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Role of Ultrasonography And Doppler in Evaluation of Neck Nodes And Differentiating Benign from Malignant Nodes

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Aims And Objectives: *To assess the diagnostic efficacy and accuracy of ultrasound and colour Doppler in differentiating malignant from benign cervical lymphadenopathy using the most specific and least number of parameters.*

I. Introduction

In clinical practice, patients with tuberculous adenitis or benign reactive cervical lymphadenitis often present with discrete, non-tender nodes in the posterior triangle. However, 50% of patients with nasopharyngeal carcinoma and other Head & Neck cancers also present with clinically palpable neck nodes. Although their clinical presentation is similar, it is important to differentiate these lesions, as their prognosis and treatment are different.

In Asia, gray scale sonography (combined with fine-needle aspiration cytology) with its high sensitivity (92%) and specificity (97%) is often considered as the initial investigation of choice for differentiating benign from malignant nodes (3,14) . It evaluates the

1) Nodal distribution
2) Shape
3) Size
4) Internal architecture
5) Margins
6) Capsular definition and
7) Roundness index.

However, on the basis of these features alone it is not possible to differentiate tuberculous from metastatic nodes(15). The gray scale sonographic features that help in differentiating the two are the presence of nodal matting and adjacent soft-tissue edema, which are common in patients with tuberculous nodes (15).

Recently many studies have shown the importance of Power Doppler sonography in evaluating neck nodes and help differentiate benign from malignant cervical lymphadenopathy.(5,6,7,16,17). We tried to differentiate nodes as benign or malignant with least and more specific variables through our study using ultrasound and Doppler as the imaging modalities.

In recent studies , presence or absence of Hilar echogenicity and Long axis length / Short axis length ratio (Roundness Index) of lymph nodes were considered valuable criteria on Grey scale sonography. We have selected the Roundness Index as the sole criteria in differentiating benign from malignant nodes on USG , since this has been shown in many studies as the most sensitive and specific criteria(4,23,24). Measurements (Long axis and Maximal Short axis diameter) were made in the same image and expressed in millimeters.

Roundness index of a node indicates the variation in the shape of the node. In benign node the accumulation of the cells in germinal centers of the nodes causes the node to show initial focal accumulation before the entire node show malignant changes. This initial focal accumulation causes change in the shape of the node from a normal spherical to oval or oblong shape. Malignant nodes maintain the spherical shape even when they are enlarged due to a malignant infiltration. This helps to differentiate benign lymphadenopathy from malignant infiltration. Colour doppler is the only modality to evaluate the angio architecture of the nodes.(20).

In Doppler, nodes can show
1) Hilar
2) Capsular
3) Mixed (Capsular & Hilar)
4) Spotted
5) Displaced vascular pattern , or can appear totally
6) Avascular.

In our study, the nodal vascular distribution viz., Hilar , Capsular and Mixed patterns of flow were taken into consideration and their Resistive index measured since these parameters are the most specific and easily reproducible. Power Doppler sonography is able to detect this abnormal vascularity, evaluate the distribution of vessels, and estimate the intranodal vascular resistance. [4,5,7,9,10,16,20].

Types Of Vascularity.
Intranodal Vascular Distribution
The Patterns Of Vascular Distribution Within Nodes Have Been Classified As :

1) Hilar: flow signals branching radially from the hilus, regardless of whether the signals originate from the central region of from the periphery.
2) Capsular (or peripheral): flow signals along the periphery of the lymph nodes, with branches perforating the periphery of the node and not arising from the hilar vessels .
3) Mixed: presence of hilar and capsular flow.

In benign reactive nodal disease, the diffuse nature of the histologic process occurring within the node preserves the normal vascular pattern and reactive nodes therefore tend to have prominent hilar vascularity owing to increased vessel diameter and blood flow .the benign nodes usually showed a hilar or a mixed vascularity.[6,8,18].

Malignant nodes have a more variable vascular pattern and show at least one of the following abnormal vascular patterns previously described [7, 19] :

1) Avascular areas.
2) Spotted vascularity.
3) Displacement of vessels.
4) Increased peripheral vessels.
5) Aberrant course of hilar vessels .

The increase in peripheral nodal vascularity is secondary to the initial deposition of carcinomatous cells in the marginal and medullary sinuses. Neovascularization by infiltrating tumor induces aberrant feeding vessels in the periphery of the tumor rests by tumor angiogenesis and sinusoid tumor vascularity within the tumor rests . The capsule and perinodal tissues may be invaded at a later stage . As the node is progressively involved with tumor, increased vascularity is seen both in the central as well as the peripheral zones of the nodes [4,15]. In this study the distribution of vessels was taken as the criteria, to test this variable.

