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Acute rhinosinusitis in primary care: a comparison of symptoms, signs, ultrasound, and radiography*

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SUMMARY

In primary care, the diagnosis of acute maxillary sinusitis (AMS) is based most often only on symptoms and clinical examination. This practice leads to many false positive diagnoses and unnecessary use of antibiotics. Sinus ultrasound has been suggested as a means to improve the accuracy of AMS diagnosis. We studied the symptoms, signs, and ultrasound findings in patients with acute rhinosinusitis. Primary care physicians received small group teaching on sinus ultrasound technique. Sinus radiography was performed in a subgroup of patients, and it acted as reference standard. A total of 150 adult patients were recruited to the study, 105 women (70%) and 45 men (30%). Thirteen patients of 32 (41%) in the radiography subgroup and 74 patients of 148 (50%) with ultrasound result had AMS. The sensitivity of ultrasound compared to radiography was 92% and specificity was 95% when results were calculated per patients as unit of analysis. With practice and teaching primary care physicians can perform sinus ultrasound as accurately as specialists. Symptoms and clinical examination were not reliable in AMS diagnosis. If the criterion for AMS diagnosis were fluid in maxillary sinuses in ultrasound instead of clinical impression, the number of antibiotic prescriptions would be reduced by half in primary care.

Key words: acute maxillary sinustitus, ultrasound, primary care

INTRODUCTION

Acute maxillary sinusitis (AMS) is a challenging diagnosis for primary care physicians. Antibiotics are generally considered beneficial in AMS (Williams Jr et al., 2000) but not in viral rhinosinusitis, which may have symptoms closely resembling AMS. Guidelines on the diagnosis of AMS give varying recommendations, and most often the preferred diagnostic strategy is to rely on symptoms and clinical examination (Table 1). However, if the diagnosis is based on clinical examination alone, the rate of false positive results is high, and consequently unnecessary antibiotics are prescribed for rhinosinusitis and antimicrobial resistance is increased (Huovinen and Cars, 1998).

Radiological imaging methods, such as computed tomography or sinus radiography, are not readily available in primary care. Their use may also be considered too time-consuming or expensive (Benninger et al., 2000).

Ultrasound has been suggested as a means to improve the accuracy of AMS diagnosis (Revonta, 1980). Yet reports of its accuracy have not been consistent: in secondary care the accuracy has been found to be good in some studies (Revonta, 1980; Savolainen et al., 1997; Puhakka et al., 2000) whereas in primary care the results have not been as favourable for ultrasound (van Buchem et al., 1995; Laine et al., 1998). When ultrasound has been compared with computed tomography (Pfister et al., 1994; Karantanas and Sandris, 1997; Hilbert et al., 2001)or radiography (Jannert et al., 1981; Rohr et al., 1986; Shapiro et al., 1986; Trigaux et al., 1988; Dobson et al., 1996) the results have also been heterogeneous.

Our aim was to study symptoms, signs, and ultrasound findings in patients with clinically suspected AMS in the context of a randomized controlled trial of AMS therapy. Sinus radiography, which acted as reference standard, was performed on a subgroup

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Table 1. Recommendations in national guidelines on the diagnosis of AMS.

Country, year, ref.	Recommended diagnostic strategy
United States 2001 (American Academy 2001)	Children </= 6, clinical criteria, >6 imaging methods may be necessary
France 2001 (Klossek and Chidiac, 2001)	History and physical examination
United States 2000 (Brooks et al., 2000)	History and physical examination, diagnostic imaging only in atypical cases and treatment failures
Finland 1999 (Suonpää et al., 1999)	Clinical examination and sinus radiography or ultrasound
Canada 1997 (Low et al., 1997)	History and findings on physical examination
United States 1995 (Gwaltney et al., 1995)	History and physical findings

of patients. Primary care physicians performed the sinus ultrasound examinations. For quality control, the results were printed and read later by an ear, nose and throat (ENT) specialist.

