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Comparison of diagnostic efficacy of ultrasound, ultrasound elastography and magnetic resonance imaging for breast lesions

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Abstract

Study aimed to evaluate and compare the performance of ultrasound, ultrasound elastography and magnetic resonance imaging in the diagnosis of breast cancer & its differentiation from benign lesions

Material & Method: This cross-sectional observational study was conducted at department of Radiodiagnosis, Era's Lucknow Medical college. The study was conducted for 18 month from January 2019 to june 2020. Patients detected with breast lesions and willing to be part of study were included in the study. The patients with cystic nodules and non-consenting patients were excluded from the present study. All the patients were subjected to B-mode USG assessment followed with Real Time ultrasound Elastography and 0.5 Tesla MRI scan. Fine needle aspiration cytology (FNAC) or biopsy was performed and the specimen were evaluated cytologically/histopathologically to confirm the diagnosis

Result: Histopathologically, 18 (36%) cases were diagnosed as malignant and remaining 32 (64%) were diagnosed as benign. Among 18 malignant cases, maximum (n=11) were intraductal carcinoma (NOS), followed by well-differentiated intraductal carcinoma (n=6) and invasive lobular carcinoma (n=1) respectively. Among 32 benign cases, maximum (n=20) were fibroadenoma, followed by breast abscess (n=3), galactocele, intraductal papilloma and simple cyst (n=2 each). There was 1 case each diagnosed as fibroadenolipoma, fibrocystic and phyllode respectively. Diagnostic efficacy of USG in terms of sensitivity, specificity, positive and negative predictive value was 77.8%, 87.5%, 77.8% and 87.5% respectively. The accuracy of USG diagnosis was 84%. Diagnostic efficacy of USG elastography in terms of sensitivity, specificity, positive and negative predictive value was 83.3%, 96.9%, 93.8% and 91.2% respectively. The accuracy of elastography diagnosis was 92%. Diagnostic efficacy of MRI in terms of sensitivity, specificity, positive and negative predictive value was 94.4%, 90.6%, 85.0% and 96.7% respectively. The accuracy of MRI diagnosis was 92%.

Conclusion: In low-resource settings, USG elastography can emerge as a suitable alternative to MRI in diagnosis of malignant breast masses with highly appreciable positive and negative predictive values.

Study Design: Observational Study.

Keywords: diagnostic, ultrasound, elastography, MRI & breast lesions

Introduction

Breast lesion is a lump or mass that is either felt by palpation or is detected by mammography. The occurrence of breast lesions is quite frequent. The prevalence of breast lesions is as high as 20% [1-2]. Breast lesions can be both malignant as well as benign. The malignant lesions represent different types of breast cancers, *viz*., non-invasive (Ductal carcinoma in situ, Lobular carcinoma in situ) and invasive (infiltrating lobular carcinoma, infiltrating ductal carcinoma, inflammatory breast cancer, medullary carcinoma, mutinous or colloid carcinoma, tubular carcinoma, Paget's disease) types [3].

Although, breast cancer remains to be the most common malignant condition in the women yet majority of breast lesions are benign in nature [4-6]. Despite the common occurrence of breast lesions and a dominance of benign lesions, breast cancer is considered as one of the most dreadful disease among women that has both physical as well as emotional impacts. Despite improvement in clinical management during the last few decades, it continues to be a major cause of cancer death among women in less developed countries.

As per a recent estimate breast cancer has ranked number one cancer among Indian females with age adjusted rate as high as 25.8 per 100,000 women and mortality 12.7 per 100,000 women [7].

As per the findings of a report, worldwide a total of 882,900 new cases of breast cancer were diagnosed and 324,300 deaths occurred in the year 2012, accounting for 25% of cancer cases and 15% of cancer deaths among females [8].

As per the clinical guidelines on the diagnosis and treatment of breast cancer, clinical examination should be followed by imaging studies using mammography, ultrasound and magnetic resonance imaging. Though techniques like diagnostic mammography are highly sensitive with sensitivity being as high as 87%, however, it also have a high false detection rate with positive predictive values as low as 22%19, thereby confining its usefulness for screening purposes only. On the other hand, MRI which is also highly sensitive, with sensitivity as high as 85 to 100% however it lacks specificity (47 to 67%) [9-10]. Moreover, MRI is a highly expensive diagnostic modality and is inaccessible to a large proportion of population in less developed and low resource countries like ours.

