Section: Radiodiagnosis

Original Research Article

ROLE OF HIGH-RESOLUTION ULTRASONOGRAPHY WITH COLOR DOPPLER IN EVALUATION OF BREAST MASSES IN WOMEN

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Abstract

Background: Breast related symptoms and breast masses are one of the common reasons for seeking health care. Approximately one fourth of the women in their lifetime are affected by breast disease. Breast ultrasonography can be utilized as a potentially viable alternative technique to mammography in resource-limited settings for early detection of breast cancer. The aim is to study the role of color Doppler with high resolution ultrasonography in characterization of breast masses. **Materials and Methods:** This study was conducted as an observational cross-sectional study on all women coming to the department of Radiodiagnosis for their breast examination at our tertiary care center during the study period of 18 months. HRSG of mass was done with proper history taking and gray scale and color Doppler features were noted. **Result:** The study was conducted on a total of 121 cases with mean age of 35.51±11.02 years. Final diagnosis was established based upon B mode and color Doppler features. The B mode as well as Color Doppler features helped in differentiating malignant breast masses from benign breast masses ($p<0.05$). The sensitivity of color and spectral Doppler in addition to B mode was 97.9% with diagnostic accuracy of 94.2% as compared to sensitivity and accuracy of B mode alone i.e., of 62.6% and 83.5% respectively. **Conclusion:** B-mode as well as color Doppler both are helpful in categorizing benign and malignant lesions. Though B mode independently can distinguish malignant from benign breast lesions, the diagnostic yield, when combined with color & spectral Doppler helps in successfully characterizing all the breast lesions with high diagnostic accuracy.

INTRODUCTION

Breast related symptoms and breast masses are one of the common reasons for seeking health care. Approximately one-fourth of women in their lifetime are affected by breast disease and of them, majority present with breast masses.[1] Though, majority of the lesions are benign, thorough examination and investigation of breast masses is particularly important as breast cancer is most common cancer in women worldwide (Incidence-12%) and second common cause of mortality.[2]
Breast ultrasonography can be utilized as a potentially viable alternative technique to mammography in resource- limited settings for early detection of breast cancer. The technique is non-invasive, low cost, portable, easily available and helps in distinguishing cystic from solid lesions.[3]
The ultrasonography can also be utilized for obtaining the biopsy sample from biopsy lesions in cases with suspected breast malignancies.[4,5]
USG techniques have been improved markedly over decades. Brightness (B) mode of ultrasonography (Grey scale) is a basic mode of examination and the introduction of tissue harmonic imaging & spatial compounding has improved the yield of B mode ultrasonography. The B-mode helps in revealing the shape, margin, orientation, echotexture, posterior acoustic shadow and calcification in the breast masses.[6] The color Doppler helps in revealing the vascularity of the mass, vascularity of surrounding tissue, vascular flow patterns, surrounding marginal and penetrating flow, incident angle and disruption of penetrating flow.[6] The Doppler ultrasonography may also be helpful in differentiating cystic lesions

from solid lesions, aggressiveness of the suspicious mass, lymph node status (inflamed, reactive or metastatic), associated arteriovenous malformations, AV fistula and superficial venous thrombosis (Mondor disease).[7] Various Doppler criterias such as resistive index (RI), pulsatility index (PI) and flow velocity are suggested for distinguishing benign lesions from malignant lesions.[8]

The American College of Radiology (ACR) formed an international expert working group to evaluate the role of ultrasound for breast masses and to develop a standardized diagnostic criterion. The ACR (2013) recently removed the doppler pattern from the BI-RADS categorization.[9] The Terminology and Diagnostic Criteria Committee of the JABTS recommend the use of Color Doppler in evaluation of breast masses.[9] With the above background, this study was conducted to determine the gray scale and color Doppler features in breast mass, to collaborate the findings of gray scale & color Doppler to determine the a radiological diagnosis as well as to characterize the lesion by adding color Doppler in comparison to gray scale imaging.

