VALUE OF B MODE ULTRASOUND FOR THE DIAGNOSIS OF MAXILLARY SINUSITIS IN CRITIC PATIENTS

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ABSTRACT

Objective: to establish the value of mode B Ultrasound (B mode US) in the diagnosis of maxillary sinusitis in patients admitted to the Intensive Care Unit (ICU). Partial or complete liquid filling of the sinus cavity was considered as a positive imaging diagnosis.

Design of the study: Prospective, comparative and blind study using computed tomography (CT) as a gold standard.

Material and methods: 50 adult patients, admissioned to the ICU in the city of Tacuarembó (Hospital Regional y Cooperativa Medica de Tacuarembó), who due to their main disease required a head, face skeleton or cervical spine CT scanning were included. The ages ranged from 21 to 78 years old (mean 45), 36 were males and 14 females. As well as the requested CT scanning six axial 5mm width and 8mm interval slices of maxillary sinuses were performed.

A single imagenologist, unaware of tomographic results, systematically performed the ultrasound assessment. The findings were initially classified for each sinus as negative (lack of echographic signs of filling), positive (visualization of the back area of the sinus) and uncertain (no conclusive images). The uncertain cases were reassigned as positive or negative by the physician before finishing the ultrasound examination. Later, a comparative analysis between ultrasound and computed tomography results was performed. CT was considered as the gold standard, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated.

Results: 100 maxillary sinuses corresponding to 50 patients admissioned to the ICU were examined. 31 of them were ecographically seen as positive, 62 were negative and 7 uncertain. Computed tomography depicted 33 positive and 67 negative. Including all the sinuses (100) B mode ultrasound showed 91% sensitivity, 92.5% specificity, 86% positive predictive value and 95% negative predictive value.

Conclusions: B mode ultrasound can be taken into account as a first line method for the diagnosis of maxillary sinusitis due to its high diagnostic accuracy. This concept is enhanced by the simplicity and quick learning of this technique in the maxillary sinuses, its availability, feasibility and costs.

Key words: maxillary sinusitis; ultrasound; critic patient.
RESUMEN

**Objetivo:** establecer el valor de la ecografía (modo B) en el diagnóstico de sinusitis maxilar en pacientes internados en cuidados intensivos (UCI). Se consideró diagnostico imagenológico positivo de sinusitis maxilar la ocupación líquida parcial o total de la cavidad sinusal.

**Diseño del estudio:** Estudio prospectivo comparativo y ciego empleado a la tomografía computada como gold standard.

**Material y método:** Se incluyeron 50 pacientes adultos, internados en las UCI de la ciudad de Tacuarembó (Hospital Regional y Cooperativa Médica de Tacuarembó) que por su patología de base requirieron valoración tomográfica (TC) de cráneo, macizo facial o columna cervical. Las edades se ubicaron entre 21 y 78 años (media 45), 36 eran hombres y 14 mujeres. Concomitantemente a la valoración TC solicitada se efectuaron seis cortes axiales de los senos maxilares de 5mm de espesor y 8mm de intervalo.

Un único médico imagenólogo, desconociendo los resultados tomográficos, realizó en forma sistematizada el estudio ecográfico. Los hallazgos se clasificaron en primera instancia y para cada seno como negativo (ausencia de signos ecográficos de ocupación), positivo (visualización del sector posterior del seno) y dudoso (imágenes no concluyentes). Los casos dudosos fueron recategorizados por el imagenólogo en positivo o negativo antes de finalizar la exploración ecográfica. Posteriormente se efectuó análisis comparativo entre los resultados ecográficos y los de la tomografía computada, considerada el gold standard, calculándose sensibilidad, especificidad, valor predictivo positivo (VPP) y valor predictivo negativo (VPN).

**Resultado:** Se exploraron 100 senos maxilares correspondientes a 50 pacientes internados en UCI. Ecográficamente se interpretaron como positivos 31 de ellos, 62 fueron negativos y 7 dudosos. Mediante tomografía fueron positivos 33, negativos 67. Incluidos todos los senos (100 senos) la ecografía modo B mostró una sensibilidad 91%, especificidad 92.5%, valor predictivo positivo 86% y valor predictivo negativo 95%.

**Conclusiones:** la ecografía puede ser tenida en cuenta como método de primera línea en el diagnosticico de sinusitis maxilar dado su elevada eficacia diagnostica. Refuerza este concepto la facilidad y rápido aprendizaje de la técnica en senos maxilares, la disponibilidad, practicidad y costos de la ecografía.

**Palabras Claves:** sinusitis maxilar; ultrasonido; paciente crítico.
INTRODUCTION

Paranasal sinusitis, particularly maxillary sinusitis (MS), is one of the most frequent causes of infection in patients admitted to intensive care units (ICU) and is related to the pathogenesis of nosocomial pneumonia and sepsis.\(^{(1,2,3)}\)

The isolation of microorganisms in the content of the paranasal cavity (endoscopic direct examination - puncture) and imaging methods have been the diagnostic key of this pathology.

