

COMPARISON OF SONOGRAPHY WITH PLAIN RADIOGRAPHY IN CLINICALLY SUSPECTED MAXILLARY SINUSITIS

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ABSTRACT

OBJECTIVE: To find the diagnostic value of ultrasound in comparison with plain radiography in clinically suspected maxillary sinusitis cases. **MATERIALS AND METHODS:** It was hospital based observational study conducted on Bir hospital, Nepal. Total of 450 patients with suspected maxillary sinusitis were enrolled in the study. Maxillary sinusitis was suspected by ear nose throat surgeons and all cases who met inclusion criteria were studied. Radiography of paranasal sinus was done in water's view in standing position. Findings like opacification, air fluid level, mucoperiosteal thickening were recorded along with demographic parameters. Sonography was conducted on sitting position by radiologist who was unaware of radiography finding. Normal sinus, likely focal lesion of sinus were also recorded along with sonographic diagnosis of sinusitis. The data were entered in statistical packages for social science version 15 and analysis done. Sensitivity, specificity of ultrasound compared to plain radiography was calculated. **RESULTS:** Most of the cases were of middle aged. Student (23%) and housewife (15.5%) were most common population group in this study. Most common symptom was headache which was present in 57.6%. Chronic sinusitis cases were commoner (59.3%) than acute sinusitis cases. Most of the sinusitis was noted in one side only (bilateral noted in 17% only) and laterality was almost equally recorded on right and left maxillary sinuses. Of the 900 total sinuses examined, only 452 sinuses were found to be diseased on radiography, 391 had sinusitis. Large number of sinuses (448) were normal. Opacification of sinus was most common radiological pattern seen which was noted in 237 sinuses (60.6%). On sonography 443 sinuses showed features of sinusitis. Almost all cases of radiographically positive sinuses showed positive results on sonography. However, few radiographically negative sinuses (52) also showed positive features on sonography. Overall, air fluid level in acute cases ($P=0.000$) and mucoperiosteal thickening (0.035) were more detected on sonography. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 99.7%, 89.9%, 88.5%, 99.8% and 94% respectively. **CONCLUSION:** This study showed that plain radiography and sonography are comparable in diagnosis of maxillary sinusitis.

Key words: Maxillary sinusitis, ultrasonography, radiography

Introduction

Sinusitis is common medical problem in ear nose throat (ENT) department and potential cause of sepsis in ill and admitted patients. Chronic sinusitis is seen in 14-16% of US population¹ and 0.4% of office visits are found to be due to acute sinusitis.² Maxillary

sinusitis is the commonest of the sinusitis because of the location of drainage orifice, which is toward roof of sinus.

Sinusitis can present with multiple clinical features and diagnosis is not mostly straight forward. Radiography, Ultrasound (USG), Computed tomography (CT) scan, Magnetic resonance imaging (MRI) has

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been described as modalities of investigation. Despite many imaging modalities advocated, confirmation is done only by culture of antral/sinus content,³ which is mostly not feasible. Generally speaking, antibiotic use in suspected sinusitis is guided by plain radiography, which is well established. Plain radiography like in most parts of world is used in our settings and regarded as standard investigation. However, there are few fallacies with plain radiography; including false positive in mucosal thickening. Moreover, radiography is not always practicable especially in intensive care unit (ICU) setting and it has radiation risk, which is of serious concern in pregnancy and children. Because of these drawbacks, MRI has become theoretically the modality of choice these days.⁴ But MRI is not generally practicable because of less availability and high cost. So despite of having some limitations, plain radiography is still the standard investigation modality for sinusitis detection and guide treatment. And, easily accessible investigation modality with more accuracy and less disadvantage is still in search as an alternative to radiography as CT/MRI are advised in complicated cases only.

