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RESEARCH ARTICLE

ROLE OF HIGH RESOLUTION ULTRASOUND AND DOPPLER IN THE EVALUATION OF NECK MASSES WITH HISTOPATHOLOGICAL CORRELATION

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Abstract

Objectives: The main objective of this study is to determine the accuracy & efficacy of high resolution ultrasound in the evaluation of neck masses and the ultrasound and Doppler characteristic features in various neck masses and correlate with histopathology. **Material & methods:** Ultrasound examination of the neck was performed using Siemens Acuson 300X PE ultrasound unit with a linear array transducer of 7.5-10 MHz. The patient was scanned in a supine position with a pillow behind the shoulders to allow hyperextension of the neck. Scanning was done from the level of the sternal notch to the submandibular region and in both longitudinal and transverse planes with oblique projections if necessary. **Results:** The maximum numbers of patients were seen within the age range 21-40 years.The most common lesions encountered were those arising from the thyroid (20), and lymph node pathologies (20). The majority of the patients were females, predominantly presenting with lesions arising from the thyroid gland. The sensitivity and specificity in the US diagnosis of Multinodular Goitre was found to be 91% and 91.6% respectively .Overall sensitivity and positive predictive value in assessing lymphnodal pathology was 90%
100% sensitivity in detection and characterisation of Thyroiditis, parathyroid adenomas, tuberculous lymphadenitis, Thyroglossal cysts and Brachial cleft cysts. Sensitivity of detection of papillary carcinoma was found to be 83%, while the specificity was 93.7%
Conclusion: High resolution Ultrasonography together with Colour doppler features is a highly efficacious investigation for detecting and differentiating various causes of neck masses
Keywords: High Resolution ultrasound, Colour Doppler Study (CDS), Resistive Index (RI), Pulsatility Index (PI), Peak Systolic Velocity (PSV), End Diastolic Velocity (EDV)

INTRODUCTION

Neck masses are any swellings or enlargements of the structures in the area between the inferior border of mandible and clavicle. They have been traditionally described based on age and location in the neck as inflammatory, congenital or developmental, neoplastic (benign vs malignant) and traumatic. The inadequacy of physical examination in the evaluation of neck masses and use of an imaging modality is necessary to aid in the diagnosis and thereby treatment.

In the past plain radiographs, xeroradiographs and tomograms were the only imaging modalities, but the advent of newer imaging modalities which include ultrasound, CT, MRI, angiography and radionuclide scans has revolutionised the diagnosis of neck masses.

It is important to proceed in logical and cost effective manner for the proper diagnosis of neck masses. Sonography is commonly the first imaging modality after clinical examination. Technical developments in high resolution gray scale ultrasound have improved the ability of USG in the evaluation of neck region. It has become one of the major diagnostic tool available providing excellent and reproducible anatomic images, while being safe, moderately priced and non invasive. It ensures rapid investigation, and does not require any specific preparation prior to scanning.

A 5 – 8 MHz sector probe is useful in examining deeper regions and in attaining an overview of the anatomy. A higher frequency (7-12 MHz) linear probe is useful in providing more detailed views of superficial structures determining pathology, volumetry, size of the tumour and guided fine needle. The additional use of colour doppler ultrasound allows assessment of vascularity within the lesion, particularly helpful in the assessment of vascular malformations, haemangiomas and enlarged lymph nodes. Thus the combination of conventional sonography and colour flow doppler provides benefits in screening sensitivity and valuable diagnostic information with a high degree of diagnostic accuracy useful in preparative evaluation of the patient. On the basis of sonographic finding, selection of additional imaging modalities including CT and MR imaging can be done more judicially.

Ultrasonography also plays an important role in precise tumour staging which helps in effective therapy and follow up. USG and USG guided fine needle aspiration cytology if necessary, is useful for evaluating thyroid and parathyroid gland lesions, cervical nodes and salivary glands along with superficial and congenital lesions. A new approach uses the small ultrasound transducer for intra-operative navigation.

AIMS AND OBJECTIVES

1. To determine the accuracy of high resolution ultrasound in the evaluation of neck masses
2. To identify the sonographic and Doppler characteristics of neck masses.
3. Confirmation of diagnosis with fine needle aspiration cytology/ histopathology/ surgical follow up wherever necessary.

MATERIALS AND METHODS

The study was done on 60 patients referred to the Department of Radiodiagnosis for the sonographic evaluation of neck masses. Ultrasound examination of the neck was performed using Siemens Acuson 300X PE ultrasound unit with a linear array transducer of 7.5-10 MHz. The patient was scanned in a supine position with a pillow behind the shoulders to allow hyperextension of the neck. Scanning was done from the level of the sternal notch to the submandibular region and in both longitudinal and transverse planes with oblique projections if necessary. The sonographic evaluation of the lesion was done to note the size/shape, site, margins, appearance (solid/cystic), echotexture and vascularity.

The diagnosis was confirmed by fine needle aspiration cytology or histopathology. Surgical follow-up was obtained wherever applicable.

INCLUSION CRITERIA:

Patients referred for the ultrasound examination of neck masses, irrespective of age and sex.

EXCLUSION CRITERIA:

Patients presenting with:

a) Mandibular lesions.
b) Neck masses of vascular origin.
c) Apical chest lesions with extension into the neck.
d) Lesions arising from the larynx and cervical oesophagus.
e) Cases wherein tissue diagnosis / surgical follow up is not obtained.

DATA ANALYSIS:

Sensitivity, specificity and predictive values were calculated on collected data. Kappa statistics were used to analyze data and findings were interpreted with other Studies. $p < 0.05$ – is taken as significant and $p > 0.05$ – as not significant

RESULTS

The study was conducted on 60 patients referred to the department of radio diagnosis for the sonographic evaluation of neck masses (FIGURE 1 to 28)

Frequency of patients in different age groups (Table 1)

The youngest patient in this study was a 4 years old infant who presented with a congenital neck swelling. The oldest patient was 72 yr. old male with bilateral multiple neck swellings. The maximum numbers of patients were seen within the age range 21-40 years

The majority of the patients were females predominantly presenting with lesions arising from the thyroid gland. Only 2 male patients were found to have thyroid pathology. **(Table 2 Sex Distribution of lesions**)

The most common lesions encountered were those arising from the thyroid (20), and lymph node pathologies (20) **(Table 3: The head and neck masses studied)**

USG features of Benign Nodular Goitre (N = 11) (Table 4)

The sensitivity and specificity in the US diagnosis of Multinodular goitre based on the above features was found to be 91% and 91.6% respectively with a positive predictive value of 83%

Sex prevalence of Thyroid Gland Pathology (Table 5)

There was a male: female ratio of 1:10 in the case of nodular goitre which shows an increased prevalence of this disease in females.

