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Ultrasonography: A novel diagnostic tool for maxillary sinusitis

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ABSTRACT

Objective: To evaluate the diagnostic accuracy of ultrasound in maxillary sinusitis keeping computed tomography as a gold standard.

Methodology: This is a Cross-Sectional validation study that prospectively included cases of suspected maxillary sinusitis using a convenience sample. A sample of either gender, above 10 years age was recruited from otolaryngology and radiology departments of Capital Hospital, Islamabad, Pakistan from December 2019 to February 2020. Computed tomography imaging of Paranasal sinuses and Ultrasound of Maxillary sinuses were used for data collection. Data was analyzed using SPSS Ver-23 and test sensitivity, specificity, PPV and NPV, and Accuracy Rate were calculated.

Results: The sample comprised 27(45%) males and 33(55%) females with a majority 31(51.7%) of the patients being 36-50 years old. Ultrasonography was calculated to have a sensitivity of 96.4% for diagnosing sinusitis, however, its specificity was only 25%, while the accuracy rate was 93.22%. The PPV of ultrasonography was 94.7%, while the NPV was 33.3%.

Conclusion: Ultrasound with an accuracy rate of 93.22% and a sensitivity of 96.4% has benefits of safety, easy availability and low cost and hence is an important investigation for maxillary sinusitis evaluation.

Keywords: Accuracy rate, Computed Tomography Imaging, Maxillary Sinusitis, Ultrasonography.

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Introduction

Maxillary sinusitis is a very common inflammatory pathology involving the sinuses[1], affecting approximately 20% of the population[2] with chronic rhinosinusitis (CRS) accounting for 5 to 15% of the cases.[3] Sinusitis may result from infection both bacterial and viral; allergic response; alteration in immunity or combination of several factors in both adults and children.[4] Diagnosis is usually based on a combination of symptom assessment and physical examination using clinical diagnostic criteria, with sudden onset of symptoms noted in acute sinusitis while the presence of two or more symptoms beyond 12 weeks indicating CRS. Clinicians usually avoid radiological investigations including X-Ray in young children, with computed tomography (CT) Scanning reserved for selected cases, especially when complications are suspected.[1]

On radiologic evaluation, opacification and air-fluid level usually correlate with acute sinusitis. On the other hand findings like mucosal thickening, small-volume sinus, sclerosis, and thickening of bone are features that are suggestive of chronic sinusitis.[4] CT scan is the Gold Standard recommended radiological imaging investigation for the diagnosis of Sinusitis.[5] CT scan can reveal a variety of findings found in maxillary sinuses and according to Drumond JPN et al. [6], it can diagnose muco-periosteal thickening (focal), polypoid lesions, chronic sinusitis, and chronic sinusitis of odontogenic origin, rhinosinusitis, and other miscellaneous lesions in the frequency of 21.25%, 10.76%, 7.48%, 2.29%, 1.77% respectively. However, CT scan has the disadvantage of radiation exposure and delivers around 1 to 10 mGy radiation to a patient and hence exposes to risk of harmful effects of radiation including cancer, with younger patients being more at risk.[7]

Ultrasound (US) imaging is a less invasive investigation and avoids the harmful effects of radiation. Some authors recommend US for the follow-up cases receiving treatment with the basic diagnosis of sinusitis established by CT scan[8]. Others conclude that on a wider scale, ultrasound could be a safer alternative to detect fluid in the maxillary sinuses in children, compared to radiological options [9]. Also in a local study by Shakeel Y et al. gave quite encouraging results from their study with a sensitivity of US to establish the diagnosis of maxillary sinusitis compared to Magnetic Resonance imaging being low (40.15%), however, its specificity was better (84.67%) [10].

Also according to Pant H, comparing US with plain X-ray showed good results with sensitivity and specificity of 99.7% and 89.9% respectively so much so that ultrasound was better able to pick air fluid level (p=0.000) and muco-periosteal thickening (p=0.035)[11]. In developing countries like Pakistan, CT imaging facility is still limited to tertiary care centers in cities in the Public sector, while the public sector institutions in the rural side are devoid of such facilities, however, most are equipped with US facility and authors have recommended research on the use of US imaging in Otolaryngology cases.[12]

Therefore, this study was conducted to evaluate the accuracy of ultrasound imaging of maxillary sinuses compared to the gold standard computed tomography imaging for the diagnosis of maxillary sinusitis. This study has importance since there is a dearth of literature on the use of US imaging compared to CT imaging, for the diagnosis of maxillary sinusitis with no study from this part of the world and might help clinicians better use this diagnostic modality both for the benefit of their patients as well as for research purposes.

