

Ultrasound and antral lavage in the examination of maxillary sinuses*

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SUMMARY

Two hundred and ninety maxillary sinuses in 206 patients, suspected of having acute or prolonged maxillary sinusitis, were examined using ultrasound (US) and then irrigated with isotonic saline. The results of the antral lavage and the US were compared and various US recording variables were analyzed. The sensitivity of US examination to find maxillary sinus secretion was 77% and the specificity 49%. The distance from the initial echo to the back wall echo (BWE) and the ratio of the echo-free area to the distance from the initial echo to the BWE were sensitive indicators of the presence of maxillary sinus secretion. The results suggest that US is a relatively sensitive method also in the diagnosis of prolonged maxillary sinus inflammations. However, its low specificity weakens its value in clinical work. The usability of US in the diagnosis of maxillary sinusitis can be increased by intermittently controlling US findings by sinus puncture. This is of particular importance for general practitioners, but also for specialists.

Key words: antral lavage, diagnosis, maxillary sinusitis, screening, ultrasound

INTRODUCTION

In diagnostic examination of the paranasal sinuses, the X-ray is increasingly being replaced by A-mode ultrasound (US). The method is used both by otolaryngologists and recently, even more frequently, by general practitioners (Mann et al., 1977; Haapaniemi, 1997; Laine et al., 1997). It is generally known that there are many difficulties in interpreting US tracings, i.e. a number of conditions that may simulate a back wall echo (BWE). Most false positive echoes arise from the teeth or the lateral wall of the maxillary sinus (Revonta, 1980). Erroneous interpretation of results is especially likely when a physician uses only US without occasionally controlling the findings by means of sinus radiography or antral lavage (Revonta, 1980; Haapaniemi, 1997). Most general practitioners have not had the relevant teaching to evaluate US findings of paranasal sinuses (Laine et al., 1997). Despite a number of reports in which US was considered a reliable and useful examination method of paranasal sinuses (Revonta, 1980; Jannert et al., 1982; Katholm et al., 1984; Savolainen et al., 1997), a recent international conference on sinus disease disputed its reliability: ultrasonography, which gives information of similar quality to that obtained from transillumination, is of dubious value, provides variable results, and is not recommended (Kennedy et al., 1995).

On the other hand, US is an inexpensive, fast and noninvasive procedure, and it is suitable for repeated use. Ethically, it is also suitable for patients without symptoms of sinusitis (van Duijn et al., 1992). Moreover, there are a number of studies where comparisons between US and X-ray examinations show a preference for US, especially in children (Revonta and Kuuliala, 1989). The concordance of US and radiography of maxillary sinuses has ranged from 68% to 94% in children (Mann et al., 1976; Revonta and Kuuliala, 1989; Haapaniemi, 1997), and from 39% to 95% in adults (Böckmann et al., 1982; Shapiro et al., 1986). Recently, Savolainen et al. (1997) showed that US and sinus X-ray were equally reliable in diagnosing fluid retention, when the results were compared to sinus irrigation. The variation in agreement is rather large due to the equipment and criteria used in evaluating examination results, and also the examiner has a great influence on US results.

Sinoscopy of the maxillary sinus and antral lavage are objective and reliable methods to show pus in the maxillary sinus. The degree of conformity between maxillary sinus US and irrigation has ranged from 86% to 94% (Mann et al., 1977; Revonta, 1980; Revonta and Suonpää, 1981; Savolainen et al., 1997). In the majority of these studies, accurate US instruments have been used with possibilities of both A- and B-scanning. However,

