ORIGINAL RESEARCH

Role of high resolution ultrasonography and doppler in the evaluation of neck masses

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ABSTRACT
Introduction: Neck masses are swellings or enlargements of the structures in the area between the inferior border of mandible and clavicle. As there are many potential causes of neck masses; it is important to proceed in logical and cost effective manner for the proper diagnosis of neck masses. Ultrasonography (B-mode, Doppler, linear probe) is a widely employed imaging modality for the study of the neck, in particular for thyroid, parathyroid, salivary glands and lymphnodes. Color Doppler allows assessment of vascularity within the lesion, e.g. in the assessment of vascular malformations, hemangiomasetc. **Objectives:** To identify the Sonographic and Doppler characteristics of neck masses and to assess the accuracy of high resolution ultrasound in the evaluation of neck masses after confirmation of diagnosis with fine needle aspiration cytology and histopathology follow up wherever possible. **Material and Methods:** this prospective observational study was conducted on a cohort of 100 patients in the Department of Radiodiagnosis and Imaging, Government Medical College, for sonographic and Doppler evaluation of the neck masses**. Result:** Out of 100 cases, patients with thyroid gland pathology formed the largest group (35%), followed by lymph nodes (30%), congenital and miscellaneous lesions (20%), salivary gland disease (13%) and parathyroid adenomas (2%). Maximum number of cases were seen in 21-40 years (46%) age category followed by 41-60 years (26%) with female predominance. Out of the total cases of thyroid gland pathology, 66% were diagnosed to have multinodular goiter. A significant correlation of p-value <0.05 was observed in our study between Duplex ultrasonography and FNAC/HPE resulting in good accuracy. **Conclusions:** Ultrasound and Color Doppleris one of the most valuable investigation tools to evaluate neck masses with respect to size, site, consistency and vascularity. It helps in distinguishing solid from cystic lesions and allows the guidance of needles accurately into the lesion of interest to obtain a diagnostic fine cytology/ biopsy

INTRODUCTION

Neck masses are swellings or enlargements of the structures in the area between the inferior border of mandible and clavicle. As there are many potential causes of neck masses; it is important to proceed in logical and cost effective manner for the proper diagnosis of neck masses. Ultrasonography is widely employed imaging modality for the study of the neck, in particular for thyroid, parathyroid, salivary glands and lymph nodes. The additional use of color Doppler ultrasound allows assessment of vascularity within the lesion, particularly helpful in the assessment of vascular malformations, haemangiomas and enlarged lymph nodes.

A higher frequency linear probe is useful in providing more detailed views of superficial structures while a curvilinear probe is useful in examining deeper regions and in attaining an overview of the anatomy. The sonographic characterization of the lesion is based on size, shape, site, margins, appearance (solid/cystic), and presence of calcifications, echo texture and vascularity. Ultrasonography also plays an important role in the precise tumor staging which helps in effective therapy and follow up. USG allows the

guidance of needles accurately into the lesion of interest, to obtain a diagnostic aspirate / biopsy.

AIMS AND OBJECTIVES
1. To identify the Sonographic and Doppler characteristics of neck masses.
2. To determine the accuracy of high resolution ultrasound in the evaluation of neck masses.
3. Confirmation of diagnosis with fine needle aspiration cytology and histopathology follow up wherever possible.

MATERIALS AND METHODS
This prospective observational study was conducted on a cohort of 100 patients for a duration of 2 years from March 2021 to February 2023 who were referred to the Department of Radio diagnosis and Imaging, Government Medical College and Guru Nanak Dev Hospital, Amritsar for the sonographic and doppler evaluation of the neck masses. Ethical clearance has been obtained from the Research and Dissertation Committee/Ethical Committee of the institution for the study.

Ultrasound examination of neck was performed using Samsung RS80A, Philips ClearVue 350 and Mindray DC-8, machine with a linear array transducer and curvilinear transducer. At the end of study, the data was collected and subjected to statistical analysis using SPSS software. The values of $p < 0.05$ was considered as significant. The qualitative variables were compared using the chi-square test.

RESULTS
The following study was conducted on 100 patients referred to the Department of Radio-diagnosis for the sonographic evaluation of neck masses.
 Demographic profile: Table 1, Table 2.

Table 1: Frequency of patients in different age groups

Age (years)	Frequency	Percentage
< 10	4	4%
11-20	16	16%
21-40	46	46%
41-60	26	26%
> 60	8	8%
Total	100	100%

Figure 1: Sex distribution of lesions
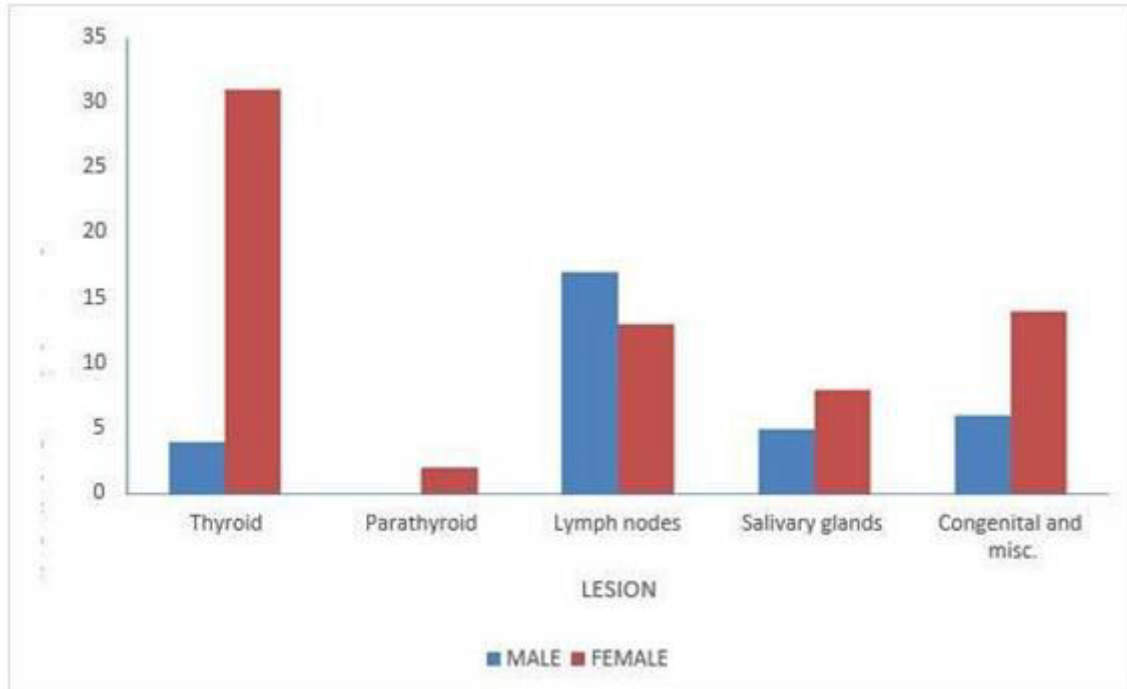
Table 2: Sex Distribution of lesions

