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The "sinusogram", a real-time ultrasound sign of maxillary sinusitis

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Abstract *Objective*: To describe a real-time ultrasound sign, the visualization of the cavity and the walls of the maxillary sinus ("sinusogram"), and to assess its correlation with total opacity of the sinus.
Design: Prospective clinical study.
Setting: The medical ICU of a university-affiliated hospital.
Patients: The significance of this sign was assessed in 50 critically ill supine patients (100 maxillary sinuses) who underwent paranasal CT.
Measurements and results: The "sinusogram" was defined as complete when the internal, external and posterior walls were frankly visible, and incomplete in the case of partial visualization of the walls. The "sinusogram" was present in all 21 cases of total opacity, in 2 of 12 cases of air-fluid level, in 8 of 14 cases of mucosal thickening, in one giant polyp, and in none of 52 normal sinuses. The "sinusogram" was complete in 10 of 21 cases of total opacity. It was incomplete in 11 of 21 cases of total opacity and in all 8 cases of mucosal thickening with positive ultrasound. For the diagnosis of radiologic maxillary sinusitis (total opacity or air-fluid level within the maxillary cavity), the sensitivity was 67% and the specificity 87%. For the diagnosis of total opacity (versus absence of total opacity, which includes fluid level), the sensitivity was 100% and the specificity 86%. When the "sinusogram" was complete, the specificity was 100% for the diagnosis of total opacity.
Conclusions: Ultrasound may be proposed in first-line diagnosis of radiologic maxillary sinusitis.

Key words Maxillary sinusitis · Critical care · Ultrasonography · Mechanically ventilated patients

Introduction

Nosocomial pneumonia is a major concern in a ventilated patient. Among risk factors, infectious maxillary sinusitis may play a role [1]. This diagnosis should be considered in the presence of infectious syndrome without obvious etiology, and usually requires referral to computerized tomography (CT) [2]. A correlation has clearly been outlined between radiologic maxillary sinusitis and the presence of infection in the maxillary sinuses [1]. Sinusitis may also be present in the frontal, ethmoidal and sphenoidal sinuses, but only the maxillary sinus is accessible to simple drainage. For safety and economic reasons, any technique that would diminish the number of CT referrals could be useful. Ultrasound has been proposed for investigation of paranasal sinuses, but the available studies refer only to the A-mode [3–13]. Though most of these studies indicate good reliability, the A-mode yields a graphical representation whose interpretation is recondite. Clinical experience suggests that total opacity of a sinus gives a concrete image using real-time (B-mode) ultrasound.

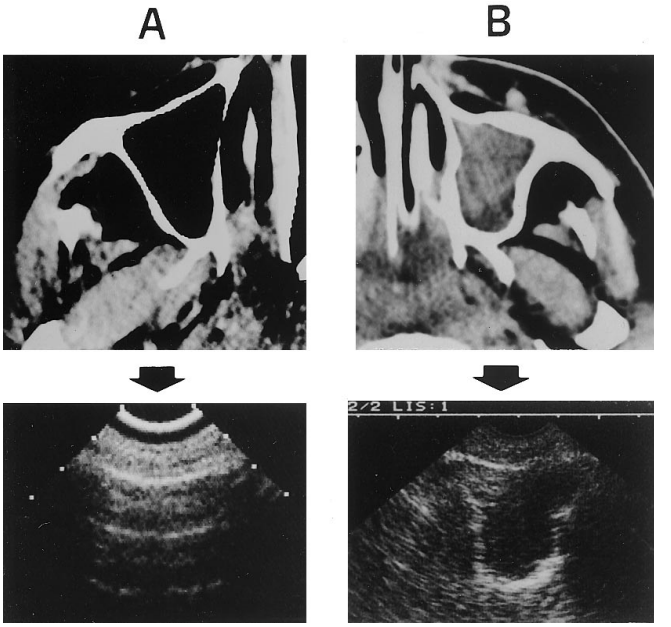

Fig. 1 Normal versus pathologic ultrasound pattern. **A**: normal right maxillary sinus (CT), and ultrasound equivalent, transverse section (*arrow*): complete acoustic barrier. **B**: total opacity of the left maxillary sinus (CT), and ultrasound equivalent : the internal, posterior and external walls of the sinus outline the opacified cavity, giving a complete "sinusogram"