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also much poorer concordances between sinus puncture results and US have been described (Jannert et al., 1982; Katholm et al., 1984; Pflleiderer et al., 1984). Recently, Laine et al. (1997) reported that the accuracy of US compared to sinus puncture was only 56% when general practitioners made the examination. The interpretation of US results is based to a large extent on the studies of Revonta (1980), Jannert et al. (1982), and Holmer et al. (1982). The first echo is always an initial echo or transducer pulse. The air-mucosa echo (AME) is the first real echo that is clearly detectable if secretion is not present. The initial echo and the AME together comprise the front wall echo (FWE). The back wall echo (BWE) is a single prominent echo at a distance of ≥ 3.5 cm (Revonta, 1980) or 4-6 cm (Jannert et al., 1982) in adults. It is also supposed that the BWE is preceded by an echo-free area of at least half (Revonta, 1980) or 1/3 (Jannert et al., 1982) of the distance from the initial echo to the BWE. The presence of a BWE is considered to be the only certain sign of secretion. Multiple echoes with regular intervals are due to a thin frontal bone of the sinus, while polypoid mucosal swelling or a cyst may also cause multiple echoes. A double echo (an echo with two peaks) after an echo-free area is a tracing indicating the presence of a cyst in the sinus.

The purpose of the present investigation was to study the concordance of the US and irrigation results in examining maxillary sinuses for suspected sinusitis. The examinations were made as a routine procedure in the busy office of an ENT specialist.

MATERIALS AND METHODS

The study comprised 206 unselected patients, who were referred for otological consultation by general practitioners because of acute or prolonged symptoms of maxillary sinusitis. Thirty-six patients had subjective symptoms of acute maxillary sinusitis. All the others were patients who had already received antimicrobial treatment for sinusitis or had had prolonged symptoms suggestive of sinusitis, such as rhinorrhea, cough or fullness in the cheek. The patients were aged 12-95 years (mean 42.3 years) and 146 (71%) were women. Only five (2.4%) of the patients were children under the age of 16. US and antral lavage were performed altogether on 290 maxillary sinuses. Of all the patients, 76 were examined two or more times. Irrigation was done under local anesthesia by inserting a trocar into the maxillary sinus via the inferior meatus. The sinus was irrigated with isotonic saline. The washout return was classified as clear (Puncture negative) and pus or cyst fluid (Puncture positive).

The US examination was performed using A-scan equipment (Sinuson 810, Teltec/Amlab, Sweden) with an oscilloscope-display. The transducer diameter was 13 mm and the frequency 3.5 MHz. The picture could be frozen with the aid of a foot-switch and transferred to a printer for data analysis. The examination method was according to Revonta (1980). The results were classified as US negative (BWE absent), when only the initial pulse with or without the AME was recorded, and US positive (BWE present), when there was an echo-free area between the AME and BWE, regardless of the length of this area. Double echoes and multiple echoes were recorded and classified as US negative.

A-scans were analyzed on paper and several variables were recorded: the area of the FWE, the distance from the initial echo to the peak of the BWE, the length of the echo-free area preceding the BWE, the height of the BWE and the ratio of the echo-free area to the distance of the BWE. The correlation between these variables and antral lavage results was studied by Spearman correlation test.

RESULTS

The correlation of US and irrigation findings is presented in Table 1. Out of all 290 maxillary sinuses irrigated, 98 (34%) yielded no secretion. The return was pus in 190 (65%) sinuses, and cyst fluid in 2 (1%). Correspondingly, the US showed 61 (21%) negative findings (BWE absent), 198 (68%) one BWE (BWE present), 28 (10%) multiple echoes and 3 (1%) double echoes. The sensitivity of US was 77%, and the specificity 49% (Table 2). If the distance to the BWE was considered the only criterion for sinusitis and the cut-off point was 35 mm, the sensitivity of US to find secretion was 73% and the specificity 55% when the distance was ≥ 35 mm (Table 3). The results were similar when the ratio of the echo-free area to the BWE was considered the only criterion and the cut-off point was 0.50 (Table 4). When the echo-free area was 1/3 of the distance to the BWE, the sensitivity increased but the specificity decreased, as presented in Table 4.

The measurement results of different variables of US printouts, are presented in Table 5. There were no statistically significant differences in the area of the FWE or the height of the BWE between puncture positive and negative sinuses ($p > 0.05$). The distance to the BWE and the echo-free area, and the ratio of these variables were, however, greater in maxillary sinuses with a positive puncture result than in those with a negative puncture result and the differences were statistically significant ($p < 0.001$). Correlation coefficients were positive, even though relatively weak: 0.270, 0.309 and 0.295, respectively. There were no differences between the sexes.