Ultrasonography (USG) is easily accessible, cheap and handy option. It has no radiation risk which makes it safer in pregnant and children, and it can be done easily in debilitated and intubated patients in ICU setting also. Detection of normal sinus and fluid filled sinus on ultrasound has been described elsewhere and sinus sonography has been found to be sensitive in maxillary sinusitis.⁵ USG is widely regarded as potential substitute to plain radiography and many researchers have found out equal sensitivity with USG in maxillary sinusitis detection⁴⁻⁸ but some have reported less.⁹ Some researchers have even documented higher sensitivity of USG in small fluid collection.⁸ But detection of other sinusitis (frontal / sphenoid) by ultrasound is found to be unreliable¹⁰ and detection of other disease pathologies like tumor, polyp, mucocele is also found to be unreliable by ultrasound.¹⁰

Although extensively studied and regarded as potential substitute to radiography in maxillary sinusitis diagnosis and better imaging modality for follow up of treatment cases, USG is not being commonly practiced as imaging modality worldwide. More so, there are no literatures available regarding use of sonography in sinusitis and related disease in our part.

We aim to find out the diagnostic value of ultrasound in clinically suspected maxillary sinusitis in comparison with plain radiography.

Methodology

It was cross sectional hospital based observational study conducted on Bir hospital, NAMS (national academy of medical sciences). Altogether 450 cases with clinical impression of sinusitis were studied. Patients already on antibiotic, suspected / proven malignancy in sinonasal area were excluded. Acute sinusitis was defined as per clinician for patients presenting with features like fever, headache, purulent nasal discharge, post nasal drip. Chronic sinusitis was defined for patients who have such features for more than 14 days; continuously or on and off. All consecutive cases were followed from 1-12-014 to 1-1-016 till our sample size is achieved. Radiography and USG will be done on same day.

Radiography was done in Siemens 500 mA machine, Model number: 4801200. Standard water's view was taken with 45 degree angulation in occipito mental position in sitting / standing position. Radioopacity of maxillary sinus is comparable to orbit with clear visualisation of wall and no added opacity will be noted within sinus. Such sinuses were defined as normal maxillary sinus. Fluid level in sinus, mucoperiosteal thickening of more than 3 mm and opacification of sinus were diagnosed as sinusitis. Mucoperiosteal thickening was looked in lateral side of maxillary sinus and thickness of more than 3 mm was regarded as thickening. Sinuses were compared to orbit for detecting opacification. Radiographic density more than that of orbit was defined as opacification of sinus. Air fluid levels were detected by opacity in lower part with straight level superiorly and sinus containing lucent areas in upper part comparable to nasal cavity. Homogenous well defined opacity with rounded one or more wall was defined as polyp or mucus retention cyst, likely not sinusitis.

USG was done by experienced radiologist on Toshiba aplio 400 with low frequency probe (3-5 MHZ). When ever feasible, higher frequency probe was also used. Both maxillary sinus were studied in longitudinal and transverse plane in sitting position. Superior to inferior extent of both sinuses were examined. Normal sinus

filled with air were noted giving rise to air shadow (air wall echo) at posterior part of anterior wall of sinus. In the normal air-filled sinus, a prominent periodic resonance artifact will be apparent, consisting of an evenly spaced series of echogenic lines that parallel the shape of the anterior surface of the maxilla and diminish in intensity at increased depth. So normal air filled sinus cannot be visualised and only tissue upto anterior wall of sinus can be appreciated on scan. Normal sinus can be confirmed in M mode also. So in our study, both B and M mode will be used. Normal sinus was defined if echo is at a distance of ≤ 1.0 cm (posterior wall not visualised), mucosal thickening if echo at 1.1-3.4 cm, fluid filled if echo is ≥ 3.5 cm (posterior wall visualised). Also hypoechoic sinus with visualisation of posterior wall and hypoechoic triangular shaped area with posterior acoustic enhancement were defined as fluid filled sinus. Cyst or polyp were defined if dual peak echo was seen. Fluid filled or air filled sinus were rechecked in M mode. Air fluid level were defined if sinus showed posterior sinus wall in lower part and evidence of air seen in upper part in the form of echo at distance of below 3.4 cm.

