Pictorial essay

Medical Ultrasonography
2008, Vol. 10, no. 2, 93-98

Artifacts and pitfalls in breast elastoultrasonography: a pictorial essay

Anca I. Ciurea[1], Dana Dumitriu[1], Cristiana Ciortea[2], Carolina Botar-Jid[1], Sorin M. Dudea[1]

[1] "Iuliu Haţieganu" University of Medicine and Pharmacy Cluj-Napoca, 400023 Cluj-Napoca, Romania
[2] Clinical Emergency County Hospital, 400006 Cluj-Napoca, Romania

Abstract

Elastography allows real-time strain image visualisation using a free-hand probe with concurrent conventional B mode imaging. It has various applications, mainly in prostate, pancreatic cancer, the thyroid and the breast [1, 2]. In the breast, it appears to be useful in BI-RADS 3 and 4 lesions in which it reduces the number of benign biopsies [3, 4].Studies published until now have been focused on the sensitivity and the specificity of the method, with special attention on the beneficial role of elastography in the reduction of the number of percutaneous biopsies. To the best of our knowledge there has been no study regarding the technique itself, how it should be performed and what the repercussions of an inadequate technique on the final elastographic score in breast pathology would be. The purpose of this paper is to present the technical factors and/or lesion characteristics which influence the elastographic examination and the final elastographic score in breast nodules.

Key Words: breast, elastography, artifacts.

Introduction

Elasticity is an intrinsic property of the tissues, which suffers changes in different conditions, such as ageing, inflammation or presence of malignant cells.

Several *in vitro* and clinical studies have already shown that elastography can be a useful tool in the diagnosis of breast lesions [3]. Elastography is, at present, used not as a stand-alone imaging method for the detection of breast lesions, but complementary to mammography and B-mode ultrasound, for a better characterisation of focal breast lesions.

In different studies, breast elastography has a sensitivity ranging between 62.5 and 94 % and a specificity between 83 and 100% [5,6]. Even if the elastographic examination is easy and quick to perform, one should be aware that several factors, related to the technique, as well as to the lesion characteristics may influence the final elastographic score.

During April - October 2007, over a 7 month interval, 164 patients were examined with elastography in the Radiology Departament of the Clinical Emergency County Hospital Cluj-Napoca. All patients were examined by B-mode ultrasound followed by Doppler ultrasound and elastography, using a 13 MHz probe, on a Hitachi EUB 8500 scanner.

During the examination a standardized protocol was used, in order to determine which factors would most affect the outcome of the examination. The reference standard for the study was the pathologic diagnosis obtained by fine needle aspiration biopsy, core biopsy or final pathology report after surgical excision. In cases of BIRADS 3 lesions the patients underwent short term follow-up (4-6 months).

We found that several factors regarding the technique itself as well as certain characteristics of the lesions influenced the final elastographic score.

Type of section

Lesions with elasticity scores of 1-3 (benign lesions) were not significantly influenced by the type of section (sagittal or transverse). However, most of the lesions which had a score of 4 or 5 on one section (malignant lesions) had a lower score on the other section (fig 1a,b). The section on which the score was more correct was not always the same: in some cases we obtained the correct score on the sagittal view and in some on the transverse view.

Address for correspondence: Anca Ciurea, Radiology Department, Clinical Emergency County Hospital, Str Clinicilor Nr 1-3, 400006, Cluj-Napoca, Romania
e-mail: ancaciurea@hotmail.com

Size of the region of interest (ROI)

The size of the region of interest (ROI) was very important for a correct evaluation of the score. When suspected benign lesions were examined (score 1-3), changing the ROI did not alter the elastographic score (fig 2a,b). Stiff lesions, with elasticity very different from that of the healthy surrounding breast (scores 4 or 5), appeared softer if a small ROI (limited to the size of the lesion) was used instead of a large one (fig 3a,b).