Aim and objectives

Aim

To study the role of color Doppler with high resolution ultrasonography in characterization of breast masses

Objectives

1. To determine the gray scale features of breast mass.
2. To determine the color Doppler features of the same breast mass.
3. To collaborate the findings of gray scale & color Doppler to:
   - Determine the type of lesion & make a radiological diagnosis.
   - To characterize the lesion by adding color Doppler in comparison to gray scale imaging.

MATERIALS AND METHODS

This study was conducted as a hospital based observational cross-sectional study on all women willing to be the part of study, coming to the department of Radiodiagnosis for their breast examination with a complain of breast mass or any lesion during the study period of 18 months i.e. from 1st December 2020 to 31st May 2022. All the women coming to the dept. of radiodiagnosis for their breast examination with a complaint of breast mass or lump for breast screening or follow up scan were included in the study whereas women with simple cysts (as only B mode is done in such cases), masses >5 cm in diameter ((as all dimensions can't be measured at a time in HRSG) and masses for which any interventional procedure has been done within 2 weeks were excluded from the study.

Sample size (n)- Around 2 patients per week reported to our department according to data of last 6 months, so 104 patients in 1 year (52 weeks) were expected and for the period of 18 months, it was estimated that around 154 patients will seek care. Applying Cochran's formula, sample size was estimated to be 112. We conducted our study on 121 patients.

Inclusion Criteria

1. All women coming to the dept. of Radiodiagnosis for their breast examination with a complaint of breast mass or any lesion.
2. Women coming for screening or follow up scan for their breast examination.

Exclusion Criteria

1. Simple cysts (for Doppler study), B mode imaging would be done for these.
2. Masses >5 cm in diameter (as all dimensions can't be measured at a time, in HRSG)
3. Masses for which any interventional procedure has been done within 2 weeks.

The study was initiated after obtaining ethical clearance from Institute ethical committee. All the women fulfilling the inclusion criteria and giving consent were enrolled. Proper relevant history was taken from the patient. All the females were subjected to Ultrasonography and Doppler examination by linear probe of 7-12 Hz frequency using GE Voluson S8 Pro-Ultrasonography & Doppler machine. Patient was made to lie in the supine position with her ipsilateral arm raised above the head. Whole of the breast parenchyma was scanned meticulously in a complete circle starting from 12 o'clock position involving all the four quadrants of breast including retroareolar area. Axilla was also scanned for any lymphadenopathy. The grey scale and Color Doppler findings were assessed. Based upon our findings and combined features of gray scale and color doppler, diagnosis was established.

Statistical Analysis

Data was compiled using MS Excel & analyzed using IBM SPSS software version 20 (IBM Corp. Illinois, Chicago). Categorical variables were expressed as frequency and proportion, whereas continuous variables were expressed as mean & standard deviation. Association of malignant lesions with B mode and color Doppler features was done using chi square test for categorical variables and independent T test for continuous variables. P value of less than 0.05 was considered statistically significant.

RESULTS

The study was conducted on a total of 121 cases presenting with breast masses with mean age of 35.51±11.02 years.

Majority of females with breast mass belonged to age range of 31 to 40 years (33.1%) and only 7.4% belonged to less than 20 years of age. The most common complaint was breast lump (74.4%),

followed by pain in breast (23.1%). History of breast feeding was present in 13.2% cases. About 3.3% women had history of fibroadenoma, 2.5% cases were on hormonal replacement therapy (HRT) and 1.7% received oral contraceptive pills. [Table 1]
Shape of the mass was oval in 70.2% cases and irregular in 27.3% cases. Margins were well circumscribed in 64.5% cases whereas margins were ill-defined in 32.2% cases. Orientation of the mass was wider in 88.4% cases. Majority of masses were hypoechoic (76%), and posterior acoustic shadow was noted in 17.4% cases. About 24.8% lesions were categorized as malignant whereas remaining 75.2% cases were benign. [Table 2]