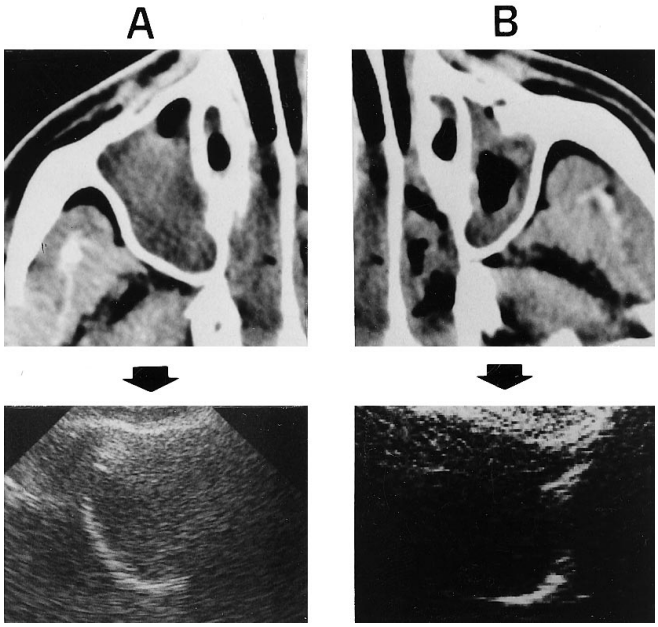

Fig. 2 Cases of incomplete "sinusogram". **A**: 90 % air-fluid level of the right sinus (CT), and ultrasound equivalent: incomplete "sinusogram", with non-visualization of the internal wall. **B**: substantial mucosal thickening of the left sinus (CT), and ultrasound equivalent: incomplete "sinusogram" (non-visible internal wall, ill-defined external wall)

Methods

Patients

This was a prospective study over a 2-year period, including all patients having CT analysis of the maxillary sinuses during a brain CT. All CTs were required clinically. One hundred sinuses in 50 consecutive patients admitted to our intensive care unit (ICU) were studied. The average age was 51 years (range 16–80, 28 men and 22 women). Thirty-six patients were on mechanical ventilation.

Computerized tomography

CT scanning was performed using a Elscint CT Twin Flash (Elscint, Haifa, Israel) on the day of ultrasound examination, in the supine position. Consecutive 8-mm slices including the paranasal sinuses from the hard palate to the orbita parallel to the orbitomeatal plane were performed [14]. As previously recommended, radiologic maxillary sinusitis was defined as complete opacification of the sinus or as the presence of an air-fluid level [1]. The presence of small anterior air bubbles was also investigated.

Real-time ultrasound

A Hitachi 405 Sumi (Hitachi Medical Corporation, Tokyo, Japan) with a micro-convex probe of 3.5 MHz and an ADR-4000 (Advanced Digital Research, Tempe, AZ) with a cardiac probe of 3.0 MHz were used at the bedside by the same investigator (D.L.), who was unaware of the CT results. Ultrasound examination was carried out within 12 h of CT examination. All patients were in the supine position. Transverse sections were obtained at the level of the front maxillary sinus wall, delineated by the lower orbital border, the nose, the upper maxilla and, laterally, by the external cheekbone. The ultrasound examination lasted less than 1 min for the two sinuses. Two types of image were observable. The image defined as normal (negative test) was an acoustic shadow arising from the front wall (Fig. 1A). The image defined as pathologic (positive test) was the visualization of the hypoechogenic sinus cavity delineated by hyperechogenic lateral and/or posterior walls (Fig. 1B). In this case, we used the term maxillary "sinusogram". Two qualities of "sinusogram" were observable: in one case, the "sinusogram" was complete, defined as a frank signal visible in the whole area of the front wall of the sinus, with clear delineation of the lateral and posterior walls (Fig. 1B); in the other, the "sinusogram" was incomplete, defined as a signal not visible on the whole surface of the front wall, with visualization of only part of the walls (Fig. 2).

Results

The feasibility of ultrasound was 100 %. The overall results are listed in Table 1. In 21 cases, CT showed total opacity of the maxillary sinus; the ultrasound test was always positive; the "sinusogram" was complete in 10 cases and incomplete in 11. In 8 of these 11 cases with total opacity but incomplete "sinusogram", air bubbles were visible at the front wall (Fig. 3A). In 12 cases, CT