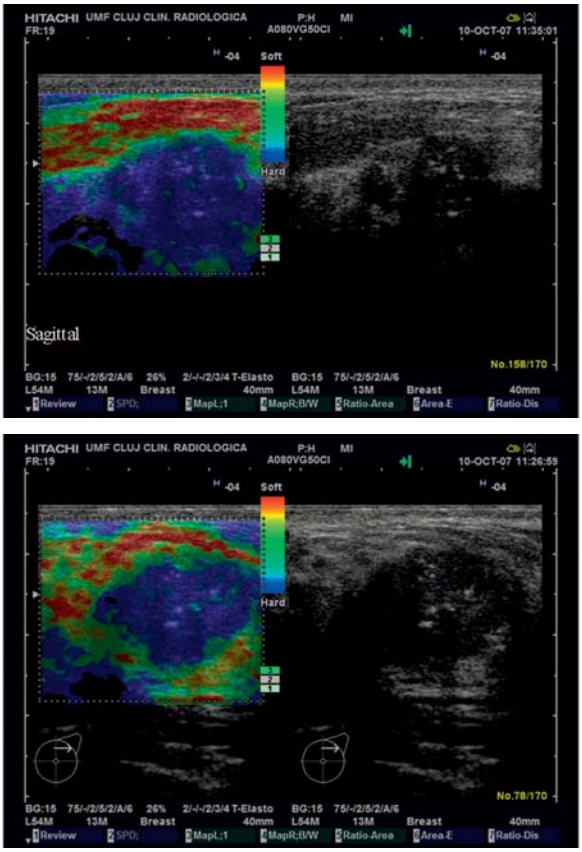


Fig. 1. Malignant lesion (invasive ductal carcinoma) with a score of 5 on the sagittal section (a) and a score of 3 on the transverse section (b).

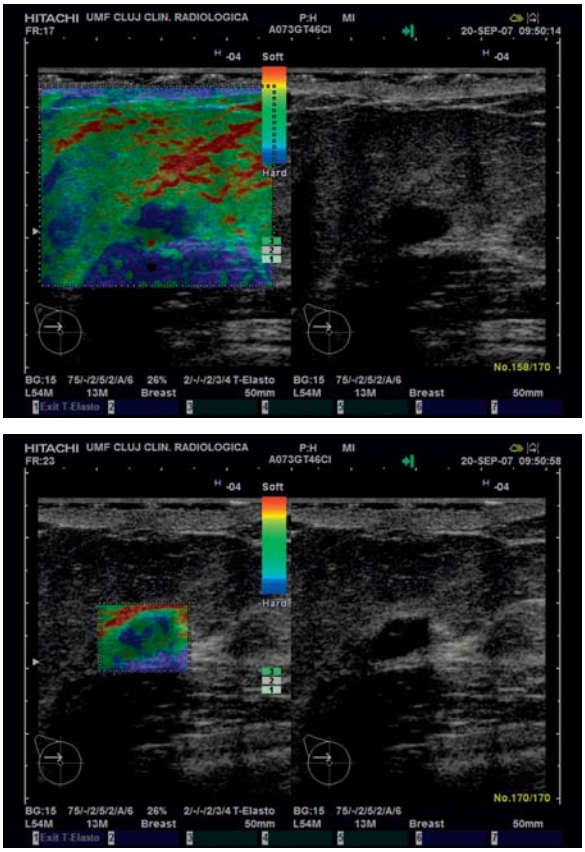


Fig. 2. Benign lesion (fibroadenoma) examined with a large (a) and a small (b) ROI. On both images the Ueno score is suggestive for the benign nature of the lesion (score 2).