PATIENTS AND METHODS

Patients

The study took place in nine health centres in Finland from November 1998 to October 1999 (Karstula, Saarijärvi, Halikko, Salo, Katriina, Simo, Kuivaniemi, Heinävesi and Tikkurila). In this study we report the diagnostic comparisons done on the patients with rhinosinusitis who participated in a randomized controlled trial comparing antibiotics and placebo. The ethical committee of the National Research and Development Centre for Welfare and Health and the local ethical committees at study centres had approved the study protocol. Patients received written and oral information of the study and gave their written informed consent.

Table 2. Parameters of symptoms and signs in study patients. Frequency (1): patients in Karstula who had radiographs taken; frequency (2): all study patients.

	Sensitivity % (n=32)	Specificity % (n=32)	LR+	LR-	Frequency (1) % (n=32)	Frequency (2) % (n=150)
SYMPTOMS						
Maxillary pain	77	11	0.86	2.19	84	85
Nasal discharge	100	*	*	*	100	89
Nasal obstruction	92	11	1.03	0.73	91	93
Hyposmia	62	42	1.06	0.91	59	60
Anosmia	31	79	1.46	0.88	25	42
Unilateral facial pain	62	47	1.17	0.81	56	61
Maxillary toothache	54	63	1.46	0.73	44	47
Postnasal drip	85	5	0.89	2.92	91	87
Malaise	31	53	0.65	1.32	41	35
Headache	69	*	*	*	88	85
Cough	85	21	1.07	0.73	81	80
Temperature 37.6°-38°	46	58	1.10	0.93	44	44
Temperature >38°	8	74	0.29	1.25	19	25
Duration of symptoms more than 5 days	62	16	0.73	2.44	75	72
Double sickening	38	53	0.81	1.17	44	54
SIGNS						
Purulent secretion in the nasal cavity	54	53	1.14	0.88	50	61
Discharge in the pharynx	38	74	1.46	0.84	31	31
Tenderness on sinus tapping	69	21	0.88	1.46	75	69

* Number of true negatives = 0
LR+ = positive likelihood ratio
LR– = negative likelihood ratio

Nurse receptionists at health centres screened patients with upper respiratory tract infections to find possible study patients. Nurses gave written information of the study to all possible rhinosinusitis patients and asked them to fill in a patient information form while waiting for the physician's consultation. Physicians discussed the study with the patients and recorded history, clinical findings and performed sinus ultrasound examination.

The study covered adult patients (over 18 years of age) with a clinical diagnosis of AMS. The minimum criteria for a clinical diagnosis of AMS were at least three symptoms and one out of three signs typical to AMS. Reasons for exclusion included duration of AMS symptoms for more than 30 days, anti-microbial treatment during the last month, pregnancy or breastfeeding, an acute phase of a diagnosed chronic maxillary sinusitis, clinical suspicion of dental or frontal sinusitis or pansinusitis or suspicion of a severe complication, and previous sinus surgery.

Symptoms and signs

The study form included 12 symptoms (Table 2) related to AMS (including temperature categories from 37.6°C to 38°C or >38°C). The patients were also inquired whether the symptoms had lasted for more than five days, and whether the disease had reappeared (double sickening). The patients were asked to mark the severity of symptoms on a 3-step scale (1 = no, 2 = little, 3 = much).

During consultation, the physicians filled in a study form that covered the patient's history of AMS and sinus punctures, possible comorbidity of chronic rhinitis and asthma, and three clinical signs: purulent secretion on rhinoscopy, secretion in the pharynx, and sinus tenderness when tapped with fingers.

Ultrasound

We used an A-mode ultrasound device with a printer (Sinuscan 102, Oriola, Finland). The frequency of the unfocused transducer was 3 MHz and the diameter of the piezoelectric disc was 8 mm. The ultrasound examination was performed according to a practised strategy as described before (Revonta, 1980, Savolainen et al., 1997). The physicians taking part in the study received a small group tutorial of 1.5 hours on the use of ultrasound given by an experienced ENT specialist (SS or MR). The criterion for AMS was a back wall echo on the screen of the device at a distance of 3.5 cm or more, indicating fluid in the maxillary sinus. None of the other pathological findings were considered sinusitis. The physician classified the result of both maxillary sinuses as sinusitis or non-sinusitis.

