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A postural change test improves the prediction of a radiological maxillary sinusitis by ultrasonography in mechanically ventilated patients

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Abstract *Objective:* The aim of this study was to evaluate a postural change test during sinus ultrasound, compared with CT scan, in case of partial sinusogram to differentiate air-fluid level from mucosal thickening. *Design:* Prospective clinical investigation. *Setting:* Medical intensive care unit. *Patients:* 150 intubated patients. *Interventions:* Patients were examined by sinus ultrasound in half-sitting position. A partial sinusogram was defined as the sole visualization of the hyper-echogenic posterior wall of the sinus. In this situation, a postural change was performed and ultrasound was achieved in supine position. If the partial sinusogram disappeared when the patient was placed in a supine position (positive test), the partial sinusogram was an air-fluid level. If the partial sinusogram did not disappear (negative test), we considered it as a mucosal thickening. The CT and ultrasound were performed on

the same day. Radiological maxillary sinusitis (RMS) on CT was defined as the presence of an air-fluid level. Absence of RMS on CT was defined as normal sinus or as the presence of mucosal thickening. *Measurements and results:* 300 sinuses were examined. A partial sinusogram was found in 90 sinuses and CT scan confirmed the presence of RMS in 55 sinuses (61%). Sensitivity, specificity, positive predictive value, and negative predictive value of postural change test compared with CT were, respectively, 94.6, 85.6, 91.2 and 90.9%. The positive predictive value increased from 61 to 91.2% after the postural change test. *Conclusions:* In case of a partial sinusogram, a postural change increases the accuracy of ultrasound to diagnose RMS.

Keywords Sinus ultrasound · Nosocomial sinusitis · Sinusogram · Radiological maxillary sinusitis · Computerized tomography

Introduction

Nosocomial sinusitis may play a role in ventilator acquired pneumonia and severe sepsis [1]. Ultrasound has been suggested in the investigation of paranasal sinuses. At the bedside, a sinus ultrasound can be performed as an initial test [2–4]. When the sinus ultrasound is normal the diagnosis of sinusitis can be eliminated. When sinus ultrasound reveals a complete sinusogram [2–4], it points to a significant hydro-aeric level or a total opacification of sinus and a puncture of the maxillary sinus can be

performed. When a sinus ultrasound shows a partial sinusogram, it could be due to air-fluid level or a mucosal thickening. The presence of a partial sinusogram is the main problem in the interpretation of sinus sonography. In this situation, we can propose an immediate postural change. We hypothesized that a viscous fluid would spread in a different manner in the supine and in half-sitting position, and that this different repartition could allow to differentiate fluid from mucosal thickening. Consequently, a partial sinusogram related to fluid would disappear in the supine position, whereas a partial

sinusogram related to mucosal thickening would be unchanged [5].

Material and methods

The experimental protocol was approved by the institutional review board of the hospital, and all patients or the next of kin provided written informed consent.

Study population

The study was carried out between January 2003 and October 2005. Inclusion criteria were: (a) patients who had undergone intubation and mechanical ventilation more than 2 days; (b) a suspicion of nosocomial maxillary sinusitis with purulent nasal discharge and body temperature $> 38^{\circ}\text{C}$; and (c) a sinus ultrasound revealing the presence of partial sinusogram.

Exclusion criteria were: (a) a history of sinusitis; (b) a transfer to the radiology department considered as a high risk of morbidity because of severe respiratory or hemodynamic instability; and (c) a recent facial or skull-base fracture.

Data collection

The following variables were recorded from patients: age and gender; the New Simplified Acute Physiology Score (SAPS II) [6]; temperature; and duration of intubation at the moment of sinusitis clinical suspicion.

Study protocol

Both CT and sinus ultrasound were performed on the same day.