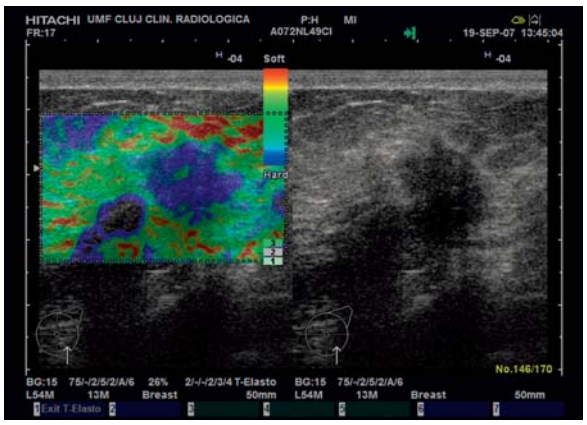


Fig. 3. Malignant lesion (invasive ductal carcinoma) examined with a large (a) and a small (b) ROI. When examined with a large ROI the Ueno score is 4, suggestive of malignancy while with a small ROI, the score is two, suggesting a benign lesion.

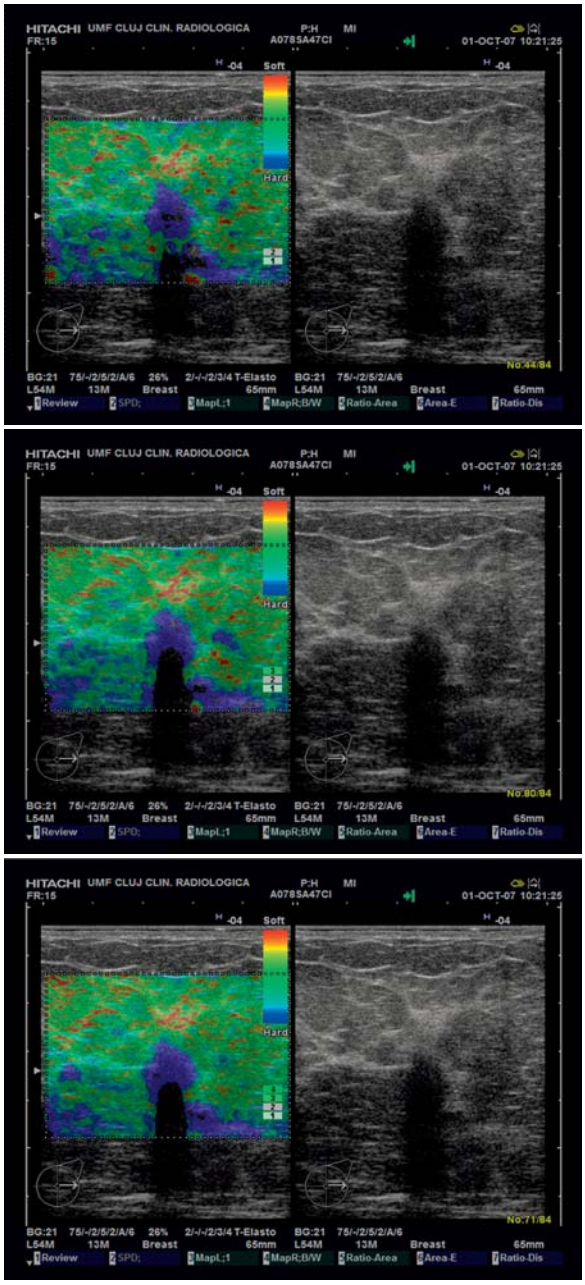


Fig. 4a-c. Malignant lesion (invasive ductal carcinoma) examined with different degrees of compression (2,3 and 4 on the compression scale of the Hitachi machine) but with the same elastographic score.