USG features of Salivary Gland Disease (Table 6)

USG features of Lymph nodal Pathology (N=20) (Table 7)

US diagnosis made based on the ultrasound features proved to be highly significant (p=). Overall sensitivity and positive predictive value in assessing lymph nodal pathology was 90%

USG features of congenital lesions (Table 8)

USG features of miscellaneous lesions (Table 9)

Table 1: Frequency of patients in different age groups

Age (years)	Frequency	Percentage
<10	**3**	**5%**
11-20	**10**	**14%**
21-40	**30**	**50%**
41-60	**14**	**24%**
>60	**3**	**7%**
Total	**60**	**100%**

Table 2: Sex Distribution of lesions

Lesions	M	F	Total
Thyroid	2	18	20
Parathyroid	0	1	1
Lymph nodes	10	10	20
Salivary glands	4	4	8
Congenital and misc	7	4	11
total	23	37	60

Table 3: The head and neck masses studied

	No. of patients	Percentage
Thyroid		
1.Multinodular goitre	7	12%
2.Solitary thyroid nodule	2	3%
3.Colloid cysts	2	3%
4.Papillary carcinoma	4	6%
5.Hashimoto's thyroiditis	3	7%
6. Other malignancies	2	4%
Parathyroid		
1.Parathyroid adenoma	1	2%
Lymph node		
1.Tubercular	6	9%
2. Reactive	5	8%
3.Metastatic	7	10%
4.Lymphomatous	2	4%
Salivary glands		
1.Tumor	1	2%
2.Sialadenitis	3	4%
3.Sialolithiasis	3	4%
4.Abscess	1	1%
Congenital and other		
1.Thyroglossal cyst	3	5%
2.Bronchial cleft cyst	1	2%
3.Dermoid cyst	1	2%
4.Lipoma	1	2%
5.Hemangioma	1	2%
6.Abscess	1	2%
7.Epidermoid cyst	1	2%
8.Cystic hygroma	1	2%
9.Fibromatosis colli	1	1%

Table 4: USG features of Benign Nodular Goitre (N = 11)

Ultrasound features	No. of patients	Percentage
Diffuse increase in size	8	77%
Multinodular	7	66%
Solitary nodule nodule/cyst	4	33%
Necrosis/degeneration/cystic area	5	50%
Calcification	4	33%
Echogenecity		
Hypoechoic	2	22%
Hyperechoic	3	33%
Isoechoic	3	33%
Mixed	3	33%

Table 5: sex prevalence of Thyroid Gland Pathology

sex	**No. of patients**	**Percentage**
Male	2	10%
Female	18	90%
total	20	100%

Table 6: USG features of Salivary Gland Disease

Disease	Ultrasound Features
Pleomorphic adenoma of parotid	Well defined lobulated hypoechoic lesion with poor vascularity on colour Doppler
Sialolithiasis: Submandibular gland Submandibular duct	Heterogeneous gland with hypoechoic collections and multiple calculi in the gland Calculi in the duct which is dilated. Enlarged hypoechoic gland
Sialadenitis	Enlarged gland with heterogenous echotexture
Parotitis	Enlarged hypoechoic gland
Castleman's disease	Hypoechoic lesion in the superficial lobe with exuberant vascularity and prominent penetrating feeding vessels entering the hilum
Sjogren syndrome	Inhomogenous gland with multiple scattered oval anechoic areas and increased parenchymal flow
Parotid abscess	Hypoechoic collection in the deep lobe of abscess

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Table 7: USG features of Lymphonodal Pathology (N=20)

	Reactive	Tubercular	Metastatic	Lymphomatous
1.Echotexture				
• **Hypoechoic**	5	5	4	1
• **Hyperechoic**	0	0	2	1
• **Isoechoic**	0	1	1	0
2.Shape				
• **Oval**	5	5	0	0
• **Round**	0	1	7	2
3.Calcification	0	1	2	0
4.Intranodal necrosis	0	5	4	1
5.Echogenic hilus	5	4	0	0
6.Border				
• **Sharp**	0	1	6	2
• **Unsharp**	4	5	1	0
7.Surrounding soft tissue				
• **Normal**	5	0	4	2
• **Abnormal**	0	1	1	0
• **Matted**	0	5	0	0

Table 8: USG features of congenital lesions

Disease	USG Features
Thyroglossal cysts	Well circumscribed hypoechoic midline / off midline cystic lesion with/without internal echoes
Branchial cleft cysts	Anechoic, thin walled lesion anterior to sternocleidomastoid
Cystic hygroma	Anechoic mass at the nape of the neck with internal septae
Fibromatosis coli	Isoechoic lesion within the sternocleidomastoid lesion
Dermoid	Hypoechoic well circumscribed lesion at the suprasternal notch with calcifications within
Epidermoid	Cystic lesion in the submental region with multiple spherical internal echoes
Haemangiomas	Hypoechoic lobular mass with increased flow on Doppler study

Table 9: USG features of miscellaneous lesions

Lipoma	Elliptical Hyperechoic mass with internal septa parallel to the skin surface
Abscess	Thick- walled, iso-hypoechoic collection with air pockets within
Parathyroid adenomas	Oval solid mass of homogenously low Echogenecity and increased vascularity

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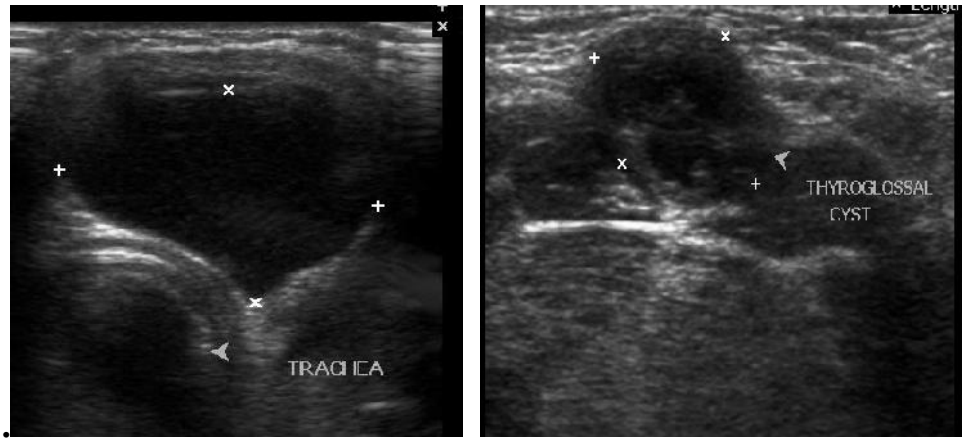
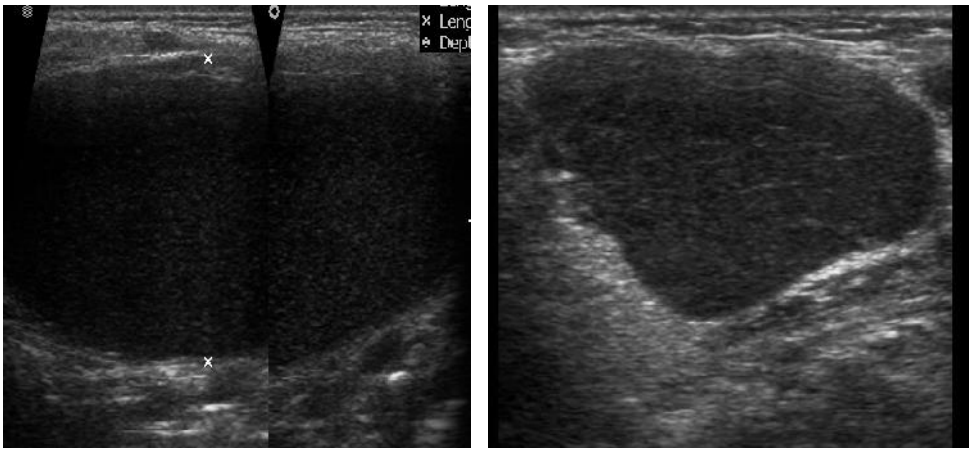
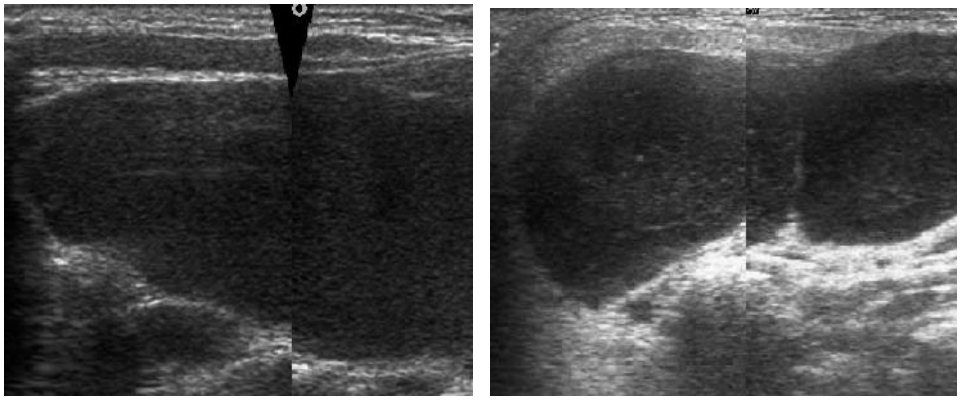