Methodology

This cross sectional validation study recruited a sample of N=60 cases prospectively, using convenience sampling. Study was conducted at radiology departments of Capital Hospital PGMI, Islamabad over three months from December 2019 to February 2020, after taking ethical approval of the institutional ethical committee of the hospital. CT scan and US scan reports of the maxillary sinuses were used for data collection. The sample size of N=68 was calculated using sample size calculator:

$$N = \frac{z^2_{\alpha/2} * p * (1-p) * DEFF}{d^2}$$

with a prevalence proportion of 0.046, α=.05, estimated effect size DEFF=1, and desired level of absolute precision of .05. 8 cases with incomplete data were excluded from the study. Following informed consent samples of both genders above 10 years of age with suspicion of maxillary sinusitis who were referred to the radiology department for CT imaging of paranasal sinuses, were included in the study. All such cases were offered free US scan of the maxillary sinuses, however, Sonologist was kept blinded regarding the CT scan findings. Cases in which CT scan or US scan could not be performed due to any reason were excluded from the study.

Ultrasound imaging was performed using Toshiba Xario ultrasound machine with 4-9 MHz transducer, while CT imaging was performed using 64 slices Toshiba computed tomography scanner. The detection of a hypoechoic/transonic, homogeneous, or non-homogeneous image, with a well-defined contour and a triangular shape within the maxillary sinuses was interpreted as a fluid collection while an alteration of the normal pneumatization of the maxillary sinuses expressed through a hypoechoic/echoic image that did not have a triangular shape and well-defined margins was diagnosed as a thickening of the sinus mucosa. The thickness greater than 5 mm was declared as abnormal thickening.

Data collected was analyzed using SPSS Version- 23. Descriptive statistics were utilized including frequency and percentage. Comparing US with gold standard CT imaging, accuracy rate, sensitivity, specificity, Positive Predictive value (PPV), and Negative Predictive value (NPV) were calculated utilizing SPSS.

Results

The sample included 27(45%) males and 33(55%) females with male to female ratio of 1:1.22. The majority 31(51.7%) of the patients were of age group 36-50 years, followed by 16(26.7%) of 19-35 years age group. (Figure 1).

Of the 52 cases diagnosed as bilateral maxillary sinusitis on ultrasonography, 4 came out to be normal, 33 were confirmed with bilateral maxillary sinusitis, 11 had left maxillary sinusitis and 4 had right maxillary sinusitis on CT scan. On other hand, 6 cases diagnosed as left maxillary sinusitis on ultrasonography, were ultimately diagnosed to have bilateral maxillary sinusitis on CT scan (Table I).

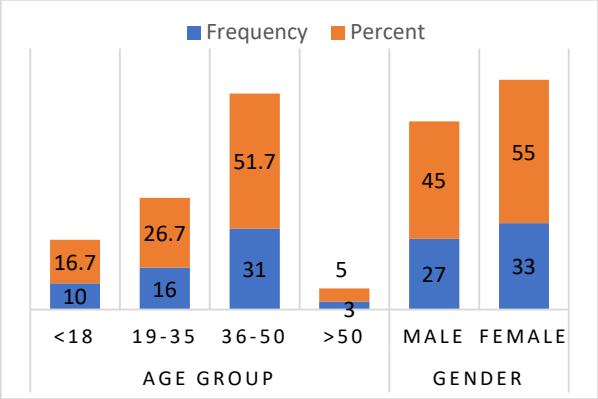

Figure 1. Demographics of the study population (N=60)

With these findings ultrasonography was calculated to be having a sensitivity of 96.4% for diagnosing sinusitis, however, its specificity was only 25%, making an accuracy rate of 93.22%. The PPV of ultrasonography was 94.7%, while the NPV was 33.3%. (Table II)

As far as picking up of the correct findings was concerned (table III), in the present study ultrasound of the right maxillary sinus picked mucosal thickness in 12(20%) cases which came out to be normal sinus in 7 cases, mucosal thickening in 2, and mucosal thickening with opaque sinus in 3 cases.