Hilar Vascularity

Both tuberculous nodes and benign reactive nodes frequently demonstrate hilar vascularity. 81% of tuberculous nodes show obvious mass effect and displacement of the hilar vessels ,due to necrosis [15]. Therefore, the presence of only displaced hilar vascularity appears to be a useful feature in differentiating tuberculous nodes from metastatic nodes [15].

Mixed (Capsular And Hilar) Vascularity

Tuberculous nodes show a mixed vascularity (53% in Wu et al's study [7] and 76% in Na et al's [6]).

Mixed vascularity was seen in 4% of reactive nodes and 86% of metastatic nodes from nasopharyngeal carcinoma[15]. Therefore, the presence of mixed vascularity may not consistently help to differentiate between a tuberculous and metastatic node.

Avascular Nodes

Avascularity noted in tuberculous nodes may be due to the necrotizing granulomatous lesions that may obliterate intranodal vessels[21]. Avascularity of tuberculous nodes may also reflect later stages of the disease, when healing has begun, and fibrosis and hyalinization cause compression and obliteration of intranodal vessels.

Avascularity was noted in benign nodes by Wu et all [6] and Na et all [7].

The avascularity of tuberculous nodes associated with intranodal necrosis may, therefore, help to differentiate it from other malignant and reactive nodes.

Avasularity in malignant nodes were also noted in other studies [4, 6, 23,24].

Capsular Vascularity

In metastatic nodes, destruction of hilar vascularity may result in the induction of vascular supply from the peripheral preexisting vessels or from vessels in the

perinodal soft tissues. A similar angiogenesis can occur in tuberculous nodes [6,15], as central necrosis may destroy hilar vascularity, resulting in vascular supply from the periphery, particulary from the inflamed perinodal soft tissues. Deformed vessels arising from the hilus can also mimic peripheral vascularity [6].

It is seen that, despite the benign nature of tuberculous nodes, the intranodal vascular distribution within tuberculous nodes (displaced hilar; mixed, avascular areas; capsular vascularity) mimics features that have previously been described for malignant nodes. However, selective hilar vascularity and avascular nodes are common in tuberculous nodes.

Hence nodes showing avascularity or showing only peripheral vascularity were considered satisfying the criteria for malignancy. Nodes showing intense hilar or mixed capsular and hilar flow are considered satisfying the criteria for benign nodes [(6,23,24)]

Intranodal Vascular Resistance (Ri)

Various studies have suggested that benign nodes can be differentiated from malignant nodes by estimating the nodal vascular resistance [(6,7,26)] Malignant nodes tend to have higher nodal vascular resistance compared with benign lymphadenopathy [(6,12, 22)].

RI is measured from the nodal vessels which show the maximum resistant flow. From the previous studies , the cut off point is taken as 0.75 and nodes showing vascular resistive index above that is considered to satisfy the criteria for malignancy and nodes which show resistive index less than 0.75 is taken as benign nodes[(6,7,26)].

The purpose of this study is to differentiate malignant nodes from benign nodes with minimum number of criteria using both ultrasound and Doppler and to verify the validity of ultrasound diagnosis of the malignant nodes. Most studies take into account many number of criteria [(6,23,25,)] and might be time consuming. The ultrasound diagnosis is verified with the histopathological diagnosis.

II. Review Of Literature

There were various studies to characterize benign from malignant cervical lymh nodes using gray scale USG and Color Doppler.

Teichgräber U, Steinkamp HJ, Mueffelmann M et al from Germany have assessed the value of Doppler for distinguishing reactive from malignant lymph node disease in 211 cases and have shown that Reactively enlarged lymph nodes showed characteristically intense hilar perfusion (82.1%), whereas nodal metastases exhibited mainly peripherally located flow (84.7%)and Lymph nodes invaded by malignant lymphoma were highly perfused displaying color signals in the center as well as in the nodal periphery (90.9%).