On the other hand, ultrasonography which is easily accessible even in low resource settings plays an important role in evaluation of breast lesions. It can effectively distinguish solid masses from cysts, which account for approximately 25 percent of breast lesions [11-12]. One of the characteristic features of cancer tissue is its lower elasticity as compared to normal tissue. This difference in elasticity makes it possible to differentiate between malignant and benign lesions by studying the difference in elasticity of the lesions. Fortunately, with the evolution of ultrasound elastography it has become possible to diagnose breast cancer tissue from normal and benign tissue [13].

Study aimed to evaluate and compare the performance of ultrasound, ultrasound elastography and magnetic resonance imaging in the diagnosis of breast cancer & its differentiation from benign lesions

Materials and Methods

This cross-sectional observational study was conducted at department of Radiodiagnosis, Era's Lucknow Medical college. The study was conducted for 18 month from January 2019 to June 2020. Patients detected with breast lesions and willing to be part of study were included in the study. The patients with cystic nodules and non-consenting patients were excluded from the present study. At enrolment, age of patients was noted and they were subjected to a clinical examination. Side of involvement, presenting complaints and clinical examination findings were noted. On the basis of clinical evaluation, a clinical diagnosis was made.

Conventional Ultrasound

All the patients were subjected to B-mode USG assessment. Two-dimensional ultrasound scanning was performed on GE Logiq P9 Ultrasound device. Side of involvement, area of involvement, size of lesion, shape of lesion, type of margins, echo pattern, echotexture, post-acoustic enhancement, type of architecture, vascularity and its pattern, duct extension, height/width ratio was calculated and diagnosis was prepared using BIRADS criteria.

US Elastography

The two-dimensional USG was followed by Real Time ultrasound elastography. The stiffness of the lesion was evaluated. Lesions classification was performed on the basis of a 5-point scoring method proposed by Tsukuba elasticity score developed by Itoh and Ueno63. Score 1: given to the lesions had the same color (green) and elasticity of normal breast tissue, score 2: lesions with inhomogeneous elasticity, displaying mixed green and blue color, score 3: lesions with elastic green periphery and stiff blue centre, and score 4: all the mass area was blue (stiff), and score 5: the lesions and the adjacent tissue showed blue color. This was followed by adjustment of elastography image to an appropriate size surrounding the lesion. The linear probe was maintained at the lesion site and a slight vibration (compression / decompression) was performed. The region of interest was set for the lesion tissue and surrounding normal tissue in the same depth as for the breast lesion. Finally, the strain ratio was calculated to assess the relative hardness of the breast lesion as compared to that of surrounding breast tissue.

Magnetic Resonance Imaging

All patients were placed prone on a 0.5 Tesla MRI scanner equipped with a dedicated breast surface coil. The scanning range included the bilateral breast and the corresponding level of prothoraxes and bilateral axillae. On MRI size, shape, margins, texture, T1-weighted and T2-weighted intensity, contrast enhancement and axillary involvement was noted. Consequently, the lesion was categorized as benign, probably benign, malignant and probably malignant.

Histopathology

Fine needle aspiration cytology (FNAC) or biopsy was performed and the specimen were evaluated cytologically/histopathologically to confirm the diagnosis.

The diagnostic efficacy of each of these techniques was compared against FNAC/Biopsy findings.

Statistical analysis: The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 21.0 statistical Analysis Software. The values were represented in Number (%) and Mean±SD. The mean difference between the continuous variables was analysed using the student t-test and chi-square test for categorical variable. The diagnostic accuracy of the methods were analysed as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy. A p-value of <0.05 was considered statistically significant.

Results

Present study was carried out to compare the efficacy of conventional ultrasound, ultrasound elastography and magnetic resonance imaging for evaluation of suspected breast lesions. For this purpose, a total of 50 symptomatic patients were enrolled in the study who underwent sonographic, real-time elastography and magnetic resonance imaging followed by histopathological evaluation. Out of 50 patients enrolled in the study, a total of 18 (36%) were diagnosed as malignant and remaining 32 (64%) were diagnosed as benign.

Out of 18 cases diagnosed as malignant, maximum (n=11) were diagnosed as intraductal carcinoma (NOS), followed by intraductal carcinoma - well differentiated (n=6) and invasive lobular carcinoma (n=1) respectively.