When clinical findings are subjective (usually fever without focus) complete opacification, partial filling with an air-fluid level, or full liquid filling of the maxillary sinuses represent the imaging signs that define the imagenologic maxillary sinusitis (IMS) \(^{(4-5)}\).

Conventional radiology has showed that it does not provide a certain diagnosis in these intubated, consciousness impaired patients \(^{(1, 6)}\).

CT has become the routine method for the diagnosis of maxillary sinusitis. However, it has some limitations related to the cost of the examination, and some issues about the security of the patient such as transportation to the ICU and the exposure to ionizing radiation.

Ultrasound is seen as an ideal method in the intensive care unit as it is innocuous, affordable and can be performed at the bedside. \(^{(1, 2, 7)}\).

There have been papers that suggest the use of ultrasound for the examination of the paranasal sinuses in critical patients since the 80s.

In the ICUs in Tacuarembó city, CT is the key diagnostic imaging method for maxillary sinusitis. The location of the CT unit outside of the medical centers requires an additional specialized transportation that increases the costs and basically also increases the risk of the patient. In order to revert this situation Ultrasound has been proposed as a diagnostic method for identification of IMS.

The objective of this study was to establish the value of B mode bidimensional ultrasound using CT as a gold standard for the diagnosis of imagenologic maxillary sinusitis in patients admitted to intensive care units.

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**Figure 1:** Normal ultrasound, a) transversal, b) sagittal. Shows the anterior wall of the maxillary sinus as an echogenic line (arrows) with an acustic posterior shadow. GO: eyeball.
MATERIAL and METHODS

The study was carried out between September 2007 and August 2009; 50 adult patients, admitted to the ICU in the city of Tacuarembó (Hospital Regional y Cooperativa Medica de Tacuarembó), who due to their main disease required a head, face or cervical spine CT scanning were included. Ages ranged from 21 to 78 years old (mean 45), 36 were males and 14 females, all of them required orothraqueal intubation. As well as the tomographic examination required, six additional 5mm-width, 8mm-interval slices of the maxillary sinuses, in conventional mode, parallel to the hard palate were performed to each patient. CT was performed in GE HI SPEED XY equipment. The diagnostic considerations are discussed in the definition item.

A single radiologist, unaware of the tomographic results, systematically performed the mode B ultrasound examination of the maxillary sinuses of all patients. The radiologist lacked experience in this kind of ultrasound and did not have a previous training before this study. US was performed in the ICU, with the patient in the supine position with a 30º tilt, with Toshiba JE 400 equipment in 47 patients, a GE Voluson 730 was used for the remaining 3. 3 to 5 Mhz electronic convex multifrequency transducers were employed. Hydro soluble gel was used to remove air in the transducer-skin interface. Axial and sagittal sections of both maxillary sinuses- through their anterior wall were performed. The transducer was placed below the inferior margin of the orbit and lateral to the nostril wing. Gain was set according to each particular patient. Echographic findings were classified for each sinus as negative (without echographic signs of occupation), positive (with echographic signs of occupation) or uncertain (no conclusive images).

Figure 2: Sinusal occupation, a) transversal, b) sagittal. Visualization of the posterior aspect of the maxillary sinus (posterior-external wall) as an echogenic line (dots). GO: eyeball.

The category uncertain was first included in order to evaluate the difficulty that the technique generated to define the findings. Each uncertain case was reclassified as either positive or negative before finishing the examination by the radiologist.
Once 100 sinuses were completed a comparative study with CT findings ("gold Standard") was done. Accuracy of US for the diagnosis of imagenologic maxillary sinusitis was expressed statistically using four main indicators: sensitivity, specificity, positive predictive value, and negative predictive value. The accuracy of US as well as the positive and negative likelihood ratios were calculated.

Positive ultrasound finding was characterized by the presence of signs of sinusual occupation represented by the visualization of the posterior area of the maxillary sinus (posterior-external wall or posterior-external and internal wall) as an echogenic line (fig 2).

True positive result (TP) was defined as the presence of a positive ultrasound finding in a sinus with a positive tomographic finding.

DEFINITIONS

Positive tomographic finding (tomographic maxillary sinusitis -TMS) was defined as the complete liquid filling or the presence of an air-fluid level (4).

Negative tomographic finding (no tomographic sinusitis) included normal tomographic examination, mucosal thickening (difuse-polipoid) or tumoral process.

Negative ultrasound finding was defined by a normal ultrasound with the visualization of an echographic line generated by the anterior sinusal wall that determines a posterior acoustic shadow (fig 1).

