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ORIGINAL ARTICLE

Gland/Lesion Strain Ratio for Predicting Malignancy of Solid Breast Lesions in Chinese Patients

JAWK Tang, JCH Tse, JHM Cheng, AYT Lai, AKY Au, BST Leung, WWC Wong

Department of Radiology, Pamela Youde Nethersole Eastern Hospital, Chai Wan, Hong Kong

ABSTRACT

Objectives: *To determine an optimal cut-off for gland/lesion strain ratio (GLR) in differentiation of benign and malignant breast lesions. The diagnostic performances of elasticity score, Breast Imaging Reporting and Data System (BI-RADS), and modified BI-RADS category were also assessed.*

Methods: *A retrospective review of all consecutive new solid breast lesions with B-mode ultrasound and strain elastography assessment was conducted in a regional hospital in Hong Kong from January 2017 to January 2018. Included subjects were Chinese women with diagnostic breast imaging and subsequent histological evaluation for BI-RADS 3 to 5 solid breast lesion(s). Modified BI-RADS was determined by incorporating the two elastography parameters. Results were analysed using Mann-Whitney* U *test and receiver operating characteristic curves.*

Results: *GLR for smaller lesions of <1 cm was not shown to be significantly different between malignant and benign pathologies. Regarding lesions of 1 to 2 cm and >2 cm, median GLR and elasticity score were significantly lower in benign lesions ($p < 0.05$). Taking an optimal GLR cut-off at 2.62, sensitivity of 84.5% and specificity of 81.4% were yielded. The optimal cut-off of elasticity score was 3.5, giving sensitivity of 93.1% and specificity of 81.4%. With these two cut-off thresholds, modified BI-RADS showed an area under the receiver operating characteristic curve (Az) of 0.906. The Az were 0.852 for GLR, 0.926 for elasticity score and 0.827 for BI-RADS. Modified BI-RADS showed higher Az than BI-RADS ($p < 0.05$).*

Conclusion: *GLR showed reasonable diagnostic performance for breast lesions of ≥1 cm in our cohort. Modifying BI-RADS with GLR and elasticity score can improve diagnostic accuracy.*

Key Words: *Diagnostic imaging; Elasticity; Elasticity imaging techniques; ROC curve*

Correspondence: *Dr JAWK Tang, Department of Radiology, Pamela Youde Nethersole Eastern Hospital, Chai Wan, Hong Kong. Email: tangwingkin2000@gmail.com*

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中文摘要

以超聲彈性成像的腺體／病變彈性比推斷華人女性的惡性實性乳腺病變

鄧永健、謝志瀚、鄭希敏、黎爾德、區嘉殷、梁肇庭、黃慧中

目的：釐定辨別良性或惡性乳腺病變的腺體／病變彈性比（GLR）的最佳截止值，並評估彈性評分、BI-RADS和按彈性成像結果的修訂版BI-RADS的診斷性能。

方法：對2017年1月至2018年1月期間在香港一家地區醫院進行B型超聲波和彈性成像評估的所有新發現實性乳房病變連續個案作回顧性研究。納入的受試者為在乳腺成像診斷中發現BI-RADS第3至5級實性乳房病變並隨後有組織學評估的華人女性。修訂版BI-RADS以結合兩個彈性成像參數而訂定的。數據是以Mann-Whitney *U*檢驗和ROC曲線作分析。

結果：對於少於1 cm的小病灶，GLR在惡性和良性病變間未有顯著差異。對於1至2 cm和超過2 cm的病變，良性病變的GLR中位數和彈性評分中位數顯著較低（$p < 0.05$）。最佳GLR截止值為2.62，靈敏度為84.5%，特異性為81.4%。彈性評分的最佳截止值為3.5，敏感性為93.1%，特異性為81.4%。利用這兩個截止值，修訂版BI-RADS的ROC曲線下面積為0.906。GLR的ROC曲線下面積為0.852，彈性評分的ROC曲線下面積為0.926，而BI-RADS的ROC曲線下面積為0.827。修訂版BI-RADS的ROC曲線下面積較BI-RADS為大（$p < 0.05$）。

