

YIELD OF ULTRASOUND IN CLINICALLY SUSPECTED MAXILLARY SINUSITIS AMONG PEDIATRIC PATIENTS CONSIDERING COMPUTED TOMOGRAPHY FINDINGS AS GOLD STANDARD

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ABSTRACT

BACKGROUND: Ultrasonography is a safe, rapid, cost effective and readily available imaging tool in pediatric clinics. The aim of this study was to determine the diagnostic value of ultrasonography in clinically suspicious maxillary sinusitis in pediatric patients, taking computed tomography (CT) as gold standard. **MATERIAL AND METHODS:** This prospective study was conducted from January to July, 2015, enrolling patients of age 3-12 years old and presenting with clinical symptoms of maxillary sinusitis. Both ultrasonography and CT were carried out in all patients. **RESULTS:** The data were analysed and quantitative metric like sensitivity ($S_n = 45\%$), specificity ($S_p = 93\%$), positive predictive values ($PPV = 94\%$), negative predictive values ($NPV = 41\%$) and accuracy ($Acc = 94\%$) of ultrasonography for detection of maxillary sinusitis were calculated. **CONCLUSIONS:** Ultrasonography offer low sensitivity and high specificity in diagnosis of maxillary sinusitis in pediatric population.

Keywords: Maxillary sinusitis, Ultrasonography, Computed Tomography

Introduction

The accurate assessment and diagnosis of maxillary sinusitis, frequently encountered in pediatric patients, is often challenging due to the non-specific signs and symptoms.¹ Sinus puncture followed by the bacterial culture of the sinus content has been considered as the standard diagnostic tool of bacterial sinusitis. However, the invasive nature of sampling the sinus content often hinders the frequent clinical implementation of this technique, particularly in pediatric patients.

A wide variety of radiological investigations is available and used as surrogates for the assessment of maxillary sinusitis; these include plain radiography, ultrasonography, computed tomography (CT) and magnetic

resonance imaging (MRI).^{2,3} In spite the availability of several imaging tools, the use of ionizing radiations for the assessment of maxillary sinusitis is one of the primary concerns, particularly in pediatric patients.⁴ Moreover, the number of maxillary pathologies that an imaging test is able to detect (i.e., the sensitivity) and the number of false positives that an imaging tool avoids (i.e., the specificity) also need to be considered. Likewise, the financial impact, procedural time, clinical availability and patient convenience for the given imaging method are also crucial factors; these factors are crucial towards the quality of life of the patient and should be closely examined in the selection of any imaging modality for maxillary sinusitis.

The primary goal of any diagnostic tool is ultimately to improve the quality of life of the patient. That said,

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previously several studies have focused on and compared the outcomes of the abovementioned imaging modalities for the assessment of maxillary sinusitis in general population.⁵⁻⁷ However, an objective comparison of these imaging tools aimed at the pediatric patients has rarely been reported, particularly in our specific local environment. In this context, we aim to present a comparative study of ultrasonography versus CT for assessment of maxillary sinusitis in pediatric patients. In particular, we analysed specific parameters including sensitivity, specificity, positive and negative predictive values and accuracy of ultrasonography versus CT. We postulate that such objective comparison may significantly facilitate clinicians in evaluating the optimal options (in terms of quality of life, convenience and treatment cost) for the management of maxillary sinusitis in pediatric patients.

Material and Methods

This prospective study was conducted at the radiology department of combined military hospital (CMH), Multan, Pakistan, from January to July, 2015. Patients of age 3-12 years old and presenting with clinical symptoms of maxillary sinusitis for more than three months duration were included in this study. However, patients with anomalies of maxillary sinus, suspected or proven malignancy in the sinonasal region, having history of trauma to the nose/ face, history of sinonasal surgery or congenital anomalies (i.e., facial clefts, cleft lip and palate) were not enrolled in this study. Based on these criteria, a total of 92 pediatric patients were included.

Both ultrasonography and CT scan were carried out in all patients included in the study group. Specifically, ultrasonography was performed in every patient by using a pediatric convex, multi-frequency 4-9MHz transducer. Both maxillary sinus were investigated for superior to inferior extents and any possible pathologies. In particular, the patients were assessed for any mucosal thickening, anechoic retention cysts, soft tissue masses and fluid levels. After ultrasonography, CT scan of all patients was performed, subsequently analysed.

Complete data for each patient such as patient particulars, clinical history, radiographic findings (normal

or abnormal sinus, type of pathology in sinus, involved sinus, etc.) were collected in a dictated, preformed proforma. The data were analysed and compared in terms of sensitivity, specificity, positive and negative predictive values and accuracy for ultrasonography versus CT scan.