A **B**



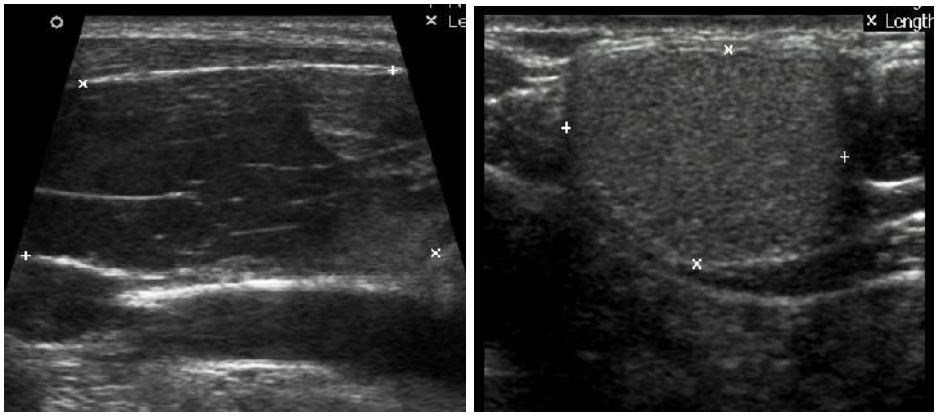
C **D**

Figure1: TGC- spectrum of appearances: A. uncomplicated anechoic, B. septated, C. with multiple internal echoes, D. Pseudosolid appearance of infected TGC**.**