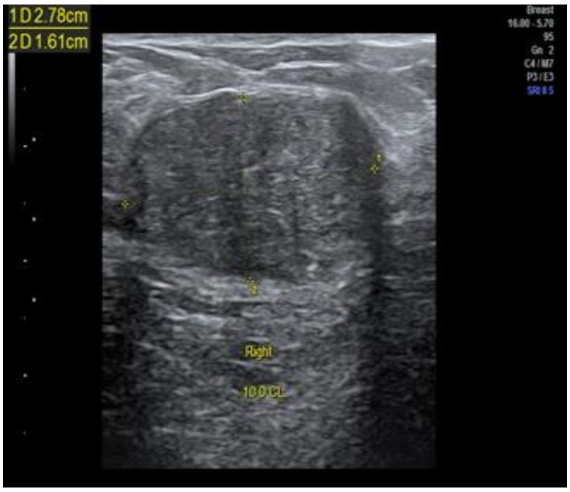

Figure 1: Fibroadenoma

A well circumscribed, oval shaped, wider >taller, hypoechoic lesion is noted at 10' clock position of upper outer quadrant of right breast. No obvious posterior acoustic shadowing or calcification noted.

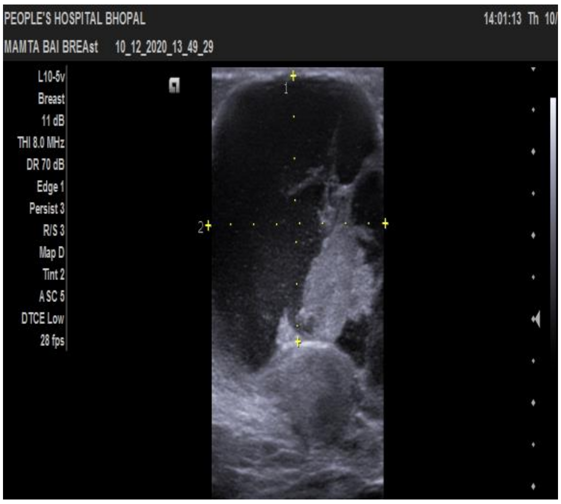

Figure 2: BIRADS 4A

A well circumscribed, oval shaped, taller>wider, hypoechoic solid- cystic lesion is noted extending from 3-6 o'clock position of left breast. It shows eccentrically located solid component within it. Some posterior acoustic enhancement is noted due to cystic component, however no obvious PAS (Posterior acoustic shadow) or calcification noted.

Figure 3: BIRADS 4C

An irregular shaped, spiculated margin, taller>wider, heterogenous lesion is noted in 11-12 o'clock position of upper outer quadrant of right breast. It shows posterior acoustic shadowing & few micro-calcifications within it.

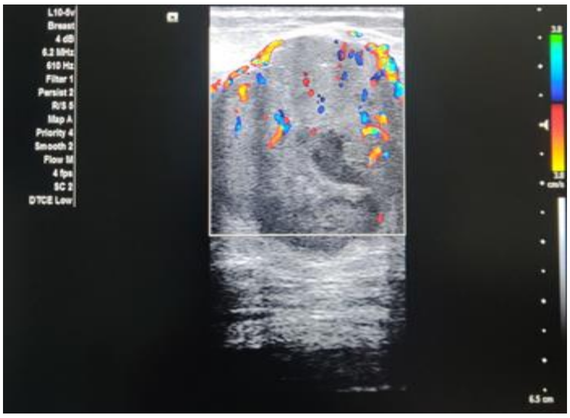

Figure 4: Hyper vascular lesion

A well-defined, oval shaped, irregularly marginated, hypoechoic lesion is noted lesion extending from 12- 2 o'clock position of upper outer quadrant of left breast. Color Doppler features- It appears hypervascular & shows both marginal & penetrating type of vascular flow pattern (Both equal).

