Maxillary sinuses ultrasonography - a reliable method in the diagnosis of acute sinusitis in children

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Learning objectives

To present the method used to examine maxillary sinuses by ultrasonography and its role in diagnosing acute maxillary sinusitis.

To illustrate the normal aspects of maxillary sinuses and the possible ultrasonographic findings of acute maxillary sinusitis.

To show comparing results of ultrasonography with other imaging techniques used to assess maxillary sinusitis.

Background

Acute sinusitis represents a frequent pathology among the pediatric population, accounting for a large amount of consultations and representing one of the diagnoses for which antibiotics are frequently prescribed.

The American Academy of Pediatrics published in 2001 a guideline for the management of sinusitis where it is stated that the diagnosis of acute sinusitis is basically a clinical one. Yet the signs and symptoms of sinusitis are nonspecific and usually overlapping those of other upper respiratory tract infections, often requiring an imaging confirmation for a certain diagnosis.

The plain radiograph of the paranasal sinuses is no longer considered accurate enough and is losing its ground in the diagnosis of acute maxillary sinusitis.

CT is now considered the criterion standard for the evaluation of all the sinuses and it is mandatory in cases where surgery is indicated.

MRI on the other hand is recommended in specific clinical situations where complications are suspected, especially extension of the infectious process into surrounding structures or thrombosis of the superior sagittal sinus.

In the seventies ultrasonography has been used in the diagnosis of sinusitis, but today it is rarely mentioned as a diagnostic technique for the assessment of the maxillary sinuses and therefore it is not widely accepted.

Imaging findings OR Procedure details
Maxillary Sinuses Ultrasonography (US)

The US examination of the maxillary sinuses is performed with the patient in a sitting position, facing the examiner and with the head mildly flexed forward. (Fig. 1)

The transducer is placed on each side of the nose, under the inferior wall of the orbit, on the anterior wall of the maxillary sinus. Then the sinus is scanned in a craniocaudal and mediolateral manner by slightly moving and angulating the transducer.

The normal aspect of the maxillary sinus highly resembles the aspect of the normal lung. The first layer is represented by the skin and subcutaneous tissue, then there is a fine, continuous hyperechoic line produced by the anterior wall of the maxillary sinus. Since the normal sinus contains air, its sonographic appearance is produced by the reflection of the sound waves back to the probe and consists of fine, parallel, echoic lines. (Fig. 2)

US Findings in Maxillary Sinusitis

Acute maxillary sinusitis is defined as an inflammation of the sinus mucosa that occurs as a result of bacterial (most often), viral or fungal infection as well as in the context of allergy or chronic nasal conditions. This inflammation is translated into swelling of the mucosa and accumulation of fluid into the sinusal cavity. Sometimes polyps or cysts may also be present inside the sinus.

The ultrasonographic correspondent of these changes has been described in detail in literature (Revonta, Puhakka, Varonen, Lichtenstein). When there is more than air inside the sinusal cavity the ultrasounds are no longer reflected back to the transducer because fluid or mucus are able to carry the sound waves to the back wall of the sinus and thus producing an image. The most frequently encountered findings associated with acute maxillary sinusitis are listed in Table 1.

"Sinusogram"

A well defined, triangular, homogeneous, hypoechoic or transonic image of the maxillary sinus is interpreted as a fluid collection. This is also called a "sinusogram" and is defined as a real-time ultrasound sign significant for sinusal walls and cavity visualization. (Fig. 3)

The "sinusogram" is considered complete if the internal, external and posterior walls are clearly visible, and incomplete if the walls are only partially visualized.

Hypoechoic or echoic images that do not have a triangular shape (incomplete sinusogram) and a fine contour are interpreted as mucosal thickening. (Fig. 4).
"Back wall echo" (BWE)

The back wall echo (BWE) is an intense hyperechoic image produced by the posterior bony wall of the maxillary sinus. When visualized the BWE is a sign of pathological content within the sinus. (Fig. 5)

If the distance from the first intensity echo to the BWE is # 3.5 cm in adults and 2 cm in children the aspect is consistent with a fluid collection.

**Tabel 1 Ultrasound aspects of maxillary sinusitis**

<table>
<thead>
<tr>
<th>Normal sinus</th>
<th>Ultrasounds return from 1 cm or less</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosal thickening</td>
<td>Distance between first echoes and air echoes is increased</td>
</tr>
<tr>
<td>Fluid collection</td>
<td>Sound waves from the posterior bone wall usually present</td>
</tr>
<tr>
<td></td>
<td>Strong, back wall echo (BWE) or complete sinusogram</td>
</tr>
<tr>
<td></td>
<td>Distance from the first echoes to the BWE # 3.5 cm (2 cm in children)</td>
</tr>
<tr>
<td>Polipoid mucosal thickening</td>
<td>Intense echoes caused by air and multiple echoic images created by the enlarged mucosa</td>
</tr>
</tbody>
</table>

Types of transducers

The examination may be performed with any type of transducer, but the most useful diameters were found to be between 8 and 12 mm and the most useful frequencies from 3 to 6 MHz.

The images presented in this poster were obtained using a convex multi frequency (4 to 9 MHz) pediatric probe. The examination was performed with a Sonoace 8000 EX ultrasound machine. (Fig. 6)

Correspondence between US and plain radiography
In our centre the plain radiography and ultrasonography were the most frequently used imaging techniques for the evaluation of the maxillary sinuses in the past few years. In selected cases (chronic or associated pathology) an MRI exam was performed.

Therefore in most cases the ultrasonographic results were compared with the radiographic ones (Fig. 7).