結論：研究顯示GLR對1 cm或以上的乳房病變具有合理的診斷性能。使用GLR結合修訂的BI-RADS和彈性評分可提高診斷準確性。

INTRODUCTION

Ultrasound (US) elastography is a major advancement in US technology that is gaining recognition for its clinical impact. It supplements anatomical features on conventional B-mode US with valuable in vivo assessment of tissue stiffness by non-invasive means. In breast imaging, US elastography shows promising role in differentiating malignant from benign lesions; therefore, elastography features have been incorporated into the second edition of Breast Imaging Reporting and Data System (BI-RADS) US lexicon. Strain elastography and shear wave elastography are the two commonly used techniques of US elastography. The two techniques are substantially different and yet both of them show similar overall diagnostic performances.[1] Strain elastography utilises the force applied onto lesion by manual compression via the transducer or by chest wall movement with patient's normal respiration to achieve deformation of the lesion and the surrounding tissue. The assessment is a relative one, that is, comparison between lesion and surrounding tissue. Semi-quantitative assessment can thus be produced in terms of strain ratio. In shear wave elastography, acoustic radiation force impulse is generated from the transducer in the form of a focused US beam which propagates in the tissue, allowing measurement of the speed of the shear wave to quantify tissue stiffness in kilopascals or meters per second.

In current literature on the application of strain elastography for breast lesion assessment, strain ratio cut-offs are predominantly determined based on fat/lesion ratio (FLR), that is, comparing lesion stiffness with that of lateral adipose tissue at the same depth of the lesion. This ideal situation is often not possible in practice particularly in Chinese population due to a different biological profile in breast density and breast volume. Breast density tends to be higher in Chinese population with less non-dense fat component in the breast[2,3] and breast volume tends to be smaller as compared with Caucasian population.[4] Both of these factors limit the available choice of lateral adipose tissue for reference. Previous researchers had encountered similar problem and derived strain ratio cut-offs with a heterogeneous dataset with some of the strain ratios comparing lesion and adipose tissue at different depths (ie, non-lateral fat) instead of the lateral counterpart.[5] This non-lateral FLR is suboptimal for two reasons. First, deformability of tissue at different depths may vary with the stiffness of lesion[6]; second, the change in tissue stiffness of adipose tissue is more significant than normal non-adipose glandular tissue and lesions on precompression.[7,8] Hence, the accuracy of the strain ratio may be affected and could constitute one of the factors for the variable optimal strain ratio cut-offs determined in different previous studies.[5,9,10]

Adipose tissue may also be minimal in those who have small breast volume such that the region of interest (ROI) for adipose tissue would inevitably include non-adipose breast tissue, rendering strain ratio calculation inconsistent among various individuals. As such, prior studies proposed optimal cut-offs for strain ratio using FLR may therefore not be applicable to these individuals. Considering these factors, gland/lesion strain ratio (GLR) can be a more pragmatic approach in our local population.

Currently, little is known of diagnostic performance of GLR in the local population. The purpose of this study was to determine an optimal cut-off value for GLR in differentiation of benign and malignant breast lesions. The diagnostic performances of elasticity score, BI-RADS and modified BI-RADS were also assessed.

METHODS

A retrospective review of 139 new solid breast lesions in 119 patients with B-mode US and strain elastography assessment performed from January 2017 to January 2018 was conducted in a regional hospital in Hong Kong. The study methodology was in accordance with the Helsinki Declaration. Included subjects were Chinese women with diagnostic breast imaging and subsequent histological evaluation for solid breast lesion(s) that were classified as BI-RADS categories 3 to 5 based on B-mode US. BI-RADS category 3 lesions underwent histological evaluation due to patients' or surgeons' preference.

B-mode Ultrasound and Elastography Assessment

All US examinations were performed by one of the five radiologists with 1 to 5 years of experience in breast imaging using Affiniti 70 US system (Philips Medical Systems, Nederland B.V., The Netherlands) with linear transducer (12-5 MHz). All the patients underwent B-mode US and strain elastography with or without preceding diagnostic mammography depending on the age. The scanning radiologists had full knowledge of the clinical information and mammographic findings, if any, of the individual subjects prior to performing breast US examinations. Findings from B-mode US were recorded before elastography images were acquired.