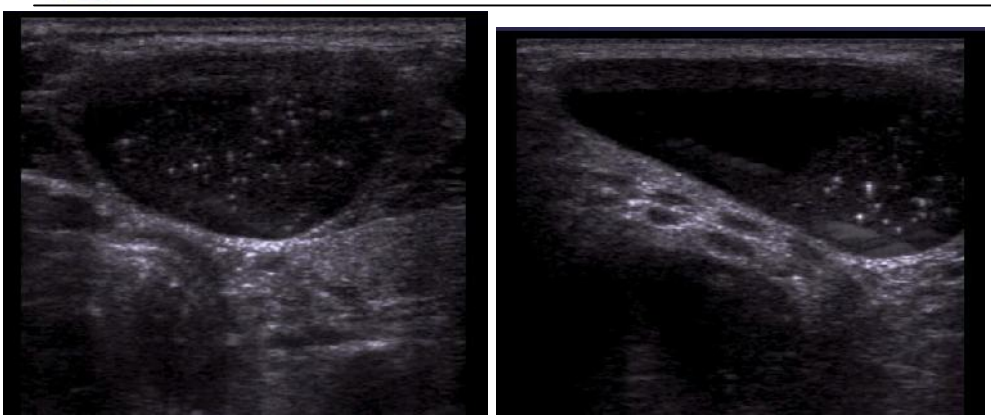
A B

Figure 2: Branchial cleft cyst: A. Uncomplicated, B. infected BCC



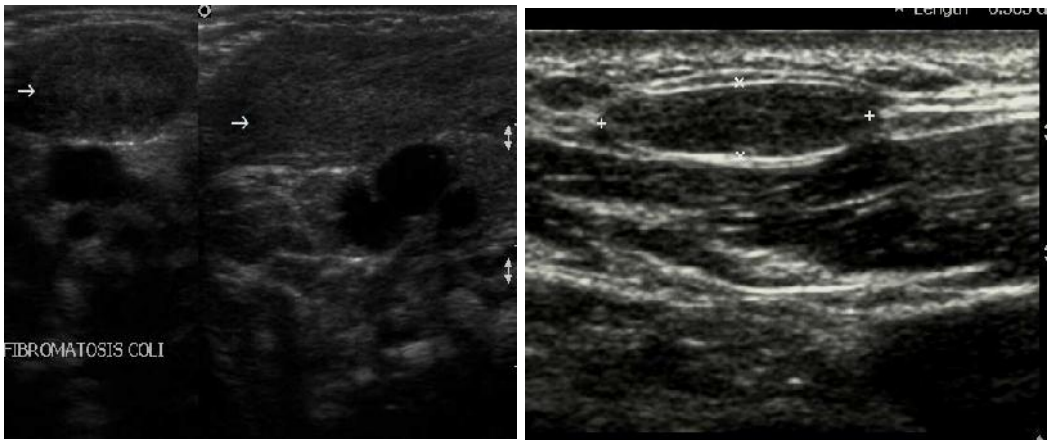
A **B**

Figure 3: A. Cystic Hygroma (Lymphatic cyst), B. Dermoid cyst



A **B**

Figure 4: Epidermoid cyst- A. transverse and, B. longitudinal planes



A **B**

Figure 5: A. Fibromatosis coli SCM- transverse and longitudinal planes,

B.- Subcutaneous Lipoma

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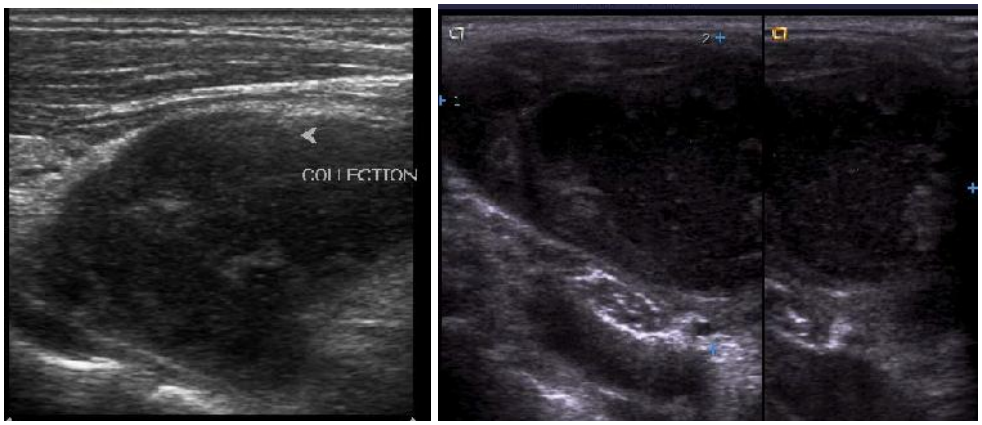


Figure 6: Neck Abscesses- appearances

THYROID GLAND

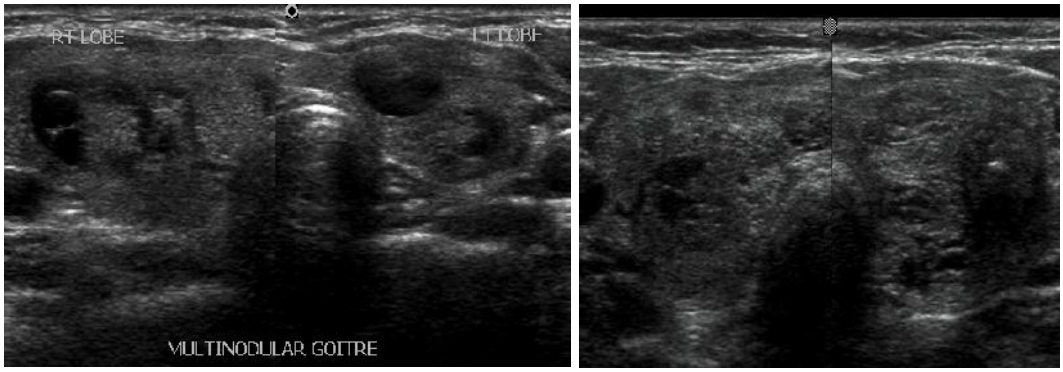


Figure 7: MNG- A. Multiple solid and cystic nodules, B. Nodule showing foci of coarse calcification

Figure 8: A and B: Benign thyroid nodules in the left lobe with peripheral sonolucent halo

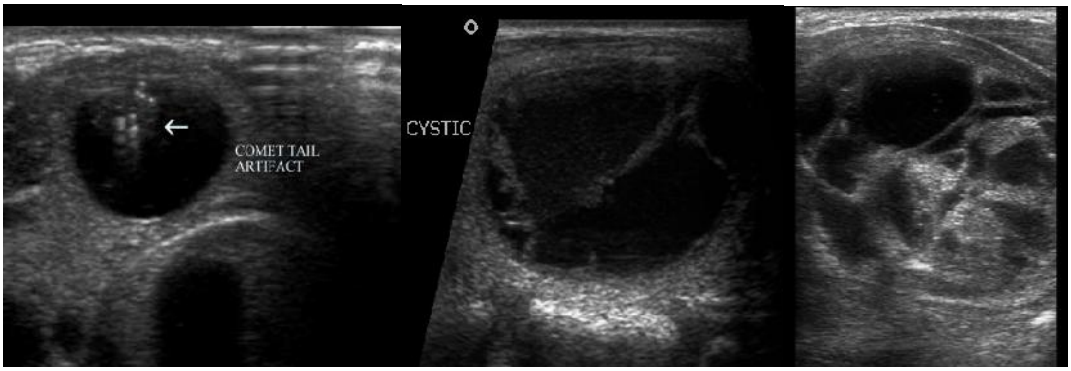


Figure 9: A-Comet tail artefact within a benign colloid cyst; B and C. Cystic Thyroid nodules

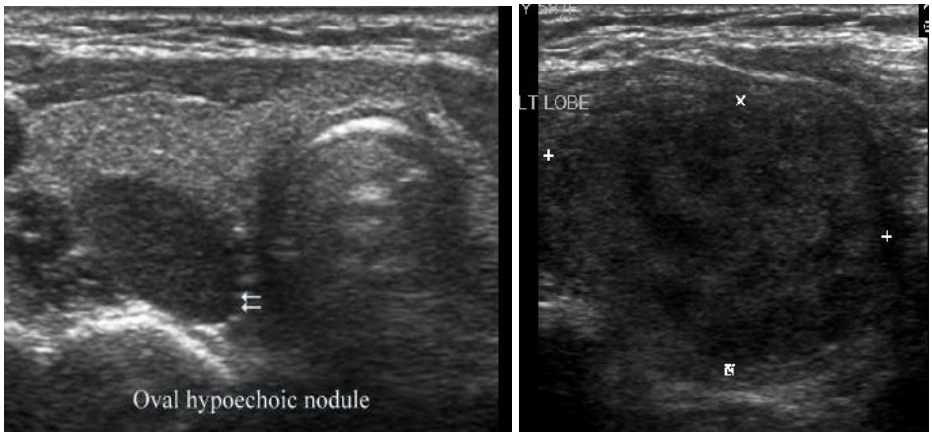


Figure 10: A.Follicular neoplasm right lobe: well-defined solitary oval hypoechoic nodule. B. Heterogenous nodule in the left lobe of thyroid**.**

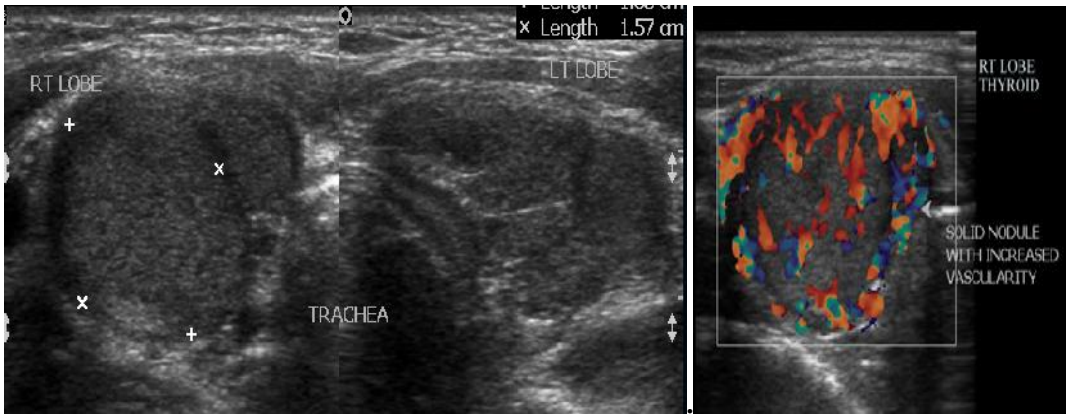


Figure 11: Follicular carcinoma: A. Solid nodule in the right lobe with thick irregular halo.