In the ultrasound of right sinus, mucosal thickening plus fluid/opaque sinus was noted in 44(73.33%) cases but on CT scan 8 came out to be normal, 2 had mucosal thickening, 17 had mucosal thickening plus opaque sinus, 6 had mucosal thickening plus opaque/ fluid and 11 with mucosal chickening plus opaque plus soft tissue density/ polyp.

In the ultrasound of left maxillary sinus, mucosal thickening was seen in 14(23.33%) of which 2 came out to be normal and 10 presented with mucosal thickening plus opaque sinus on CT scan, while 42(70%) cases of

Table I: Ultrasound diagnosis * Computed tomography Diagnosis. Cross Tabulation (n=60)

		Computed Tomography Based Diagnosis				
		Normal	Bilateral Max Sinusitis	Left Max sinusitis	Right Max sinusitis	Total
Ultrasound Scan Based Diagnosis	Normal	0	2	0	0	2
	Bilateral Maxillary Sinusitis	4	33	11	4	52
	Left Maxillary Sinusitis	0	6	0	0	6
	Total	4	41	11	4	60

Table II: Diagnostic Accuracy of Ultrasound taking CT Scan as Gold Standard. (n=60)

		Computed Tomography Scan Result		Total	
		Pathology	**No Pathology**		Accuracy
Ultrasound	Pathology	True +ve: 54 **(a)**	False +ve: 3 **(b)**	57	93.22%
		PPV: 94.7%	5.30%	100.00%	
		Sensitivity: 96.4%	75.00%	95.00%	
	No Pathology	False -ve: 2 **(c)**	True –ve: 1 **(d)**	3	
		66.70%	NPV: 33.3%	100.00%	
		3.60%	Specificity: 25%	5.00%	
	Total	56	4	60	

Table III: Ultrasound Findings * CT Scan Findings in Sinusitis. Cross tabulation. (N=60)

		Computed Tomography Scan Findings					X^2, P
Ultra Sound Maxillary Sinuses	Findings N(%)	Normal	Mucosal Thickening	Mucosal Thickening + Opaque	Mucosal Thickening + Opaque/ Fluid	Mucosal Thickening + Opaque+ Soft tissue density/polyp	
Right	Normal 4(6.67)	0	2	2	0	0	22.26, 0.004
	Mucosal thickening 12(20)	7	2	3	0	0	
	Mucosal Thickening + Fluid / Opaque 44(73.33)	8	2	17	6	11	
	Total	15	6	22	6	11	
Left	Normal 4(6.67)	2	2	0	0	0	15.13, 0.056
	Mucosal thickening 14(23.33)	2	0	10	0	2	
	Mucosal Thickening + Fluid/ Opaque 42(70)	4	8	19	2	9	
	Total	8	10	29	2	11	

ultrasound showed mucosal thickening plus fluid/ opaque, proved on CT scan to be normal in 4, mucosal thickening in 8, mucosal thickening plus opaque in 19 and mucosal thickening plus opaque / fluid in 2 cases on CT scan.

Discussion

The present study compared Ultrasonography with Gold Standard CT Scan for the diagnosis of Maxillary Sinusitis with a balanced sample with equal male female ratio and the majority of the population (51.7%) being 36-50 years of age. Figure 2 shows CT scan and Ultrasonography results of some cases.

