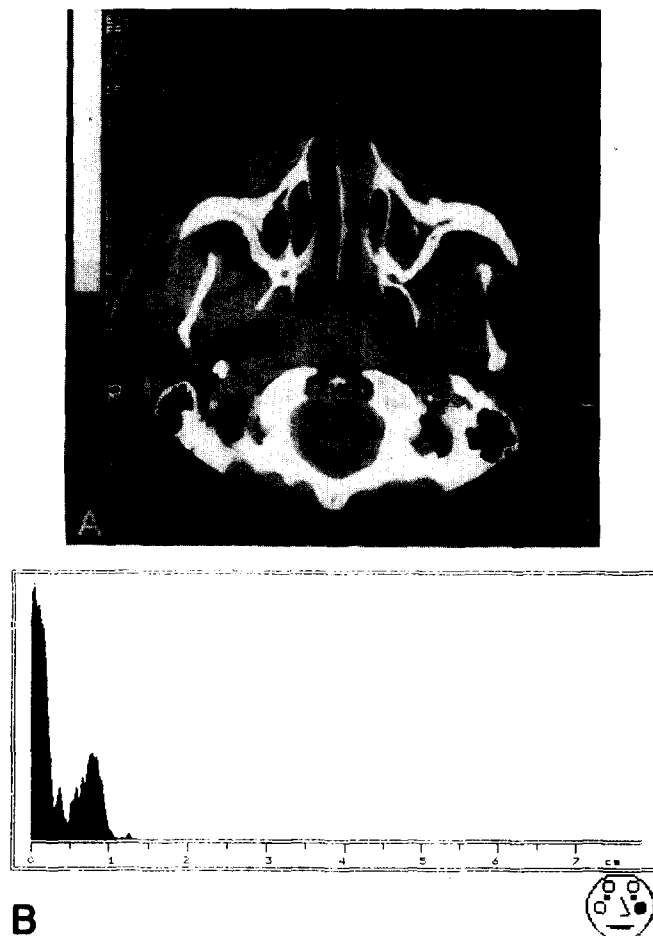


FIG. 1. Marked mucosal thickening on CT (A) with normal US reading (B), patient 10.

the inflammation causing this mucosal hyperplasia and the inflammation seen in asthma indicates that we may be looking at different manifestations of the same underlying inflammatory process.

In patients with asthma, it makes sense to differentiate between microscopic and macroscopic sinusitis. One is the mucosal inflammation present in the lining of the airways. We are not able to detect it with our imaging techniques until it has resulted in mucosal thickening; however, direct endoscopic visualization and nasal cytologic studies may be helpful. The potential significance of this inflammation for the course of the asthma has also been demonstrated by recent data showing that control of allergen-induced inflammation in the nasal mucosa reduces bronchial hyperreactivity.^{12, 13} this could indicate a benefit from local antiinflammatory treatment in cases with marked inflammatory changes of the mucosa visible on inspection.

Once the inflammation has led to significant

swelling of the nasal and paranasal mucosa with blockage of the ostia, it may predispose the patient toward acute or chronic bacterial sinusitis. Of the 19 patients studied, five showed such marked chronic hyperplastic sinusitis with involvement of the ostial-meatal complex. However, newer imaging techniques such as CT and nuclear magnetic resonance imaging have demonstrated that some degree of mucosal or mucoperiosteal thickening in any of the sinuses can also be found in as many as 70% of normal, symptom-free individuals.^{9, 14-17} This is a diagnostic dilemma because it is often difficult or even impossible to determine by a single method what represents a pathologic condition.^{25, 26}

As far as imaging techniques are concerned, an optimal screening method for sinus involvement in asthmatics should distinguish all patients with marked mucosal hyperplasia, as well as those with acute or chronic bacterial sinusitis involving antral fluid. In addition to being as sensitive and specific