Lesion	M	F	Total
Thyroid	4	31	35
Parathyroid	0	2	2
Lymph nodes	17	13	30

Salivary glands	5	8	13
Congenital and misc.	6	14	20
Total	32	68	100

Figure 2: The head and neck masses studied
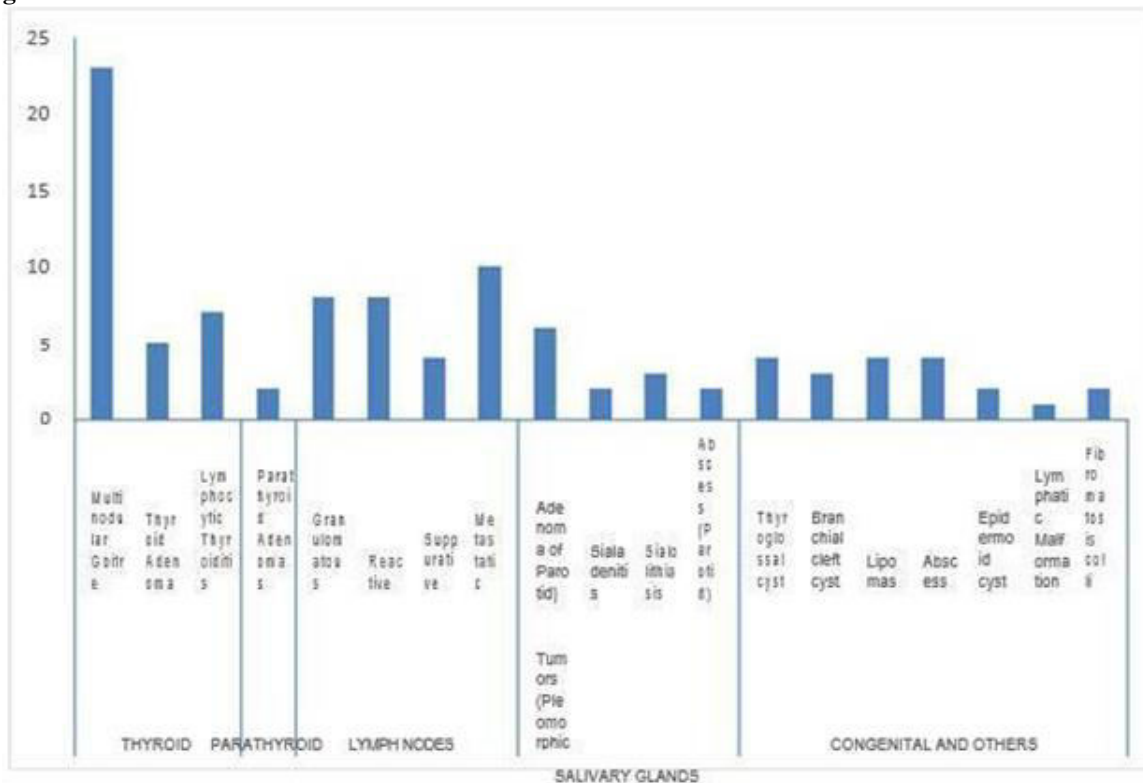
In our study, maximum number of cases were seen in age category 21-40 years (46%) followed by age group 41-60 years (26%). The youngest patient in this study was a 3 years old who presented with a neck swelling. The oldest patient was a 77 years old male. Males accounted for 32 lesions while 68 females presented with neck masses.

Table 3: The head and neck masses studied

	No. of Patients	%age	p-value
Thyroid			
1. Multinodular Goitre	23	23%	0.001
2. Follicular Adenoma	5	5%	0.001
3. Lymphocytic Thyroiditis	7	7%	0.001
Parathyroid			
1. Parathyroid Adenomas	2	2%	0.003
Lymph nodes			0.001
1. Tubercular	8	8%	
2. Reactive	8	8%	0.001
3. Suppurative	4	4%	
4. Metastatic	10	10%	0.001
Salivary glands			
1. Tumors (Pleomorphic Adenoma of Parotid)	6	6%	0.03
2. Sialadenitis	2	2%	
3. Sialolithiasis	3	3%	
4. Abscess (Parotid)	2	2%	
Congenital and others			
1. Thyroglossal cyst	4	4%	
2. Branchial cleft cyst	3	3%	
3. Lipomas	4	4%	
4. Abscess	4	4%	

5.	Epidermoid cyst	2	2%	
6.	Lymphatic Malformation	1	1%	
7.	Fibromatosiscolli	2	2%	

Out of total 100 cases in our study, thyroid gland pathology was seen in 35% of patients. Multinodular goiter was seen in majority of patients followed by lymphocytic thyroiditis and follicular adenoma of thyroid gland. Parathyroid adenoma was seen in 2% of cases. Out of 30 cases of lymph node pathology studies, metastatic lymphadenopathy was seen in maximum number of cases. In salivary glands tumors, pleomorphic adenoma of parotid was observed in 6% of cases. Most common congenital lesion of neck masses noted in our study is thyroglossal cyst

Out of 100 cases, USG-FNAC/HPE correlation was done in 83% of cases. While in 17% cases, only USG was done before final diagnosis.

THYROID GLAND PATHOLOGIES
Sex Prevalence of thyroid gland pathology: There was a male: female ratio of 1:8 in the case of thyroid pathology which shows an increased prevalence of this disease in females. Out of total 35 patients presenting with thyroid pathologies, 4 were male accounting for 11.5% of total while females accounted for 88.5% cases (31) Table 4, Figure 3.