For quality control, the ultrasound results on the screen of the device were frozen and printed. The print outs were later read by an ENT specialist (MR) without knowledge of the clinical situation. All A-mode echo peaks at the depth of 3.5 cm or more were accepted as back wall echoes except those that were probably caused by multiple reflections of ultrasound between the probe and air in an aerated sinus. The interpretations were compared with those of the primary care physicians.

Radiography

At Karstula health centre, all patients had a sinus radiography taken (occipito-mental projection, Waters' view) within 15 minutes to 1 hour from the ultrasound examination. Two ENT specialists (MR and SS) interpreted the radiographs independently and without knowledge of the clinical situation or the ultrasound result. Criteria for AMS were total opacification, and existence of an air-fluid level or mucosal thickening of 6 mm or more.

Statistical analysis

Sinus radiography served as a reference standard for patients at Karstula health centre. We calculated the sensitivity and specificity, their confidence intervals (CIs), and positive and negative likelihood ratios (LRs) for symptoms, signs and ultrasound compared to radiography. We performed logistic regression to analyse the correlation of symptoms and signs to radiography findings. We cross-tabulated symptoms and signs with ultrasound results and tested for possible correlations. We calculated Cohen's Kappa statistics for the comparison of the interpretations of ultrasound performed by primary care physicians and specialists. For statistical analyses we used StatView 5.0 software.

RESULTS

Patients

Thirty-five primary care physicians in nine health centres recruited patients to the study. The study included 150 patients with clinically suspected sinusitis, 105 women (70%) and 45 men (30%). The age range of the patients was from 18 to 75 years, and the mean was 39.7 years. One hundred twenty five patients (83%) reported having had AMS before and 45 (30%) had undergone sinus puncture. The information on possible comorbidity, allergic or vasomotor rhinitis and asthma is presented in Table 3.

Symptoms and signs

The study patients had many symptoms related to AMS: the mean number of symptoms (little or much) was 8.1 (SD 1.9, range 4 - 12). Nasal obstruction, nasal discharge, postnasal drip, maxillary pain, headache and cough were among the most common symptoms (Table 2). In 72% of the patients the symptoms had persisted for more than 5 days, and 54% had experienced reappearance of the symptoms (double sickening). Likelihood ratios for symptoms were close to 1 (Table 2), and such LRs alter the pre-test probability of disease little, if at all (Jaeschke et al., 1994).

The occurence of the reported symptoms were cross-tabulated with the results of sinus ultrasound (Figure 1). The reported

Table 3. Comorbidity of chronic rhinitis or asthma in study patients.

	Ultrasound: No sinusitis (n=74) n (%)	Ultrasound: Sinusitis n=74) n (%)
Allergic rhinitis	15 (20)	19 (26)
Vasomotor rhinitis	4 (5)	7 (9)
Asthma	5 (7)	5 (7)

symptoms occurred frequently both in patients with rhinosinusitis and in those with AMS. In patients with sinusitis verified by ultrasound the mean number of symptoms was 8.0 (SD 1.9) and in patients without sinusitis the mean was 8.2 (SD 1.8). The patients with sinusitis on ultrasound reported more often much secretion in the pharynx, cough and anosmia. Unilateral facial pain was reported by 58% of patients in ultrasound negative and 65% in ultrasound positive group. However, the differences were not statistically significant. In the subgroup of patients with radiological sinusitis, the mean of symptoms was 7.8 (SD 1.7) in patients with sinusitis and 8.1 (SD 1.4) in those without sinusitis. None of the symptoms predicted radiography findings reliably in logistic regression.

We chose the symptoms and signs with the highest correlation coefficients in logistic regression and tested different combinations of symptoms to find tools to predict AMS. If a patient had two out of three signs (maxillary pain, maxillary toothache or postnasal drip), sensitivity was 71% (95% CI 56 - 87%) and specificity was 42% (95% CI 25 - 59%). We did not find practicable combinations of symptoms that would increase the specificity of AMS diagnosis.