A. Colour Doppler shows increased perinodular and chaotic intranodular flow

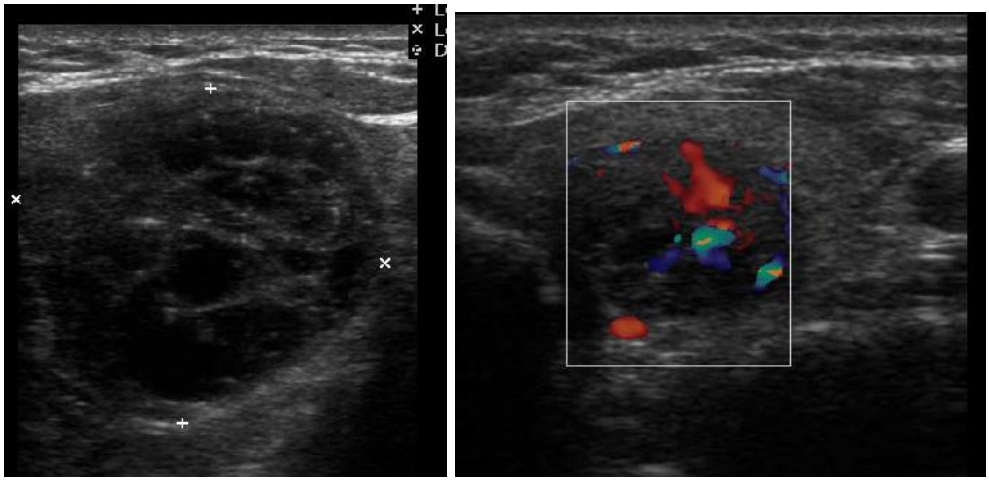
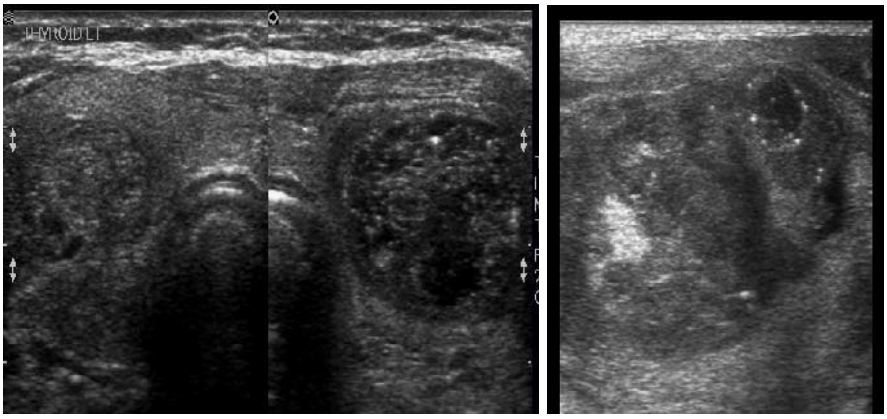


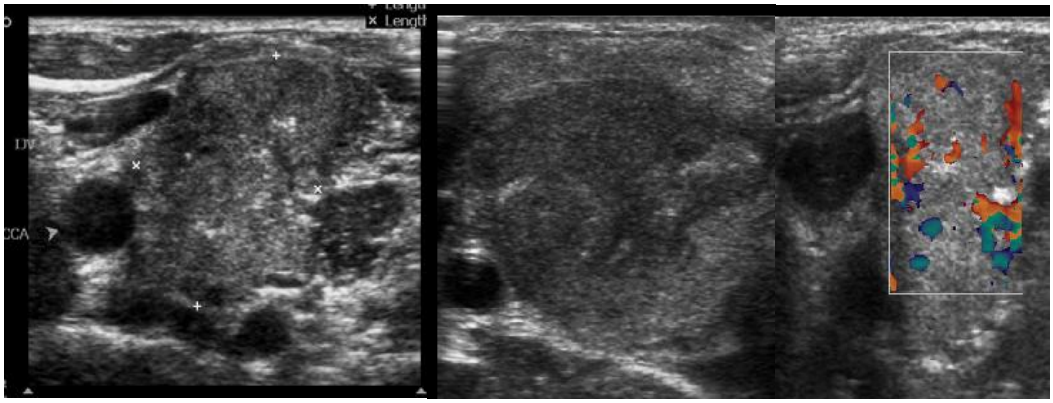
Figure 12: Medullary carcinoma: A. Cystic nodule with echogenic calcific foci;

B. Intranodular flow on colour doppler



A **B**

Figure 13: Papillary carcinoma of thyroid gland: Spectrum of appearances: A. Nodule in the left lobe with honeycombing and punctate microcalcifications; B. Ill defined, heterogenous nodule with microcalcifications**.**



A **B** **C**

Figure 14: Anaplastic carcinoma: A and B. Ill-defined solid heterogenous nodule encasing the CCA. Chaotic intranodular flow on colour doppler

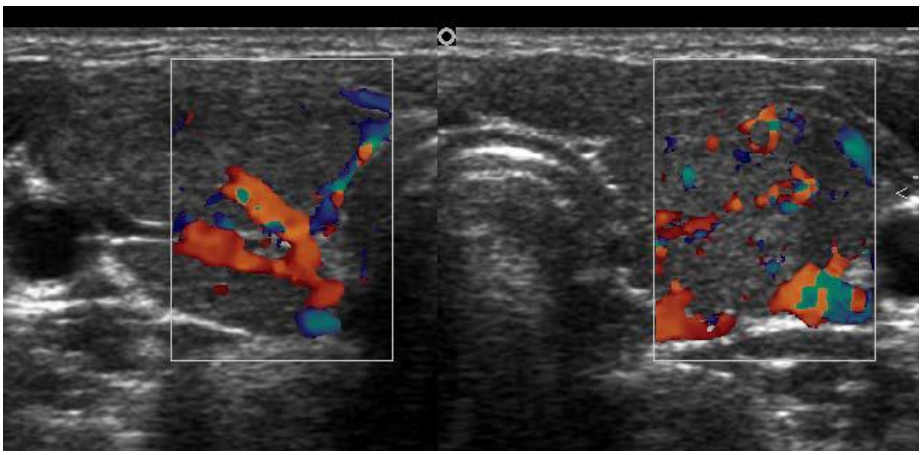


Figure 15: Hashimoto's Thyroiditis: Coarsened parenchymal echotexture with multiple discrete hypoechoic micronodules and shows Increased vascularity on colour doppler.