Tschammler et al and associates in their study involving 117 lymph nodes had shown that use of color Doppler ultrasonography in the assessment of intranodal angioarchitecture in superficial lymph nodes is a reliable and reproducible method of differentiating between reactive and malignant lymphadenopathy. Reactive nodes showed hilar flow and malignant nodes showed peripheral flow with increase in short axis diameter. With color Doppler ultrasonography, a total of 88 percent of nodes were classified correctly, resulting in a specificity of 77 percent and a sensitivity of 96 percent

Ariji Y, Kimura Y, Hayashi N, Onitsuka T, Yonetsu K, Hayashi K, Ariji E, Kobayashi T, Nakamura T et al in their study involving 291 nodes (71 metastatic & 220 non-metastatic) had observed that Power Doppler sonography showed characteristic features of parenchymal blood flow signal in 59 (83%) of the 71 metastatic lymph nodes. By contrast, only four (2%) of the 220 nonmetastatic nodes showed these power Doppler signals. In addition, power Doppler sonography showed high levels of sensitivity (83%) and specificity (98%) in depicting metastatic lymph nodes, which were superior to the values (66% sensitivity and 92% specificity) obtained by applying size criteria (transverse to longitudinal ratio). However, a combination of the two criteria (parenchymal color signal and transverse to longitudinal ratio) improved diagnostic accuracy to 92% sensitivity and 100% specificity. They concluded that the power Doppler criteria of no hilar flow, peripheral parenchymal nodal flow, and a transverse to longitudinal ratio of more than 0.65 together constitute a powerful tool for depicting metastatic lymph nodes in patients with cancer.

Chikui T, Yonetsu K, Nakamura T et al had studied 133 nodes with gray-scale sonographic features of the presence or absence of hilar echoes, parenchymal echogenicity, and short and long axis lengths as well as the power Doppler features of normal hilar flow and abnormal parenchymal flow. They observed that the sonographic criteria most predictive of metastatic cervical lymph nodes were absent hilar echoes and increases in short axis length, as assessed by logistic regression analysis. Compared with these gray-scale criteria, color-flow criteria had fewer predictive advantages.

Ahuja A, Ying M et al in their study on 286 patients had shown that except metastatic nodes from papillary carcinoma of the thyroid that showed low resistance, metastatic nodes had a higher vascular resistance than benign / reactive nodes.

Wu CH, Chang YL, Hsu WC, Ko JY, Sheen TS, Hsieh FJ et al in their study on 289 nodes observed that the resistive index of malignant nodes were statistically much higher than that of benign / reactive nodes and concluded high vascular resistance to have a positive correlation with malignant lymphadenopathies.

Na DG, Lim HK, Byun HS, Kim HD, Ko YH, Baek JH et al studied 117 lymph nodes and assessed patterns of hilar vascularity, central nodal vascularity , peripheral vascularity and resistive indices. They observed that 32(94%) of 34 nodes with benign reactive disease showed normal patterns of nodal vascularity; central hilar vascularity, radial symmetric central vascularity, and no peripheral vascularity. At least one of six abnormal patterns of vascularity (eccentric or absent hilar vascularity; deformed radial, aberrant multifocal, or absent central vascularity; and peripheral vascularity) was observed in 98% (65/66) of nodes with malignant disease. Cutoff value of 0.8 for the Resistive index was 100% specific for malignancy. However, sensitivity for this cutoff value was 47%.

Yonetsu K, Sumi M, Izumi M, Ohki M, Eida S, Nakamura T et al studied 338 histologically proved cervical lymph nodes (108 metastatic and 230 nonmetastatic) in 73 patients with head and neck cancer. The sonographic topography of the nodes was compared with dissected specimens, and their position in the neck was categorized into three levels (I, II, and III+IV). The diagnostic accuracy of sonography was evaluated by using the single criterion of short-axis diameter of the node or by the combined criteria of short-axis diameter and Doppler blood flow features (the absence or presence of normal hilar flow). They concluded that , as compared with the single criterion of short-axis nodal diameter, the combined criteria of nodal size and Doppler blood flow patterns increased the diagnostic accuracy of sonography at all levels in the neck. Accordingly, the best cut-off values were improved to 6, 7, and 5 mm for nodes at levels I, II, and III+IV, respectively. In addition, the combined criteria yielded high sensitivites (> or = 89%) and specificities (> or = 94%).

Anil Ahuja , Michael Ying, Yuen Hok Yuen and Constantine Metreweli et al in another study assessed the intranodal distribution of vessels and the intranodal vascular resistance of vessels in 42 tuberculous , 28 metastatic and 27 benign reactive cervical nodes. He observed that avascularity of nodes and displacement of hilar vascularity were frequent in tuberculous nodes. Metastatic nodes (resistive index [RI], 0.81±0.09) had a higher vascular resistance than did tuberculous nodes (RI, 0.71±0.11). Tuberculous nodes had a higher vascular resistance than did reactive nodes (RI, 0.66±0.09) and concluded that Avascularity, displaced hilar vessels, and low intranodal vascular resistance are clues that may suggest the tuberculous nature of neck nodes. However, there is overlap of appearance between tuberculous nodes, benign reactive neck nodes, and metastatic nodes. Thus histologic analysis is often required for a definitive diagnosis.