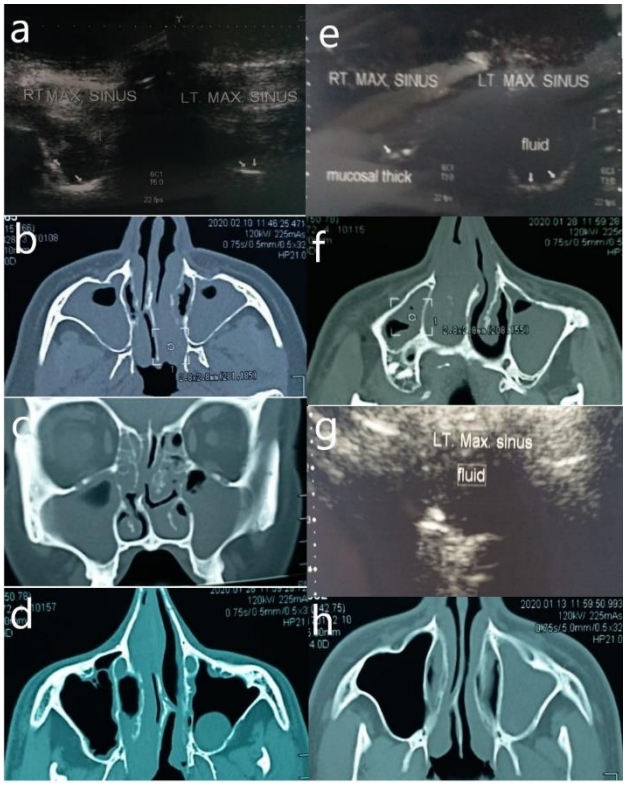

Figure 2: (a) US with posterior enhancement, (b) & (c) CT scan axial and coronal view of same case confirmed maxillary sinusitis, (d) CT scan axial view showing polypoidal lesion in Left maxillary sinus, (e) US scan shows mucosal thickening and debris in Right maxillary sinus & fluid level in left maxillary sinus with bright echoes posteriorly and (f) CT scan axial view of same case shows bilateral maxillary sinusitis, (g) US with bright echoes in left maxillary sinus while (h) CT scan confirmed maxillary sinusitis.

With all these findings ultrasonography was calculated to be having a sensitivity of 96.4% for diagnosing sinusitis, however, its specificity was only 25%, making an accuracy rate of 93.22%. While the PPV of ultrasonography was 94.7%, while the NPV was 33.3%. In contrast to our study in another comparative study of US with CT Scan by Fernando L et al. reported that B mode US had a sensitivity of 91%, the specificity of 92.5%, positive predictive value of 86% and negative predictive value of 95% in Intensive care patients and proposed B mode US to be considered as first line diagnostic modality for maxillary sinusitis.[13] According to Zarei E et al. compared to CT, US has a sensitivity of 92%, specificity (88%), PPV (92%), and NPV of (88%).[14]

In the current study ultrasound of the right maxillary sinus picked mucosal thickness in 12(20%) cases which came out to be normal sinus in 7 cases, mucosal thickening in 2, and mucosal thickening with opaque sinus in 3 cases. In the ultrasound of the right sinus, mucosal thickening plus fluid/opaque sinus was noted in 44(73.33%) cases but on CT scan 8 came out to be normal, 2 had mucosal thickening, 17 had mucosal thickening plus opaque sinus, 6 had mucosal thickening plus opaque/ fluid and 11 with mucosal chickening plus opaque plus soft tissue density/ polyp. In the ultrasound of left maxillary sinus, mucosal thickening was seen in 14(23.33%) of which 2 came out to be normal and 10 presented with mucosal thickening plus opaque sinus on CT scan, while 42(70%) cases of ultrasound showed mucosal thickening plus fluid/ opaque, proved on CT scan to be normal in 4, mucosal thickening in 8, mucosal thickening plus opaque in 19 and mucosal thickening plus opaque / fluid in 2 cases on CT scan. A study by Zagólski & Strek, reported the agreement rate of US and CT in the diagnosis of maxillary sinusitis being 81.45, with 58.8% for acute and 85% for chronic sinusitis, and correlation was statistically significant [8]. In another study by Abdalla AA et al. to see the detection ability of US in comparison to CT in cases with facial pain, reported that pathological changes picked up by US included polyp (30%), fluid (12%), cysts 2%, mucosal thickening 12%, polypoidal mucosal thickening 6% and normal sinus in 38% [15]. Also, Zarei E et al. have reported that US errors are low while detecting normal and opacification of sinuses, but high (47%) in detecting mucosal thickening hence more suitable for diagnosis of acute maxillary sinusitis, while high level of errors in diagnosing mucosal thickening.[14]

The utility and effectiveness of US imaging in the diagnosis of maxillary sinusitis is also evident from a study by Hsu CC et al. to determine the effectiveness of US in Acute and subacute sinusitis, there was a

significant diagnostic correlation between US and rigid naso-endoscopy .[16]

Limitation of Study: The study had limitation of small sample size, since patients were required to undergo both Ultrasound and CT imaging, hence not many patients consented for the study.

Conclusion

We conclude that Ultrasound with an accuracy rate of 93.22% and a sensitivity of 96.4% has emerged as an important investigation for diagnosing maxillary sinusitis. It is cheaper, less time consuming, easily available and free from radiation hazards due to which it can be used in pregnancy and children as well.

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