Whole-breast US examinations were performed on all subjects on supine position with ipsilateral arm placed behind their head during scanning. Radial scanning was performed to systematically examine the entire breast. Lesions were documented in transverse and longitudinal planes after real-time B-mode US assessment. Individual included lesions were graded according to American College of Radiology BI-RADS US lexicons based on B-mode US features alone without incorporation of elastography findings. Strain elastography was subsequently performed. Light compression was applied via the transducer to the lesion vertically. The colour-mapping displayed a scale from blue (highest strain, least stiff) through green (intermediate strain, moderately stiff) to red (no strain, most stiff). Field-of-view box in elastography was set to include subcutaneous tissue at the superficial aspect and pectoralis muscle at the deepest aspect; laterally, normal breast tissue of at least 5 mm from the lesion margin were included. Real-time strain elastography images were recorded in form of cine loop for at least 3 seconds once steady compression was established as indicated by minimal pressure variation in the real-time pressure feedback display function in the US system. GLR was obtained with a default ROI box in the US system which included normal breast tissue as "strain 1" and another ROI box of the same size which include the stiffest portion of lesion as "strain 2". The US system would calculate an average strain ratio (ie, strain 1/strain 2) based on the acquired cine loop images. Visual assessment of the elastography cine loop was performed to decide elasticity score based on the most reproducible image in the cine loop. The assignment of a 5-point elasticity score was in accordance to the description by Itoh et al.[11]

In addition, modified BI-RADS categories were determined for each lesion after the optimal cut-offs of GLR and elasticity score from receiver operating characteristic (ROC) curve analysis. Modified BI-RADS categories were decided based on a previously proposed method: Modified BI-RADS = BI-RADS + a + b, where a and b are the modification factors based on the optimal cut-offs of elasticity score and GLR, respectively.[5,12] The modification factor can be a value of -1 or +1. If the elastography parameter of the lesion was higher than the optimal cut-off value as determined by ROC curve analysis, the modification factor would be +1; and vice versa. The final modified BI-RADS would be taken as 5 if it was ≥5 and as 3 if it was ≤3 (Figures 1 and 2).

Histological Evaluation

Histological results were used as the gold standard of reference. All of the lesions underwent US-guided core needle biopsy and/or surgical lumpectomy. US-guided core needle biopsy was performed using 16-gauge biopsy needle with a minimum of two tissue cores obtained from each lesion. The final pathology of lumpectomy specimen would be taken as the gold standard of reference for lesions with both US-guided core needle biopsy and subsequent surgical lumpectomy.

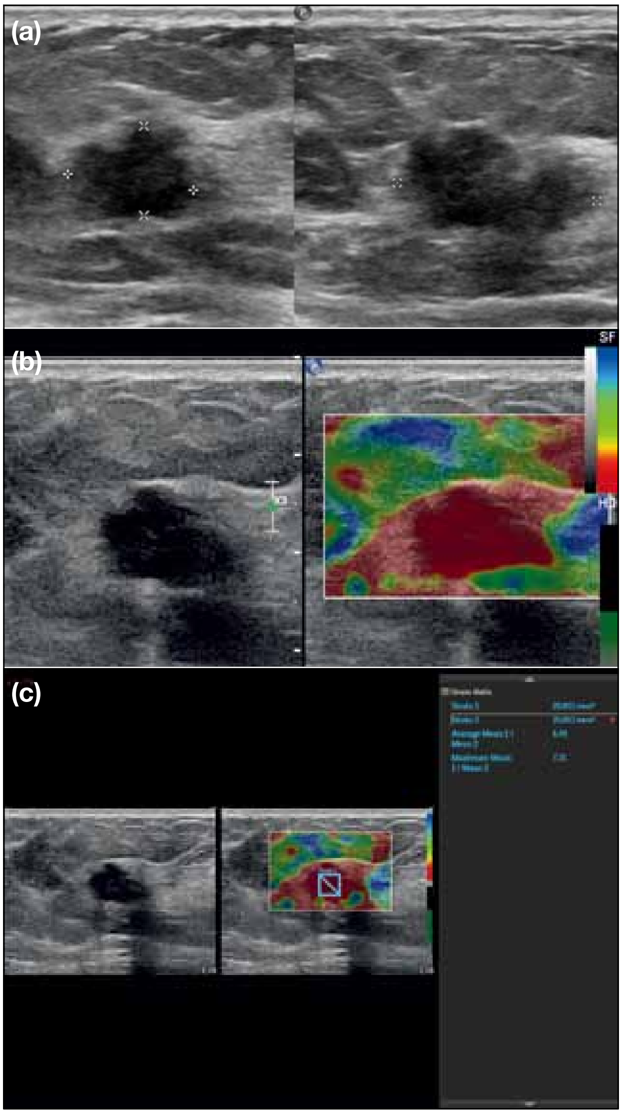

Figure 1. Triple-negative invasive ductal carcinoma. (a) B-mode ultrasonography. An irregular hypoechoic nodule with microlobulated margin, Breast Imaging Reporting and Data System (BI-RADS) category 4 based on conventional B-mode ultrasound findings alone. (b) Strain elastography. The entire lesion and the surrounding breast tissue were shaded in red, ie, stiff (elastography colour scheme from blue to red represents soft to hard). Elasticity score was 5. (c) Gland/lesion strain ratio was 6.44, higher than the optimal cut-off of 2.62 in our study. Together with elastography parameters, BI-RADS was upgraded from category 4 to modified BI-RADS category 5 based on the equation of 4 + 1 + 1 = 6 (>5 was taken as 5), ie, modified BI-RADS category 5.