III. Materials And Methods

A total of 126 new subjects attending the OPD of the department between May 2003 and April 2004 were subjected to standard set of USG imaging norms to finally classify the diagnosis as “BENIGN” or “MALIGNANT”. The histopathological diagnosis is taken as the gold standard for confirmation.

Cases

Inclusion Criteria :

1) All patients with clinically palpable Cervical nodes

Exclusion Criteria :

1) Proven cases of Tuberculosis , lymphoma or malignancy etc.
2) History of Chemotherapy or Irradiation
3) History of biopsy / FNAC of lymphnodes.

Equipment & technique:

1. Gray-scale and power Doppler sonography were performed using a 3500 series Aloka unit, equipped with a wide bandwidth (range, 6–13 MHz) linear array transducer. Gray-scale sonography was performed at 7.5MHz. Power Doppler sonography was performed at 7.5MHz, and the standard Doppler settings were chosen for optimal detection of the signals from the lymph node vessels, which had low-velocity flow. In all patients, power Doppler sonography was performed using standardized parameters. Settings of power Doppler sonography were set for high sensitivity with a low wall filter to allow detection of vessels with low blood flow. Pulsed repetition frequency was 700 Hz and medium persistance was used. The color gain was increased until background noise appeared and then reduced until the noise was suppressed, thus ensuring maximum sensitivity. When consistent Doppler signals were obtained, the color map was used to guide the placement of the pulsed Doppler gate and tracings of the arterial signal recorded by using a sample volume of 1 mm.

Representative images by gray-scale and power Doppler sonography were obtained from each lymph node so that the maximal area of the lymph node appeared on the gray-scale sonographic images. Transducers were kept at right angles to the node and measurements were taken in the same image. Calipers were kept at the outer aspect of the capsule on either side. The patients were examined in supine position with mild neck extension.
This study was done by a single observer and thus interobserver variation was eliminated.

IV. Method

A preliminary examination of the neck nodes was done and the largest node which showed good vascular flow was selected for analysis. The nodes were classified as benign or malignant using the following protocol :

Step I : Roundness index was taken as the sole ultrasound criteria. The nodes were presumptively divided into benign or malignant based on the Roundness index. Roundness Index is measured by taking the ratio of the longest axis of the lymphnode to the maximal short axis in the same image. Any node with a Roundness Index of more than 2 is considered benign and less than 2 is taken as metastatic node.
Step Ii : Doppler evaluation was done for all these nodes. The nodes were examined using power Doppler. Nodes showing peripheral (capsular) or no vascularity were considered malignant. Nodes with Roundess Index of more than 2 and showing Central (hilar) or Mixed (both hilar & capsular) vascularity are considered benign.
Step Iii : The Resistive Index (RI) of the vessels , which is the most valuable Doppler criteria(6,7,26), is calculated in the nodes which have Roundness Index of less than 2 and show central of mixed vascularity and in nodes which have Roundness Index of more than 2 and show peripheral vascularity. Vascular flow with RI more than 7.5 is considered malignant and RI less than 7.5 is taken as benign. In nodes which show mixed flow , the vessel showing the highest RI is taken for the analysis. Resistive index was calculated for all the nodes that showed vascularity.
Step Iv : Nodes were finally labeled malignant or benign according to their satisfying the ultrasound criteria and either one of Doppler criteria.
Step V : FNAC of the nodes was done and the USG / Doppler diagnosis was correlated with the HPE results. This study takes into account 3 variables (one ultrasound criteria and two Doppler criteria) to detect malignant nodes. This study confines to the ethics and was done with the consent and full cooperation of the patients.

V. Observations

A total of 126 new subjects attending the OPD of the department between May 2003 and April 2004 were subjected to standard set of USG imaging norms to finally classify the diagnosis as “BENIGN” or “MALIGNANT”. The histopathological diagnosis is taken as the gold standard for confirmation.

Statistical Method

The outcome measure studied is the HPE based or USG based diagnosis classified dichotomously as “BENIGN” or “Malignant”. The distribution of subjects by the outcome studied is represented by descriptive statistics giving the number of cases and the proportion (%) by each outcome. The differences in the proportion and their statistical significance are elicited using the non-parametric CHI-SQUARE test. The ability of the various diagnostic indices to correctly classify the diagnosis as “MALIGNANT” or “BENIGN” is assessed by the measures of sensitivity and specificity respectively. From these measures, the positive and negative predictive values are respectively calculated. The concordance measure gives the total extent of correctly classifying the diagnosis.