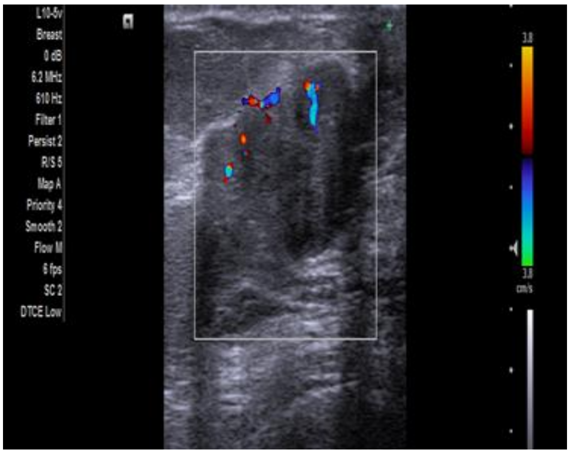

Figure 5: Penetrating vessel

An ill defined, irregular shaped, taller>wider, heterogenous lesion is noted at 8-9 o'clock position of right breast. It shows posterior acoustic shadowing. Color Doppler features- It is moderately vascular with P>M vascular flow pattern. White thick arrow shows penetrating vessel

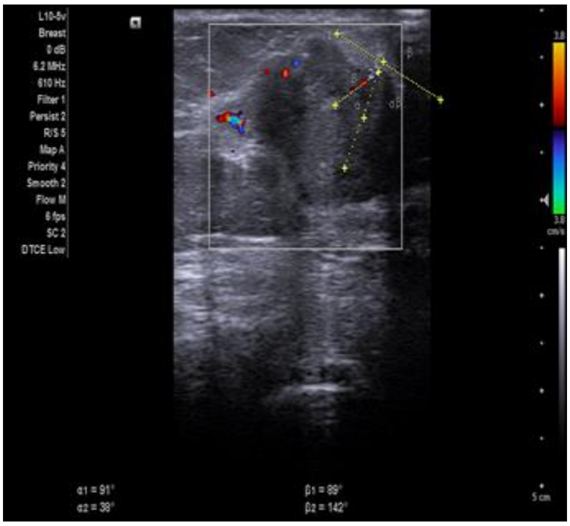

Figure 6: Incident angle <45 degree

A well-defined, irregular shaped, taller> wider, hypoechoic lesion is noted with PAS. Color Doppler features – It is moderately vascular with M>P type of vascular flow pattern & an incident angle of 38 degree. Findings suggestive of a malignant lesion – BIRADS 4B.

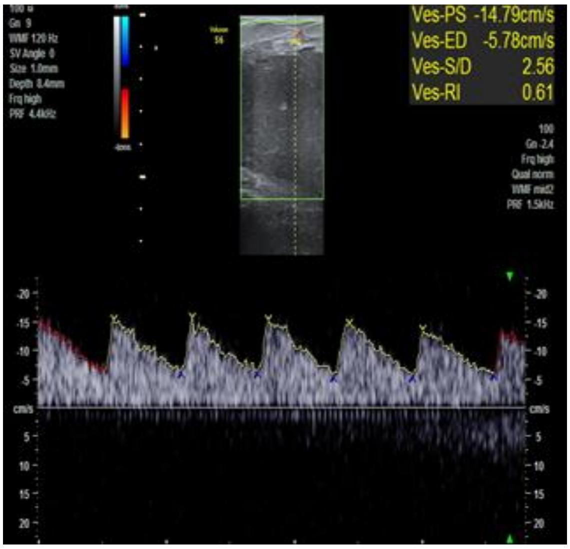

Figure 7: Peripheral vessel RI was found to be 0.61 with a PSV of 14.7 cm/sec

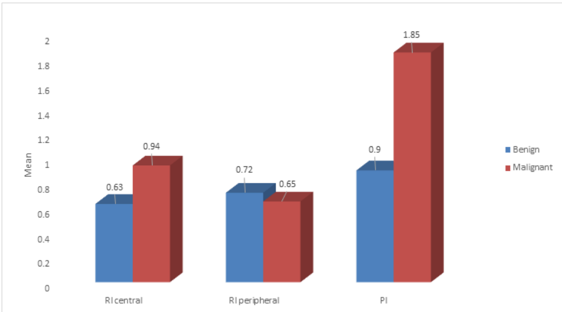

Figure 8: Comparison of spectral waveform findings between benign and malignant breast masses