Radiographic image was read by radiologist after doing ultrasound. The findings dictated were noted in preformed proforma. Patient particulars, important clinical history, radiographic findings (normal or abnormal sinus, type of disease pathology in sinus, which sinus is involved by disease; etc) and ultrasonographic findings were also noted. Data were entered in SPSS (statistical package for social science) version 16. Variables like age group of patients, gender, duration of clinical symptom were recorded. Important symptoms of patients were also recorded. In radiography, status of sinus (pathological or not) were entered as important variable. Features of sinusitis were recorded in detail; including air fluid level present or not, sinus opacification present or not and mucoperiosteal thickening in mm if present. Presence of focal lesion in sinus like polyp/mucocele were entered as single variable. Unilaterality or bilaterality of involvement were recorded. From the ultrasound, findings of both maxillary sinus were recorded. In USG also, air fluid level, mucosal thickening were entered. Mucosal thickness more than 1.1 mm was documented in mm which was later correlated with x ray findings. Sonographic features denoting normal sinus or other

pathology like polyp were also documented. Important data are presented in tables and charts. Among the important findings, comparability of USG with radiographic findings was checked. Number of cases with sonographic diagnosis of sinusitis or normal sinus were found out in total and compared with radiography. Presuming radiography as standard diagnosis, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) of USG were calculated. Sensitivity, specificity, PPV, NPV and accuracy were calculated by standard formula as below:

Sensitivity = $TP/TP+FN$

Specificity = $TN/FP+TN$

PPV (Positive predictive value) = $TP/TP+FP$

NPV (Negative predictive value) = $TN/TN+FN$

Accuracy = $TP+TN/TP+TN+FP+FN$

TP = True positive, FN = False negative, TN = True neagative, FP = False positive

In sonographically negative cases, or when alternative sonographic diagnosis noted, cause for same were looked for if relevant. Any numerically significant variables were statistically analysed to find they are due to chance or are really significant by Chi square test. P value of <0.05 were taken as statistically significant.

Results and Observations

Total of 450 cases were enrolled in study. Most patients were of middle age. Age group 16-30 years and 31-45 comprise 46.9% and 28.7% respectively (Tab. 1). Mean age of presentation was 29.98 (S.D.13.24) years. Males were numerically more in our study. Out of 450 patients, 267 (59.3%) were males and 183 were females. As compared to acute sinusitis, chronic was more common. Clinically, acute sinusitis was present in 183 (40.7%) cases. Most patient presented with headache (57.6%), discharge (27.3%) and fever (23.3%). Cough and cold was also common presentation (30% cases). Multiple symptoms were predominant complain in 20% patients. Acute sinusitis patients mainly had fever (105 Of 183 cases). None of the chronic sinusitis cases had fever as presenting complain. Headache was present in 85.4% (228 of 267) of chronic sinusitis cases. Majority of the patients were students (23.1%) and housewives (15.5%), however teachers, and businessman were other common occupations. Many patients didn't express

their profession/they were jobless. Overall, chronic sinusitis was commoner (59.3%) than acute. Both gender showed more cases of chronic sinusitis. There was no difference in chronicity according to gender. Sinusitis was present in most cases of clinically suspected maxillary sinusitis (74.7%). Few other cases (13.6%) showed diseased sinus in the form of focal lesion of sinus. Clinical suspicion of sinusitis were mostly correct to detect diseased sinus as only 11.8% patient showed no disease in the sinuses. Overall, radiograph showed sinusitis in 336 (74.7%) cases. Of the total 336 cases, 53 showed bilateral involvement (15.7% of total sinusitis). Total of 391 sinuses were diseased. Right side of sinus was involved in 47.3%, and 52.7% in left. Of the remaining cases with no radiographic sinusitis, 61 (13.5%) cases showed polyp/mucus retention cyst and 53 (11.7%) had no evidence of maxillary sinus disease on radiograph.

