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Original Article

Radiology Section

The Role of Grey Scale and Color Doppler Ultrasound in Evaluation and Differentiation of Major Salivary Gland Lesions

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ABSTRACT

Introduction: Ultrasonography (USG) plays a significant and crucial role in the diagnosis and management of salivary gland lesions and it is widely accepted as the first imaging method for assessment of major salivary glands. Grey scale and color Doppler are valuable tools in evaluation of salivary gland pathologies. They are helpful in characterising pathologic conditions of major salivary glands. USG is useful in diagnosis of infective and inflammatory conditions of salivary glands. It is useful in diagnosis of salivary gland tumours. USG and Doppler findings are useful in differentiation of pleomorphic adenoma from other salivary gland tumours.

Aim: To study the role of grey scale and color Doppler USG in evaluation of major salivary gland lesions. Also, to evaluate sensitivity and specificity of grey scale and color Doppler USG, in differentiation of benign and malignant salivary gland tumours.

Materials and Methods: Patients with neck swelling, pain or any complaints related to major salivary glands were screened with USG. Detailed study was done by grey scale, color Doppler, power Doppler and pulse wave Doppler in patients with major salivary gland lesions.

Results: Total 70 patients enrolled. Parotid, submandibular and sublingual glands were involved in 74.5%, 24% and 1.5%, respectively. Total 65% were neoplastic lesions and 83% of pleomorphic adenomas occurred in parotid gland. Out of 28 benign nodules 22 (78.5%) showed grade 0/1+ vascularity and of the 18 malignant tumours 16 (88.8%) had Grade 2+/3+ vascularity. PSV was >25 cm/sec in 77.7% malignant tumours. Total 72% of malignant tumours had RI of >0.8, while only 10.7% of benign tumours showed RI of >0.8. Malignant tumours showed PI of >1.8 in 66.6%, in comparison 14.3% in benign tumours. Total 13 (72.2%) out of 18 were correctly diagnosed on grey scale USG alone, while 16 (88.8%) were correctly diagnosed when Doppler was used along with grey scale USG.

Conclusion: USG is the initial imaging modality of choice in evaluation of major salivary gland lesions. Grey scale USG plays essential role in detection of salivary gland tumours. Doppler USG is helpful in differentiating benign and malignant tumours.

Keywords: Parotid gland, Pleomorphic adenoma, Malignant tumours

INTRODUCTION

Salivary glands are affected by variety of disease processes which include infective, inflammatory, systemic, obstructive and neoplastic conditions [1]. Clinical examination alone will not provide the correct diagnosis of salivary gland pathologies. Thus, radiological evaluation is essential in correct diagnosis [2,3].

USG plays a significant and crucial role in the diagnosis and management of salivary gland lesions. Results of the USG examination alone may suggest the final diagnosis or provide important differential diagnostic data [4]. USG can differentiate intraglandular from extraglandular lesions in 98% of cases. It can differentiate salivary gland lesions as focal or diffuse. Characterisation of focal lesions into benign and malignant can be done by evaluation of edges. With high resolution transducers USG is better than CT or MRI in detection of unsharp borders [5].

Color Doppler findings are helpful in characterising the pathologies. It is helpful in diagnosing pleomorphic adenoma. Doppler findings of intralesional vascularity, type and grade of vascularity, PSV, RI and PI are useful in differentiating benign from malignant tumours [6]. Pathological diagnosis can be established by Fine Needle Aspiration Cytology (FNAC). FNAC is preferably done under USG guidance. This helps in further

enhancing ability of USG to differentiate between benign and malignant lesions [2].

Other radiological investigations for evaluation of salivary gland pathologies are plain radiography, sialography, CT, MRI and PET-CT [7].

Sometimes it is not possible to visualize lesions completely on USG because of their location, extension into the deep lobe of the parotid gland or behind the acoustic shadow of the mandible In these situations, further imaging with CT or MRI is necessary [4,8].

MATERIALS AND METHODS

This prospective observational study was carried out over a period of 2 years from July 2005 to October 2007, in Radiology Department at S.S.G. Hospital, Medical College Vadodara, India. Institutional Ethical Committee permission was taken before starting the study. Patients were explained about the nature of study and written informed consent was taken before enrolment in the study. All subjects were free to withdraw their participation at any point of time from the study.