Table 4: Sex prevalence of thyroid gland pathology

| Sex	No. of patients	Percentage
Male	4	11.5%
Female	31	88.5%
Total	35	100%

Figure 3: Sex prevalence of thyroid gland pathology
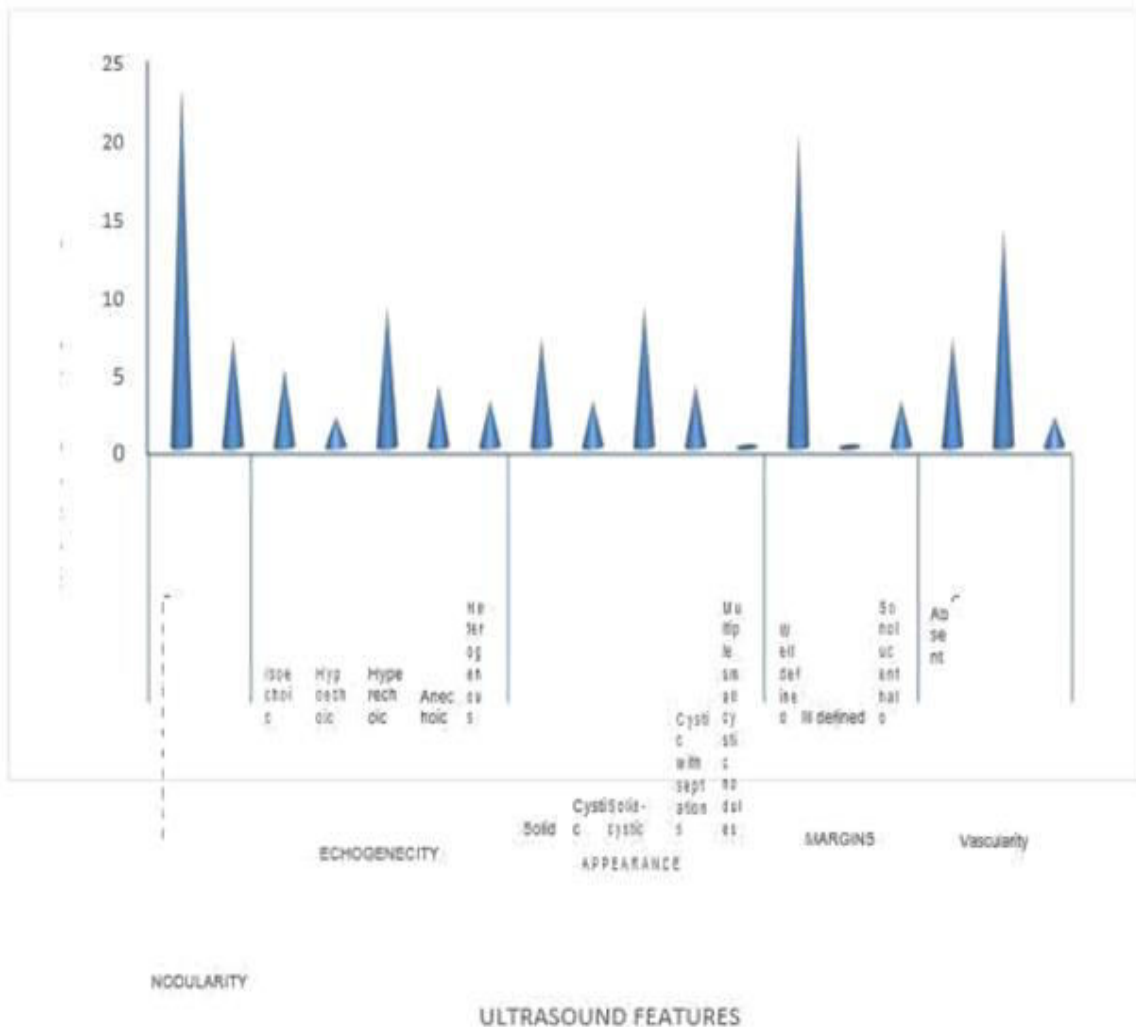
Table 5: USG features of multinodular goitre (Figure 4)

Ultrasound features	No. of patients	Percentage
1. NODULARITY		
∟ Multinodular	23	100%
∟ Calcification	7	30%
2. ECHOGENECITY		
∟ Isoechoic	5	22%
∟ Hypoechoic	2	8%
∟ Hyperechoic	9	39%
∟ Anechoic	4	17%
∟ Heterogenous	3	13%
3. APPEARANCE		
∟ Solid	7	30%
∟ Cystic	3	13%
∟ Solid-cystic	9	39%
∟ Cystic with septations	4	17%
∟ Multiple small cystic nodules	0	0%
4. MARGINS		
∟ Well defined	20	87%
∟ Ill defined	0	0%
∟ Sonolucent halo	3	13%
5. Vascularity		
∟ Absent	7	30%
∟ Perinodular	14	61%
∟ Intranodular	2	8%