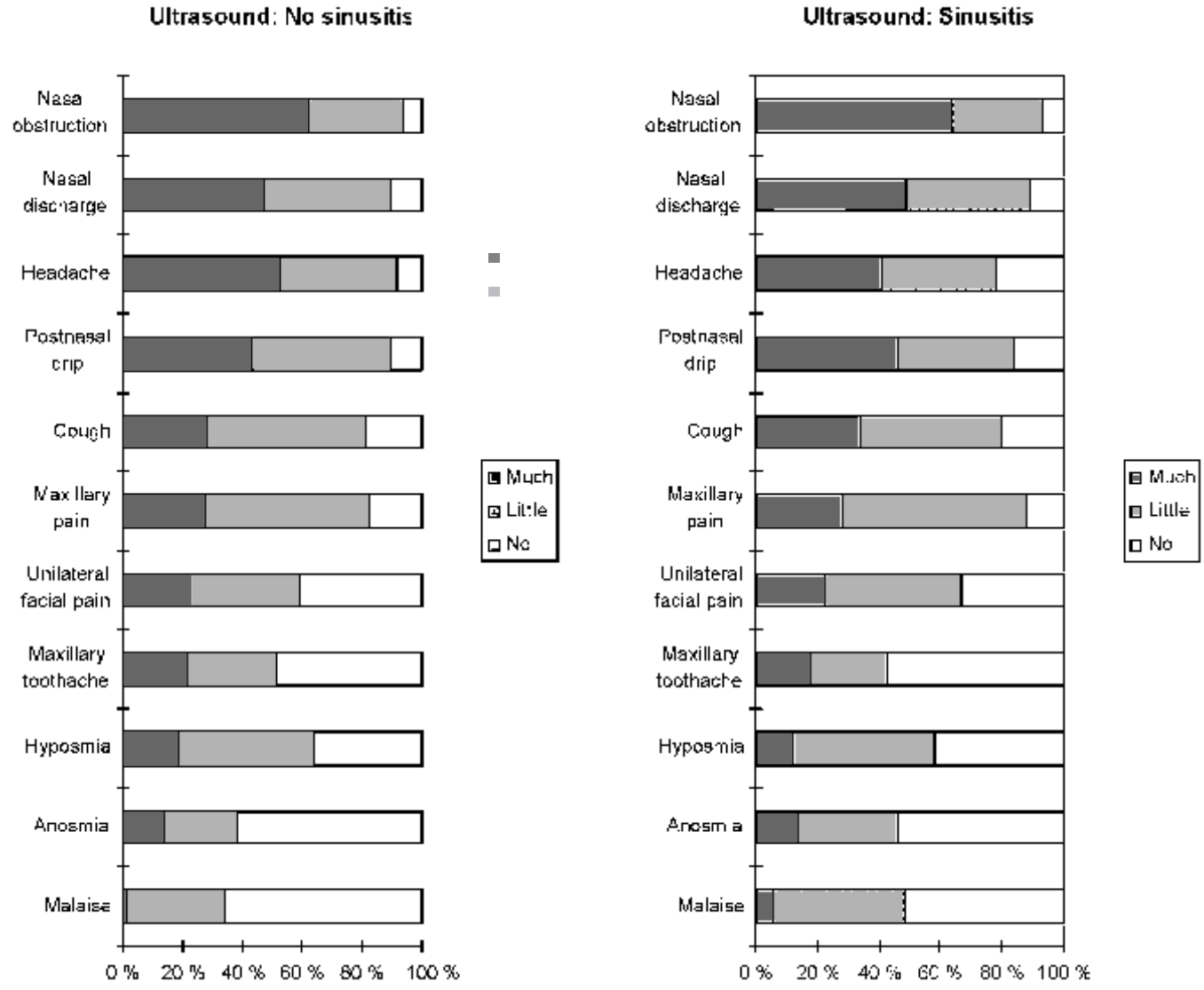

Figure 1. Frequency of symptoms cross-tabulated according to the ultrasound result (n=148).