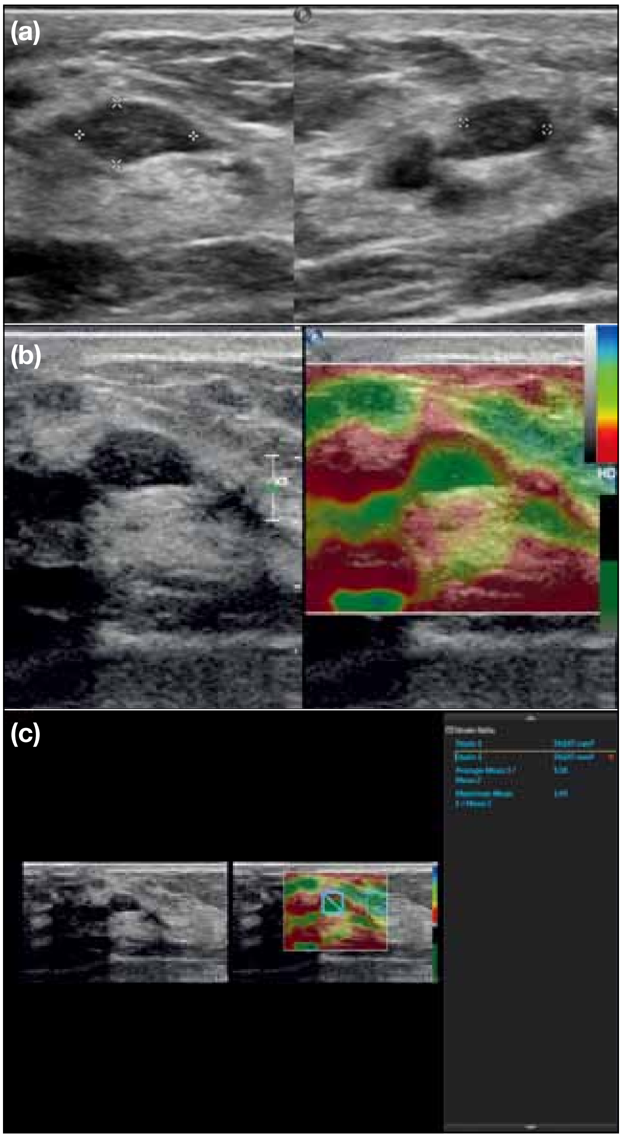

Figure 2. Fibroadenoma. (a) B-mode ultrasonography. An oval parallel hypoechoic nodule with circumscribed margin, Breast Imaging Reporting and Data System (BI-RADS) category 3 based on conventional B-mode ultrasound findings. (b) Strain elastography. The entire lesion was shaded in green, as was the variegated shading of green in the surrounding breast tissue. Elasticity score was 1. (c) Gland/lesion strain ratio was 1.38, lower than the optimal cut-off of 2.62 in our study. Modified BI-RADS category 3 was concluded based on the equation of 3-1-1 = 1 (<3 was taken as 3), ie, modified BI-RADS category 3. Elastography parameters were in keeping with the benign pathology.

Statistical Analysis

Statistical analysis was performed using SPSS (Windows version 19.0; IBM Corp, Armonk [NY], United States) and ROC curve analysis was done with MedCalc 18.2.1 (MedCalc Software, Ostend, Belgium). Mann-Whitney *U* test was performed to compare the median between benign and malignant lesion groups. The area under the ROC curve (Az), optimal cut-offs, specificity and sensitivity of the four tested parameters: (1) GLR; (2) elasticity score; (3) BI-RADS categories; and (4) modified BI-RADS categories were determined using ROC curve analysis. A significance level at p value of 0.05 was used for the statistical analyses.

Table 1. Histological results and occurrence (n = 154).