Sinus ultrasound and postural change

A Philips-Envisor C (Philips Ultrasound, Bothell, Wash.) with a cardiac probe was used at the bedside by the same investigator [3, 4]. The ultrasonographer was intentionally unaware of the clinical examination, of the CT results, and was not in charge of the patient. All patients were in a semi-recumbent position (45°C). The normal sinus was defined as an acoustic shadow arising from the front wall. A partial sinusogram was defined as the only visualization of the hyperechogenic posterior wall of the sinus. A complete sinusogram was defined as the hyperechogenic visualization of posterior wall and the extension by the internal wall of the sinus outlining the hypoechogenic sinus cavity [3, 4].

Patients with partial sinusogram were included in the study and a postural change was performed. A second sinus ultrasound was carried out in a supine position (0°C). The time elapsed between the two ultrasound examinations was 10 min. A dynamic test was considered positive when the partial sinusogram visualized with the patient in a half-sitting position disappeared once the patient was placed in a supine position (Fig. 1). The partial sinusogram was most likely an air-fluid level and echographic sinusitis evidence was suspected. Conversely, a dynamic test was considered negative when the partial sinusogram was visualized both in a semi-recumbent and supine position. The partial sinusogram was probably related to a mucosal thickening.

Computerized tomography

Each patient included in the study was transported to the radiology department and a computerized tomography (CT) of the paranasal sinuses was performed [7]. Radiological maxillary sinusitis (RMS) was diagnosed by a senior physician from the radiology unit based on CT findings. The RMS was defined as the presence of an air-fluid level or as complete opacification of the sinus, and the absence of RMS was defined as normal sinus or as the presence of mucosal thickening [8]. The CT reader was intentionally unaware of the ultrasound results and to the clinical assessment of the patient.

Data Analysis

A true-positive result was defined as a positive dynamic test and the presence of RMS on CT. A true-negative result was defined as a negative dynamic test and the absence of RMS on CT. A false-positive result was defined as a positive dynamic test with sinus ultrasound and the absence of RMS on CT. A false-negative result was defined as a negative dynamic test with ultrasound and the presence a RMS on CT. Standard formulas were used to calculate sensitivity, specificity, positive predictive value, and negative predictive value [9]. The 95% confidence intervals (CI) of sensitivity and specificity were computed using the binomial exact distribution [10].

Results

Patients

During the study period, of the 156 patients potentially suitable for this study, only 6 were excluded because of the unavailability of the CT scan. Finally, 150 patients were eligible for the study; thus, 300 paranasal sinuses were examined. The characteristics of the patients are detailed in the Table 1.

Fig. 1 Postural change in patient with suspected nosocomial sinusitis. **a** Positive dynamic test. If the partial sinusogram visualized with the patient in a half-sitting position disappears when the patient is placed in a supine position, the partial sinusogram is probably an air–fluid level (acoustic shadow secondary to small air bubbles); **b** Negative dynamic test. If the partial sinusogram does not disappear when the patient is placed in a supine position, the partial sinusogram is most likely to be a mucosal thickening