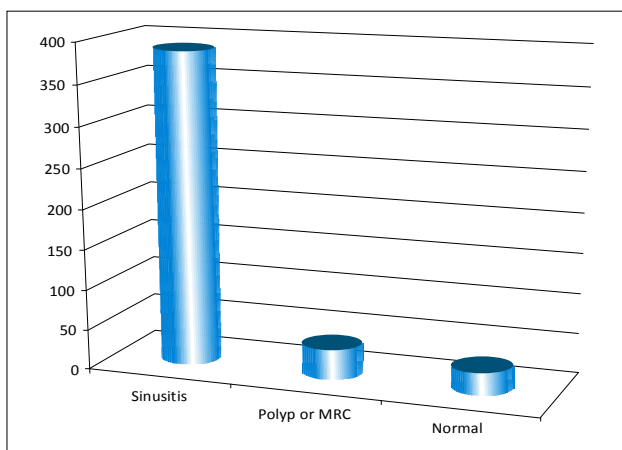


Figure 1: Bar diagram showing sonographic diagnosis / findings of total suspected maxillary sinusitis patients.

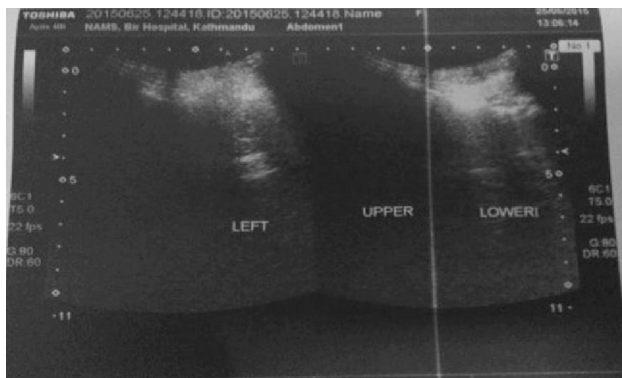


Figure 2: Sonography of left maxillary sinus showing visualization of posterior wall in lower part, which is located more than 3.5 cm from skin surface. There is air shadow and nonvisualization of posterior wall echo complex in upper part. Findings are consistent with air fluid level.

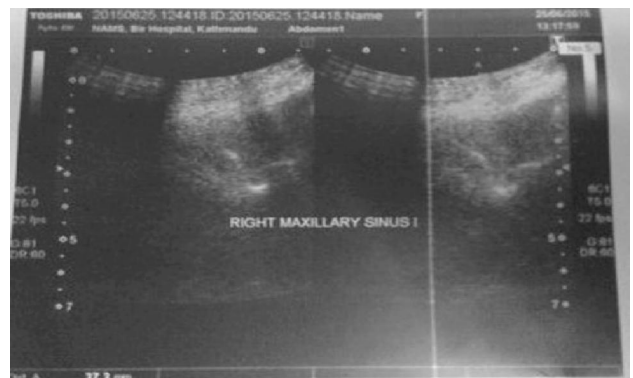


Figure 3: Ultrasound of right maxillary sinus showing clear visualization of all the walls of sinus with anechoic content within. The posterior wall echo distance is about 4 cm from the skin surface. Findings consistent with opacification of sinus.

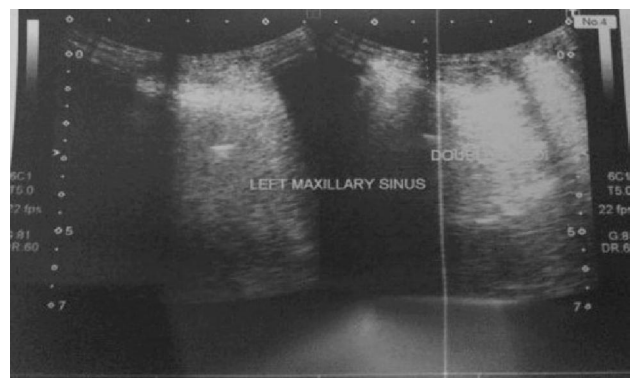


Figure 4: USG of left maxillary sinus showing at least two echo complex. Second echo complex is posterior to anterior echo complex. However, distance from the skin surface is 2.9 cm, suggesting it is not posterior wall. Findings suggestive of focal lesion of sinus.