Compression

However, changing the frequency and amplitude of movement (graded from 1-6 on the "quality" scale displayed by the machine) did not alter the aspect of the lesion whether it was benign or malignant (fig 4a-c),

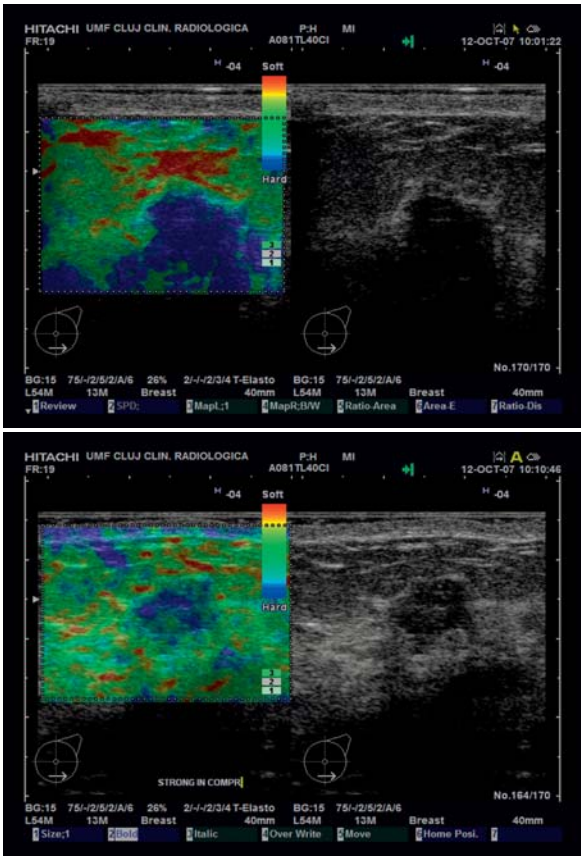
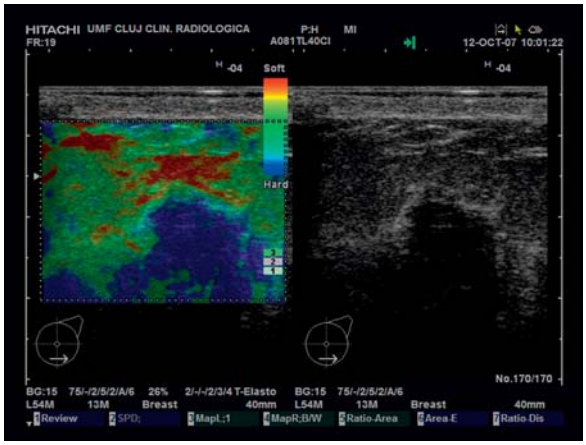


Fig. 5. Invasive ductal carcinoma, examined with light initial compression on the skin in the beginning of the examination (score 5 – malignant lesion). When applying a strong initial compression, the score changes (b).

while the degree of initial compression did significantly influence the elastographic score. Applying a strong initial compression with the transducer on the skin at the beginning of the examination, decreased the elasticity score for the lesions with a score of 4 or 5 (fig 5a,b). If a strong compression was applied in the course of the examination (frequency and amplitude), the main artifactual effect was the displacement of the lesion out of the region of interest, which secondarily altered its elastographic score and size.

Angulation of the transducer

When comparing the image of lesions with a high elasticity score (4, 5) on sections that were strictly perpendicular to the lesion with those obtained after angling the transducer, there was a decrease in the elasticity score and a softer appearance of the lesions (fig 6a,b). Note that the lesions with a score of 1 or 2 on the perpendicular sections did not seem harder with the angulation of the transducer, but maintained their original score.



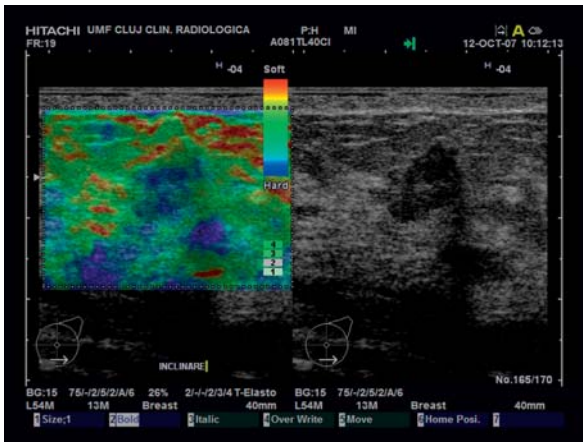


Fig. 6. Same lesion as in fig 5 (a). Angling the transducer during the examination also produces an inadequate assessment of the score (b).