VI. Results

Table 1: Distribution of subjects by HPE diagnosis

HPE diagnosis	Number	%
Malignant	72	57.1
Benign	54	42.9
All subjects together	**126**	**100.0**

Among the subjects included for the study, 57% were classified as “malignant” and 43% as “benign” based on HPE diagnosis.

Table 2: Distribution of subjects by USG diagnosis

HPE diagnosis	Number	%
Malignant	61	48.4
Benign	65	51.6
Total	**126**	**100.0**

The proportion of subjects classified as malignant by USG diagnosis was 48.4% while the figure for benign was 51.6%.

Table 3: Distribution of HPE & USG diagnosis by age group

Age group	**HPE**				**USG**			
	Malignant		**Benign**		**Malignant**		**Benign**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
<=9 years	3	4.2	7	13.0	1	1.6	9	13.8
10-19	7	9.7	22	40.7	10	16.4	19	29.2
20-29	14	19.4	10	18.5	7	11.5	17	26.2
30-39	11	15.3	4	7.4	9	14.8	6	9.2
40-49	16	22.2	8	14.8	14	23.0	10	15.4
50+ years	21	29.2	3	5.6	20	32.8	4	6.2
All ages	72	100.0	54	100.0	61	100.0	65	100.0
χ^2 – value **p - value**	27.45 <0.001				25.19 <0.001			

About half the number of subjects classified as malignant by HPE and USG are aged 40 years and above. More than two-thirds of subjects classified as benign by HPE and USG are aged 29 and less. These differences are statistically significant in both HPE (p<0.001) and USG (p<0.001).

The final diagnosis on the basis of USG is arrived at by using the indices like (i) Round index, (ii) Vascularity and (iii) Resistant index under standard norms to finally classify a subject as "malignant" or "benign". The distribution of each of these indices by the final USG diagnosis to study the extent of concordance and misclassification is given below:

Table 5: Concordance and extent of misclassification of different indices by final USG diagnosis

Indices	**USG**				**Concordance**	**Misclassification**
	Malignant		**Benign**			
	No.	**%**	**No.**	**%**		
Round index					91.3%	8.7%
1	60	98.4	10	15.4		
2	1	1.6	55	84.6		
Vascularity						
1	10	16.4	3	4.6		
2	35	57.4	4	6.2		
3	16	26.2	58	89.2		
Resistant index*					92.9%	7.1%
2	50	98.0	7	11.3		
3	1	2.0	55	88.7		

** not applicable in 13 cases*

With the malignant and benign subjects taken together, the concordance rate with respect to agreement with the final USG diagnosis as "malignant" or "benign" ranged between 91-93% for individual indices. The extent of misclassification was therefore 7-9%. The concordance was higher among those classified as malignant (98%) compared to those classified as benign (85-89%). This indicates a high degree of prediction of USG based diagnosis of malignancy and a reasonable degree of prediction of a benign diagnosis on USG by adhering to the standard norms of these indices.

With a reasonable degree of agreement forthcoming between the indices used and USG diagnostic classification as malignant or benign, the individual indices are compared for agreement with HPE diagnosis .

Table 6: Comparison of agreement between round index and HPE diagnosis

Round index	**HPE diagnosis**		**Total**
	Malignant	**Benign**	
Malignant	57	13	70
Benign	15	41	56
Total	**72**	**54**	**126**
Sensitivity	79.2%		
Specificity	75.9%		
Concordance	77.8%		
PPV	81.4%		
NPV	73.2%		

Table 7: Comparison of agreement between vascularity and HPE diagnosis

Vascularity	HPE diagnosis		Total
	Malignant	Benign	
Malignant	42	10	52
Benign	30	44	74
Total	72	54	126
Sensitivity	58.3 %		

Specificity	81.5%
Concordance	68.3%
PPV	80.8%
NPV	59.5%

Table 8: Comparison of agreement between resistant index and HPE diagnosis

Resistant index*	HPE diagnosis		Total
	Malignant	Benign	
Malignant	47	10	57
Benign	16	40	56
Total	**63**	**50**	**113**
Sensitivity	74.6%		
Specificity	80.0%		
Concordance	77.0%		
PPV	82.5%		
NPV	71.4%		

* not applicable in 13 cases

Table 9: Comparison of agreement between USG and HPE diagnosis

USG diagnosis	HPE diagnosis		Total
	Malignant	Benign	
Malignant	53	8	61
Benign	19	46	65
Total	**72**	**54**	**126**
Sensitivity	73.6%		
Specificity	85.2%		
Concordance	78.6%		
PPV	86.9%		
NPV	70.8%		