DISCUSSION

The age- and sex-distribution of our patients was similar to that of other studies, and the vast majority of adult patients were female (Berg and Carenfelt, 1985; Mäkelä and Leinonen, 1996). US of maxillary sinuses is reported to be most accurate in normal, air-containing sinuses (Pflleiderer et al., 1984; van Buchem et al., 1992; Dobson et al., 1996; Haapaniemi, 1997). The results of the present study cannot confirm this finding, as the absence

Table 1. The correlation of US and puncture results, when all the different findings were included.

Puncture	Ultrasound				Total
	BWE present	BWE absent	Multiple echoes	Double echo	
Secretion	147	32	11	0	190
Cyst fluid	1	0	1	0	2
Negative	50	29	16	3	98
Total	198	61	28	3	290

Table 2. Comparison of US and puncture findings when puncture results were either positive (pus or cyst fluid) or negative and the BWE either present or absent (including multiple and double echoes).

Puncture	Ultrasound				
	n	BWE present		BWE absent	
		n	%	n	%
Positive	192	148	77	44	23
Negative	98	50	51	48	49

Sensitivity, 77 % (148/192)
 Specificity, 49 % (48/98)

Table 3. Correlation between puncture findings and US results when the cut-off point of the distance to the BWE was the 35 mm that differentiates the healthy sinus from the diseased (Revonta et al., 1980). The figures describe the accuracy of the distance to the BWE for the detection of sinusitis.

Puncture	n	BWE ≥35 mm		BWE absent or <35 mm	
		n	%	n	%
		Positive	192	141	73
Negative	98	44	45	54	55

Sensitivity, 73 % (141/192)
 Specificity, 55 % (54/98)

Table 4. Puncture results according to the ratio of the echo-free area and the BWE, when the cut-off points were 0.50 (Revonta, 1980) and 0.33 (Jannert et al., 1982).

Puncture	Ratio of the echo-free area to the BWE								
	n	≥0.50		<0.50		≥0.33		<0.33	
		n	%	n	%	n	%	n	%
Positive	192	143	74	49	26	155	81	37	19
Negative	98	40	41	58	59	59	60	39	40

Ratio ≥0.50: Sensitivity, 74 %
 Specificity, 59%
 Ratio <0.33: Sensitivity, 81 %
 Specificity, 40 %

Table 5. Different US variables in sinuses with negative or positive puncture results, in male, female, and all sinuses.

	Ultrasound variables				
	Area of the FWE (n=290)	Height of the BWE (n=229)	Distance to the BWE (n=229)	Echo-free Area (n=229)	Ratio (n=229)
Puncture positive	16.1	7.7	42.9	26.9	0.62
Puncture negative	16.8	6.9	38.4	20.9	0.52
Male	16.7	7.9	41.7	24.8	0.58
Female	16.2	7.4	41.5	25.2	0.59
Total	16.3	7.5	41.5	25.1	0.59

FWE = front wall echo
 BWE = back wall echo
 Ratio = ratio of the echo-free area to the distance of the BWE

of the BWE predicted a negative puncture result only with a 52% probability (48/92). Excellent results are obtained also from diseased sinuses when US is done under well-controlled conditions by experienced examiners employing sophisticated US units (Mann et al., 1977; Revonta, 1980), while routine and readily accessible office examinations often afford inconclusive and incorrect results, producing problems in interpretation (Shapiro et al., 1986; van Buchem et al., 1992; Laine et al., 1998). The results often also vary according to the equipment used, as Jannert et al. (1982) have reported. In the present study, the accuracy of US was weaker than in many other studies made by ENT specialists, at least partly because of the different patient material. We presume that the diagnostic accuracy of US is better in patients with acute maxillary sinusitis than in patients with more prolonged symptoms and findings.