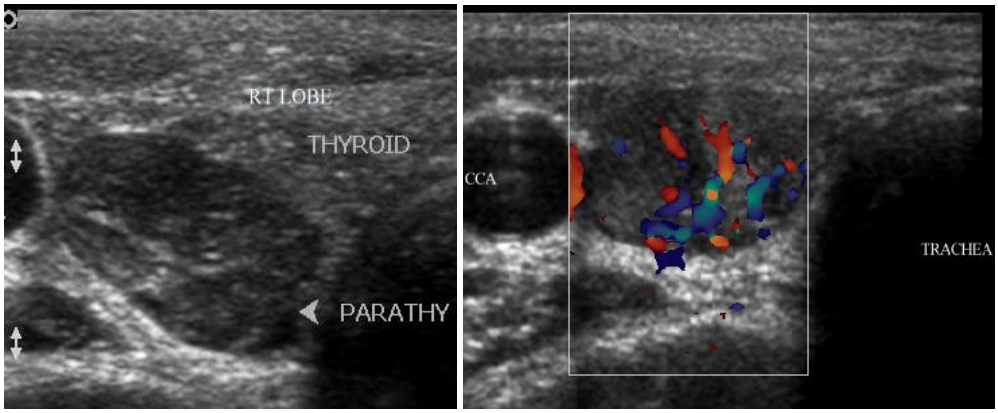


Figure 16: Right Parathyroid Adenoma: Oval hypoechoic lesion with increased vascularity on colour doppler

SALIVARY GLANDS

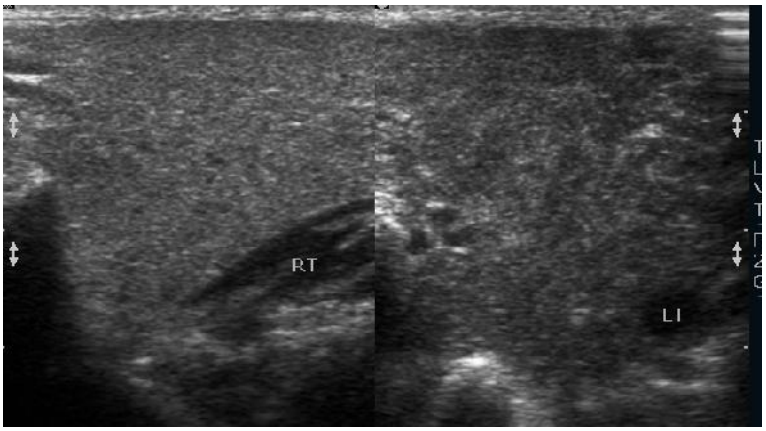
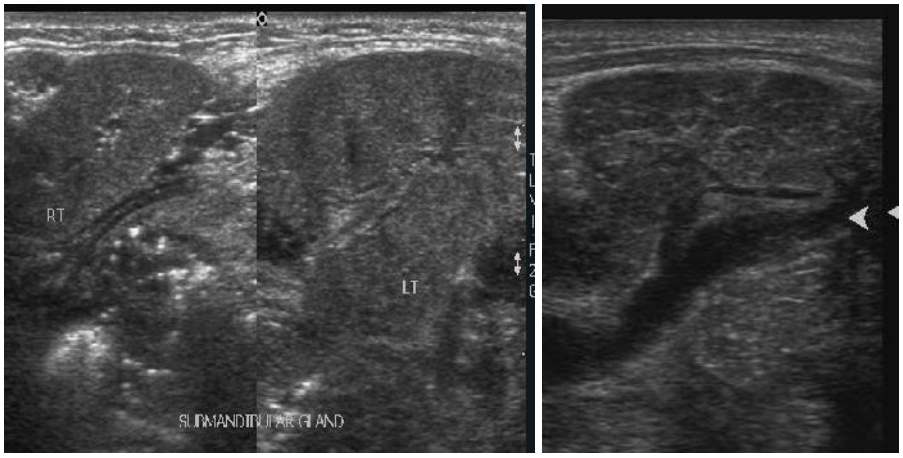


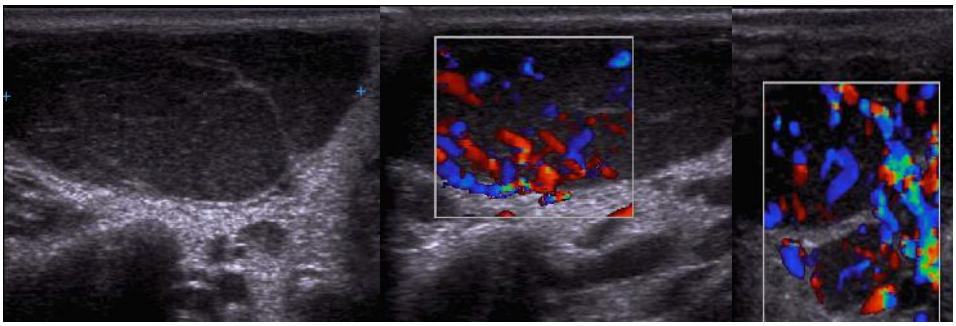
Figure 17: Left Parotitis- Enlarged hypoechoic gland



A **B**

Figure 18: A-Bilateral acute Submandibular Sialadenitis,

B-Chronic Sialadenitis with dilated duct



A **B** **C**

Figure 19: Castleman's disease of the parotid: A. Uniformly hypoechoic mass arising from the superficial lobe of the left parotid gland; B and C. Colour Doppler study showing exuberant peripheral vascularity with prominent feeding vessels

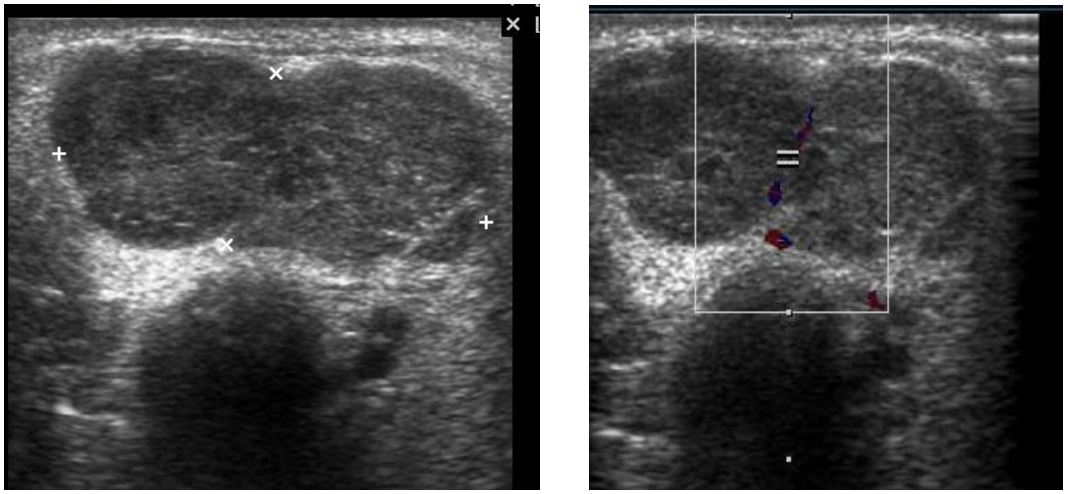


Figure 20: Right Parotid Gland- Pleomorphic Adenoma- Hypoechoic, well-defined, lobulated lesion with posterior acoustic enhancement and poor vascularity on colour Doppler