Table 10: Agreement of HPE and USG diagnoses among different age groups

	Age group at diagnosis			
	Age= 1&2	Age= 3&4	Age = 5	Age = 6&7
Sensitivity	30.0%	64.0%	87.5%	95.2%
Specificity	72.4%	100.0%	100.0%	100.0%
Concordance	61.5%	76.9%	91.7%	95.8%
PPV	27.3%	100.0%	100.0%	100.0%
NPV	75.0%	60.9%	80.0%	75.0%

The comparison of measures of agreement of USG and HPE diagnoses reveals interesting observations. Both sensitivity and specificity of malignant diagnosis are the least in the youngest age group. While it is uniformly 100% for specificity in the higher age groups, the sensitivity is seen to show an increasing trend with increasing age group. The concordance of diagnoses also shows an increasing trend with age. The positive predictive value is the least in the youngest age group and 100% thereafter. The negative predictive value ranges between 61-80% for various age groups.

Table 121: Agreement of HPE and USG diagnoses among males and females

	Gender	
	Male	Female
Sensitivity	77.4%	70.7%
Specificity	81.6%	93.8%
Concordance	79.7%	77.2%
PPV	77.4%	96.7%
NPV	81.6%	55.6%

The measures of agreement of USG and HPE diagnoses show distinct variation by gender. While the sensitivity of malignant diagnosis does not show much variation between male (77%) and female (71%), the specificity is observed to be lower among males (82%) than females (94%). The concordance rate was almost the same in both sexes. The positive predictive value was significantly higher among females (97%) than males (77%) while the negative predictive value was significantly higher among males (82%) compared to females (56%).

VII. Discussion

In this study , cervical lymph nodes of 126 patients were assessed by both Gray scale and Color Doppler imaging. Roundness Index and Vascular pattern were assessed in all the nodes and Resistive Index was measured in all nodes showing vascularity.

In our study the number of nodes that showed Roundness Index more than 2, satisfying the criteria for benign nodes were 56(42.85%) . The number of nodes that showed Roundness Index less than 2, satisfying the criteria for malignant nodes were 70(57.14%). The sensitivity and specificity for malignant nodes obtained were 79.2 % and 75.9% respectively. The Positive predictive value was 81.4% indicating that Roundness Index has a high PPV with a high concordance of 77.8%. Studies by Dietmar Koischwitz and N. Gritzmann et al showed that Roundness Index greater than 2 indicated benign disease in 84% , whereas a Roundness Index less than 2 favours malignancy in 71%.(4,20,23,24). 57 out of the 70(81.42%) nodes that were classified as malignant nodes using roundness index proved to be malignant. Significant increase in detecting malignant nodes by roundness index was noted in our study. In other studies, multiple variables were considered in evaluating the nodes by ultrasound (20,23,25). In this study we took only one parameter (roundness index) as the ultrasound criteria as it is considered more specific.(4,23,24).

Ultrasound was able to detect only 73.21% of benign nodes correctly indicating that roundness index is more specific for malignant nodes than benign nodes.

A reduction in the sensitivity and the specificity is noted on comparison with other studies (4,23,24).

The reduction in the sensitivity for the roundness index criteria could be due to

1) Small nodes with a very small short axis diameter.
2) Early detection of pathological nodes.
3) Measurement error.

This reduction might be due to the single ultrasound parameter evaluation, still this single variable is significant ($p<0.005$).

Vascular pattern in most malignant nodes were peripheral with loss of hilar vascularity and some showing no vascularity. This finding was noted in other studies(4,5,6,7,18). Benign nodes showed intense hilar and mixed vascularity as noted in other studies (6,20,23). The specificity is 81.5% , with a Positive Predictive value of 80.8%. No significant variation in the diagnostic accuracy between Toru chikui et all and our study could be made out.(23) Most of the nodes that had either peripheral or no vascularity were found to be malignant other than lymphoma. The highest degree of correlation was noted with the squamous cell carcinoma which was incidentally the most studied malignant lesion in this study.

The sensitivity of vascularity for malignancy was 58.3% this is generally low when compared to other studies(20,26) but significantly higher than the sensitivity noted in study by Giovagnorio (18,25). A reduction in the sensitivity might be due to the inclusion of Lymphoma in the category of malignant nodes with a significant contribution by papillary carcinoma of thyroid.