Table 1: Distribution of patients according to baseline variables

Baseline variables		**Frequency (n=121)**	**Percentage (%)**
Age (Years)	<20	9	7.4
	21-30	33	27.3
	31-40	40	33.1
	41-50	25	20.7
	>50	14	11.6
Complaints	Pain	28	23.1
	Discharge	1	0.8
	Lump	90	74.4
	Pain & fever	1	0.8
	Swelling	1	0.8
History	Fever & pain	1	0.8
	History of fibroadenoma	4	3.3
	History of lump	2	1.7
	On hormonal replacement therapy	3	2.5
	Family history	2	1.7
	History of breast feeding	16	13.2
	History of implant	1	0.8
	History of previous lump	1	0.8
	History of trauma	1	0.8
	Obesity	1	0.8
	Oral contraceptive pill Intake	2	1.7
	Operated Ca Breast	1	0.8
	None	86	71.1

Table 2: B-mode features of ultrasonography in breast masses

B mode features		**Frequency (n=121)**	**Percentage (%)**
Shape	Round	1	0.8
	Bilobed	1	0.8
	Irregular	33	27.3
	Oval	85	70.2

	Tubular	1	0.8
Margin	Well Circumscribed	78	64.5
	Ill Defined	39	32.2
	Irregular	1	0.8
	Spiculated	3	2.5
Orientation	Taller	14	11.6
	Wider	107	88.4
Echopattern	Heterogeneous	11	9
	Hyperechoic	14	11.6
	Hypoechoic	92	76.0
	Isoechoic	4	3.3
Posterior acoustic shadow	No	100	82.6
	Yes	21	17.4
Calcification	None	106	87.6
	Micro calcification	12	9.9
	Coarse calcification	3	2.5
Type of lesions	Benign	91	75.2
	Malignant	30	24.8

Table 3: Color Doppler features in breast masses

Color Doppler features		**Frequency (n=121)**	**Percentage (%)**
Vascularity	Avascular	34	28.1
	Hypovascular	57	47.1
	Moderately vascular	24	19.8
	Hypervascular	6	5.0
Vascular flow pattern	Avascular	31	25.6
	Marginal	30	24.8
	M>P	26	21.5
	P>M	5	4.1
	Both Equal	27	22.3
	π Type	1	0.8
	Imperceptible Internal Flow	1	0.8
	Penetrating flow	0	0
Incidental angle	<45°	23	19.0
	>45°	40	33.1
	Mean±SD	1.63±0.5	
RI central	Mean±SD	0.78±0.300	
RI peripheral	Mean±SD	0.69±0.175	
PI	Mean±SD	1.23±0.662	
Type of lesions	Benign	88	72.7
	Malignant	33	27.3

Table 4: Distribution according to final diagnosis based upon B mode combined with color Doppler features

Diagnosis		**Frequency (n=121)**	**Percentage (%)**
Benign	Abscess	13	10.7
	Lactating Adenoma	1	0.8
	Lipoma	1	0.8
	Phyllodes	2	1.7
	Post Op Scar	1	0.8
	Retroare. Abs	1	0.8
	Solid Cystic	2	1.7
	Fat Necrosis	1	0.8
	Galactocele	4	3.3
	Inflammatory	7	5.8
	Intrammmatory lymph node	2	1.7
	Fibroadenoma	54	44.6
Malignant	BIRADS 3	6	5.0
	BIRADS 4A	9	7.4
	BIRADS 4B	9	7.4
	BIRADS 4C	8	6.6

Table 5: Comparison of B mode and color Doppler features between benign and malignant breast masses (B mode+color Doppler)

Ultrasonography		**Benign(n=89)**		**Malignant(n=32)**		**P value**
		n	**%**	**n**	**%**	
Shape	Round	1	1.1	0	0	0.001
	Bilobed	1	1.1	0	0	
	Irregular	14	15.7	19	59.4	
	Oval	73	82.0	12	37.5	
	Tubular	0	0	1	3.1	
Margin	Well-Circumscribed	68	76.4	10	31.3	0.001