Histological result	Occurrence, No. (%)
Benign	
Fibroadenoma/fibroadenomatoid changes	50 (32.5%)
Non-proliferative fibrocystic change	6 (3.9%)
Proliferative fibrocystic change	10 (6.5%)
Intraductal papilloma	6 (3.9%)
Adenosis	2 (1.3%)
Sclerosing adenosis	1 (0.6%)
Fat necrosis	1 (0.6%)
Fibroadipose tissue	1 (0.6%)
Lactational change	2 (1.3%)
Atypical ductal hyperplasia	1 (0.6%)
Lobular carcinoma in situ	1 (0.6%)
Malignant	
Mucinous carcinoma	2 (1.3%)
Metaplastic carcinoma	1 (0.6%)
Encapsulated papillary carcinoma	1 (0.6%)
Ductal carcinoma in situ	10 (6.5%)
Invasive ductal carcinoma	53 (34.4%)
Invasive lobular carcinoma	4 (2.6%)
Malignant phyllodes tumour	1 (0.6%)
Lymphoma	1 (0.6%)

RESULTS

The age of the included patients ranged from 24 to 88 years, with a mean age of 55.5 ± 14.7 years. The size of the lesions ranged from 0.5 cm to 4.7 cm, with a mean size of 2.4 ± 1.0 cm. Among the 139 lesions, 71 were benign (51.1%) and 68 were malignant (48.9%). Thirteen lesions had more than one histological diagnosis, giving a total of 154 histological diagnoses. The commonest benign pathology was fibroadenoma/fibroadenomatoid change (50/154, 32.5%) while the malignant counterpart was invasive ductal carcinoma (53/154, 34.4%). The histological diagnoses are detailed in Table 1.

GLR was not significantly different between benign and malignant lesions of <1 cm (p = 0.088; Table 2). Therefore, all lesions >1 cm (n = 38) were excluded from subsequent ROC curve analysis.

In the remainder of the lesions (n = 101), 63 lesions were 1 to 2 cm in size and 38 lesions were >2 cm in size. The median GLR and elasticity score were significantly lower in benign lesions than in malignant ones. Benign lesions were also graded lower BI-RADS and modified BI-RADS categories than were malignant lesions ($p < 0.05$; Table 2).

Using ROC curve analysis, the Az were 0.852 for GLR, 0.926 for elasticity score and 0.827 for BI-RADS. Taking an optimal GLR cut-off at 2.62 for differentiation of benignity and malignancy yielded sensitivity of 84.5% and specificity of 81.4%. The optimal cut-off of elasticity score was 3.5, giving sensitivity of 93.1% and specificity of 81.4%. With these two cut-off thresholds, the ROC curve of modified BI-RADS was plotted, yielding Az of 0.906. Elasticity score showed significantly higher Az than GLR as well as BI-RADS ($p < 0.05$; Figures 3 and 4). Modified BI-RADS also showed higher Az than BI-RADS ($p < 0.05$; Figure 5). Taking BI-RADS category

Table 2. Elastography parameters by lesion size groups in comparison with histological assessment.

Elastography parameter	Lesion size, median (interquartile range)		
	<1 cm	1-2 cm	>2 cm
Strain ratio			
Histologically benign	1.59 (1.26-2.23)	1.50 (1.12-2.44)	1.91 (1.35-2.67)
Histologically malignant	2.32 (1.65-2.64)	3.71 (2.85-5.66)	4.11 (3.23-5.66)
p Value*	0.088	<0.001	<0.001
Elasticity score			
Histologically benign	2.00 (2.00-4.00)	2.00 (2.00-3.00)	2.00 (2.00-3.00)
Histologically malignant	4.50 (4.00-5.00)	5.00 (4.75-5.00)	5.00 (4.00-5.00)
p Value	<0.001	<0.001	<0.001

* Mann-Whitney *U* test.

4 and above as optimal cut-off for defining malignancy, BI-RADS and modified BI-RADS have sensitivity of 100% and 94.8%, respectively, and specificity of 44.2% and 83.7%, respectively (Table 3).

DISCUSSION

Breast US elastography has gained wide acceptance as an adjunctive assessment tool in addition to conventional B-mode US. Current major guidelines on breast US elastography suggest the use of FLR as a semi-quantitative assessment[13,14] which is often impractical in our population. Our data suggests that GLR alongside with elasticity score are useful adjuncts in differentiating malignant from benign lesions with size of ≥1 cm. Yet, GLR for smaller lesions of <1 cm were not shown to be significantly different between malignant and benign pathologies in our cohort. This finding is different from other previous studies using FLR which showed both strain ratio and elasticity score were significantly different between malignant and benign groups in lesions of <1 cm.[5,15] It is uncertain whether the use of GLR in our study could have contributed partly to such difference from prior study results. However, in an earlier study on GLR in Chinese population by Zhi et al,[16] it was found that small lesions of ≤1 cm showed high Az of 0.973 in ROC curve analysis, yielding high sensitivity of 95.7% and specificity of 91.6%. Zhi et al[16] also reported no significant difference in diagnostic performance between GLR and elasticity score for this small lesion size group. This is discordant with our finding that elasticity score was significantly different between benign and malignant pathologies while GLR was not in this size group.