Ultrasound

The physicians performed sinus ultrasound on 148 patients, and 74 (50%) tested positive. Fourteen patients (23%) had bilateral sinusitis. Examinations of 129 patients were printed and analysed later also by an ENT specialist (MR). In the subgroup of radiological confirmation, ultrasound predicted well the occurrence of AMS. When the results were calculated per patient, the overall sensitivity of ultrasound was 92% (95% CI 83 - 100%) and specificity 95% (95% CI 87 - 100%) (Table 4). When the results were calculated per sinus the sensitivity was 71% (95% CI 59 - 82%) and specificity was 91% (95% CI 85 - 98%) (Table 4b). Positive likelihood ratios were 17.5 and 11.1, respectively. LRs over 10 produce major changes from pre-test to post-test probabilities (Jaeschke et al., 1994).

Table 4. Comparison of ultrasound by a primary care physician versus radiography: Patients as the unit of study (n=32).

PATIENTS	Radiography: Sinusitis	Radiography: No sinusitis	Total
Ultrasound: Sinusitis	12	1	13
Ultrasound: No sinusitis	1	18	19
Total	13	19	32

Sensitivity = 0.92 (95% CI 0.83 – 1.00)
Specificity = 0.95 (95% CI 0.87 – 1.00)
LR + = 17.5
LR – = 0.08

Table 4b. Comparison of ultrasound by primary care physician versus radiography: Sinuses as the unit of study (n=64).

SINUSES	Radiography: Sinusitis	Radiography: No sinusitis	Total
Ultrasound: Sinusitis	12	4	16
Ultrasound: No sinusitis	5	43	48
Total	17	47	64

Sensitivity = 0.71(95% CI 0.59 – 0.82)
Specificity = 0.91 (95% CI 0.85 – 0.98)
LR + = 8.29
LR – = 0.32

The interpretations of ultrasound examinations by the primary care physicians and the interpretations of the printouts by the specialist correlated moderately well (Table 5). The observed agreement was 81% and the Cohen's Kappa for agreement was 0.47. The specialist disagreed on sinusitis diagnosis in 35 cases. Of these, the reading of ultrasound printouts revealed 11 sinuses (31%) with a false positive A-mode echo peak at the distance of 3.5 cm or more due to multiple reflections of ultrasound between the probe and air in an aerated sinus. When compared to radiography, the ultrasound interpretation by specialist was false positive in four sinuses and there were no false negatives.

Radiography

Radiography was studied in 33 patients at Karstula health centre. One patient was dismissed from analysis because of an unreadable radiograph. Thirteen patients of the 32 (41%) tested positive for AMS. In the first reading, the two ENT specialists (SS and MR) disagreed on six sinus interpretations in four patients. These radiographs were read again, and disagreements were solved by consensus. Four patients had sinusitis in both maxillae, and nine had unilateral sinusitis. The findings in 17 pathological radiographs included air - fluid level in 12 cases (70%), total opacification in two cases (12%), and mucosal thickening of 6 mm or more in three cases (18%). Slight mucosal thickening (5 mm or less) was seen in seven sinuses of five patients diagnosed as not having sinusitis. The radiography findings are compared to ultrasound diagnosis of the primary care physician in Table 6.

DISCUSSION

The accuracy of ultrasound compared to radiography was better in our study than in earlier primary care studies. The best results, sensitivity 0.92 and specificity 0.95, are on the same level as the results of specialists in earlier studies (Revonta, 1980; Savolainen et al., 1997). In this study the aim of the ultrasound examination was to detect fluid in the maxillary sinus as a sign of AMS. The good results may be due to this

Table 5. Agreement of ultrasound by a primary care physician and interpretation of ultrasound printouts by a specialist (Number of sinuses 251).

Ultrasound	Specialist: Sinusitis	Specialist: No sinusitis
Primary care physician: Sinusitis	33	35
Primary care physician: No sinusitis	12	171

Observed agreement 81%, Cohen's Kappa 0.47 (moderate agreement)

Table 6. Comparison of radiography findings and primary care physicians sinus ultrasound diagnosis (Number of sinuses = 64).

Radiography finding	Ultrasound: Sinusitis	Ultrasound: No sinusitis	Total
Air-fluid level	8	4	12
Total opacification	2	0	2
Mucosal thickening ≥ 6 mm	2	1	3
Mucosal thickening ≤ 5 mm	1	10	11
Normal	2	33	35
Cyst	1	0	1
Total	16	48	64

simple strategy, but also to the fact that the physicians at Karstula health centre were experienced and had used sinus ultrasound for several years.