Results

A total of 92 patients with mean age of 8.1 ± 2.3 years (range = 3-12 years) were included in this comparative study; 67 (~73%) were male and 25 (~27%) were females.

The present study consisted of pediatric (<12Y) patients who underwent CT scans of the head and were further evaluated with ultrasonography to find out sensitivity, specificity, positive and negative predictive values and accuracy of ultrasonography keeping CT scan as gold standard.

On ultrasonography 61 (~66%) patients didn't reveal any positive findings while 31 (~34%) patients had positive findings. For the patients with positive findings, 19 (~61%) patients were having right, left or bilateral mucosal thickening alone while 12 (~39%) patients showed fluid in the sinus. Alternatively, CT scan demonstrated 65 (~71 %) patients had positive findings while 27 (~29 %) patients exhibited normal maxillary sinuses. For the patients with positive findings on CT scan, 27 (~42 %) showed mucosal thickening, 13 (~20 %) had total opacity and 25 (~38%) had air / fluid level. An illustrative image showing maxillary sinusitis for each CT scan and ultrasonography has been shown in (Fig. 1) while the patterns of positive findings for ultrasound and CT scan are summarized in (Tab. 1).

The confusion matrix presenting a one to one comparison of the positive findings of ultrasonography versus CT scan in diagnosis of clinically suspicious maxillary sinusitis is depicted in (Tab. 2). It may be

Findings	Ultrasound				Computed Tomography			
	Right	Left	Bilateral	Total	Right	Left	Bilateral	Total
Mucosal thickening	8	6	5	19	11	9	7	27
Sinus fluid	6	3	3	12	11	10	4	25
Total opacity					6	4	3	13
Normal				61				27

Table 1: Ultrasonography versus CT scan positive findings in the clinical maxillary sinusitis pediatric patients

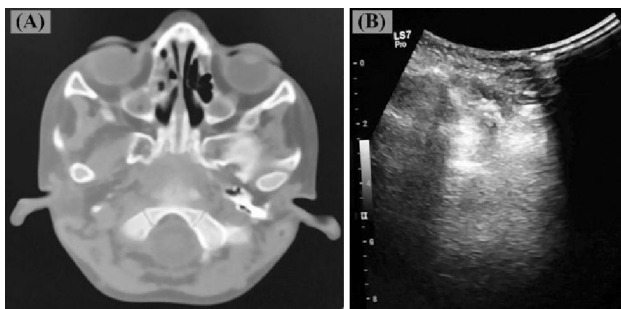


Figure 1: Maxillary sinusitis seen on CT scan and Ultrasound

noted that ultrasonography illustrated positive findings in 02 patients who were shown normal on CT scan. On the other hand, 36 patients were positive for maxillary sinusitis on CT scan but were not picked up on ultrasound.

Sinusitis on ultrasound	Sinusitis on CT	
	Positive	Negative
Positive	29	02
Negative	36	25

Table 2: Confusion matrix for ultrasonography versus CT scan positive findings of maxillary sinusitis pediatric patients

In the next step, CT scan was assumed as gold standard for the detection of clinically suspicious maxillary sinusitis and the quantitative efficiency of ultrasonography was evaluated in terms of statistical metrics such as sensitivity (S_n), specificity (S_p), accuracy (Acc), positive predictive values (PPV) and negative predictive values (NPV). To this end, confusion matrix, which describes the detection parameters in the most fundamental form i.e., true positive (TP); false positive (FP); true negative (TN); false negative (FN) has been calculated for comparing the detection efficiency of ultrasonography (with CT scan as gold standard) and presented in (Tab. 3). It may be noted that the elements 1 and 2 of the first row represent TP and FN for maxillary sinusitis while

Parameters	Percent
Sensitivity	45
Specificity	93
Accuracy	59
Positive predictive value	94
Negative predictive value	41

Table 3: Diagnostic value of ultrasonography in maxillary sinusitis of pediatric patients considering CT scan as gold standard

elements 3 and 4 of the second row represent FP and TN for normal patients, respectively. The useful statistical metrics parameters (i.e., S_n , S_p , Acc , PPV and NPV) were derived from the confusion matrix; these metrics came out to be $S_n = 45\%$, $S_p = 93\%$, $Acc = 94\%$, $PPV = 94\%$, $NPV = 41\%$.