Total seventy patients were selected for the study (41 male and 29 female patients). Patients were selected from the outpatient and inpatient Department of Otorhinolaryngology and Surgery Department.

Patients with neck swelling, pain or any complaint related to major salivary glands were screened with ultrasonography. Patients with lesions of major salivary glands only, were included in the study. Patients who underwent detailed USG and color Doppler study, FNAC, surgery and excision biopsy also, in patients with non surgical conditions, findings on follow-up USG, radiological and clinical improvement after medical line of treatment were considered for establishing final diagnosis.

Patients with facial swelling arising from extra salivary glands as well as patients who were lost for follow-up or in whom final diagnosis could not be established were excluded from the study.

Technique: Patients with neck swelling, pain or any complaints related to major salivary glands were screened with ultrasonography. Detailed study was done by grey scale, color Doppler, power Doppler and pulse wave Doppler in patients with major salivary gland lesions. All patients were examined on Esaote AU5 color Doppler machine with 7.5-10 MHz linear transducer.

Patients were positioned supine on the examination couch with the patient's neck hyperextended with a pillow under the patient's shoulders and lower neck. Patients head was turned to the opposite side. Bilateral parotid, submandibular and sublingual glands were studied.

USG of the parotid gland was performed in transverse and longitudinal planes. Transverse scan was performed with the transducer perpendicular and inferior to the ear lobe. Longitudinal scan was done by placing the transducer anterior and parallel to the long axis of ear. Submandibular gland was examined in transverse plane. Oblique and coronal adjustments help to localise lesions and to trace vessels. Submental region was scanned in transverse plane for evaluation of sublingual salivary gland. Both side glands were examined for symmetry, comparison and detection of clinically non palpable lesions. Rest of the neck was scanned to assess lymph nodes and search for concomitant or related disease.

Color Doppler, power Doppler and pulse wave Doppler was used to study the vascularity in the gland and the lesion. When Power Doppler Sonography (PDS) was used, the Doppler setting was optimised at high sensitivity, low wall filter, medium persistence and Pulsed Repetition Frequency (PRF) was set at 700 Hz for detecting small vessels. Color gain was increased till the artefacts or noise appears. Then it was reduced slowly till it disappears. Intra tumour vascularity seen on color Doppler sonograms was graded subjectively on a four-step analog scale of 0 to 3+ as follows:

0: No color signal is detectable.

1+: Occasional pixels of color are transiently present within tumour parenchyma and/or a single feeder vessel is visible at the hilum.

2+: Multiple pedicles in fold within the mass and/or well-defined vessels are visible throughout the tumour.

3+: Large feeder vessels and a high number of color signals are easily detected within the mass.

Pattern of vascular distribution in the nodule was characterised as either peripheral (basket like), hilar (branching), or mixed. In the evaluation of the vascular resistance [Resistive Index (RI), Pulsatility Index (PI)] of lesions, spectral Doppler was used and the more prominent vessels were usually selected for the measurement. Peak Systolic Velocity (PSV)] was measured with angle correction made at an angle of 60 or less.

Grey scale USG features of the lesion were assessed and diagnosis was made. Then final USG diagnosis was made after assessing the Doppler characteristics of the lesion and correlating with grey scale features. USG diagnosis of benign tumour was based on the lesion homogeneous or heterogeneous echopattern, well defined margins, posterior acoustic enhancement, low grade of vascularity (0/1+), PSV <25 cm/sec, RI <0.8 and PI <1.8. The diagnosis of malignant tumour was made in a lesion with heterogeneous echo pattern, ill-defined margins, extension into adjacent structures, high grade of vascularity (2+/3+), PSV >25 cm/sec, RI >0.8 and PI >1.8. Final diagnosis was made by FNAC or surgical

biopsy. In 14 patients in whom pathological examination was considered not necessary, operative findings and clinical follow-up was used to verify the diagnosis.

Grey scale and Doppler diagnosis of lesion was correlated with the final diagnosis. The observations of the study were analysed and correlated with the previous studies.