The optimal cut-off of GLR in this study was 2.62, which yielded a sensitivity of 84.5% and specificity of 81.4%. Different studies reported inconsistent optimal cut-off values, for instance, 1.54 by Zhou et al,[17] 3.05 by Zhi et al,[16] and 3.06 by Zhao et al.[18] Our cut-off is an intermediate one among these values. ROI discrepancy could contribute partly to the difference. In those studies, the lesion in the imaged plane was contoured as the lesion ROI and the ROI of reference glandular tissue was of a different size drawn manually. In the present study, we included the hardest portion of the lesion as lesion ROI and an ROI box of the exact same size was used as the ROI of reference glandular tissue. The divergent practice in ROI measurement was related to the technical consideration in practice. In our US system, reference tissue ROI should be drawn first, and an identical ROI box would be generated by the machine for selecting the lesion. It was therefore not possible to accurately include the entire lesion using the ROI box as it would be difficult to imitate the shape of the lesion accurately when the ROI box was first drawn in the neighbouring reference tissue. For the other studies using different US systems, although the ROI boxes for lesion and reference tissue were drawn separately, large lesions could not be matched with an ROI box of an equivalent size for the reference tissue because of the finite elastography field-of-view. As such, they resorted to measurement using ROI boxes of different sizes for lesion and reference tissue. The strain ratios in these different studies should therefore not be treated as equivalent.

Another factor that could contribute to the different optimal cut-off values among these studies is the inherent limitation of strain elastography as being operator dependent. Strain elastography requires compression either exerted manually or indirectly from patients' respiration, which varies between operators/patients. It was shown in previous observer study that even though there was moderate-to-substantial agreement for interpretation of static elastography image, the agreement was only fair for hands-on performance of real-time elastography among various operators.[19] Although being a semi-quantitative and supposedly more objective method of assessing lesion elasticity, strain ratio in our particular study could differ from other studies due to the additional step of selecting the hardest portion of the lesion to include as the lesion ROI for strain ratio calculation based on visual assessment of real-time elastography whereas the other studies did not require this step. This implied that individual variation in scanning technique could affect the result of real-time strain elastography and subsequent strain ratio calculation. The optimal cut-off values from various other studies are thus not directly translatable across to our study setting.

An approach similar to our ROI measurement but using FLR had been studied previously by Ikeda et al,[20] who coined the term "maximum-FLR (max-FLR)". Ikeda et al[20] speculated that contouring the entire lesion in the imaged plane as lesion ROI could underestimate the stiffness of the lesion due to tumour heterogeneity as components thereof (eg, cystic necrosis, infiltration to normal surrounding tissue, etc.) may show lower stiffness. On the contrary, focal stiff area within a relatively soft lesion may be a malignant focus (eg, ductal carcinoma in situ within fibroadenoma[21]) and strain ratio may again be underestimated by contouring the entire lesion. Our data showed relatively lower sensitivity at various strain ratio cut-off as compared with the findings by Ikeda et al[20] (Table 4). This is also concordant with previous study comparing FLR and GLR by Zhou et al,[17] which underlined better diagnostic performance with the former ratio in terms of higher sensitivity.