Table 1 Comparison between CT and ultrasound, overall results

B-mode ultrasound	Computerized tomography: absence of radiologic maxillary			Computerized tomography: radiologic maxillary sinusitis		Total
	Normal sinus	Mucosal thickening	Giant polyp	Fluid level	Total opacity	
Complete "sinusogram"	0	0	0	0	10	10
Incomplete "sinusogram"	0	8	1	2	11	22
Absent "sinusogram"	52	6	0	10	0	68
Total	52	14	1	12	21	100

revealed air-fluid levels, with percentage filling ranging between 10 and 90%; an incomplete "sinusogram" was present in two cases where percentage filling was 70% and 90% (Fig. 4A); ultrasound showed absence of "sinusogram" in 10 cases where percentage filling was 50% or less (Fig. 4B). In 14 cases, CT showed mucosal thickening (Fig. 2B); ultrasound gave a positive pattern in 8 cases; in all of these cases, the "sinusogram" was incomplete. In one case of giant polyp, the ultrasound test was positive, showing an incomplete "sinusogram". Lastly, CT showed a normal sinus in 52 cases (Fig. 1A); the ultrasound test was always negative.

We first assessed the accuracy of ultrasound for diagnosing "radiologic maxillary sinusitis" (Table 2). The ten cases of air-fluid level not diagnosed using ultrasound were considered as false-negatives. The sensitivity of ultrasound was 69%, specificity 86%, positive predictive value 72% and negative predictive value 85%.

Table 2 Value of the "sinusogram" for the diagnosis of maxillary sinusitis

B-mode ultrasound	Absence of radiologic maxillary sinusitis (CT)	Radiologic maxillary sinusitis (CT)	Total
Present "sinusogram"	9	23	32
Absent "sinusogram"	58	10	68
Total	67	33	100

We also assessed the accuracy of ultrasound for diagnosing "total opacity of the sinus" versus absence of total opacity (Table 3). Two air-fluid levels giving a "sinusogram" had to be considered as false-positives. The sensitivity of ultrasound increased to 100%, specificity was 86%, positive predictive value 65% and negative predictive value 100%.

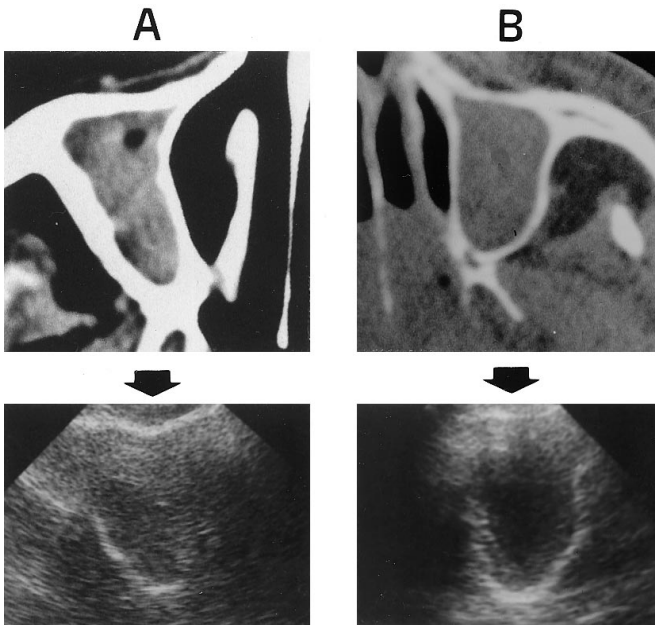

Fig. 3 **A**: Total opacity of the right sinus with a small anterior air bubble (CT), associated with an incomplete "sinusogram" (ultrasound). **B**: total opacity of the left sinus with homogeneous pattern (CT), associated with a complete "sinusogram" (ultrasound)