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	Ill Defined	21	23.6	18	56.3	
	Irregular	0	0	1	3.1	
	Spiculated	0	0	3	9.4	
Orientation	Taller	0	0	14	43.8	0.001
	Wider	89	100.0	18	56.3	
Echopattern	Heterogeneous	7	7.9	4	12.5	0.07
	Hyperechoic	9	10.1	5	15.6	
	Hypoechoic	72	80.9	20	62.5	
	Isoechoic	1	1.1	3	9.4	
Posterior acoustic shadow	No	89	100.0	11	34.4	0.001
	Yes	0	0	21	65.6	
Calcification	None	84	94.4	22	68.8	0.001
	Microcalcification	2	2.2	10	31.3	
	Coarse	3	3.4	0	0	
Vascularity	Avascular	32	36.0	2	6.3	0.001
	Hypovascular	47	52.8	10	31.3	
	Moderately vascular	10	11.2	14	43.8	
	Hypervascular	0	0	6	18.8	
Vascular flow pattern	Avascular	31	34.8	0	0	0.001
	Marginal	28	31.5	2	6.3	
	M>P	13	14.6	13	40.6	
	P>M	0	0	5	15.6	
	Both Equal	17	19.1	10	31.3	
	π Type	0	0	1	3.1	
	Imperceptible Internal Flow	0	0	1	3.1	
	Penetrating flow	0	0	0	0	
Incidental angle	<45°	4	4.5	19	59.4	0.001
	>45°	30	33.7	10	31.3	
	Mean±SD	1.88±0.33		1.34±0.48		
RI central	Mean±SD	0.63±0.137		0.94±0.346		0.001
RI peripheral	Mean±SD	0.72±0.186		0.65±0.148		0.12
PI	Mean±SD	0.90±0.90		1.85±0.721		0.001

[Table 3] About 47.1% were hypovascular and Avascularity on flow pattern was observed in 25.6% cases whereas the vascularity is marginal in 24.8% cases. Incident angle was below 45° in 19% and above 45° in 33.1% cases. Mean RI at central and peripheral area was 0.78±0.30 and 0.69±0.175 respectively whereas mean PI in cases with breast masses was 1.23±0.662. Based upon the color Doppler features, 27.3% lesions were categorized as malignant.

[Table 4] Among benign lesions, most common diagnosis was fibroadenoma (44.6%), followed by abscess (10.7%). However, among malignant lesions, about 7.4% masses each were categorized as BIRADS 4A and 4B, whereas 6.6% masses were BIRADS 4C.

[Table 5] Above table reveal that B mode (except echo pattern) as well as Color Doppler features (except RI peripheral) alone helped in differentiating malignant breast masses from benign breast masses ($p<0.05$).

DISCUSSION

Though B mode alone is helpful in distinguishing certain malignant and benign lesions, it may be impossible to distinguish all the benign lesions from malignant breast masses using it. Addition of color Doppler ultrasonography for differentiating the malignant lesions from benign lesions has improved the diagnostic accuracy of B mode ultrasonography.[6,8] The present study was conducted on a total of 121 cases presenting with breast masses. The B mode features and color Doppler features were assessed separately and then the findings of both B-mode with color Doppler were combined to determine the type of breast lesion. Out of 121 cases, 89 masses were benign whereas 32 masses were malignant. Abscess was the most common cause of benign breast lesions (10.7%) whereas BIRADS 4a & 4b were the most common findings in malignant lesions (14.8%).