Figure 4: USG features of multinodular goitre

■ Male ■ Female
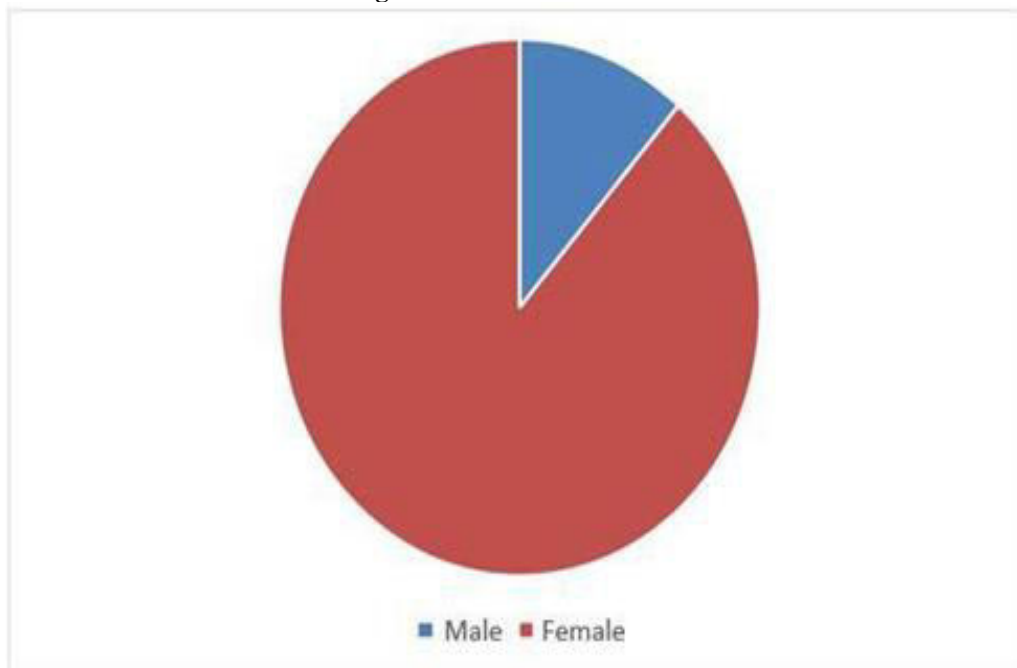
Figure 4: USG features of lymph nodal pathology
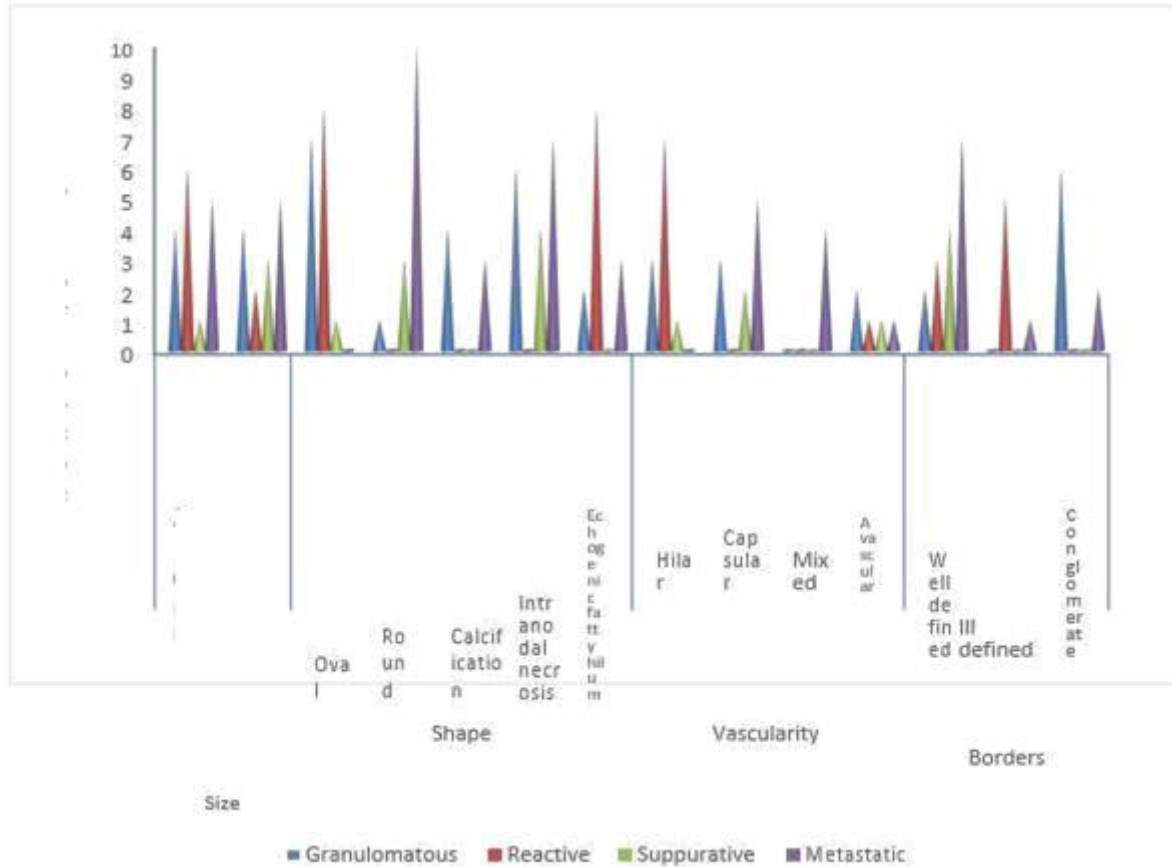
In multi nodular goiter, most of the nodules were well defined, solid cystic in appearance and isoehoic to hyperechoic in echotexture, with intranodular vascularity seen on colr Doppler.

High resolution ultrasonography and Color Doppler showed a sensitivity of 95.2% and specificity of 78.5% with accuracy of 88.57% in the detection of Multinodular Goiter (MNG). Out of the 23 cases diagnosed as MNG on USG, 20 were confirmed on FNAC/HPE. 3 cases were found to be Follicular Adenoma. (Post FNAC/HPE).

Sensitivity of detection of Follicular Adenoma was found to be 57.1%, while the specificity was 96.4% with accuracy of 88.57%. Out of 5 cases diagnosed on USG as Follicular Adenoma, 4 were confirmed on FNAC/HPE. 1 case diagnosed as Follicular Adenoma on USG was found to be MNG (Post FNAC/HPE).

USG and Doppler showed a sensitivity and specificity of 100% in the diagnosis of Lymphocytic Thyroiditis. Out of 7 patients in our study, Ultrasound and Color Doppler features of Lymphocytic Thyroiditis proved to be both sensitive and specific in reaching the diagnosis.

PARATHYROID

There were two cases of parathyroid adenoma in our study. USG showed 100% sensitivity and 100% Positive predictive value in detection and characterization of parathyroid adenomas. This may be attributed to the small sample size.

LYMPH NODAL PATHOLOGY:

USG showed a sensitivity of 60% and specificity of 90% with accuracy of 80.3% in detection of granulomatous lymphadenitis. Two cases of granulomatous/tubercular lymphadenitis on USG were diagnosed as metastatic deposits on FNAC/HPE. Out of the 8cases diagnosed as granulomatous on USG, six were confirmed on FNAC/HPE. Three cases of reactive lymphadenitis and one case of metastatic deposits were found to be tubercular on USG.

USG showed a sensitivity and specificity of 100% and 88% respectively in diagnosing Reactive Lymphadenitis and showed a sensitivity and specificity of 72.7% and 89.4% respectively in diagnosing metastatic lymphadenopathy.

Accuracy in diagnosing metastatic lymphadenopathy was found to be 83.33%. Out of the ten cases diagnosed as Metastatic Lymphadenopathy on USG, eight were confirmed on FNAC/HPE. Two cases of Metastatic deposits on USG were diagnosed as Granulomatous and Suppurative Lymphadenitis on FNAC/HPE. 3 cases of metastatic deposits on FNAC/HPE were misdiagnosed as Tubercular and suppurative lymphadenitis on USG.