STATISTICAL ANALYSIS

Age and gender related distribution of all tumour lesions entered into excel sheet and according to this percentage were calculated. Final diagnosis of lesions and grade of vascularity of salivary gland also entered into the excel spread sheet and percentage calculated. For comparison of PSV, RI and PI in benign and malignant tumours Chi-square test is used. It is done in SPSS 20.0 and open EPI software. The p-value <0.05 is significant according to Chi-square test.

RESULTS

Present study comprised of 70 patients, 41 males and 29 females. Most common presenting complaint was swelling (97%). Most of them presented with painless swelling (60%). Fever was present in 12 cases (17.1%) in patients with infection and inflammatory diseases. Other complaints were neck mass, dental pain, pain while eating. Parotid gland was the most commonly affected gland in 52 patients (74.5%). Submandibular gland was affected in 17 (24%) cases. Sublingual gland was uncommonly involved (1.5%).

Major salivary glands were affected by variety of infective, inflammatory, neoplastic and non neoplastic disorders. Out of 70 cases, 46 patients (65.7%) had neoplastic lesions. Total 83% of pleomorphic adenomas occurred in parotid.

Color and power Doppler findings: Grade and pattern of vascularity were evaluated in the tumours [Table/Fig-1]. The only benign tumour which showed Grade 3+ vascularity was hemangioma. Pleomorphic adenoma showed predominantly peripheral pattern of vascularity (70.5%). All five Warthin's tumours had hilar type of flow. In malignant tumours, 66.6% of lesions showed mixed pattern of vascularity.

Pulse wave Doppler findings: Mean PSV in malignant tumours was 36.7 cm/sec while in benign tumour it was 17.9 cm/sec. The mean RI values for malignant and benign tumours were 0.84 and 0.62 respectively. The highest values were 1.3 and 0.9 for malignant and benign tumours respectively. The mean PI values for malignant and benign tumours were 1.6 and 1.2 respectively. The highest values were 2.1 and 1.9 for malignant and benign tumours respectively [Table/Fig-2]. [Table/Fig-3] depicts the accuracy of PSV, RI and PI in differentiating malignant from benign tumours. [Table/Fig-4] shows comparison of histopathological and USG diagnosis for benign and malignant salivary gland tumours. Out of 18 patients with malignant tumours, 13 (72.2%) were correctly diagnosed on grey scale USG alone, while 16 (88.8%) were correctly diagnosed when Doppler was used along with grey scale USG.

Histopathological Diagnosis	No. of Cases (n=46)	Grade of Tumour Vascularity			
		0	1+	2+	3+
Pleomorphic Adenoma	18	1	12	5	0
Warthin's Tumour	5	0	5	0	0
Oncocytoma	1	0	1	0	0
Lipoma	1	1	0	0	0
Hemangioma	1	0	0	0	1
Mucoepidermoid Carcinoma	8	0	1	3	4
Adenoid Cystic Carcinoma	1	0	0	0	1
Adenocarcinoma	1	0	0	1	0
Squamous Cell Carcinoma	3	0	0	1	2
Lymphoma	2	0	1	1	0
Metastasis	3	0	0	2	1
Cyst	1	1	0	0	0
Plunging Ranula	1	1	0	0	0

[Table/Fig-1]: Grade of vascularity of salivary gland tumours. Benign tumours revealed predominantly low grade vascularity except hemangioma. Malignant tumours showed high grade vascularity.

	Malignant	Benign	Total
Peak Systolic Velocity (cm/s)			
>25 (+ve)	14	4	18
<25 (-ve)	4	24	28
Total	18	28	46
Resistive Index			
>0.8 (+ve)	13	3	16
<0.8 (-ve)	5	25	30
Total	18	28	46
Pulsatility Index			
>1.8 (+ve)	12	4	16
<1.8 (-ve)	6	24	30
Total	18	28	46

[Table/Fig-2]: Comparison of PSV, RI and PI between benign and malignant tumours. Malignant tumours show high PSV, RI and PI.

Doppler Index	Sensitivity %	Specificity %	PPV %	NPV %
PSV >25 cm/sec	77.7	85.7	77.7	85.7
RI >0.8	72.2	89.2	81.2	83.3
PI>1.8	66.6	85.7	75	80

[Table/Fig-3]: Sensitivity, specificity, PPV and NPV of PSV, RI and PI in differentiating benign & malignant tumours of salivary glands. Of the three indices PSV has high sensitivity and RI has high specificity in differentiating malignant tumour from benign tumour.