Table 1: Distribution of cases according to Final Diagnosis (n=50)

Diagnosis	No. of cases	Percentage
Malignant	18	36.0
Benign	32	64.0

Out of 32 cases diagnosed as benign - maximum (n=20) were diagnosed as fibroadenoma, followed by breast abscess (n=3), galactocele, intraductal papilloma and simple cyst (n=2 each) and fibroadenolipoma, fibrocytic and phyllodes (n=1 each) respectively

Table 2: Distribution of Cases according to Different HPE Diagnoses

Diagnosis		Number of cases
Malignant	Intraductal carcinoma	11
	Intraductal carcinoma well differentiated	6
	Invasive lobular carcinoma	1
Benign	Fibroadenoma	20
	Breast abscess	3
	Galactocele	2
	Intraductal papilloma	2
	Simple cyst	2
	Fibroadenolipoma	1
	Fibrocytic	1
	Phyllodes	1

Age of patients ranged from 20 to 60 years. Mean age of patients was 37.12±9.93 years. Mean age of cases with malignancy was significantly higher (43.28±11.04 years) as compared to that of patients with benign lesions (37.12 ± 9.93 years) (p=0.001).
Most of the cases (96%) had unilateral involvement. Only 2 (4%) cases had bilateral involvement. Though proportion of those having involvement of left side was higher in malignant group (61.1%) as compared to that in benign group (43.8%) yet this difference was not significant statistically (p=0.345).
Clinical findings like pain, discharge, retraction, heaviness, mobility, warmth/redness, pain on mobility and hardness/firmness were seen in 4%, 8%, 10%, 2%, 40%, 20%, 16% and 14% patients respectively. However, the difference between benign and malignant groups was significant statistically only for retraction, mobility, warmth/redness and hardness/firmness respectively. It was seen that proportion of those having clinical features like retraction, warmth/redness and hardness/firmness was higher in malignant as compared to benign group while those showing mobility were significantly higher in benign as compared to malignant group.
Clinical diagnosis was established as probable benign in 24 (48%), probable malignant in 4 (8%), benign (26%) and malignant (18%) respectively. Proportion of those with probable malignant / malignant diagnosis was significantly higher in malignant group as compared to that in benign group (p=0.002).

Table 3: Diagnostic Efficacy of Clinical Diagnosis against Final Diagnosis

<table>
<tr><th rowspan="2">Clinical Diagnosis</th><th colspan="3">Final Diagnosis</th><th rowspan="2">Total</th></tr>
<tr><th colspan="2">Malignant</th><th>Benign</th></tr>
<tr><td>Malignant/ Malignant</td><td colspan="2">10</td><td>3</td><td>13</td></tr>
<tr><td>Benign/ Benign</td><td colspan="2">8</td><td>29</td><td>37</td></tr>
<tr><td></td><td colspan="2">18</td><td>32</td><td>50</td></tr>
<tr><td>Sensitivity</td><td>Specificity</td><td>PPV</td><td>NPV</td><td>Accuracy</td></tr>
<tr><td>55.6</td><td>90.6</td><td>76.9</td><td>78.4</td><td>78.0</td></tr>
</table>

Considering clinically probable malignant and malignant as comparable to histopathologically malignant, a total of 10 cases were true positive, 3 were false positive, 8 were false negative and 29 were true negative. Correspondingly, sensitivity, specificity, positive predictive value, negative predictive value and accuracy of clinical evaluation was 55.6%, 90.6%, 76.9%, 78.4% and 78% respectively.
On USG, a total of 5 (10%) cases had multiple lesions, bilateral involvement was seen in 2 (4%) cases. Upper outer quadrant involvement, size >2 cm, irregular shape and ill-defined margins were seen in 21 (42%), 33 (66%), 16 (32%) and 25 (50%) cases. Hypoechoic pattern, heterogenous echotexture, post-acoustic enhancement and distorted architecture were seen in 44 (88%), 19 (38%), 47 (94%) and 6 (12%) cases. Moderate to marked vascularity, peripheral/central vascularization, microlobulations, duct extension and taller than wider appearance were seen in 22 (44%), 28 (56%), 18 (36%), 15 (30%) and 18 (36%) cases respectively.
Statistically significant difference between malignant and benign groups were seen for features irregular shape, ill-defined margins, heterogenous echotexture, distorted architecture, moderate to marked vascularity peripheral/central vascularization, microlobulations, duct extension and taller than wider appearance respectively ($p<0.05$). On the basis of USG features, a total of 20 (40%) were identified as BIRADS 2, 12 (24%) as BIRADS 3, 11 (22%) as BIRADS 4 and 7 (14%) as BIRADS 5. Proportion of those with BIRADS 4 and 5 was significantly higher in malignant as compared to benign group ($p<0.001$).