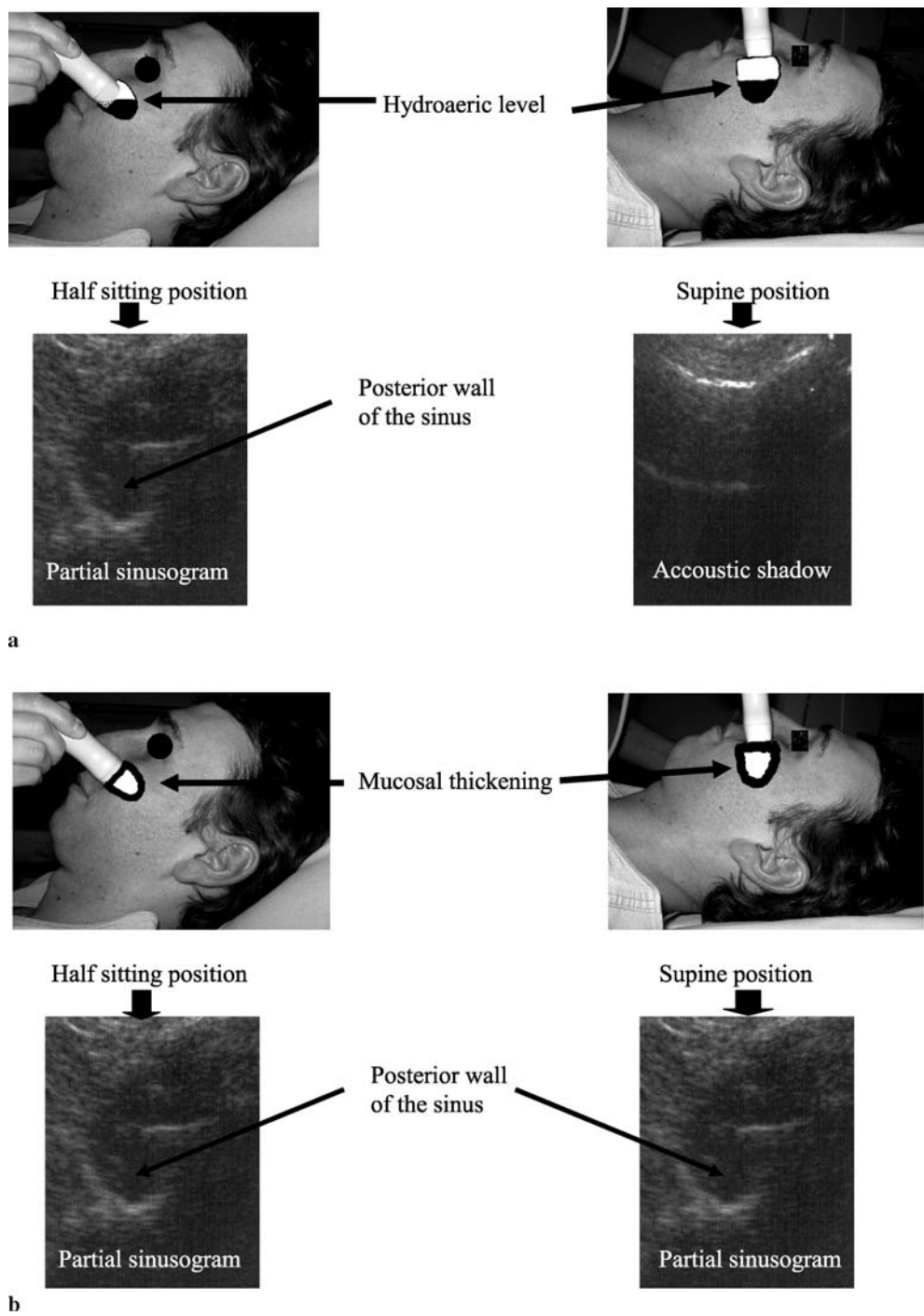


Table 1 Characteristics of the 150 patients at the inclusion; SAPS Simplified Acute Physiology Score [6]

Age (years) ^a	62 ± 18
Male, female	83 (55), 67 (45)
Temperature (°C) ^a	38.6 ± 0.5
Nasal intubation (n)	79 (52)
SAPS II score ^a	31 ± 5
Duration of intubation (days) ^a	6 ± 4.0

Numbers in parentheses are percentages; ^a Results are expressed in mean ± SD

Table 2 Accuracy of the postural change test during sinus ultrasound; *RMS*: radiological maxillary sinusitis on computed tomography defined as the presence of an air-fluid level or a complete opacification of the sinus; *Absence of RMS*: defined as normal sinus or as the presence of mucosal thickening; *Postural change test*: A partial sinusogram was defined as the sole visualization of the hyperechogenic posterior wall of the sinus by ultrasound in half-sitting position. In this situation, a postural change was performed and ultrasound was achieved in supine position; *Positive dynamic test*: A dynamic test was considered positive when the partial sinusogram disappeared once the patient was placed in a supine position. The partial sinusogram was most likely an air-fluid level and echographic sinusitis evidence was suspected; *Negative dynamic test*: A dynamic test was considered negative when the partial sinusogram was visualized both in a semi-recumbent and supine position. The partial sinusogram was probably related to a mucosal thickening

	Computed tomography RMS	Absence of RMS	Total
Postural change test			
Positive dynamic test (n)	52	5	57
Negative dynamic test (n)	3	30	33
Total (n)	55	35	90

Sinus ultrasound

The feasibility of sinus ultrasound was 100%. The duration of sinus echography was < 5 min per patient.