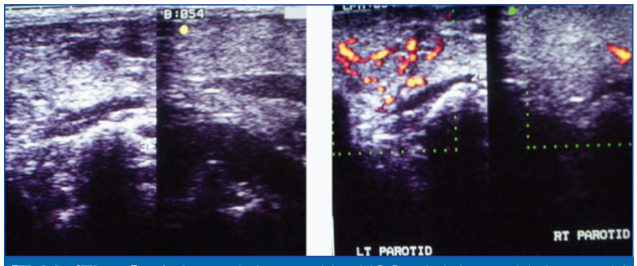
Histopathological Diagnosis	No. of Lesions	Correctly diagnosed at grey scale (%)	Correctly diagnosed with addition of Doppler Ultrasound	Correctly diagnosed at grey scale & Doppler (%)
Benign	28	24 (85.7)	2 (7.14)	26 (92.8)
Malignant	18	13 (72.2)	3 (16.6)	16 (88.8)
Total	46	37 (80.4)	5 (10.8)	42 (91.3)

[Table/Fig-4]: Comparison of histopathological diagnosis and USG diagnosis of benign and malignant tumours. Addition of Doppler to grey scale USG increases the predictability of both benign and malignant tumours.

DISCUSSION

All major salivary glands on USG are usually homogenous and echogenic [4].

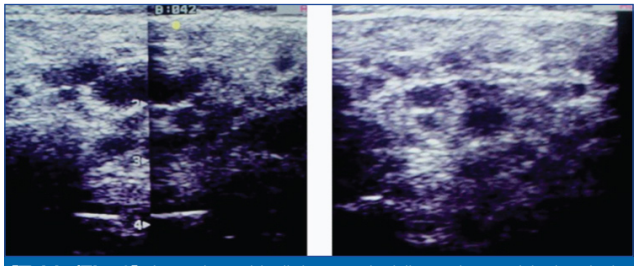
Inflammatory conditions are most common disease affecting salivary glands. Acute inflammation shows enlarged and hypoechoic salivary glands. They may show inhomogeneous appearance or contain multiple small, oval and hypoechoic areas. They show increase in vascularity [4] [Table/Fig-5].



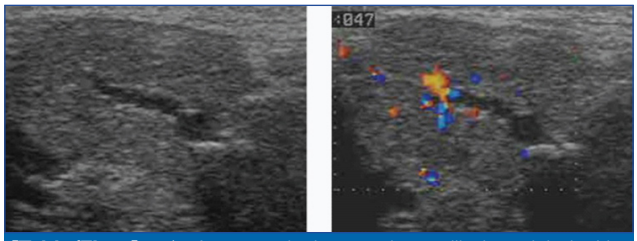
[Table/Fig-5]: a) Acute left parotitis. USG of right and left parotid glands show enlarged left parotid gland with heterogeneous echotexture. b) Right parotid gland is normal. Color Doppler shows increased vascularity in left parotid gland. Right parotid gland shows normal vascularity.

In chronic sialadenitis salivary glands are normal sized or smaller. They are hypoechoic and heterogeneous. They usually show hypovascularity except in case of granulomatous diseases such as parotid sarcoidosis [4,9-12]. Multiple small, round or oval, hypoechoic lesions representing ectatic ducts can be seen scattered throughout the gland parenchyma. The differential diagnosis at this stage includes sarcoidosis, Sjögren's syndrome, disseminated lymphoma, haematogenous metastases, benign lymphoepithelial lesions in HIV positive patients, [Table/Fig-6]. Sjögren's syndrome is a chronic autoimmune disorder characterized by intense lymphocytic and plasma cell infiltration and destruction of the salivary and lacrimal glands [4,13,14]. USG monitoring of patients with Sjögren's syndrome is needed for the early detection of lymphoma [15,16]. Mycobacterial disease of the major salivary glands may present as a salivary gland mass and mimic malignancy [17].