Table 4: Diagnostic efficacy of USG against final diagnosis

Clinical Diagnosis	Final Diagnosis			Total
	Malignant		Benign	
Malignant/ Malignant	14		4	18
Benign/ Benign	4		28	32
	18		32	50
Sensitivity	Specificity	PPV	NPV	Accuracy
77.8	87.5	77.8	87.5	84

Considering USG categorized BIRADS 4 and 5 cases as comparable to histologically malignant cases, a total of 14 cases were true positive 4 were false positive, 4 were false negative and 28 were true negative. Correspondingly, sensitivity, specificity, positive predictive value, negative predictive value and accuracy of USG evaluation was 77.8%, 87.5%, 77.8%, 87.5% and 84% respectively.

Table 5: Comparison of Elastography Evaluation Findings between Benign and Malignant groups

Characteristics	Malignant		Benign		Total		Statistical significance	
	Mean	SD	Mean	SD	Mean	SD	t	p-value
Elasticity Score	4.22	0.73	1.97	1.03	2.78	1.43	8.17	<0.001
Strain ratio	4.60	0.77	2.66	0.85	3.36	1.25	8.00	<0.001

On elastography, mean elasticity score of malignant cases was 4.22±0.73 as compared to 1.97±1.03 for benign cases, thus showing a statistically significant difference between two groups ($p<0.001$). Similarly, strain ratio was also found to be significantly higher in malignant (4.60±0.77) as compared to benign (2.66±0.85) cases ($p<0.001$).

Table 6: Receiver-Operator Characteristic Curve Analysis for prediction of Malignancy using Elasticity Scores and Strain Ratio

Variable(s)	Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
				Lower	Upper
Elasticity Score	0.941	0.030	<0.001	0.882	1.000
Strain Ratio	0.964	0.035	<0.001	0.871	1.009

On receiver-operator characteristic curve analysis, the area under the curve values of elasticity score and strain ratio were observed to be 0.941 and 0.964 respectively. Proposed Cut-off value for Elasticity Score was >4 which was 83.3% sensitive 87.5% specific. Proposed Cut-off value for Strain ratio was calculated as >4.25 which was 83.3% Sensitive and 96.9% Specific.

On MRI, features like >2 cm size, irregular / lobulated / speculated shape, ill-defined / speculated / lobulated or irregular borders, heterogenous, T1w hypointense / T2w hyperintense images, contrast enhancement and axillary involvement were seen in 33 (66%), 15 (30%), 20 (40%), 29 (58%), 37 (74%), 23 (46%) and 9 (18%) cases respectively. A statistically significant difference between two groups was observed for Irregular/ lobulated/ spiculated shape, Ill-defined / Spiculated / lobulated or irregular border, Heterogenous, contrast enhancement and axillary involvement respectively. For all these features the proportion of those in malignant group was higher as compared to that in benign group ($p<0.05$). On the basis of MRI features, a total of 25 (50%) cases were diagnosed as benign, 5 (10%) as probable benign, 15 (30%) as malignant and 5 (10%) as probable malignant respectively. Statistically, proportion of those diagnosed as probable malignant and malignant was significantly higher in malignant as compared to benign group ($p<0.001$).

Table 7: Diagnostic Efficacy of MRI against Final Diagnosis

Clinical Diagnosis	Final Diagnosis			Total
	Malignant		Benign	
Malignant/ Malignant	17		3	20
Benign/ Benign	1		29	30
	16		32	50
Sensitivity	Specificity	PPV	NPV	Accuracy
94.4	90.6	85	96.7	92

Taking MRI diagnosed probable malignant and malignant cases as comparable to histopathologically diagnosed malignant cases, a total of 17 cases were true positive, 3 were false positive, 1 was false negative and 29 were true negative. Correspondingly, the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of MRI was 94.4%, 90.6%, 85%, 96.7% and 92% respectively.