Table 6: USG features of lymphnodal pathology

		Tubercular	Reactive	Suppurative	Metastatic
1. Size					
└	<10mm	4	6	1	5
└	>10mm	4	2	3	5
2.	Shape				
└	Oval	7	8	1	0
└	Round	1	0	3	10
3.	Calcification	4	0	0	3
4.	Intranodal necrosis	6	0	4	7
5.	Echogenic fatty hilum	2	8	0	3
6.	Vascularity				
└	Hilar	3	7	1	0
└	Capsular	3	0	2	5
└	Mixed	0	0	0	4
└	Avascular	2	1	1	1
7.	Borders				
└	Well defined	2	3	4	7
└	Ill defined	0	5	0	1
└	Conglomerate	6	0	0	2

Case 1: Multinodular goitre
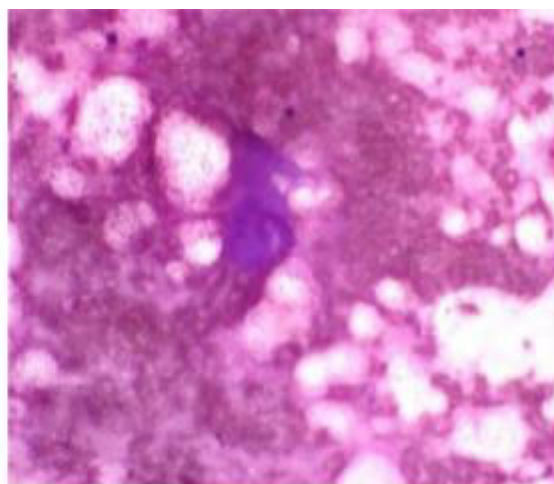
(a)   **(b)**

30 years old female presented with painless swelling in both sides of the neck

a)   High resolution gray scale ultrasound shows enlarged thyroid gland with multiple solid and cystic nodules of variable size in bilateral lobes suggestive of MultinodularGoitre.

TIRADS assessment

1.   Echogenicity : isoechoic
2.   Composition : mixed solid cystic
3.   Shape :wider than taller
4.   Margins :smooth
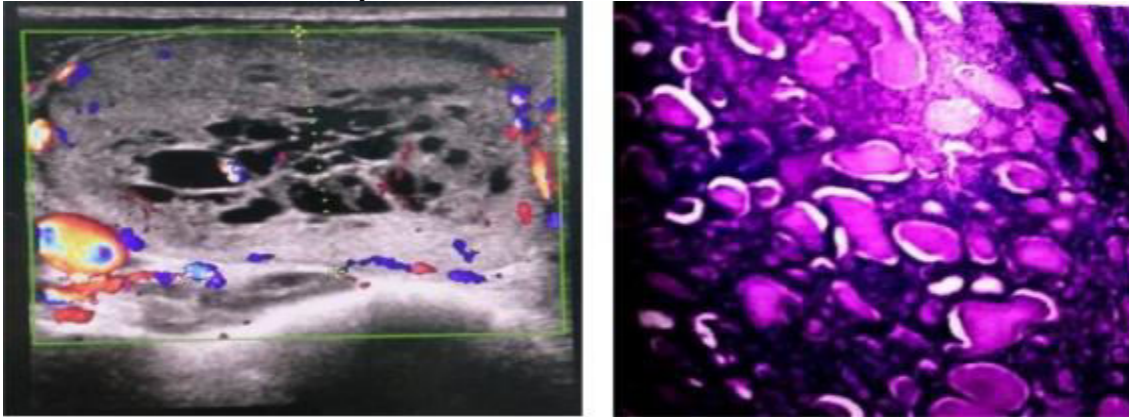5.   Echogenic foci :absent (score 0)

TIRADS POINTS: 2

ACR TIRADS CATEGORY: TR 2 FNAC reveals Colloid Goitre

(b) FNAC image shows colloid in a colloid goitre

Case 2: Follicular Adenoma Of Thyroid Gland


(a)   (b)

58Years old female presented with painless swelling in the right side of the neck

a)   Duplex Ultrasound demonstrated a Follicular Adenoma with few internal cystic areas and peripheral sonolucent halo in right thyroid lobe. On Color doppler, it showed peripheral vascularity.

b)   Histopathological examination of thyroid nodule reveals closely packed variable sized follicles containing colloid with maintained capsule (arrow) suggestive of follicular adenoma

Case 3: Lymphocytic Thyroiditis
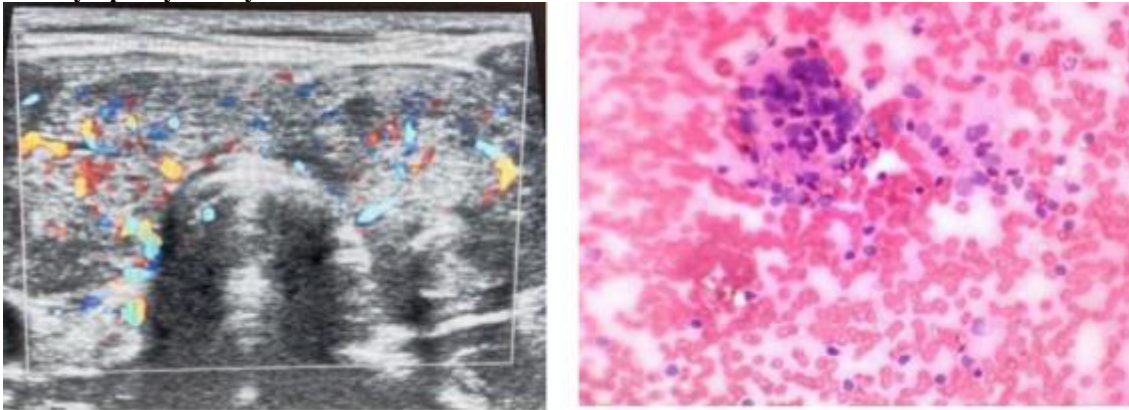

(a)   (b)

18 yr old male patient presented with neck swelling

a)   High resolution Ultrasound shows diffusely enlarged thyroid gland with multiple hypoechoic micronodules in both lobes and coarsened echotexture. On Color Doppler, significant vascularity is seen. FNAC revealed Lymphocytic Thyroiditis.

b)   FNAC image shows follicular cells with infiltrating lymphocytes in Lymphocytic thyroiditis.