LYMPH NODES

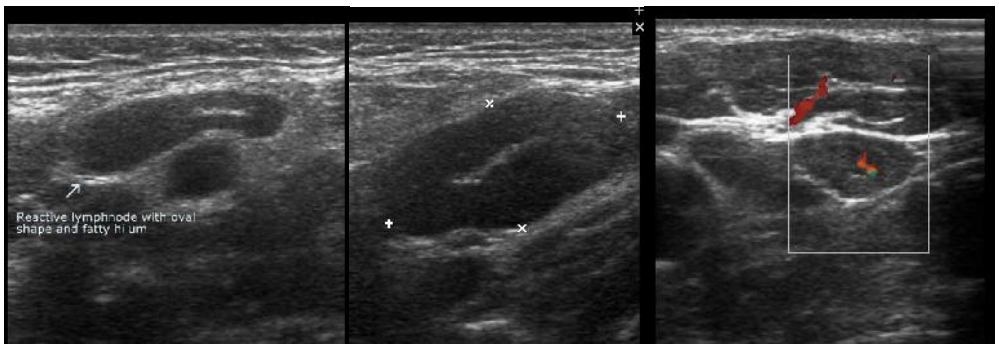
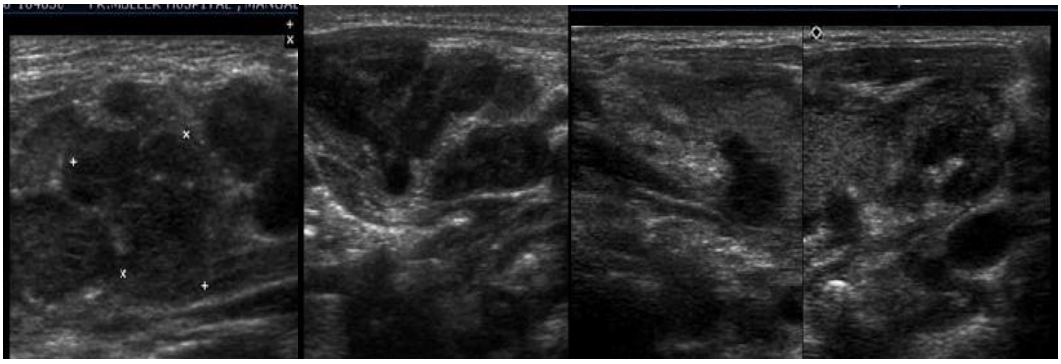
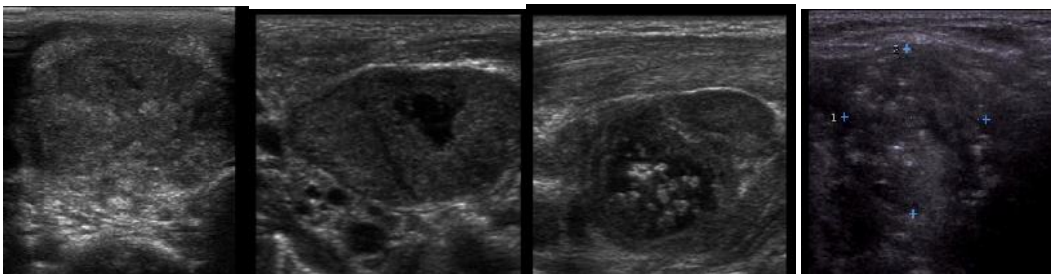


Figure 21: Reactive/ Inflammatory lymph nodes with fatty hilum and type A hilar vascularity



A **B** **C**

Figure 22: Tubercular nodes with A and B intranodal necrosis, C. localised necrotic collection and surrounding soft tissue oedema



A **B** **C** **D**

Figure 23: Metastatic nodes: A. Enlarged heterogenous node; B. Enlarged necrotic hypoechoic node; C. Enlarged necrotic node with coarse calcific foci; D. Enlarged node with punctate microcalcifications (metastasis from papillary Ca Thyroid)

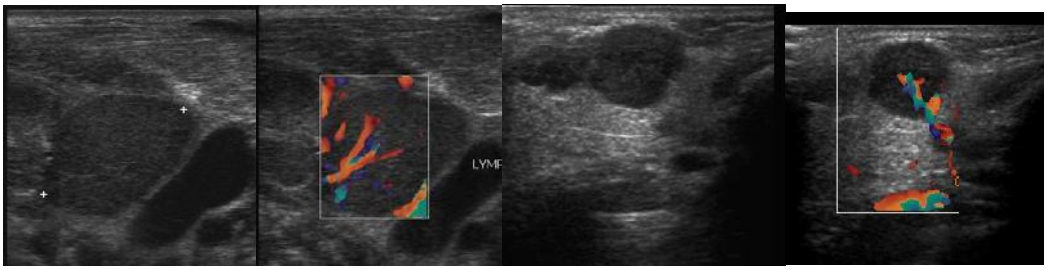


Figure 24: Lymphomatous lymph nodes: Enlarged hypoechoic lymph nodes with predominantly hilar (activated) vascularity

DISCUSSION

Ultrasonography was found to be the initial investigation modality opted by clinicians for the evaluation of superficial structures of the neck, following which CT or MR imaging was done to determine further extent and involvement of disease.

The Thyroid gland:

Majority of patients presented with history of neck swelling and pain/ difficulty while swallowing. The male: female ratio in this study was 1:10. Female predominance in the prevalence of nodular goitre is consistent with literature. Multinodularity was a feature in 66% of our patients, while 33% of cases revealed solitary nodules. Ultrasound showed 100% accuracy in diagnosing solid from cystic nodules, and in demonstrating internal septae/ echoes within a cyst.

Khati and co-workers[1], concluded from their study that ultrasound plays a prominent role in the management of thyroid disease by assessing nodularity and characterizing them as cystic, solid or complex. The presence of comet tail artefact (closely spaced discrete echoes) on US was found to be consistent with presence of colloid within a cyst. Ahuja et al[2] in their study have emphasized the clinical significance of the comet tail artifact in diagnosing colloid cysts.

Khati et al[1] and Wong et al[2] have described the usefulness of ultrasound in detecting thyroid malignancies. Rodrigues et al[3] found, ultrasound showed a sensitivity of 65%, specificity of 86% and an overall accuracy of 82%in detecting thyroid cancer. They also found it to be ideal for post operative follow up. In our study, we came across 4 cases showing US features suggestive of Papillary carcinoma, 3 of which were confirmed by FNAC/ HPE. The sensitivity and specificity were 75% and 93.7% respectively. The presence of punctuate calcifications within the lesion and neighbouring lymph nodes found in our study was suggestive of Papillary carcinoma. Various studies have shown the presence of punctuate calcifications as highly suggestive for papillary carcinomas. The appearance of microcalcifications have been mentioned as highly specific for malignancy with a sonographic specificity of 93% to 95%

Encasement of carotid vessels and thrombosis of the IJV with extra lesional spread of tumour can be demonstrated on USG with good accuracy. There was 1 case of Follicular neoplasm in this study which was confirmed as Follicular carcinoma on HPE. USG cannot distinguish between benign and malignant lesions. Surgical excision and HPE is necessary to exclude the possibility of carcinoma in a follicular neoplasm. This has been emphasized by Reading and others[4] in their study of thyroid cancer.