Discussion

Timely diagnosis of clinically suspicious maxillary sinusitis has always been a substantial challenge for primary care physicians, most likely due to the unspecific clinical symptoms including rhinorrhea, cough, nasal voice, fever, headache, sinus tenderness, inflammation of nasal mucosa, postnasal drip, etc. Chronic sinusitis is particularly difficult to diagnose as the symptoms are usually vague and may even be shared by other diseases such as vasomotor rhinitis, allergic rhinitis, migraine, myofascial pain syndromes, etc. That said, the patient's ability to convey a cogent history appears very crucial for the clinical diagnosis of the sinusitis; however, this factor is also lacking in pediatric patients (age <12 years), further confounding the early diagnosis. Moreover, the high load of patients and limited consultation time available to each patient in developing countries like Pakistan may also contribute to hinder the accurate diagnosis of the sinusitis. On the other hand, the physician is also reluctant to perform the standard diagnostic test of sinusitis (i.e., antral puncture followed by bacterial culture) in pediatric patients, because of the invasive nature of the technique. Nevertheless, failure to diagnose maxillary sinusitis can lead to potentially serious complications. Overall, these factors contribute in establishing the diagnosis through conventional radiologic imaging. Computed tomography (CT) and ultrasonography are the frequently used medical imaging modalities used in clinics worldwide. As such, these two imaging tools are also used for detection of clinically suspicious maxillary sinusitis in pediatric patients. In particular, CT scan is able to sensitively determine the extent and severity of sinusitis but is typically carried out when patients have complications or when chronic sinusitis is suspected.^{8,9} Alternatively, ultrasonography is a rapid, readily available, relatively inexpensive and convenient imaging method for evaluation of maxillary sinusitis.^{10,11} In this context, this study was

planned to compare both these imaging tools to explore and describe the possible options in various scenarios of pediatric clinics without compromising the quality of life of the patients.

The observed trends in the diagnosis of clinically suspicious maxillary sinusitis revealed that CT scan is a clearly superior imaging method as compared to ultrasonography. Keeping the CT scan as gold standard, ultrasonography detected considerably lower number of maxillary sinusitis. The common finding of ultrasonography was unilateral mucosal thickening followed by bilateral sinus involvement. Since the bilateral involvement was mostly seen in acute sinusitis patients, thereby the observed trend in the findings may have stemmed from the fact that our sample cohort contained higher number of chronic sinusitis cases as compared to acute sinusitis cases. Moreover, the sensitivity of ultrasonography for detection of maxillary sinusitis is low ($S_n = 45\%$), however it offers very good specificity and accuracy ($S_p = 93\%$, $Acc = 94\%$). Furthermore, ultrasonography is safe (as it does not utilize ionizing radiations), less expensive, allows for real-time assessments and frequently available. In this context, it is postulated that ultrasonography may be used as a first hand tool in the diagnosis of clinically suspicious maxillary sinusitis, particularly in pediatric patients.

The findings of this study appear consistent with similar previous studies. For instance, comparison of ultrasound to CT scan for acute maxillary sinusitis have previously demonstrated sensitivity and specificity levels of 66.7% and 94.9%, respectively.¹² Other studies dealing with the characterization of maxillary sinus have also demonstrated almost similar sensitivity and specificity metrics.¹³⁻¹⁵ To enhance the accuracy of ultrasound, a postural change during sinus ultrasound has been suggested. In particular, sinus ultrasound, as typically performed in half-sitting position, gives a partial sinusogram (i.e., the sole visualization of the hyperechogenic posterior wall of the sinus), indicative of air-fluid level. The ultrasound was repeated with a postural change in the patient position (i.e., in supine position) where the appearance (or disappearance) of the partial sinusogram was correlated with mucosal thickening (or air-fluid level). The postural change for sinus ultrasound increased the value of PPV from 61 to 91.2%.¹⁶ Likewise, ultrasound and plain radiography were investigated

and found comparable in the diagnosis of maxillary sinusitis. Specifically, the S_n , S_p , Acc , PPV and NPV values of ultrasound in comparison of plain radiography were 99.7%, 89.9%, 94%, 88.5% and 99.8%, respectively.⁷ Moreover, ultrasound and plain radiography showed agreement in detection of fluid accumulation and air-fluid level in the maxillary sinuses.¹⁷ Overall, these studies suggest that ultrasound is a simple and efficient imaging tool for the assessment of clinically suspicious maxillary sinusitis.

Conclusion

In this study, we have compared the efficiency of ultrasonography against CT scan for the assessment of clinically suspicious maxillary sinusitis in pediatric patients. In particular, ultrasonography offers low sensitivity but very good specificity and accuracy compared to CT scan. Ultrasonography is a safe, rapid, cost effective and readily available imaging tool for the initial assessment of clinically suspicious maxillary sinusitis in pediatric patients.

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