Table 8: Summary diagnostic efficacy of different modalities

Modality	Sensitivity	Specificity	PPV	NPV	Accuracy
Clinical	55.6	90.6	76.9	78.4	78.0
USG	77.8	87.5	77.8	87.5	84.0
Elastography (Strain Ratio)	83.3	96.9	93.8	91.2	92.0
MRI	94.4	90.6	85.0	96.7	92.0

Among different diagnostic modalities, MRI had maximum sensitivity (94.4%) while clinical evaluation had minimum (55.6%). The specificity was maximum for elastography (96.9%) and minimum for USG (87.5%). Elastography had maximum positive predictive value (93.8%) while MRI had maximum negative predictive value (96.7%). The diagnostic accuracy of clinical, USG, elastography and MRI was 78%, 84%, 92% and 92% respectively.

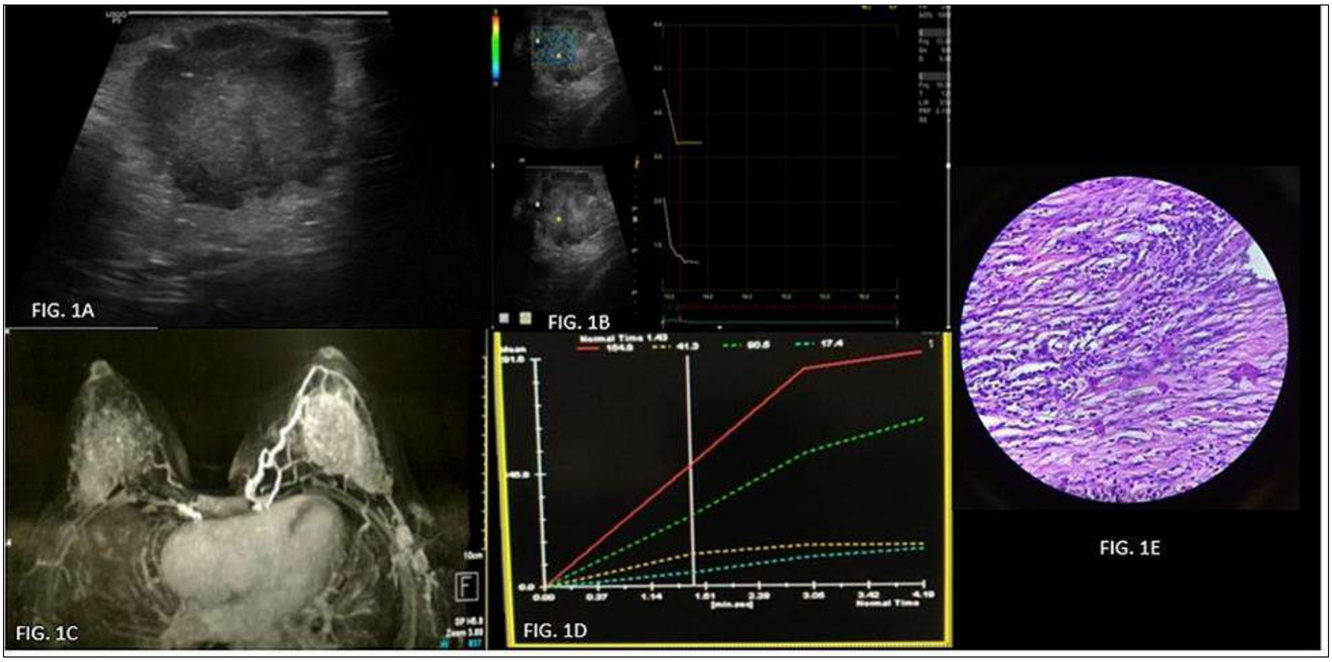

Fig 1: Case 1

Fig 1A: Targated gray scale ultrasound image shows uncircumscribed mass lesion measuring (~4.5x4.2x3.8 cm) in superior quadrant of left breast. Lesion is taller than wider with angular margins. A thick hyperechoic hallo with surrounding echogenic foci likely punctate calcification. Ultrasound findings a typical of BIRADS V.

Fig 1B: Elastographic imaging, a region of interest is placed in the lesion and one other in adjacent fat. The calculates the relative stiffness of fat with strain ratio 3.3 and elasticity score of 5 as entire lesion and surrounding area are stiff. Elastography findings are typical of malignant lesion.