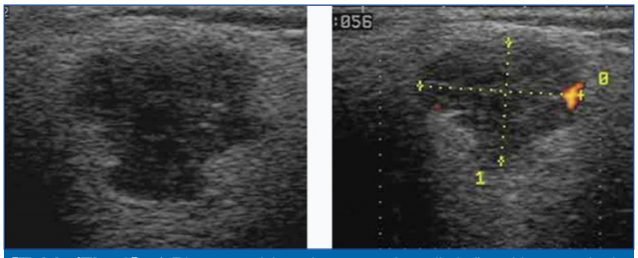
Approximately 80 to 90% of salivary gland calculi occur in the submandibular gland [Table/Fig-7]. Pleomorphic adenoma on



[Table/Fig-6]: Lymphoepithelial cysts in bilateral parotid glands in HIV+ve patient. USG of both parotid glands show multiple variable sized hypoechoic and anechoic lesions.



[Table/Fig-7]: a) Acute calculous submandibular sialadenitis. Ultrasound of submandibular gland shows intraductal calculus in submandibular duct. b) Increased intraglandular vascularity is seen on Doppler study.



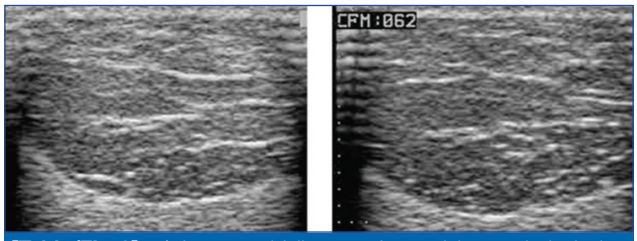
[Table/Fig-8]: a) Pleomorphic adenoma. A well defined hypoechoic lesion with lobulated margins is seen in submandibular gland on ultrasound. b) Distal acoustic enhancement is seen. Peripheral pattern and Grade 1 vascularity is seen on Doppler study.

USG appears as a well-defined, lobulated hypoechoic lesion with posterior acoustic enhancement. It shows low grade vascularity and peripheral pattern [Table/Fig-8]. Warthin's tumour appears as oval, hypoechoic well defined tumour often containing multiple anechoic areas. It is often hypervascular with hilar type of flow [4].

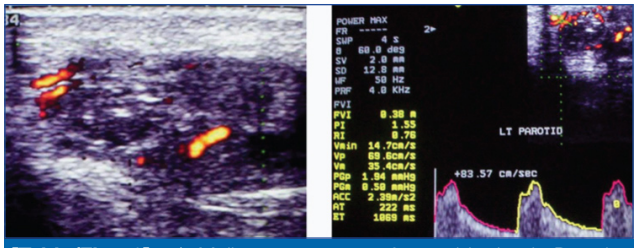
Lipoma of salivary gland is uncommon and most commonly seen in parotid gland. It appears as a well defined oval hyperechoic lesion with linear striations [Table/Fig-9].

Malignant neoplasms account for approximately 20% of all salivary gland tumours. Mucoepidermoid carcinoma and adenoid cystic carcinoma are the most common salivary gland malignancies [18,19].

USG features of malignant neoplasm include irregular shape, irregular borders, hypoechogenicity and heterogeneity [20]. USG alone is not able to distinguish between benign and malignant tumours [21,22]. Malignant lesions show high vascularity, high PSV, PI and RI [Table/Fig-10].



[Table/Fig-9]: a) Intraparotid lipoma. An oval hypoechoic lesion with linear striations is seen in parotid gland. b) Absent intralesional vascularity is seen on Doppler.



[Table/Fig-10]: a) Malignant tumour of parotid gland. Doppler study shows an ill defined lesion in parotid gland. b) It shows mixed pattern and Grade 2 vascularity. Pulse wave doppler shows PSV of 69.6 cm/sec. PI is 1.5 and RI is 0.76.

The age range of the patients in present study was 1 to 80 years with a mean of 43 years. In Zaleska-Dorobisz U et al., and Martinoli C et al., studies the range of age was 14-70 years and 23-91 years respectively, with mean age of 35 years and 57 years respectively [23,24].