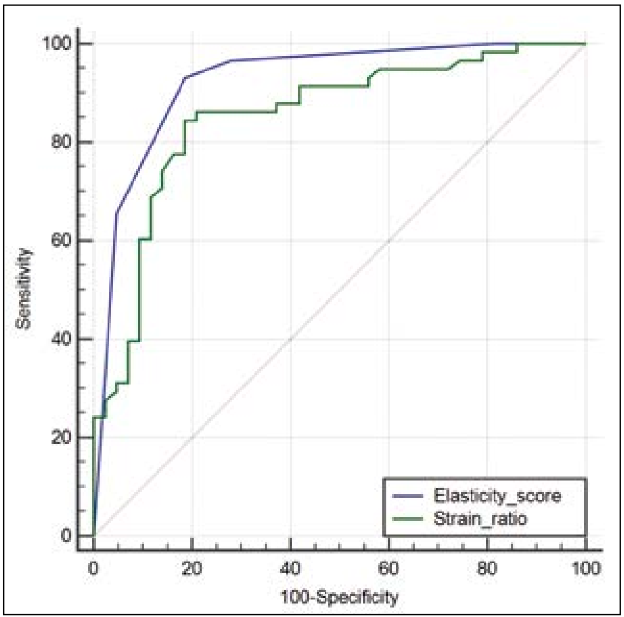

Figure 3. Receiver operating characteristic curves for elasticity score and gland/lesion strain ratio (GLR). Area under the receiver operating characteristic curve was significantly higher for elasticity than for strain ratio (difference = 0.0734, 95% confidence interval = 0.00267 to 0.144, $p < 0.05$).

The sensitivity of BI-RADS was higher than that of both elastography parameters in our study whereas specificity was lower. Concordant findings had been reported in the literature.[15,22-27] After coupling with elastography parameters, we observed an overall increase in specificity of BI-RADS from 44.2% to 83.7%, such an impact was also reported in the literature[15,22,25,26]; however, sensitivity decreased from 100% to 94.8%. In our cohort, a total of 21 lesions were downgraded from BI-RADS category 4 to 3, three of these lesions were malignant in histological evaluation, giving rise to overall malignancy rate of 7.7% (3 of 39) for modified BI-RADS category 3. This is unfortunately higher than the risk of malignancy for BI-RADS category 3, suggesting that it would be more prudent to use elastography for upgrading lesions instead of downgrading them. A total of 32 lesions were upgraded, either from BI-RADS category 3 or 4 to 5, 27 (84.4%) of them were malignant while 5 (15.6%) were benign. There was an overall trend of dichotomisation of BI-RADS categories after incorporating elastography, mainly due to up- or downgrading BI-RADS category

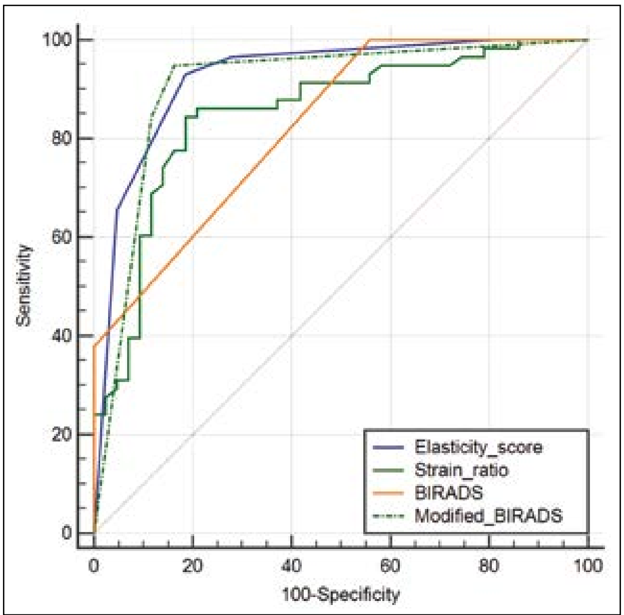

Figure 4. Receiver operating characteristic curves for Breast Imaging Reporting and Data System (BI-RADS), elasticity score, gland/lesion strain ratio and modified BI-RADS. Apart from significant differences in Az between elasticity score and strain ratio as well as BI-RADS and modified BI-RADS, Az of elasticity score was also significantly higher than BI-RADS (difference in Az = 0.0990, 95% confidence interval = 0.0232 to 0.175, $p < 0.05$).