Fig 1C: MRI breast contrast shows heterogeneous fibroglandular architecture of both breast. Marked background parenchymal enhancement is noted. Large well defined (~3.9 x 3.8 x 4.5 cm) (AP x TR xCC), irregular margined heterogenous altered signal intensity lesions with few speculation involving superior quadrant of left breast. Lesions is moderately hyperintense on T2WI and shows moderate heterogenous mass like enhancement suggesting BIRADS V.

Fig 1D: MRI Breast contrast Type 2/3 dynamic curve suggesting BIRADS V.

Fig 1E: Histopathological study shows small uniform tumour cells arranged in a single file and in targetoid fashion around the duct with a dense fibers stroma. Mitotic index raised. Histopathological type–invasive lobular carcinoma.

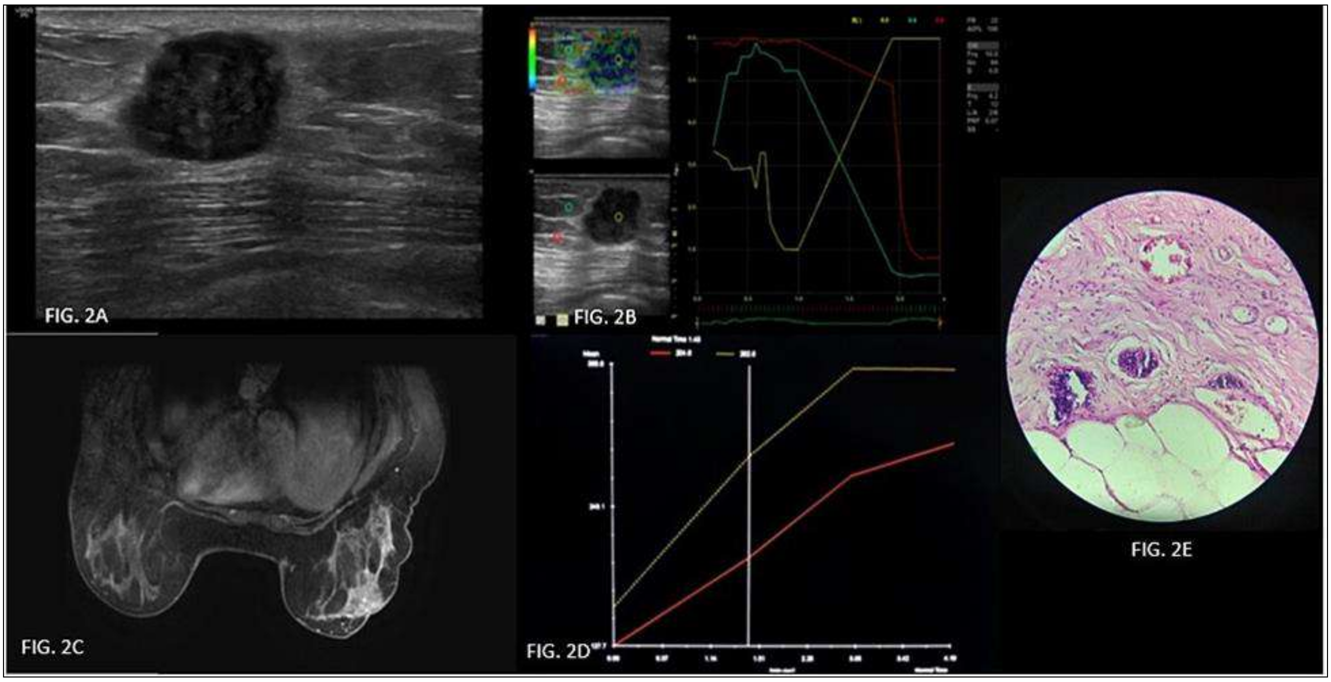

Fig 2: Case 2

Fig 2A: Targeted gray scale ultrasound image shows uncircumscribed mass lesion measuring (~3x4.2x3.1 cm) in inferior quadrant of left breast. Lesion is taller than wider with speculated margins and microcalcifications Ultrasound findings a typical of BIRADS V.

Fig 2B: Elastographic imaging, a reason of interest is placed in the lesion and two other in adjacent fat. The systems calculates the relative stiffness of fat with strain ratio 6.0 and elasticity score of 5 as entire lesion and surrounding area are stiff. Elastography findings are suggestive of typical malignant lesion.