It seems that the 35 physicians in this study had learned the right pattern of ultrasound reading. It is probable that the small group tutorial had an effect on the physicians' skills of sinus ultrasound interpretation. The overall correlation of ultrasound interpretations by the specialist and the primary care physicians was good – of the 251 sinuses agreement was found in 204 (81%).

The main difference was found when primary care physicians reported sinusitis but the specialist did not find the back wall echo on the printouts. In one third of the cases this difference was due to multiple reflections, e.g. the ultrasound beam was bouncing back and forth between the probe and the air in the sinus – both are good reflectors – and caused several A-mode echo peaks on the display at equal intervals, up to the distance of 3.5 cm or more.

Another possible explanation to the disagreement is that the primary care physicians were not able to freeze the best echo for printing and the specialist did not get all positive cases for evaluation. Sinus ultrasound is a dynamic examination, and having the best view frozen and printed requires special skills and successful timing. The origins of possible false positive interpretations in sinus ultrasound, as well as the technique of freezing and printing the results should be emphasized in education even more than we did in our tutorial.

Performing sinus ultrasound has recently become a part of the curriculum in some medical faculties; yet many physicians are still unfamiliar with the interpretation of sinus ultrasound. In a previous primary care study (Laine et al., 1998), the physicians had only the manufacturer's written information on the use of ultrasound and the results were much weaker than ours.

Lack of good reference standards makes studying the accuracy of ultrasound difficult in primary care settings. Radiography was the only feasible reference standard for our study. Computed tomography is generally not available in primary care, and it also tends to produce false-positive findings (Gwaltney et al., 1994; Lindbaek et al., 1996b). Sinus puncture is an accurate reference standard, but it is invasive and not ideal for primary care patients. Radiography is not an error-free reference standard, and both false-negative and false-positive interpretations are possible. False-negative interpretations are even more likely when only one view is used. An imperfect reference standard reduces the estimated sensitivity and specificity of the test studied (Begg, 1987). The misclassifications due to the imperfect reference standard can be corrected (Staquet et al., 1981). However, the size of our material did not allow making these corrections.

All patients in our study had a clinical suspicion of AMS. They reported having on average eight symptoms related to AMS. This type of a patient population would in most cases be treated with antibiotics if the diagnosis were based on history and clinical examination alone. We tested for different combinations of symptoms and signs to find tools to predict AMS. Combining several items of clinical examination increased sensitivity, and with high sensitivity, clinical examination may rule out AMS. However, when patients tend to have a large number of symptoms and signs, clinical criteria can hardly ever rule out AMS.

The combination of symptoms did not lead to better specificity. The number of false positives remained high, and symptoms and signs were not helpful in choosing patients for treatment with antibiotics. This study strengthens the findings of previous works (Hansen et al., 1995; Lindbaek et al., 1996a): history and clinical examination are very uncertain tools in diagnosing AMS. More specific diagnostic methods are needed to rule in AMS.

Meta-analyses on the diagnosis of AMS have presented variation in ultrasound performance (Engels et al., 2000; Varonen et al., 2000). This may be explained by different aims: ultrasound is not accurate in the diagnosis of mucosal swellings, and in patients with chronic sinusitis polypoid masses may resemble fluid in the sinuses (Vento et al., 1999). Our results can not be generalized to patients with chronic or dental sinusitis that were excluded from our study. Sinus ultrasound is a specific and reliable diagnostic method if the aim is to detect fluid in the maxillary sinuses in patients with suspected AMS.

CONCLUSIONS

In our study of patients with a high clinical suspicion of sinusitis, 41% of the patients had AMS on radiography and 50% on ultrasound. The use of these diagnostic methods would reduce the number of antibiotic prescriptions by half in patients with AMS diagnosed with clinical criteria. Even a short tutorial can improve primary care physicians' accuracy in sinus ultrasound examination. The education should put emphasis on the origins of possible false positive interpretations in sinus ultrasound. If ultrasound were used more widely in primary care, the number of radiological examinations could be reduced and unnecessary courses of antibiotics for AMS prevented.

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