USG showed evidence of sinusitis in 388 (86.2%) cases, only 26 cases showing negative USG findings (total 476 sinuses). In remaining 36 cases (8%), double echo was noted in some part of sinus likely due to polyp / MRC. USG also showed most cases had unilateral involvement. Bilateral involvement was detected in 34 of acute cases (34 of 134 cases) where as 19 of 204 cases of chronic sinusitis showed bilaterality. Acute cases showed more bilateral involvement. It was statistically significant (χ^2 value 15.7, $P=0.000$).

Findings	Radiography	USG
Sinusitis	336 (74.7%)	388 (86.2%)
Polyp or MRC	53 (11.77%)	36 (8%)
Normal	61 (13.6%)	26 (5.8%)

Table 1: Radiography vs sonographic findings in clinical sinusitis cases

Overall the radiographic and sonographic diagnosis of patients were comparable. Sonography detected more diseased sinus (424 vs 389). Sonography showed less patients with disease free sinus. However, focal lesion detection by sonography was less as compared to radiography (36 vs 53).

Radiographic Findings	Number	Percentage
Air fluid level	53	5.8
Sinus opacification	237	26.3
Mucoperiosteal thickening	101	11.2
Normal sinus	448	49.7
Polyp/MRC	61	6.7

Table 2: Radiographic findings in suspected case of sinusitis(of total sinus)

Of the 391 involved sinuses, Opacification of sinus was most common pattern of presentation, found in 237 (60.6%) followed by mucoperiosteal thickening (101 cases, 25.8%) on radiography (Tab. 4). Air fluid level was found in 53 (13.6%). Few patients had more than one findings on either of the maxillary sinus when bilateral involvement was noted.

USG Findings	Number	Percentage
Air fluid level	81	9
Sinus opacification	237	26.3
Mucoperiosteal thickening	125	13.9
Normal sinus	421	46.7
Other/dual echo	36	8.0

Table 3: USG findings in suspected sinusitis cases(of total sinuses)

On USG, total of 443 sinus showed features of sinusitis. In sonographically sinusitis sinuses, opacification, mucoperiosteal thickening and air fluid level was detected in 237 (53.5%), 125 (28.2%) and 81 (18.28%) respectively. Mean mucoperiosteal thickening of USG was 17.7mm (range 11 to 25). Mucoperiosteal thickening was detected in many sinuses, both in radiography and USG. Sonography showed more sinuses with MPT(101 vs 125). Detection of MPT by USG was better as compared to X ray (22.4 vs 27.7%). When MPT was less than 15mm(chi² value 4.4, P= 0.035), detection of MP thickening by PR is poor as compared to USG. USG was found to be poor in detecting focal lesions of sinuses. Detection of sinus opacification was equal on both radiography and sonography. The most common pattern of sinus findings in sinusitis cases

was opacification in both imaging methods. Air fluid level was relatively uncommon finding on both USG and radiography in sinusitis cases. It was commoner in sonography (81 vs 53). Detection of air fluid level was more in acute cases. Focal lesions of sinuses were common in suspected sinusitis cases especially in radiography, which was present in 6.7%. USG showed less focal lesions of sinuses.

Air fluid level was more detected in acute cases in both radiography and USG. Air fluid level was significantly more detected in acute cases by ultrasonography. P value was 0.000. Sonography showed more cases with air fluid level. MPT and air fluid level was more detected with USG.