True negative result (TN) was defined as the presence of a negative ultrasound finding in a sinus with a negative tomographic finding.

False positive (FP) was defined as a positive ultrasound finding in a sinus with a negative tomographic finding.

False negative (FN) was defined as a negative ultrasound finding in a sinus with a positive tomographic finding.

RESULTS

One hundred maxillary sinuses belonging to fifty patients admissioned in the ICU were explored.

The average delay time between CT and US was less than 39 hours.
CT revealed signs of maxillary sinusitis (TMS) in 33 sinuses, the remaining 67 were negative. Thirty-one sinuses were interpreted as positive with the ultrasound, 62 were negative and 7 were uncertain. These last ones corresponded in 4 cases to a minimal liquid occupation of the sinus and a mild mucosal thickening in the remaining 2. Considering the total of sinuses (including the uncertain ones re-labeled) 35 were positive and 65 were negative. Using these results the following comparative table was done.

<table>
<thead>
<tr>
<th>Positive US</th>
<th>Positive TMS</th>
<th>True Positive</th>
<th>False Negative</th>
</tr>
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<tbody>
<tr>
<td>31</td>
<td>31</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>62</td>
<td>65</td>
<td>57</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>4</td>
<td>3</td>
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The 5 false positive corresponded to 4 mucosal thickening and 1 polyp. The 3 false negative were sinuses with a minimal quantity of liquid. Performing the comparative study with CT, B mode US showed, 91% sensitivity, 92.5% specificity, 86% positive predictive value and 95% negative predictive value. The diagnostic accuracy was 92%; 12, 2 positive LR and 0.097 negative LR.

DISCUSSION OF METHODOLOGY

The performance of US by a professional without experience in the examination of the maxillary sinuses and the absence of previous training in this technique was previously defined, with the intention of establishing the difficulty of the method and to assess an eventual learning curve. It was assumed that the results obtained would be influenced by this fact. It is questionable to include complete sinusal occupation without telling whether it was mucose or liquid as positive tomographic cases.

It was decided to include them basically because this differentiation does not determine any change neither in the therapeutics nor in the diagnosis in the ICU. Administration of endovenous contrast material does not guarantee any defining data in these uncertain cases. This differentiation is not specified in the reviewed articles of the Literature that use CT as a gold standard (2, 15).

Mucosal thickening is a controversial sign as a manifestation of an infectious sinus process due to its low specificity; its only presence does not determine a therapeutic approach, so it
was not estimated in this study as an evidence of imagenologic sinusitis. Similar concepts were found in the literature (2, 15).

<table>
<thead>
<tr>
<th>ULTRASOUND</th>
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<tr>
<td>+</td>
<td>30TP</td>
<td>5FP</td>
<td>35</td>
</tr>
<tr>
<td>-</td>
<td>5EN</td>
<td>62TN</td>
<td>67</td>
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<td>35</td>
<td>67</td>
<td>100</td>
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TP: true positive; TN: true negative; FP: false positive; FN: false negative

DISCUSSION OF RESULTS

In the critic patient maxillary sinusitis represents a potentially life threatening event because of its relation with nosocomial pneumonia and sepsis (3, 8, 9).

It is a frequent infectious complication and a diagnostic challenge due to the peculiar conditions of these patients. The mortality associated to maxillary sinusitis can be as high as 11%, though both mortality and morbidity have been decreasing, due to an early treatment, which stresses the importance of an early diagnosis (10, 11).

The suspicion of maxillary sinusitis in this population is generally established by the presence of fever without a clear clinical cause (12, 13). The finding of sinusal occupation by imaging methods supports this suspicion and the definite diagnosis is based on the isolation of the microorganism in the material obtained from the cavity of the sinuses (14). The presence of intra sinusal liquid is the indirect evidence of an infectious disease and it determines specific diagnostic and therapeutic measurements. (7). This fact determines that imagenologic identification of either partial or complete occupation signs of the sinus (imagenologic maxillary sinusitis) can be considered from a practical and operative point of view as evidence of maxillary sinusitis.

The different imaging techniques reveal a quite varied efficacy for the diagnosis of imagenologic maxillary sinusitis (2, 3).

The conventional radiology has shown that it does not provide a certain diagnosis in this intubated, consciousness impaired patients (6, 9). CT has become the first line modality to evaluate paranasal sinuses (7, 9). It has the disadvantage of the cost, the exposure to ionizing radiation, and particularly in critic patients the necessity of moving them outside of the ICU, with a 14% reported decrease of the cardiac index and the oxygen arterial pressure (1, 2, 7).

US come up as an ideal diagnostic method in the critic patient due to its availability, affordable cost, harmlessness and its performance in the ICU.