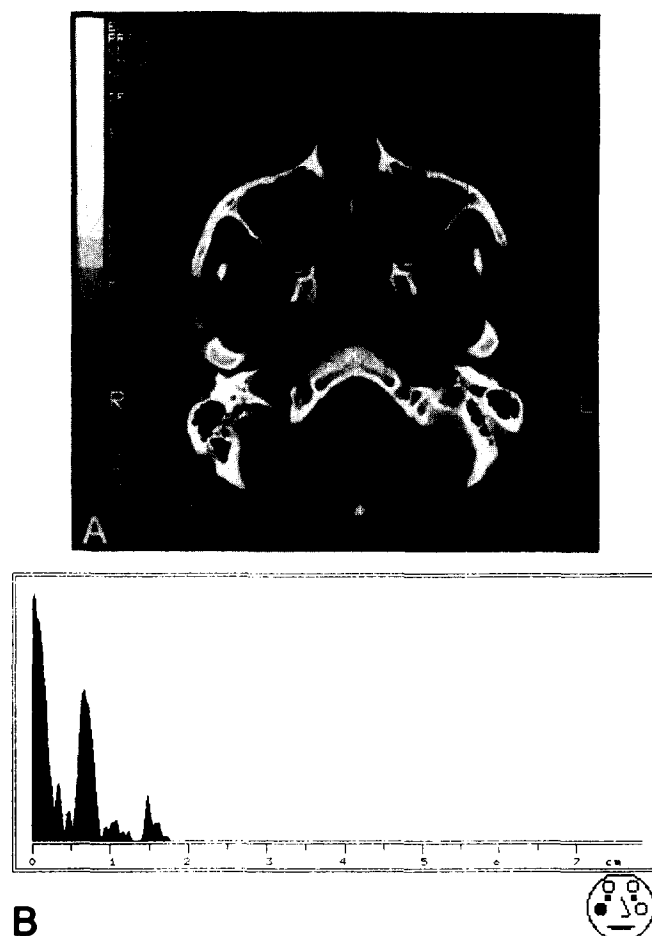


FIG. 2. Normal appearance on CT (A) with US (B) indicating mucosal thickening, patient 7.

as possible, it should be noninvasive and not harmful to the patient, be quick and cost-effective, and have good reproducibility.

US has the advantage of not involving ionizing radiation and thus not limiting the number of follow-up studies. Unfortunately, the method is restricted mainly to the maxillary sinuses, whereas sinus pathology and nasal polyps often originate from the ethmoid.^{18, 19} Another inherent problem with the US examination is that in the absence of fluid in the sinus, only the anterior wall can be evaluated because of complete US reflection by the air in the maxillary sinus. This discrimination of fluid may be helpful in the diagnosis of acute sinusitis,²⁰ but, as mentioned previously, it is not a common finding in routine screening of patients with asthma. The evaluation of mucosal thickening by US remains controversial. Problems also occur because of anatomic variations and the wide range for interpretation.^{3, 21}

In our patients, the US method achieved an overall sensitivity of 70%. However, we have no explanation for the negative US tracings in the two most pronounced cases of mucoperiosteal thickening (Fig. 1). Further investigation is needed to determine whether this represents a physical phenomenon caused by the altered texture of the tissues. In addition to this problem, the specificity of US was as low as 22.2%. The many false-positive readings (Fig. 2) make the method unsuitable as a screening device for these patients.

Previous reports on the use of US have been conflicting and limited by lack of a sufficient gold standard, such as CT or magnetic resonance imaging.^{3, 11, 22} Our results for a group of patients with asthma are similar to those previously published²³ for a group of patients with clinical aspects of sinusitis.

Conventional plain-view radiography managed

to detect all cases of severe mucosal thickening, but sensitivity for minimal mucosal hyperplasia was rather low, at 52.2%. The specificity was satisfactory, at 86.7%. Although two views (occipitodental and occipitofrontal) were applied for this study, the additional information from the occipitofrontal radiograph in our opinion does not justify its primary use as a screening procedure in patients without symptoms. Further limiting factors are the radiation and the fact that patients with a history of previous sinus surgery cannot be evaluated by this method.

Our results show that there is no ideal routine screening method for sinus disease in patients with asthma. The low specificity of US would initiate too many unnecessary additional investigations, so we no longer apply it in symptom-free patients with asthma. It may be useful as a follow-up procedure, where the anatomy is known and especially if antral fluid is involved. When readily available, protocols with a limited CT series of the sinuses may represent a good alternative.²⁴

We continue to employ the standard Waters' view radiograph as a first-line screening method for the paranasal sinuses, as well as the lower third of the nasal cavity. If the known limitations are considered, it remains a fast and cost-effective procedure, followed up by inspection and endoscopic evaluation. Initiation of treatment is always based on the combination of both methods. Obviously if symptoms or results of endoscopic evaluation indicate serious discrepancies or any surgical procedure is considered, CT should be performed.

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