Variables	P value
MPT less than 15 mm USG vs Radiography	0.003
Air fluid level detection by USG in acute sinusitis vs radiography	0.000
Bilaterality in acute sinusitis	0.000

Table 4: Table showing significant variables

Sonography detected less number of focal lesion of sinuses. Overall exclusion of normal sinus was higher with sonography (421 vs 448). However it was not statistically significant. Of the 900 of total sinuses examined, USG overall showed more evidence of sinusitis compared to plain radiography, 443 vs 391. Only single USG negative case was found to be positive on radiograph. Overall sensitivity and specificity being 99.7% and 89.9%. Accuracy of USG was 94% considering radiograph as gold standard.

Parameters	Percent
Sensitivity	99.7%
Specificity	89.7%
PPV	88.3%
NPV	99.8%
Accuracy	94.2%

Table 5: Showing diagnostic value of ultrasound in maxillary sinusitis considering X ray as gold standard

Discussion

Maxillary sinusitis is defined as an inflammatory or infectious process of the maxillary sinuses mucosa with fluid retention in the sinus. The term used now is rhinosinusitis as the inflammation of the paranasal

sinuses almost always accompanied by the contiguous inflammation of the nasal mucosa.¹¹ Symptoms in sinusitis are sometimes unspecific: rhinorrhea, cough, fever, nasal voice, headache, inflammation of nasal mucosa, sinus tenderness, postnasal drip. The sinus infection is diagnosed by puncture followed bacterial culture. But because this is an invasive technique, less invasive or non-invasive imaging methods may be used in establishing the diagnosis. These are: The conventional radiograph, CT scan, MRI and ultrasonography. Yet, these investigations may lead to a false positive diagnosis of infection when mucosal thickening, polyps, sinus cysts or anatomical anomalies are present.⁷

Computed tomography is considered to be the gold standard in the diagnosis of sinusitis. But there are authors who consider that this radiation exposing imaging technique should be considered only in certain situations: recurrent sinusitis, chronic sinusitis and no response to therapy.¹²⁻¹⁴ Radiologic exams to confirm the diagnosis of uncomplicated sinusitis are recommended by some authors just for children older than 6 years.¹⁵ Others literature data suggest that imaging investigations are not necessary in uncomplicated acute rhinosinusitis.^{16,17} The role of radiography is very important in ruling out sinusitis, however there is long debate because of the radiation risk especially in children and pregnant women. So, we need a radiation free simple, non-invasive, rapid, safe inexpensive and readily available method for diagnosing maxillary sinus diseases.⁴

Age and gender distribution of our study was comparable to that of other studies.³ Some study showed more female dominance in study populations.^{5,18,19} we had relatively less children because the study was conducted in hospital with no pediatric department. Age group most commonly affected were similar in other study conducted in Nepal by Ishwar Singh et al.¹⁹ The occupation most commonly affected by sinusitis was housewife (43.3%) in that study, however we found higher number of students overall, only about 15.5% were housewives. This could be because of smaller number of female patients in our population. Males were numerically more in our study probably because our institution has no gynaecology department. Headache was the commonest symptom (57.6%) in our study population (about 86% of chronic sinusitis cases) which is consistent with on

study of chronic rhinosinusitis.^{19,20}

Bilateral sinus involvement was not common findings in our patients which may be explained by less acute sinusitis cases in our study. Most of the bilateral involvement was seen in acute sinusitis cases. Chronic cases mostly showed unilateral involvement which could be explained due to some structural deformity related to OMC leading to persistent obstruction of ostium.

Of the total patients, 49.7% showed normal sinus which was comparable to 47% reported by Fufezan et al³ and 27.5% found by Alameer et al.⁶ Fluid collection was most common pattern of radiographic presentation in those sinusitis cases, which was found in 32.2% of sinus examined which was in agreement with the findings of Fufezan (29%). But Alameer and groups reported mucoperiosteal thickening as most common radiographic presentation of maxillary sinusitis, which was detected in 22%. We detected 11.2% sinus with MPT. The sinus fluid was detected only in 1% sinuses. This may be due to too small sample size in that study, where most of the cases could have been chronic cases. We also detected high number of air fluid level in acute cases by both radiography and USG. As acute cases present with fluid collection, these findings are as expected. The air fluid detection was higher as compared to radiography. Fufezan et al. reported similar or slightly better detection of air fluid level by USG (26 vs 25).³