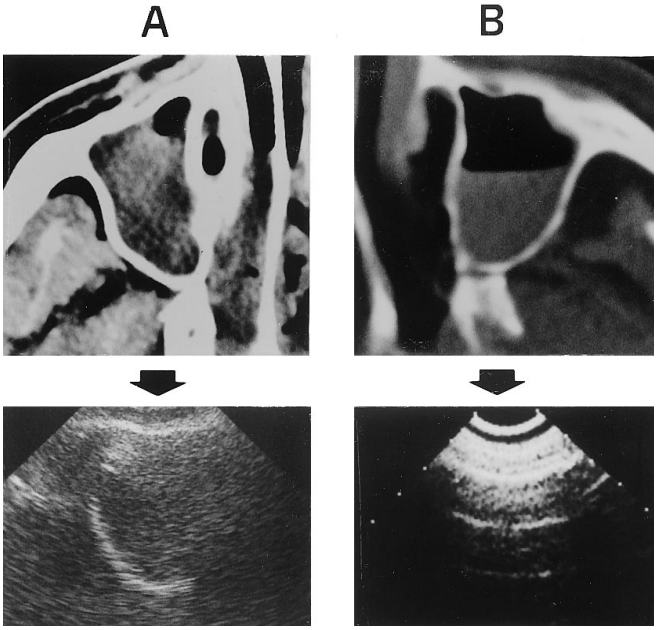

Fig. 4 Two cases of air-fluid level. **A**: 90% air-fluid level of the right sinus (CT), associated with an incomplete "sinusogram" (ultrasound). **B**: 50% air-fluid level of the left sinus (CT), associated with an acoustic barrier (ultrasound)

Table 3 Value of the "sinusogram" for the diagnosis of total opacity of the maxillary sinus

B-mode ultrasound	Absence of total opacity of the maxillary sinus on CT	Total opacity of the maxillary sinus on CT	Total
Present "sinusogram"	11	21	32
Absent "sinusogram"	68	0	68
Total	79	21	100

Including cases of air-fluid level, mucosal thickening and normal sinuses

If the quality of the signal is taken into account (Table 4), an incomplete "sinusogram" was associated with total opacity in 11 of 21 cases, to mucosal thickening in all 8 cases with positive "sinusogram" and in the case of polyp. A complete "sinusogram" was thus indicative of total opacity of the sinus (versus absence of total opacity) with a sensitivity of 47 % but a specificity of 100 % and a positive predictive value of 100 %.

Discussion

The present study showed that total opacity of the maxillary sinus always gave a "sinusogram". The effectiveness of ultrasound can be explained by the thinness of the front wall, allowing the passage of ultrasound through maxillary fluid collections. In this study, half of the cases of total opacity were definitively diagnosed at the bedside. Such cases do not need further confirmation by a paranasal CT scan.

Three limitations to this technique should be outlined.

1) An incomplete "sinusogram" could not distinguish total opacity (which should be drained) from substantial mucosal thickening (which should not). Pending further improvements of the technique based on dynamic maneuver, an incomplete "sinusogram" should logically lead to confirmation of radiologic maxillary sinusitis by means of CT.
2) Half (52 %) of the cases of total opacity gave an incomplete "sinusogram". In these cases, small air bubbles visible at the front wall on CT (a frequent pattern) may explain the degradation of the ultrasound signal (Fig. 3A).
3) An ultrasound acoustic barrier could not distinguish air-fluid level from normal sinus. This may appear logical in a protocol performed on supine patients. The aim of the present study was just to describe a simple ultrasound sign accessible to a simple technique. However, preliminary results seem to show that a dynamic maneuver such as a half-sitting position may overcome this limitation. The relevance of semi-recumbent positioning was outlined in a study performed with the A-mode [13]. Our preliminary results, in fact, show that a negative dynamic maneuver may predict the absence of sinusitis, and should also result in deferral of CT.

Real-time offers basic advantages over A-mode. The A-mode semiology may appear complicated, whereas real-time allows concrete visualization of the opacified sinus (for this reason, comparison with the results of A-mode studies is difficult). The learning curve is short. This application allows the patient to benefit from the well-known advantages of ultrasound, the main one being immediate diagnosis at the bedside. Other attractive features were appreciated. A small, simple device without Doppler was suitable. A 2.5–5 MHz range was adequate to pass through the bone. Above all, the presence in the ICU of a portable real-time device allowed many vital applications, some of them not yet routine (screening for pneumothorax, alveolar or interstitial syndrome, placement of venous catheters and others), which may allow ultrasound to be considered as a visual stethoscope [15].

In conclusion, a complete "sinusogram" appeared specific for total opacity of the maxillary sinus. This information should minimize referral of critically ill patients for CT. Highly feasible and sensitive, real-time ultrasound is easy to perform at the bedside and may be proposed first-line in a ventilated patient with suspicion of maxillary sinusitis.

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Table 4 Value of a complete "sinusogram" for the diagnosis of total opacity of the maxillary sinus

B-mode ultrasound	Absence of total opacity of the maxillary sinus on CT[1]	Total opacity of the maxillary sinus on CT	Total
Complete "sinusogram"	0	10	10
Incomplete or absent "sinusogram"	79[2]	11	90
Total	79	21	100

[1] Including cases of air-fluid level, mucosal thickening and normal sinuses
[2] including incomplete "sinusogram" in 11 cases and absence of "sinusogram" in 68

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