In the present study, Sinuson 810 was used in all examinations because it is easy to perform, non-invasive, and has a relatively easily interpreted display where the height of the BWE often correlates directly with the amount of secretion in the sinus. To date, there are four studies in which Sinuson 810, an oscilloscope-display US device designed for outpatient clinics and invasive control has been used. In the study of Jannert et al. (1982), Sinuson 810 detected the pathology correctly in 74% of sinuses when mucosal swelling, secretion and cyst were examined. When only fluid was considered, ultrasound found it in 76% of sinuses. The results of the present study are in accordance with those of Jannert et al. (1982). Katholm et al. (1984) reported a correspondence between the puncture and ultrasound in 62% of cases when 5 different physicians, and in 91% of cases when one ENT specialist, examined all patients. Pfleiderer et al. (1984) reported the accuracy of US to be 60% in predicting the lavage findings. Berg and Carenfelt (1985) found the correspondence between the two methods to be 82% with a sensitivity of 70% and a specificity of 91%. As to US detection of fluid in the sinus, the results of the present study are good for sensitivity but poor for specificity.

The greatest advantages of A-mode US are reported to be in examination of the maxillary sinuses and in children from the age of 3 years, especially in the follow-up of sinusitis, because US shows normal findings clearly earlier than radiography (Revonta and Kuuliala, 1984). Due to the small number of children in the present study, conclusions on the latter cannot be drawn from this investigation. During pregnancy, US is the method of choice in examining the maxillary sinuses without unnecessary ionizing radiation. US is of limited value in diagnosing mucosal swelling and its capability to demonstrate details in the maxillary sinus, such as polyps and cysts, is poor (Jensen and von Sydow, 1987; Reilly et al.; 1989 Savolainen et al., 1997). This was also found in the present study.

Many authors classify the US tracing as mucosal swelling when the area of the FWE is 1.5 - 3.0 cm (Jannert et al., 1982; Jensen and von Sydow, 1987). According to the present study, nothing can be established about mucosal swelling using US. There were no statistical correlations between the area of the FWE and puncture results.

The tracing of multiple echoes is a questionable finding and makes conclusions controversial. According to Jannert et al. (1982), multiple echoes are caused by the rebounding of the ultrasound beam in the frontal wall of the sinus. In the present study, in approximately 60% of sinuses with a finding of multiple echoes, irrigation was negative.

On the basis of the results of the present study, the examiner cannot be quite sure about the condition of the maxillary sinuses, when the BWE is absent or when there are multiple or double echoes. This is due to the fact that approximately half of the sinuses (32/61), in which US showed no BWE, yielded secretion on irrigation. The authors recommend the use of a sinus X-ray, according to which the treatment can be planned. The number of false-positive findings in this case was rather low (17%) and thus US of maxillary sinuses can be considered a sensitive method. The strategy for handling patients with a positive finding on US is to treat them as patients with maxillary sinusitis. We recommend that the examiner intermittently controls US findings by sinus puncture. This is particularly important among general practitioners for more correct interpretation of the significance of different US echoes. In two recent examinations, made in Finnish primary care, it was concluded that US examinations are difficult to interpret, and that the techniques of performing US and interpreting the findings need to be taught (Mäkelä and Leinonen, 1996; Laine et al., 1998). We are of the opinion that the blind and incompetent use of US among general practitioners has led to an increase in sinusitis diagnosis that does not correspond to reality. False-positive findings are easily obtained by an inexperienced examiner. Therefore, otolaryngologists must undertake to train general practitioners in the use of US by recommending antral puncture verification of the US echoes. Controlling US findings by sinus puncture is the best education in the use of US, even for specialists.

In conclusion, US is a relatively sensitive method in the diagnosis of fluid in adult maxillary sinuses. We cannot set exact criteria for the BWE because secretion was found, even though the distance to the BWE was <35 mm or the ratio of the echo-free area to the BWE was <0.50 or <0.33. However, the possibility of finding fluid is higher when the distance to the BWE is ≥ 35 mm and the ratio is ≥ 0.50 .

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