In various studies, Lymphoma nodes were shown to have intense hilar and mixed vascular perfusion patterns(5) as also noted in this study.. The inclusion of metastatic nodes from primary papillary carcinoma of thyroid could be a reason for the low sensitivity since these nodes were observed to have intense Hilar and mixed vascular perfusion patterns in the previous studies.(27) This differs partially from the observation made by WU CH et al , that in lymphomas(71%) and tuberculous (72%) lymphadenopathy either avascular or hilar vascular pattern is observed (7).

2 out of the 34(94.11%) nodes that had peripheral vascularity turned to be malignant. 8 out of 10 (80%) nodes that had no vascularity were proven malignant. This indicates that malignant nodes exhibited peripheral vascular pattern more frequently than a no vascular pattern though both indicate a malignant type of nodal pattern.

Of the 26 nodes that had a mixed or hilar vascularity, 12 (46.15%) nodes proved to be malignant on the basis of the roundness index and resistive index. Observation made in our study is that less than 50% of malignant nodes had a mixed vascularity and their presence favours a benign diagnosis.

The malignant nodes (26 in number) that showed a mixed vascular flow were distributed more in younger age groups (11 cases in the 1^{st} and 2^{nd} decade) and more in female gender (11cases). This pattern of distribution can be attributed to the lymphoma and metastasis from papillary carcinomas of thyroid.

14 (30.43%) of the highly vascular nodes were misclassified. Out of the 14 nodes, 13 proved to be malignant and one proved to be benign. The misclassification for malignant nodes by vascular pattern is more on comparing to the other two parameters taken in this study. The histopathology of these vascular malignant nodes proved to be either lymphoma or papillary carcinoma. Such presentation was noted by other studies.(5,27)

7 out of the 56 (12.5%) that had a roundness index >2 and showed either peripheral or no vascularity were misdiagnosed by our study. 4 of the 7 nodes proved to be benign had peripheral vascularity.

Such vascularity in benign nodes were proved to be caseating nodes. No age correlation could be noted in such vascular distribution. Absent vascularity is seen in 13 nodes (10.31%) amongst the 126 nodes examined under color doppler. Of these nodes , 9 nodes were proved to be malignant by HPE. Among these 9 nodes , only one node showed Roundness Index more than 2 and was diagnosed as Benign node by USG. In the remaining 4 nodes proved to be Benign on HPE , only 2 nodes showed Roundness Index more than 2 and hence USG was correct in 50% of the cases. Absent vascularity might also be due to small Doppler shift or due to low signal intensity form the tiny peripheral vessels.

Some nodes (5 in number) diagnosed as malignant because of Roundness Index less than 2 and showing high resistant mixed vascular pattern , were benign in histopathological examination. The reason attributed to this occurrence could not be traced out.

In terms of vascularity, this study showed a lower sensitivity than the roundness index and the resistive index although other studies do quote a higher diagnostic accuracy than this study (5,20). The miscalculation for vascular pattern was higher when compared to other variables.

With a threshold of 0.75, resistive index of the malignant nodes were significantly higher than the benign nodes. High concordance (92.9%) was achieved even with a lower threshold. Metastasis from papillary carcinomas showed a lower resistive index . This observation was also made by Ahuja A, Ying M. (27,28) Reactive lymphadenopathy and tuberculous lymphnodes showed a lower resistive index as noted by WU CH et all (7). With the reduction in the resistive index threshold , a increase in the sensitivity was expected which did not occur. The reason could be due to inclusion of lymphoma and metastatic nodes from papillary carcinoma thyroid which show low resistant vascular flow pattern. This confers with other studies (26,27,28). Of the 57 nodes that had a higher resistive index, 7 proved to be benign. 82.45% of the high resistant flow nodes were found to be malignant in histopathological examination, with only 71.42% of nodes proving to be benign. This Doppler index again showed a higher specificity for malignant nodes than the benign nodes .Resistive index showed a higher concordance(92.6%) than vascularity in this study compiling with the observation noted in other studies.(6,7,26,28)

A unique situation arose were the roundness index favoured a malignant node while both the Doppler indices favoured a benign diagnosis or vise versa. In such state we favoured a Doppler diagnosis as two indices were fulfilled by the node. 50% of the time were correct in diagnosis, indicating that such reliability on either ultrasound or Doppler alone in such state have a high chance of misclassification and only histopathology can provide a correct diagnosis.

The amount of misclassification in differentiating malignant nodes from benign nodes was low even with a single parameter. The most specific parameter in ultrasound , the roundness index had misclassification of only 8.7% and the specific Doppler resistive index had a 7.6% misclassification. This indicates that among these three parameters the resistive index had the least degree of misclassification indicating this can diagnose malignant nodes in situations where other parameters give a equivocal result.