Case 4: Parathyroid adenoma
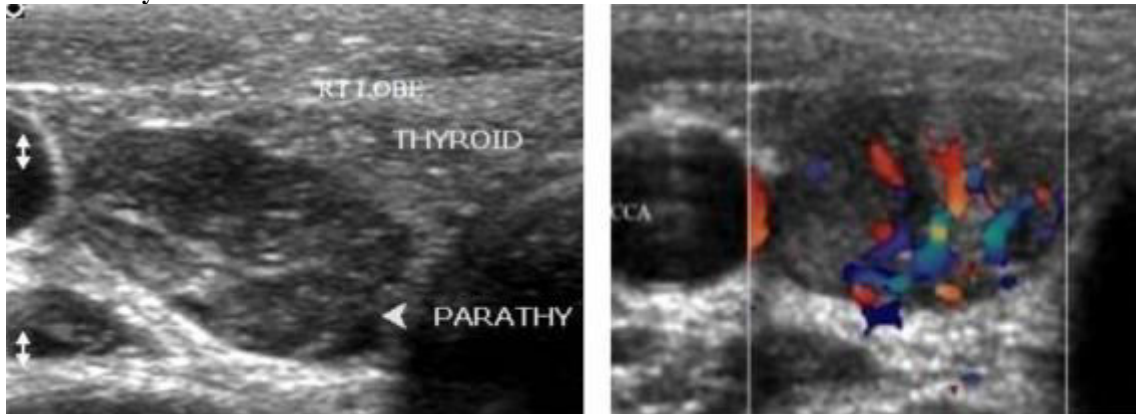
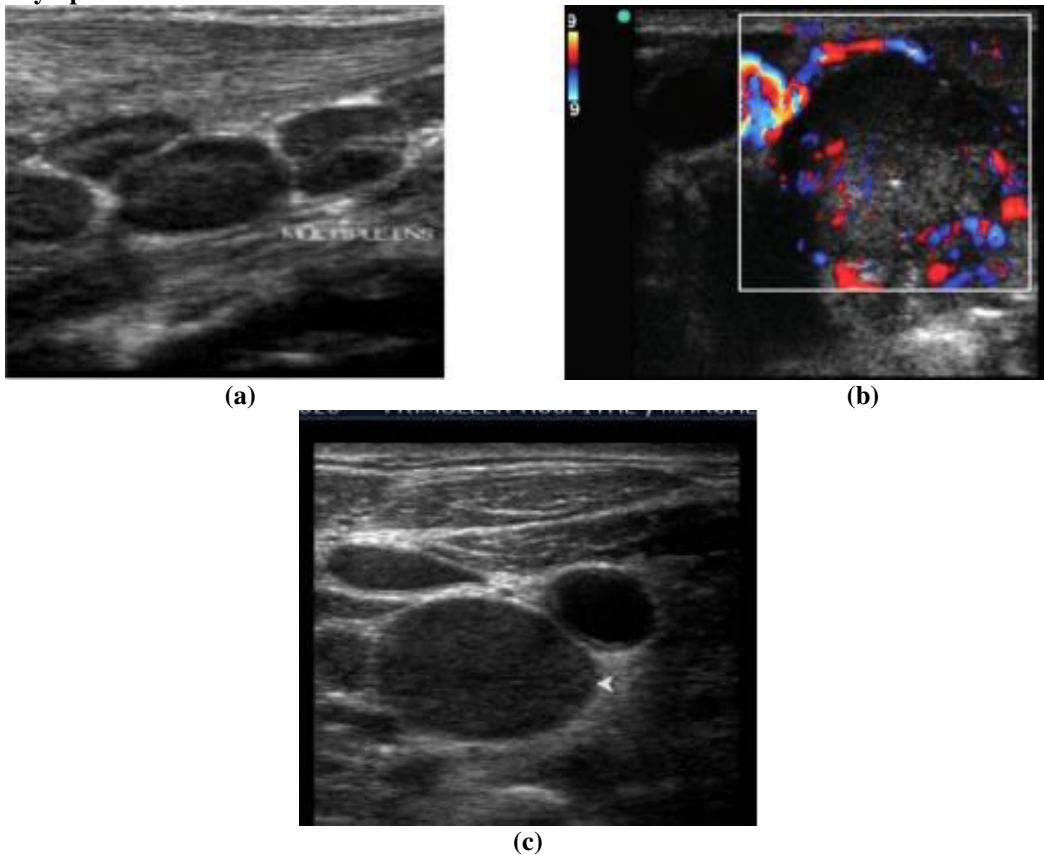(a)   (b)

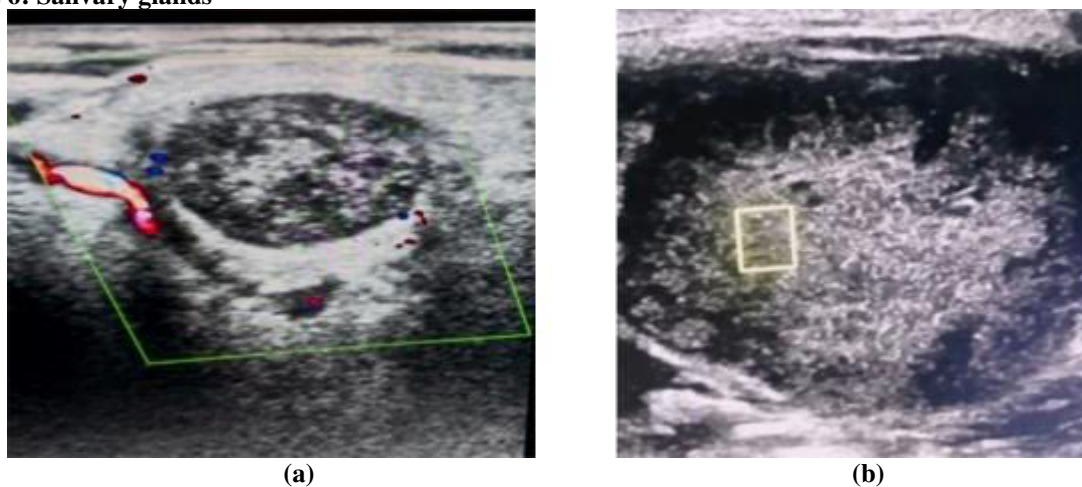38yr old female patient presented with the right sided neck swelling

a) Ultrasound shows Oval solid mass of homogeneously low echogenicity in inferior lobe of thyroid suggestive of Parathyroid adenoma
b) On color Doppler, raised vascularity is seen within the lesion

Case 5: Lymph Nodes

(a)

(b)

(c)

a) USG and Doppler shows well defined oval Conglomerated lymph nodes with partially maintained fatty hilum suggestive of Tubercular Lymph nodes.
b) Ultrasound reveals well defined round hypoechoic lymph node at level Ib of cervical region of neck associated with loss of fatty hilum. Color Doppler image of malignant lymph node showing mixed/peripheral vascularity.
c) USG and Doppler shows well defined round to ovoid necrotic node with loss of echogenic fatty hilum-FNAC revealed metastatic deposits.