In present study 82.6% of the tumours were seen in parotid gland. Submandibular and sublingual glands were involved in 15.2% and 2.2% of the cases. This distribution of salivary gland tumours is comparable to the Gritzmann N et al., study in which parotid was involved in 94.6% of the cases [25]. However, in our study submandibular gland was relatively more commonly involved. Among all lesions the benign and malignant tumours in present study were 60.8% and 39.2% respectively. In comparison to Gritzmann N et al., study the occurrence of malignant tumours in our study was two times more common [25]. The possible causes for the higher incidence of malignant tumours in this study are tertiary referral hospital and high prevalence of head and neck cancer. In present study salivary calculi were detected in only submandibular gland. The cause for this disparity could be the small study group. In study by Zenk J et al., the occurrence of sialolithiasis is more common in submandibular glands [26]. In Zenk J et al., study intraductal and intraglandular calculi were equally distributed [27].

Observations of the present study regarding the tumour margins are similar to the findings of the Gritzmann N et al., study [25]. The benignity of the tumour was assessed correctly in 93.5% of the cases. USG alone may predict malignancy in 80-89% of cases [28]. The significant association of well-defined and ill defined tumour margins with benign and malignant tumours respectively is an important grey scale for USG finding. However, up to 28% of all malignant salivary tumours have sharp margins and thus cannot be differentiated from benign lesions on the basis of the USG appearance alone. In addition, early cancers (<2 cm) may appear well encapsulated and homogeneous [25]. The failure of grey scale sonography to depict some malignant tumours has raised interest in Doppler imaging as an additional tool for tumour differentiation.

In the present study 78.5% of benign tumours showed Grade 0/1+ vascularity and only 21.5% showed 2+/3+ Grade of vascularity. Of the 18 malignant tumours, 16 (88.8%) had Grade 2+/3+ vascularity. The findings of Grade of tumour vascularity in our study are comparable to Martinoli C et al., study [24]. These features may be related to a more intense vascularity in malignant tumours because of the presence of intratumoural arteriovenous shunting [29,30]. Schick S et al., in their study observed Grade 0 or 1+ in 88.5% of benign lesions, whereas it was Grade 2+ or 3+ in 82% of malignant lesions [31].

In present study, 80% of pleomorphic adenomas showed peripheral pattern of vascularity. Martinoli C et al., study demonstrated peripheral pattern of vascularity in 88.8% of pleomorphic adenomas [24]. In present study 66.6% of malignant tumours showed mixed pattern of flow. A “basket type” or peripheral type vascularity in pleomorphic adenoma and diffuse vascularity in cases of malignant lesions seen in our study is in accordance with study by Patange NA et al., [32].

In their study Schick S et al., concluded that PSV is statistically significantly higher in malignant lesions than in benign lesions [31]. They used 25 cm/s as a threshold PSV for differentiating malignant tumours from benign tumours. With this criterion the sensitivity was 72% and specificity was 88% for detection of malignant tumours. It is difficult to diagnose malignant tumours with certainty by color and power Doppler alone. Even if grey scale USG suggests benign lesion, high vascularity and PSV on Doppler should raise the suspicion of malignant tumour [31]. In present study malignant tumours showed PSV of >25 cm/sec in 77.7% of the patients.

There was wide range of RI and PI in both benign and malignant tumours in present study as compared to study by Bradley MJ et al., however there were significant number of malignant tumours having RI of >0.8 and PI of >1.8 [33]. It is difficult to explain the increased values for malignant lesions in salivary gland tumours.

LIMITATION

Although, this study achieved its aims and objectives, there were some limitations. Study was conducted at a single centre. Patients’ number was less. Whole study was done by single observer leading to intraobserver bias. Size and presence of calcification in tumours were not studied for differentiating benign and malignant tumours. Deep lobe of parotid gland is difficult to assess completely by USG alone and in some

cases need help of cross sectional imaging.

CONCLUSION

USG is the initial modality of choice for the evaluation of lesions of major salivary glands. USG is useful in detecting infective, inflammatory and neoplastic lesions of salivary glands. Morphology of lesion is helpful in diagnosing and differentiating benign and malignant tumours. Color and pulse wave Doppler provides additional diagnostic information in detection of malignant tumours. Sometimes it might be difficult to differentiate benign and malignant tumours on USG and Doppler alone. In these cases pathological diagnosis by FNAC or biopsy is essential.

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