There was more detection of sinusitis by ultrasound as compared to radiography. Mucoperiosteal detection and air fluid level detection was more in ultrasound. Minimal fluid could have been missed in PR and so there were more sinusitis cases on USG. Overall fluid collection was more detected by Fufezan et al also but they detected more MPT by radiography as compared to USG. There was only one case with PR diagnosis of sinusitis which was found to be negative on USG. The detection rate of focal lesion of sinus like polyp/MRC was significantly less by USG as compared to PR. Sensitivity and specificity of USG in detection of sinusitis was good in our study, which was reported to be different in different studies, but range from 31 to 99% and 61 to 100%.^{3,4,9,10,21-23} Data from study by Fufezan et al reports sensitivity of 94.9%, which is comparable to ours but it was less in study by Puhakka et al (54%). Sensitivity of 94.9%, specificity of 98.4%, positive predictive value of 97.4% and a negative predictive value of 96.9% was reported

by Fufezan et al which is comparable to our study. Lots of variation in sensitivity and specificity in different study is probably related to diagnostic criteria set by researchers in identifying diseased sinus. Most of the studies had no well defined criteria as such.^{21,22}

Study	Sensitivity	Specificity	PPV	NPV
Our	99.7%	89.9%	88.5%	99.8%
Fufezan etal ³	94.9%	98.4%	97.4%	96.9%
Puhakka etal ⁴	56%		-	-
Shapiro etal ⁹	44-58%	55-61%	-	-

Table 6: Showing comparison of ultrasonography vs radiography in diagnosis of maxillary sinusitis (PR as gold standard)

The radiography, ultrasound, CT scan and MRI has been studied to evaluate the diagnostic modality in suspected sinusitis cases, which are compared to sinus puncture. Radiography and ultrasound give similar accuracy. USG has been found to be very accurate to exclude the diseased sinus^{3,5} and good correlation with antral lavage has been detected (Katholm et al²⁴ haapevieni et al). when USG is used in combination with radiography, the detection rate has been found to be better and some authors even advocate using PR in selective cases only.^{5,25}

We found out some PR sinusitis negative cases showed evidence of sinusitis in USG. Whenever there is evidence of sinusitis in form of fluid collection or mucosal thickening, such sinuses are found invariably found to be diseased on antral lavage in previous studies, as false positivity rate is quite low.³ But false positivity of mucosal thickening has been found to be significant in comparison to antral lavage which is true to both USG and PR.³ Also, agreement between the rates of abnormalities in standard radiographs and the presence of secretions obtained by sinus aspiration has shown considerable variation in several clinical studies.⁸ So these finding may suggest the better detection rate of sinusitis by USG as compared to radiography if well established diagnostic criteria are used along with the good equipment. MRI are presently most preferred and imaging modality of choice^{4,26} because of many limitations of plain radiography and USG could be possible better option especially in setup with less resources.

Conclusion

Ultrasound yields similar results of plain radiography. There is consensus on diagnosis of fluid filled sinus by sonography on all studies and we also add to that. Some radiographically negative cases also can be found to be diseased in USG which increases the sensitivity of diagnosis. Similar facts has been reported by few researchers and disagreed by some. However if we use standard criteria for mucosal thickening as wall echo distance more than 11 mm, most of the mucosal thickening could be accurately diagnosed. The technique, machine used, expertise involved and criteria used could have led to variable results in the past.

So, handy, radiation free, noninvasive and cheap procedure like USG is diagnostically even better to radiography especially to rule out fluid collection in acute sinusitis. There are hardly any false negative cases. Few false positive results(compared to PR) could be true positive too. In developing countries where resources are limited, USG could be best investigation modality for suspected maxillary sinusitis.

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