One known case of medullary carcinomas, post-operative status, presented to us with vague swelling in the neck and was found to have tumor recurrence on ultrasound examination. HPE further confirmed tumor recurrence in the thyroid bed.

Antonelli et al [5] have reported that ultrasound is capable of detecting recurrent tumor in the thyroid bed as well as cervical lymph node metastasis.

Three cases of thyroiditis were diagnosed on USG, which were confirmed by FNAC/HPE. 100% sensitivity and specificity was noted. USG features of hypoechoic gland with multiple ill-defined hypoechoic areas separated by thickened fibrous strands, were described by Seyfettin Ligan et al [6] as being highly suggestive of Hashimoto's thyroiditis.

The Parathyroid glands:

Ultrasound examination done on one patient with elevated serum calcium levels and pathological fractures (Brown tumors), revealed parathyroid adenomas. According to Meilstruf

et al[7] and Kamaya et al[8], a pre-operative parathyroid ultrasound screening will help in better localization, decreased surgical time, decreased morbidity, complications and cost of treatment. The sensitivity and specificity in detecting parathyroid adenomas is 70-80% and 92-97% respectively. Our study showed a sensitivity and specificity of 100%, which can probably be attributed to small sample size.

The salivary glands:

This study had 10 cases of salivary gland pathology diagnosed on USG. One case of pleomorphic adenoma was demonstrated as well defined lobulated hypoechoic lesion in the superficial parotid lobe with poor vascularity on colour Doppler. This finding was consistent with that seen by Bialek and others[9] and Alyas et al[10].

Bozzato et al[11] noted that no reliable distinct sonomorphological criteria have been defined that enables histological tumor type to be identified. Claudia et al[12] have emphasized USG as the first modality of choice for evaluation of parotid neoplasms and for guiding FNAC/ biopsy.

This study had one case of submandibular gland calculi, ultrasound features of which included heterogenous gland with hypoechoic collections and multiple calculi in the gland. This was confirmed by histopathology. Two cases showed intraductal calculi with dilated duct and an enlarged hypoechoic gland. These features were consistent with those described in literature.[9,13-16]

Salivary gland calculi occur most commonly in the Wharton's duct. This was seen in our study as all 3 cases involved the submandibular gland. US clearly showed the exact location of the calculi and this helped in avoiding the surgical removal of the entire gland.

One case of parotitis and 2 cases of acute submandibular sialadenitis were detected. Two cases of chronic inflammation showed normal sized gland with decreased vascularity and hypoechoic texture. One case of Sjögren syndrome was detected with features consistent with those described by Bialek and others[9].

One case of parotid abscess was noted involving the superficial lobe which was hypoechoic with hyperechoic gas foci seen within. This feature is consistent with parotid abscess described by Bialek and others[9].

This study had one case which showed a hypoechoic lesion in the superficial lobe of the Parotid, with exuberant vascularity and prominent penetrating feeding vessels seen entering the hilum. These features were found to be consistent with Castleman's disease of the parotid.

Lymph nodes:

Ultrasound showed hypoechoic echotexture in all cases of inflammatory nodes, 5 (87%) cases of tubercular nodes and 4 (75%) cases of metastatic lymphadenopathy. 2 cases of metastatic lymphadenopathy showed hyperechogenecity. All inflammatory nodes displayed oval shape, while metastatic and lymphomatous nodes showed rounded shape on US, which was suggestive

of malignancy. Matting and unsharp borders were seen in 5 (87%) tubercular nodes. The above findings were consistent with those described by Chan et al[17] and Hajek et al[18].

According to Bruneton et al[19], ultrasound is of primary value in providing information of an anatomical nature including the distribution of subclinical nodes, volumetric evaluation and determination of vascular connection.

Sumi et al[20] found ultrasound has a great potential in detecting metastatic nodes from squamous cell carcinoma in the head and neck region because of its ability to delineate changes in internal architecture. Our study revealed similar results.

According to Anand et al[21], the sensitivity and specificity in detecting metastatic nodes was 82% and 92.5%. Our study showed a sensitivity and specificity of 85.7% and 92.3% respectively.

USG showed 100% sensitivity and specificity in detecting tubercular nodes based on unsharp borders, matting, displaced vascularity and clinical features of pulmonary / extrapulmonary tuberculosis. These findings have also been described by Asai et al[22] and Chan et al[17]. Nearly 92% of reactive nodes are shown to have significant hilar vascularity, 84% of metastatic nodes had peripheral vascularity and 79% of lymphomatous nodes showed mixed vascularity. According to Giovagnorio et al[23], type II vascularity (activated Hilar) was more frequently associated with lymphoma. Peripheral subcapsular vessels, typical of metastasis, are rare in lymphoma (exception-high grade lymphomas). The differential diagnosis between lymphoma and lymphadenitis is frequently impossible with sonographic and Doppler patterns alone.

Others:

Three cases of Thyroglossal cyst including one with superadded infection were accurately diagnosed by US. The features were consistent with those described by Anil T et al[24] and Turkington J R A[25] in their respective studies.

One case of Branchial cleft cysts was diagnosed by USG, and two cases of lipoma showed well defined elliptical hyperechoic appearance parallel to the skin with internal septae. These features were consistent with those described by Ahuja et al[26]

Hypoechoic collection posterior to the Submandibular gland with multiple enlarged lymph nodes was diagnosed as Ludwig's angina.

Another abscess was seen anterior to the sternocleidomastoid muscle. Ultrasound guided abscess drainage was done. Chang et al[17] observed that real time capability of ultrasound is useful in monitoring the process of evacuating the purulent abscess. It also yields material for culture sensitivity for selection of appropriate antibiotics.

Our study included one case of Haemangiomas confirmed on HPE. Sladjana et al[27] have described Haemangiomas as masses of low reflectivity with irregular margins and occasionally a sponge like pattern due to tiny vessels and/ or small blood pools better demonstrated with colour flow mapping.

One case of Fibromatosis coli was diagnosed on US and confirmed on HPE. USG also accurately diagnosed one case of Dermoid cyst and one case of Epidermoid cyst. The USG features were consistent with those described in literature.[25,27,28]

CONCLUSION

1. Congenital neck masses such as thyroglossal cysts, branchial cleft cysts, cystic hygromas show a variety of sonographic features which aid in pre- operative assessment.
2. Salivary gland disease can be characterized into inflammatory and neoplastic conditions.
3. Ultrasound is the primary imaging modality in the evaluation of thyroid gland pathology.
4. Colour Doppler imaging enables the assessment of vascularity and its distribution within the lesion, as well as invasion of the great vessels of the neck by a growth or metastatic lymph node, thereby avoiding surgery in inoperable cases.
5. Ultrasound can differentiate etiology of lymph node enlargement to a significant extent.

Although no single sonographic criterion should be used alone in deciding whether a lymph node is normal or malignant, the combination of characteristics such as increased size, round shape, absence of an echogenic hilus, intranodal necrosis, and peripheral or displaced vascularity make malignancy more likely.

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