**Case 6: Salivary glands**

(a)

(b)

(c)

40yr old female patient presented with right sided neck swelling

a)   Duplex Ultrasound showing well defined heterogeneous predominantly hypoechoic parotid mass with peripheral vascularity on Color Doppler. FNAC revealed Pleomorphic Adenoma of Parotid gland.

b)   USG shows Hypoechoic collection in the deep lobe of parotid gland suggestive of abscess.

c)   High resolution USG shows dilated duct and echogenic Intraductal calculus with distal acoustic shadowing in submandibular gland suggestive of Submandibular gland calculus with Sialadenitis
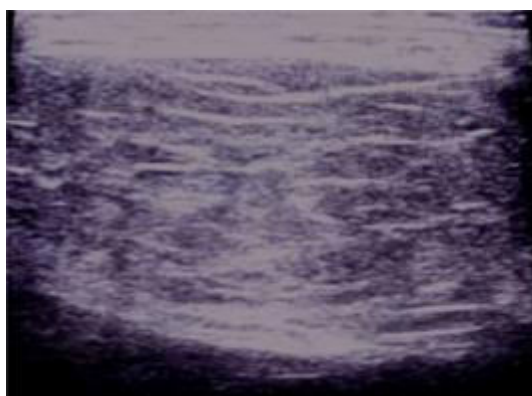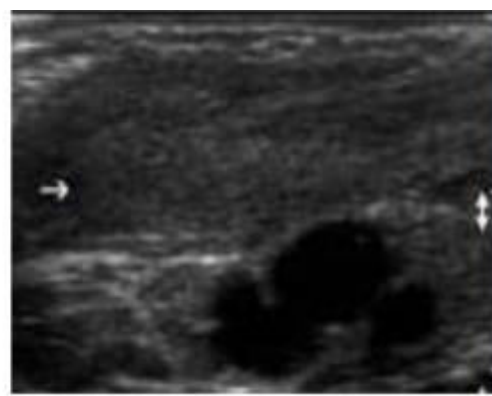
Case 7: Congenital/miscellaneous lesions
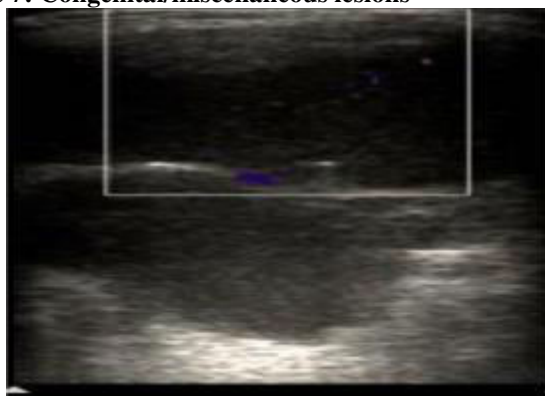
(a)
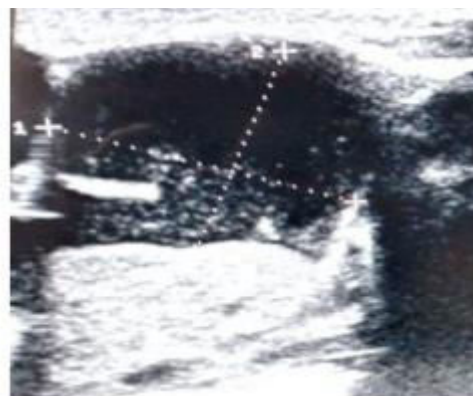
(b)

(c)

(d)

13yr old female patient presented with the left sided neck swelling

(a) High resolution Ultrasound shows well circumscribed hypoechoic midline cystic lesion with internal echoes sugestive of Thyroglossal cyst.

(b) USG shows well defined oval anechoic lesion with internal echoes and septation suggestive of Branchial cleft cyst.

(c) High resolution Ultrasound reveals elliptical hyperechoic mass with internal septa parallel to the skin surface suggestive of Lipoma.

(d) High resolution Ultrasound shows Isoechoic lesion within the sternocleidomastoid muscle suggestive of Fibromatosis coli

PAROTIDS / SALIVARY GLANDS

USG and Doppler showed 100% sensitivity and 66.6% specificity with accuracy of 87.5% in detection and characterization of Pleomorphic Adenoma of Parotid gland. Out of the six cases diagnosed as Pleomorphic Adenoma on USG, five were confirmed on FNAC/HPE. One case of Pleomorphic Adenoma on USG was diagnosed as Parotid Abscess on FNAC/HPE.

DISCUSSION

The present study was undertaken to evaluate the role of High resolution Ultrasonography and Doppler in the evaluation of neck masses. A total of 100 patients of either sex referred to the Department of Radiodiagnosis, Government Medical College Amritsar with neck swelling were included in the study.

DEMOGRAPHIC PROFILE

In our study, maximum number of cases were seen in age category 21-40 years (46%). The youngest patient in this study was a 3 years old who presented with a neck swelling. The oldest patient was a 77 years old male.

Majority of the patients were females, predominantly presenting with lesions arising from the thyroid gland. However, male predominance was seen in case of Lymphadenopathy. The male: female ratio in thyroid gland pathology was 1:8. Female predominance was seen in multinodular goiter.

Patel S et al[1] (2016) observed that age group of patients ranged from 5 years to 70 years with mean age of 40.57 years. The majority of the patients were in the age group of 31-40 years, and most of them were females forming a female to male ratio of 6.6:1[1]. Chakraborty S et al[2] (2016) also yielded similar findings. In a similar study by Shrestha E et al[3], a prospective study of a total of 70 patients, 59 (84.3%) were female and 11 were male (15.7%) with a male: female ratio of 1:1.8. Studies by Khati N et al[4] and Patel S.B et al[5] revealed similar results, the peak age of cases was 35 to 50 years, and females were three times more likely than males to have the multinodular goiter.

The spectrum of disease in our study included patients with thyroid gland pathology as the largest group (35%), followed by lymph nodes (30%), congenital and miscellaneous lesions (20%), salivary gland disease (13%) and parathyroid adenomas (2%). Syed et al[6] in 2020, concluded that out of 41 benign lesions thyroid gland accounted for 19 (46%) cases followed by lymph node accounting for 10 (24%) cases and developmental anomalies accounted for 5 (12%). Malignant lesions of the lymph node were found to be dominant, accounting for 6 cases (including both primary and secondary lymph node diseases) followed by thyroid which accounted for 2 cases. Thyroid gland was the most common site of involvement accounting for 21 cases (42%) followed by lymph node lesion 15

(30%) which is in accordance with our study[6]. In 2021, similar to our study, Soneshkumar R Chougule[7] observed that Multinodulargoitre (48%) was found to be the most common cause followed by cervical lymphadenopathy.