The standard projection for the evaluation of the paranasal sinuses is the occipitomental projection (Water's view).

Ultrasonographic and radiographic findings correlated as follows:

- a complete sinusogram (back wall echo at more than 2 cm from initial echo) on US corresponded to a total opacity on the radiography
- an incomplete sinusogram on US was consistent with either an air/fluid level or a concentric mucosal thickening on the radiography
- sometimes a normal aspect on the ultrasound correlated with mild concentric mucosal thickening on the radiography while normal looking x rays were found in patients with incomplete sinusograms on the US.

Several studies report an agreement of about 80% between ultrasonographic and radiographic findings in the evaluation of the maxillary sinuses. The results are even more consistent for the normal aspects and for the detection of fluid collections (total opacity on the x ray and complete sinusogram on US).

**Correspondence between US and CT scan or MRI**

There are not too many studies comparing maxillary sinus US with computed tomography. Ahmed M et al reported a sensitivity of 76.4%, a specificity of 95.7% and an accuracy 93.3% of US findings compared with CT. Similar results were obtained by Karantanas AH et al - 66.7% sensitivity and 94.9% specificity of US.

Puhakka et al reported a sensitivity of 64% and a specificity of 95% of US when compared with MRI.

**Case presentation**

Figures 8-10 present the case of a 9 years old boy who presented with symptoms suggestive for acute maxillary sinusitis (purulent nasal discharge, headache, coughing). The radiography acquired in Water's view projection revealed complete opacification of
the right maxillary sinus consistent with fluid collection and eccentric opacification of the left maxillary sinus suggestive for mucosal thickening. (Fig. 7)

The ultrasound performed in the same day showed bilateral complete sinusogram, with a back wall echo present at more than 2.5 cm from the initial echo. The ultrasonographic findings were interpreted as bilateral fluid collection. (Fig. 8)

The patient underwent antibiotic treatment and had several follow-up ultrasound exams. Figure 8 presents the progressive resolution of the fluid collection. Two months after the first exam the ultrasound reveals normal aspect on the left and persistence of the back wall echo on the right. Since the symptoms had resolved, but there was still a pathological aspect on the right the child underwent an MRI examination which revealed persistence of a small fluid collection on the left (which was no longer visible on the US) and the presence of a cyst on the right. The MRI findings explained the nonspecific US aspect.

Looking carefully at the images obtained on the first US exam a rather subtle difference of echogenicity can be observed between the two sinuses. The right sinus is almost transonic while on the left there are more echoes. This feature may lead the examiner to suspect a cystic lesion.

Discussions

The purpose of this poster was to present the possible ultrasound aspects of acute maxillary sinusitis.

The superiority of CT scan in the visualization of the pathological aspects of acute maxillary sinusitis and of the MRI in differentiating between acute and chronic disease and evaluating complications are undoubted.

The place of ultrasonography alone is restricted to uncomplicated cases and considered useful as it is easily accessible, cheaper, avoids radiation exposure (important especially in children and pregnant women) and may reduce unnecessary antibiotic drugs prescription.

The basic idea is that almost any alteration of the normal US aspect of the maxillary sinus should be considered suspicious for pathological content of sinusal cavity (exceptions are found in patients with decreased bone density or other bone structure changes).

Like all ultrasonographic exams maxillary sinuses US is highly examiner dependent and the findings must always be correlated with the clinical status of the patient, with the lab studies and other investigations or associated pathologies.
Fig. 1: Maxillary sinus ultrasonography - image acquisition

Fig. 2: Normal aspect of the maxillary sinus compared with the normal aspect of the lung
Fig. 3: Complete "sinusogram" - posterior, medial and lateral walls of the maxillary sinus are visible
Fig. 4: Bilateral incomplete "sinusogram". The findings on the right were interpreted as mucosal thickening and the ones on the left as fluid collection (distance from the BWE to the first echo was 3.1 cm).

Fig. 5: Bilateral back wall echo (BWE) at different depths from the first echo (fluid collection on the right and mucosal thickening on the left).
**Fig. 6:** Same patient, same examination - different types of transducers. Note how the quality of the images improves as the diameter of the probe reduces.
**Fig. 7:** US - X-ray correlations. US reveals changes characteristic for mucosal thickening on the right and for fluid collection on the left. X-ray shows concentric opacification of the right maxillary sinus and complete opacification of the left maxillary sinus.

**Fig. 8:** Water's view projection of the skull reveals opacification of the right maxillary sinus and eccentric opacification of the left maxillary sinus walls.
**Fig. 9:** First US exam (upper right) reveals bilateral complete "sinusogram" consistent with bilateral maxillary fluid collection. Note that the aspect improves on the follow-up examinations, but does not resolve completely. On the last examination (lower left) there is still a BWE present on the right, but there is a normal aspect on the left.
Fig. 10: Comparative aspects of maxillary sinuses - US and MRI performed in the same day (almost 2 months after first US and x ray exam). US shows BWE on the right and normal aspect on the left. T2w MRI reveals a right maxillary cyst and a small fluid collection on the left.
Conclusion

Maxillary sinuses ultrasonography is possible due to the presence of air in the sinusal cavity, the normal image being produced by the reflected echoes returning from the posterior wall of the sinus.

The presence of a "sinusogram" or of a back wall echo at various depths of the sinus are possible US aspects produced by fluid collection and/or mucosal thickening, which are pathological features of acute maxillary sinusitis.

Ultrasonography can be considered a trustworthy imaging technique in the diagnosis of uncomplicated acute sinusitis in children, thus avoiding unnecessary radiation exposure and antibiotic drugs prescription.

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