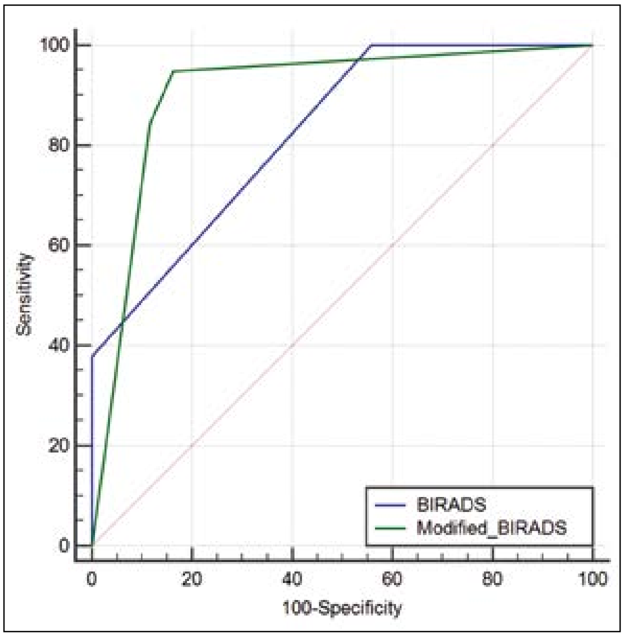

Figure 5. Receiver operating characteristic curves for Breast Imaging Reporting and Data System (BI-RADS) based on conventional B-mode ultrasound (US) and modified BI-RADS after incorporating US elastography. Area under the two receiver operating characteristic curves was significantly higher for modified BI-RADS than for BI-RADS (difference = 0.0796, 95% confidence interval = 0.00416 to 0.155, $p < 0.05$).

Table 3. Overall sensitivity, specificity, PPV and NPV of various parameters (excluding lesions <1 cm).

	Sensitivity	Specificity	PPV	NPV	Accuracy
BI-RADS	100% (93.8%-100%)	44.2% (29.1%-60.1%)	70.7% (59.5%-80.0%)	100% (79.1%-100%)	76.2% (66.7%-84.1%)
Gland/lesion strain ratio	84.5% (72.6%-92.7%)	81.4% (66.6%-91.6%)	86.0% (76.5%-92.0%)	79.6% (67.7%-87.8%)	83.2% (74.4%-89.9%)
Elasticity score	93.1% (83.3%-98.1%)	81.4% (66.6%-91.6%)	87.1% (78.3%-92.7%)	89.7% (77.1%-95.8%)	88.1% (80.2%-93.7%)
Modified BI-RADS	94.8% (85.6%-98.9%)	83.7% (69.3%-93.2%)	88.7% (79.9%-94.0%)	92.3% (79.8%-97.3%)	90.1% (82.5%-95.2%)

Abbreviations: BI-RADS = Breast Imaging Reporting and Data System; NPV = negative predictive values; PPV = positive predictive value.

Table 4. Sensitivity and specificity of elastography at each cut-off level for differentiation of benign and malignant breast lesions.

Strain ratio cut-off level	Sensitivity	Specificity
1.0	98.3%	18.6%
2.0	87.9%	58.1%
3.0	77.6%	83.7%
4.0	46.6%	90.7%
5.0	31.0%	95.3%
6.0	19.0%	100%

4 lesions so that the number of lesions in this category dropped from 60 to 8. This could have potential impact in providing stronger evidence to suggest biopsy in patient counselling, especially for the setting wherein lesions were upgraded to modified BI-RADS category 5 that would otherwise be categorised as BI-RADS category 4 without elastography.

Limitations

Our study had several limitations. Firstly, the retrospective nature and relatively small sample size were major drawbacks. Secondly, we did not examine the effects of inter-observer and intra-observer variability in performing US elastography. This could potentially affect the accuracy of our results and translatability of the result across different operators. Thirdly, the lack of blinding of the radiologists to the clinical and mammographic findings of the patients could have introduced bias in performing and interpreting US elastography. The effect should be insignificant as the radiologists followed a standard protocol in performing elastography. Further, we did not account for the factors that could affect GLR (such as breast density, lactation, phase of menstrual cycle, etc)[17,28] and overall quality of elastography (such as breast thickness at the location of the lesion).[29] Additionally, the various commercially available elastography techniques in clinical use are developed with specific algorithms pertinent to that vendor. The current study only attempted to evaluate one of these techniques and the results thus produced may not be construed as universal standard across different vendor-specific techniques.

Despite these limitations, our study proposes a different approach to strain ratio in elastography that takes into account of the distinct biologic profile in terms of breast density and breast volume pertaining to Chinese women, providing a solution for the practical difficulty arisen thereof in performing breast elastography. Our findings could serve as local data of reference in applying strain elastography and, in particular, an optimal cut-off for GLR in Chinese population.

CONCLUSIONS

Strain elastography is a promising and non-invasive technique that may potentially help further characterise breast lesions and improve diagnostic confidence. The use of GLR cut-off at 2.62 showed reasonable diagnostic performance in our cohort for lesions of ≥1 cm. Coupling with GLR and elasticity score, BI-RADS assessment could be modified to yield better diagnostic accuracy, which helps streamline the management that follows. Breast radiologists should therefore familiarise themselves with US elastography and apply it in their day-to-day practice.

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