From the 80s there are publications that have assessed US for the examination of the paranasal sinuses. The results of the studies performed in critic patients have been controversial and generally not comparable among themselves. The objective of our study was to establish the value of B mode the bidimensional US for the diagnosis of imagenologic maxillary sinusitis in

patients admitted to intensive care units, using CT as a gold standard. The bibliographical research done did not identify any similar national study regarding the value of US in maxillary sinusitis.

Early international publications such as Shapiro G and cols. in the Journal Allergy Clin. Immunologic in 1986 as well as more recent papers establish the scope of sinusual ultrasound in mode A, so they will not be considered when discussing the results (15-16).

The results of our study show that the ultrasound mode B compared to the CT is accurate for the diagnosis of IMS in critic patients; with 91% sensitivity, 92.5% specificity, 86% positive predictive value and 95% negative predictive value. The diagnostic accuracy was 92%; 12.2 positive LR and 0.097 negative LR.

Puidupin M et al published in 1997 striking low indices compared to ours (sensitivity 78% - specificity 84%) (17); these results are certainly biased by the performance of the examination in supine position which makes the identification of occupation signs (2) and the use of conventional radiology as a gold standard difficult (6). An important detail of the echographic examination highlighted in the bibliography is the necessity to put the patient over 30 degrees from the horizontal plane (1, 2).

Other papers reveal better indices than the ones we obtained and place the sensitivity in 100%, specificity 96 to 98%, positive predictive value 92 to 98, 6% and 100% for negative predictive value (1, 2). These differences are certainly explained by: a) in other series the clinical suspicion of maxillary sinusitis was an inclusion criterion which raises the possibility of imagenologic sinusitis (2); b) the learning curve of the technique in our group was included in the study.

Considering the high indices obtained in our study including the technique learning, ultrasound of the maxillary sinuses seems to be a quick-to-learn and easy-to-interpret method. This concept is reinforced by the low number of uncertain diagnosis: 7 sinuses (uncertain cases) out of 100. It is remarkable that 6 of these corresponded to the examination of the first 25 patients, in other words 86% of imagenologic uncertainties were produced while examining the first 50 sinuses, so it is valid to assume that the imagenologic difficulty will certainly be less when performed by previously trained personnel. It was not possible to compare this item in other papers as there was no parameter available.

Out of 7 uncertain examinations 6 cases presented sinusal pathology (4 mild occupation, 2 mucosal thickening), so the presence of US diagnostic uncertainty could be eventually interpreted as pathologic. If there is clinical suspicion of maxillary sinusitis ultrasound could screen off these patients as candidates for CT.

Similarly to the studies reviewed, the most common cause of false negative was a small quantity of secretion (figure 3) and the most common cause of false positive was the mucosal thickening or polyps/cysts (figure 4) (2, 18). These are typical limitations of ultrasound, however they could be reduced if it is only performed when maxillary sinusitis is suspected, as the complete occupation or the occupation more than a half the sinusal cavity is more frequent in these patients and there are few cases with a small quantity of secretion or mucosal thickening (2).

Since the most frequent false positive cases (mucosal thickening and polyps)
are limitations of the technique and the frequency of minimal sinusal occupation that produces a false negative in patients with suspected maxillary sinusitis is low, it can be assumed that the key point in the learning curve of the technique would be to solve the diagnostic doubts that are included as uncertain cases in this study. Keeping in mind that 86% of these cases showed up when the first 50 sinuses were examined, we could admit that the learning curve in the technique should not include a lower number than this one in a similar population. This study did not aim to reveal the degree of sinusal occupation. Similar communications have highlighted the high concordance (Kappa coefficient more than 83%) between CT and US to distinguish the magnitude of the occupation; this could help to define the therapy in critic patients with maxillary sinusitis (2). Hilbert et al defined that the echographic assessment of the posterior-lateral and internal walls of the sinus is an evidence of important occupation and confirms an imagenologic maxillary sinusitis; the identification of just the posterior wall reveals a moderate occupation that may correspond to a small air-fluid level or mucosal thickening, in such cases an imagenologic sinusitis should be confirmed by CT or a second ultrasound. (2) These studies also agree in showing a high negative predictive value, close to 100%, placing B mode US as an excellent method to rule out IMS (1). Despite antral puncture is recommended as the first diagnostic method in nosocomial sinusitis in some papers (19) most of them suggest that it should be performed after the systematic examination using imaging techniques, specifically ultrasound (1).

CONCLUSIONS

The ultrasound mode B can be proposed as the first line imaging method for the diagnosis of maxillary sinusitis in critic patients because of its high diagnostic accuracy. Its availability, affordability, capacity of performance in the same care unit, and harmlessness make it an ideal method in this population of patients. It requires a relatively simple technique, this study suggests Than it is learned quickly. Its introduction as the first examination in the diagnostic algorithm could decrease the use of CT in critic patients.

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