THYROID GLAND

Out of 35 patients of thyroid gland, Multinodularity was a feature in 23% of our patients, while 5% of cases were diagnosed as Follicular Adenoma and 7% of cases as Lymphocytic Thyroiditis. High resolution ultrasonography and Color Doppler had a sensitivity of 95.2% and specificity of 78.5% in the detection of MNG. Out of the 23 cases diagnosed as MNG, 3 cases were found to be Follicular Adenoma, four of which were confirmed on FNAC/HPE. Sensitivity of detection of Follicular Adenoma was found to be 57.1%, while the specificity was 96.4%. Seven cases of Lymphocytic thyroiditis were diagnosed on USG, which were confirmed by FNAC/HPE with 100% sensitivity and specificity. According to a study conducted by Jena A[8] et al in 2015, ultrasound plays a prominent role in the management of thyroid disease by assessing nodularity and characterizing them as cystic, solid or complex cysts.

Multinodularity detected by ultrasound es not necessarily exclude malignancy. Ultrasound had 100% accuracy in diagnosing solid from cystic nodules and demonstrating internal echoes &septations within a cyst.

Ultrasonographic correlation with FNAC is 100% accurate in diagnosing Hashimotos thyroiditis in a study conducted by Soneshkumar R Chougule.[7] similar to our results.

In our study, FNAC could not distinguish between Follicular Adenoma and Follicular Carcinoma. HPE is necessary to exclude the possibility of carcinoma in a follicular neoplasm. This has been emphasized by Reading and others[9] in their study of thyroid cancer. According to their study, in classic pattern 3, most follicular neoplasm are benign adenomas and appear solid, homogenous in echogenicity on USG. HPE finding of microscopic capsular or vascular invasion is consistent with Follicular carcinoma of thyroid gland.[9] USG features of heterogenousechotexture of gland with multiple hypoechoicmicronodules separated by thickened fibrous strands, were described by Soneshkumar R Chougule in 2021[7] who concluded that Ultrasonographic correlation with FNAC is 100% in diagnosing Hashimotos thyroiditis.

PARATHYROID GLANDS

In our study Ultrasound and Color Doppler study done on two patients revealed Oval solid mass of homogeneously low echogenicity and increased vascularity in parathyroid gland suggestive of parathyroid adenomas which were confirmed on FNAC/HPE. Our study showed a sensitivity and positive predictive value of 100%, which can probably be attributed to small sample size. According to

Meilstruf et al [10] and Kamaya et al [11], a pre-operative parathyroid ultrasound screening will help in better localization, decreased surgical time, decreased morbidity, complications and cost of treatment. Their study showed sensitivity of 70-80% and specificity of 92-97%.

SALIVARY GLANDS
Our study had 13 cases of salivary gland pathology diagnosed on USG. Six cases were of pleomorphic adenoma in parotid gland. USG and Doppler showed 87.5% accuracy in detection and characterization of Pleomorphic Adenoma of Parotid gland while in a study conducted by Bialek and co-workers[12], pleomorphic adenoma was diagnosed with up to 84% accuracy.

Our study had three cases of submandibular gland calculi. Two cases showed dilated duct and an enlarged hypo echoic gland with increased vascularity on Color Doppler imaging favoring sialadenitis. Salivary gland calculi occur most commonly in the Wharton's duct. USG shows the exact location of the calculi and this helps in avoiding the surgical removal of the entire gland.

According to Bialeket al[13], salivary stones are most often located in the submandibular gland (60%– 90% of cases). In sialadenitis, salivary glands are enlarged and hypo echoic. They may contain multiple small, oval, hypo echoic areas, and may have increased blood flow on duplex ultrasonography. These findings are in accordance with our study.

In our study, two cases of parotid abscess were observed involving the superficial lobe extending into deep lobe of parotid gland. USG with Doppler showed hypo echoic collection with echogenic air foci seen within. This feature was consistent with parotid abscess as described by Bialek and co-workers.[12]

LYMPH NODES
In our study, 8 cases each of Tubercular Lymphadenitis and Reactive Lymphadenitis, 4 cases of Suppurative Lymphadenitis and 10 cases of metastatic lymphadenopathy were diagnosed on USG. The above findings were similar to studies done by Chan et al[14] and Hajeck et al[15]. Our study showed 100% sensitivity and 88% specificity in detecting granulomatous / tubercular nodes based on conglomeration, intranodal necrosis and vascularity on Color Doppler. These findings have also been described by Chan et al.[14]

In our study USG showed a sensitivity and specificity of 72.7% and 89.4% respectively in diagnosing metastatic lymphadenopathy. 2 cases of metastatic deposits diagnosed on USG were diagnosed as Granulomatous and Suppurative Lymphadenitis on FNAC/HPE. 3 cases of metastatic deposits on FNAC/HPE were misdiagnosed as Granulomatous and Suppurative Lymphadenitis on USG. Knappeet al[16], found that ultrasonography combined with FNAC is a highly accurate technique for the investigation of cervical lymph node metastasis. The sensitivity, specificity and accuracy were 89.2%, 98.1% and 94.5% respectively which is similar with our study.

Sumi et al[17] found that 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 also revealed metastatic deposits from squamous cell carcinoma in FNAC/HPE findings.

CONGENITAL AND MISCELLANEOUS LESIONS
In our study three cases of Branchial cleft cysts were diagnosed by USG similar to the study by Ahuja et al.[18]

Four cases of Thyroglossal cyst were diagnosed by USG and Doppler. USG also diagnosed one case of lymphatic malformation, four cases of lipoma and two cases each of Fibromatosis coli and Epidermoid cyst. The USG features were similar with those described in study conducted by Turkington J.R.A et al and Petrovic S et al.[19,20]

CONCLUSION
Ultrasound and Color Doppler are one of the most valuable investigation tools to evaluate neck masses with respect to size, site, consistency and vascularity. It helps in distinguishing solid from cystic lesions and allows the guidance of needles accurately into the lesion of interest to obtain a diagnostic fine cytology biopsy. A significant correlation of p-value < 0.05 was observed in our study between Duplex ultrasonography and FNAC/HPE resulting in good accuracy.

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