In our study , malignant nodes were correctly picked up in 86.88% of cases indicating high accuracy.

No significant variation in the specificity and the diagnostic index was noted between ultra sound(specificity-75.9% : concordance - 91.3%) and Doppler(specificity-80-81.5%; concordance-92.9%).In our study a equal diagnostic accuracy between ultrasound and Doppler was noted whereas other studies quote in the contrary(20,23,25). No significant complimentary effect by the Doppler variables to the roundness index in the diagnostic accuracy was noted but they did increase the specificity and positive predictive value. The inclusion of other variables of ultrasound might add to the accuracy of ultrasound diagnosis of the malignant nodes (23,25).

No single variable taken in this study showed a 100% diagnostic accuracy independently. The comparison of measures of agreement of USG and HPE diagnoses reveals interesting observations. Both sensitivity and specificity of malignant diagnosis are the least in the youngest age group. While it is uniformly 100% for specificity in the higher age groups, the sensitivity is seen to show an increasing trend with increasing age group. The concordance of diagnoses also shows an increasing trend with age. The positive predictive value is the least in the youngest age group and 100% thereafter. The negative predictive value ranges between 61-80% for various age groups. With the increase in the incidence of malignancy in older age groups the value of the use of ultrasound and Doppler in older age groups will prove to be of much use in diagnosing malignant nodes.

Of the three parameters taken in our study resistive index was found to be the most accurate and specific parameter in the diagnosis of malignant nodes

Patient presenting to the Out patient department as cervical Lymph nodal enlargement is quite common in our country and there is always a diagnostic dilemma whether the nodes are benign or malignant. The commonest cause for benign cervical lymphnodal enlargement is Tuberculosis and the commonest cause for malignant cervical lymphadenopathy is metastasis from Head and Neck carcinoma.

In our study , the diagnostic accuracy in predicting a benign node is around 85%.

Hence, USG / Color Doppler can be the initial modality of choice to differentiate a malignant node from a benign node . If a node proves to be benign on USG/ Doppler, Investigations can be proceeded appropriately for a specific diagnosis. The patients can be assured and the apprehension of malignancy can be avoided. In cases that show malignant nodal pattern, it is ideal to proceed with FNAC for confirmation and the cytology might give a clue in detecting the primary in cases of unknown malignancy. In younger age groups, as the diagnostic accuracy is low FNAC is the gold standard Therefore the need for USG / Doppler evaluation of all patients presenting initially to the clinics with Cervical Lymphadenopathy need not be emphasized.

Routine ultrasound investigation of all patients presenting to the OP department is not helpful in the workup of the disease process. As ultrasound is easily available and a noninvasive procedure and is readily acceptable, subjecting those patients presenting with a cervical lymphadenopathy for an ultrasound evaluation will lead to narrowing of the investigative process as this imaging modality will exclude malignancy in more than 85% of patients.

The use of other ultrasound and colour Doppler parameters might add to the diagnostic accuracy and can enhance the sensitivity of this imaging modality.

VIII. Summary

No single variable was found to have a 100% specific for diagnosing malignant nodes. The parameters were complimentary to each other. Though the three parameters in our study are more specific among other parameter of ultrasound and Doppler, a number of parameters are to be considered for a better diagnostic accuracy . These parameters alone did not increase the sensitivity for malignant nodes but did have a high specificity for malignant nodes. 100% specificity was noted with these parameters in older individuals of malignant nodes. Histopathological examination still remains the gold standard for the classification of the nodes**.**

IX. Conclusion

No single variable was found to be 100% accurate in differentiating malignant from benign nodes.

The Doppler parameters had a significant contributory effect to the roundness index in improving the specificity and the positive predictive value.

The resistive index had a better concordance to the histopathological diagnosis than the vascularity distribution. Resistive index was found to be more specific and more accurate than roundness index and vascularity.

High Specificity In Diagnosing Malignant Nodes With Increase In Age.

Although a reasonable agreement between the ultrasound and Doppler parameters were noted, the sensitivity and specificity were less when many variables were taken for evaluation of the nodes. with the histopathological diagnosis still being the gold standard in nodal evaluation,Ultrasound and Doppler can guide in the evaluation of lymphadenopathy in older patients and in known cases of malignancy for staging the disease.

Conclusively, ultrasound and Doppler evaluation of cervical lymph nodes using these three parameters showed a high diagnostic accuracy in ruling out a malignant node.