Fig 2C: MRI Breast contrast shows heterogenous fibroglandular architecture of both breast. Marked background parenchymal enhancement is noted. Large well defined (~3.0 x 3.2 x 4.1 cm) (AP x TR x CC), irregular margined heterogenous altered signal intensity lesions with few speculation involving inferolateral quadrant of left breast with retroareolar extension. Nipple retraction is seen with heterogenous enhancement. Lesions is moderately hyperintense on T2WI and shows moderate heterogenous mass like enhancement suggesting BIRADS V.

Fig 2D: MRI Breast contrast Type 2/3 dynamic curve suggesting BIRADS V.

Fig 2E: Histopathological study shows tumour cells arranged in forms of ducts and tubules. Cells exhibit marked pleomorphism, hyperchromatic nuclei and scanty cytoplasm. Mitotic index raised. Histopathological type – Grade I Invasive duct carcinoma.

Discussion

Breast cancer is one of the most common cancers affecting the women. The incidence of disease is high in developed countries as compared to developing and underdeveloped countries [14], however this high incidence in developed countries as compared to less developed or underdeveloped countries might be owing to lack of adequate screening and diagnosis in the lesser developed countries owing to lack of awareness, adequate infrastructure, screening programmes and appropriate diagnostic facilities owing to lack of resources.

Among different imaging modalities, ultrasound has emerged as a modality which is available even in primary and secondary care facilities. Ultrasound is recognized to have a high diagnostic yield in evaluation of breast lesions, however, it is often criticized for variable specificity [15], in the recent years, Ultrasound elastography is emerging as a modality that can enhance both the sensitivity as well as specificity of B-mode ultrasound in evaluation of suspected breast lesions. It is very cost-effective and helps to characterize the breast lesions effectively that in turn enhance the diagnostic yield of ultrasound [16].

In present study, histopathologically, 18 (36%) cases were diagnosed as malignant and remaining 32 (64%) were diagnosed as benign. Thus malignancy rate in present study was 36%. The malignancy rate in different studies reviewed by us has shown a considerable variability. In some studies carried out among asymptomatic women, this rate has been reported to be as low as 1.6% to 10.4% [17-18]. However, studies conducted among women with suspected breast lesions/masses have reported a higher malignancy rate ranging from 30% to 69.8% [19-24]. Although, some studies conducted among suspected women have reported this incidence to be less than 30%.(24-27) As such the malignancy rate in different studies might vary substantially depending upon the inclusion criteria, strength of suspected clinical features, age and level of exposure to other risk factors.

In present study, among 18 malignant cases, maximum (n=11) were intraductal carcinoma (NOS), followed by well-differentiated intraductal carcinoma (n=6) and invasive lobular carcinoma (n=1) respectively. A wide variation in type of malignancy has been reported in different studies. Kuhl *et al.* [17], reported 34/43 cases as invasive cancers and remaining 9 as ductal carcinoma-in-situ. Gheonea *et al.* [19], on their study reported infiltrative ductal carcinoma as the most common type of malignant lesion. Sardanelli *et al.* [18] also reported 44/52 malignant cases as invasive and remaining 8/52 as ductal carcinoma.

There were 32 benign cases. Among these maximum (n=20) were fibroadenoma, followed by breast abscess (n=3), galactocele, intraductal papilloma and simple cyst (n=2 each). There was 1 case each diagnosed as fibroadenolipoma, fibrocytic and phyllode respectively. Similar to present study, Gheonea *et al.* [19] also reported fibroadenoma, cyst and fibrocystic change as the common types of benign lesions. Kanumuri *et al.* [24], too found fibroadenoma (41%), fibrocystic disease (20.5%) and simple cyst (12.8%) as the most common benign lesions. Kanagaraju *et al.* [25], also made similar observations. As such fibroadenoma has been reported as the most common benign lesions in different series as seen in present study too.

Among different demographic and clinical features, higher mean age, higher proportion of stable, warm/red and hard/firm masses were significantly associated with malignancy. Increasing age is a recognized risk factor for breast cancer. Similar to present study, Kanagaraju *et al.* [25] also reported mean age of patients with malignancy to be significantly higher as compared to that of benign cases. Clinical evaluation is considered to be an important part of evaluation of suspected breast lesions. Epidemiological studies report that a significant number of cancers could be missed if clinical examination is not carried out 101. However, the efficacy of a clinical examination is highly skill dependent. In present study, clinical diagnosis was found to be 55.6% sensitive and 90.6% specific. The positive predictive value was 76.9% and negative predictive value was 78.4%. The accuracy of clinical diagnosis was 78%. As such it could be seen that in experienced hands, clinical evaluation could also hold a reasonable accuracy, however, it must be noted that clinical evaluation alone was missing as many as 44.4% of breast malignancies. Thus despite having a higher diagnostic efficacy than just a flip coin probability, the clinical diagnosis required further evaluation.