Ultrasound in half sitting position

Of the 300 sinuses examined by sinus ultrasound in half-sitting position, we found a complete sinusogram in 98 cases, a normal sinus in 112 cases, and a partial sinusogram in 90 cases. Of the 90 partial sinusogram, CT scan confirmed the presence of RMS in 55 sinuses (61%). Of the 112 normal sinuses, CT scan showed absence of RMS in 106 cases (95%). In the case of complete sinusogram, CT scan systematically confirmed the presence of RMS.

Postural change

The accuracy of the postural change during sinus ultrasound, compared with CT, to differentiate between an air-fluid level or a mucosal thickening is shown in Table 2. Sensitivity, specificity, positive predictive value, and negative predictive value were, respectively, 94.6% (95% CI = 87–100%), 85.6% (95% CI = 74–97%), 91.2% (95% CI = 85–97%), and 90.9% (95% CI = 85–97%). The positive predictive value increased from 61 to 91.2% after the postural change test.

Discussion

This study shows that, in the case of partial sinusogram, an immediate postural change compared with CT could improve the diagnosis of RMS, with a sensitivity of 94.6% and a specificity of 85.6%; however, we obtained five false-positive and three false-negative results. The screening of these three false-negative results showed that there were both a small air-fluid level and a mucosal thickening. Concerning the false-positive results, in 3 of 5 cases, the mucosal thickening was not located on the total area of the maxillary sinus but only to the posterior wall of the sinus.

During ultrasound examination, the position of the patient is of utmost importance. Because of total reflection of the sound beam, the floor of the maxillary sinus did not show up in a “well-pneumatized” sinus. The sound beam was attenuated and thus no graphic information was obtained (i.e., typical “ring-down” artifact) [11]. In case of air-fluid level in the maxillary sinus, small air bubbles may cause the degradation of the ultrasound and an ultrasound acoustic barrier cannot distinguish air-fluid level from normal sinus. The half-sitting position may overcome this limitation. The relevance of semi-recumbent positioning was outlined in a study performed with the A-mode [12]. Our previous studies showed that ultrasound accuracy for all lesions (complete or partial sinusogram) is improved in the semi-erect patient [3, 4]; however, echographic sinusitis evidence of partial sinusogram could be due to a mucosal thickening. The concept of thickness dynamics and its relevance for indicating immediate postural changes in the case of a partial sinusogram has been suggested by Lichtenstein [5]. The information obtained from this postural change test could minimize referral of critically ill patient for computed tomography in situations where CT scans require time-consuming transfer of complex patients [13–15].

For this study, we decided that all sinus ultrasounds would be performed by the same operator. This is a potential limitation of the generalization of the results of

this study; however, in our intensive care unit, many physicians are able to perform sinus ultrasound in a reliable manner. For all new procedures it is usual to consider the level of expertise necessary to perform the procedure. We have observed that it is necessary to perform 20 sinus ultrasonographies to become proficient in this technique.

In mechanically ventilated patients with a suspicion of nosocomial maxillary sinusitis, a sinus ultrasound can be performed initially with the patient in half-sitting position. In case of partial sinusogram, we propose an immediate postural change (semi-recumbent to supine). If an acoustic barrier is visualized in the place of the partial sinusogram,

the partial sinusogram is related to an air-fluid level and a sinus puncture can be performed. If the partial sinusogram does not disappear in a supine position, the partial sinusogram is related to a mucosal thickening.

In conclusion, in the case of a partial sinusogram, a postural change of the patient in a supine position could improve the diagnosis of RMS and minimize referral of critically ill patients for computed tomography.

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