Ultrasonography is a safe, radiation free and cost-effective imaging modality, in which waveforms are reflected by the tissues in the form of echoes.[10] Based upon B mode features, 75.2% lesions were benign whereas 24.8% lesions were malignant. Significantly higher proportions of benign lesions had oval shape whereas 59.4% malignant lesions were irregular in shape ($p<0.05$). Similarly, margins were well circumscribed in significantly higher proportions of benign and ill-defined in higher proportions of malignant lesions ($p<0.05$). Orientation was taller in significantly higher proportions of cases with malignant lesions ($p<0.05$). However, posterior acoustic shadow and micro calcifications were documented in significantly higher proportions of malignant lesions ($p<0.05$). Rjosk-Dendorfer et al examined cases of fibroadenoma and of them, majority were ovoid in shape.[11] Our study findings were also supported by the findings of Okello et al, that confirmed features of malignant & benign lesions similar to our study.[12] Ibrahim et al documented presence of calcification, along with shape, margin and posterior acoustic features to be significant predictor of malignant lesions.[13]

Color Doppler sonography, by exploiting the Doppler effect help in determining the blood flow, vascularity, vascular flow pattern.[6] These features helps in differentiation benign lesions from malignant lesions. On color Doppler, low grade malignancies may have only feeding vessels with no or minimal internal vascularity whereas intermediate-grade carcinoma of breast are associated with increased peripheral as well as internal vascularity. However, high-grade breast cancers may have peripheral net of vessels.[14] In present study, 72.7% lesions were classified as benign and 27.3% were classified as malignant. Vascularity was significantly increased in malignant lesions and "penetrating more than marginal" type of vascular flow pattern was associated with malignant lesions. Incident angle was below 45° in significantly higher proportions of malignant lesions ($p<0.05$). On spectral waveform, mean RI and PI values were significantly higher in malignant lesions ($p<0.05$).

Rjosk-Dendorfer et al reported large fibroadenomas to show significantly higher vascularity as compared to smaller lesions ($p<0.05$).[11] Okello et al also reported significantly higher vascularity in malignant as compared to benign lesions ($p<0.05$).[12] Ibrahim et al also supported our findings.[13] Gupta et al reported hypervascularity, presence of penetrating artery, internal vascularity, and tortuous arteries to be significantly associated with malignancy.[15] Watanabe et al also reported vascularity, vascular flow pattern, and incident angle to be significantly helpful in differentiating benign from malignant lesions.[6]

The combined use of color Doppler with that of B mode was first used by Zeng et al for making differential diagnosis of breast neoplasms.[16] The authors reported significant difference in the color & spectral Doppler features between benign and malignant breast lesions.[16] The diagnostic accuracy of Color Doppler with spectral waveform was documented to be higher (94.2%) as compared to B mode alone (83.5%). The sensitivity, specificity, PPV and NPV of Color Doppler with spectral waveform was higher than that of B mode alone, for diagnosing malignancy.

Kalmantis et al however reported the sensitivity & specificity of 3D ultrasonography as 92.4% & 86.1 respectively for diagnosis of malignant breast lesions.[17] Ibrahim et al reported sensitivity and specificity of grey scale US findings for diagnosis of malignant breast lesions as 100% and 71.4% respectively with PPV of 74.1% and NPV of 100%. The specificity was reported to be higher when gray scale was combined with color Doppler features (89%).[12] Hashim et al documented the diagnostic accuracy of B mode and color Doppler as 93.29% with sensitivity and specificity of 97.09% and 80.65% in differentiating malignant from benign lesions.[18] The pooled sensitivity & specificity of USG in detecting malignant lesions in a study of Sood et al was 80.1% & 88.4% respectively.[19] Watanabe et al also supported the above mentioned findings.[6]

CONCLUSION

B mode as well as color Doppler both are helpful in categorizing benign and malignant lesions. Irregular shape, ill-defined margin, posterior acoustic shadow, microcalcification and taller orientation are characteristic B mode features for predicting malignant lesions. However, increased blood flow (vascularity), penetrating vascular flow pattern, low incident angle, high resistive index and pulsatility index are features on color Doppler predicting malignancy. Though B mode alone and color Doppler with spectral waveform both independently can distinguish malignant breast lesions from benign breast lesions, their diagnostic yield when combined may help in successfully characterizing all the breast lesions with high diagnostic accuracy.

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