In present study, diagnostic efficacy of USG in terms of sensitivity, specificity, positive and negative predictive value was 77.8%, 87.5%, 77.8% and 87.5% respectively. The accuracy of clinical diagnosis was 84%. Compared to present study, earlier studies have reported a low sensitivity of ultrasound. Sardanelli *et al.* [18], in their study reported the sensitivity of USG to be 52% only but found it to be >95% specific. In present study, the sensitivity of USG increased considerably owing to addition of multiple criteria and the fact that we used high-resolution USG and had a clinically suspected study population. Yahyazadeh and Mehraeen [26], also reported both high sensitivity (91.7%) as well as high specificity (87.2%). Although, some workers like Stachs *et al.* [21], reported the sensitivity of conventional USG to be as high as 97.4% but reported the specificity to be too low (42.6%).

On USG elastography, mean elasticity score was found to be 4.22±0.73 in malignant and 1.97±1.03 in benign cases whereas mean strain ratio was found to be 4.60±0.77 in malignant as compared to 2.66±0.85 in benign cases. Both mean elasticity and strain ratio were significantly higher in malignant as compared to benign cases. Similar to present study, mean strain ratio and/or elasticity scores were found to be higher in malignant as compared to benign cases in almost all the studies evaluating role of USG elastography. Gheonea *et al.* [19], in their study reported mean SR to be 6.28 for malignant and 2.08 for benign cases and found this difference to be significant. In their study, all except 1 malignant case had elasticity score <3 but 78.6% of benign cases had elasticity scores <3, thus showing that benign cases were associated with lower elasticity score as observed in present study. Zhao *et al.* [27], also reported mean elasticity scores and strain ratio of malignant lesions as 4.07±0.26 and 6.66±4.62 respectively as compared to 1.62±0.69 and 2.06±1.27 respectively for benign lesions, thereby showing a significant difference as observed in present study. Other workers also observed similar differences [21-22].

In present study, diagnostic efficacy of MRI in terms of sensitivity, specificity, positive and negative predictive value was 94.4%, 90.6%, 85.0% and 96.7% respectively. The accuracy of MRI diagnosis was 92%. Magnetic resonance imaging with contrast enhancement is able to differentiate between different imaging features suggestive of malignancy efficiently. This helps in a better differentiation than other techniques. Magnetic resonance imaging is known to have a high sensitivity for malignancy detection in suspected breast lesions. More than 90% sensitivity as well as specificity for MRI as observed in present study has also been reported by a number of other workers [17]. A slightly lower sensitivity and specificity of MRI (88% and 80%) has been reported by ElSaid *et al.* [20] in their study. Among different studies reviewed by us, a few studies reported specificity of MRI to be less than 80% - reporting them to be 69.7%, 50% and 57.5% respectively [23-28] but both the studies found it to be highly sensitive with sensitivity of 92.5%, 100% and 98.2% respectively.

In present study, we found among different imaging tools we found elastograpahy to hold high sensitivity (83.3%) as well as specificity (96.9%) and it to hold an equivalent accuracy as for MRI (92%). Similar to present study, ElSaid *et al.* [20], also found US elastography to be comparable to MRI with respect to accuracy (84%) and did not find much difference in sensitivity and specificity of two techniques (84% vs 88% and 84% vs 80%). Song *et al.* also found the sensitivity and specificity of elastography (94.3% and 85.7%) to be too close to that of MRI (96.2% and 91.4%) [29]. In their study, Parajuly *et al.* [30], reported a higher sensitivity and specificity of conventional USG (91.8% and 84.8%). In another study, study Cheng *et al.* found that USG elastography performed better than MRI in terms of diagnostic accuracy (82.5% as compared to 75.4%) [31].

Conclusions

Study showed that while MRI was most sensitive, USG elastography was most specific. USG elastography had a reasonably high sensitivity too. Hence, it can be concluded that in low-resource settings like ours, USG elastography can emerge as a suitable alternative to MRI in diagnosis of malignant breast masses with a highly appreciable positive and negative predictive values.

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