Characteristics of the lesions

As far as the characteristics of the lesions are concerned, it was easier to estimate the correct score for small lesions, which were surrounded by a large quantity of healthy tissue, than for large lesions which occupied the entire ROI (fig 7 and 8).

Also, the score was more accurately evaluated for superficial lesions than for deeper-located ones. It is important to underline that the depth of a lesion should be evaluated taking into account the size of the breast. At the same distance from the skin, the elasticity of a lesion is easily correctly evaluated in a big breast but in a small breast, if the lesion is located in the vicinity of the stiff structures of the chest wall, the artifacts that occur would make the recording of useful elastographic information difficult (fig. 9 and 10).

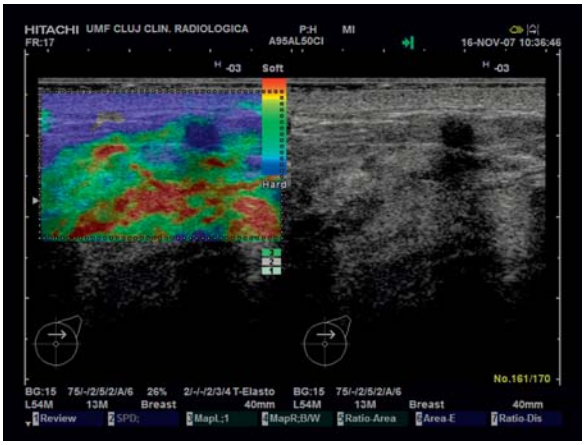


Fig. 7. Small lesion (invasive ductal carcinoma) in which the score is accurately evaluated.

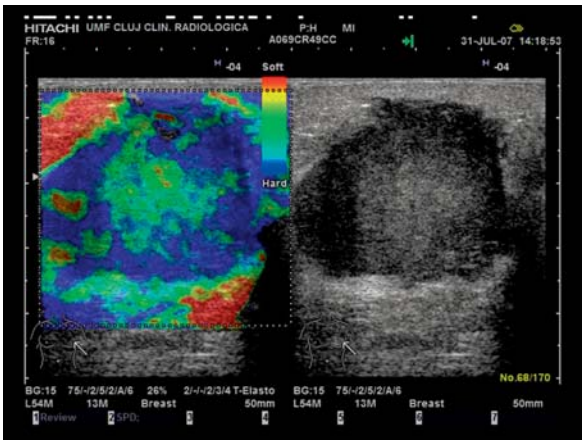


Fig. 8. Large lesion, occupying the entire ROI, in which the score is inadequately evaluated (score of 2, suggestive of benign lesion).

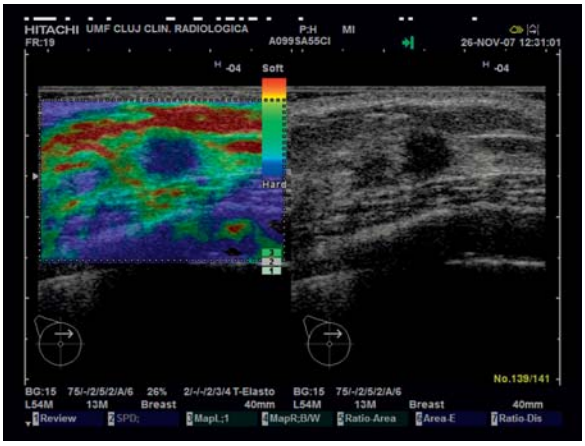


Fig. 9. Superficial malignant lesion, in which the score is correctly estimated (score 5).

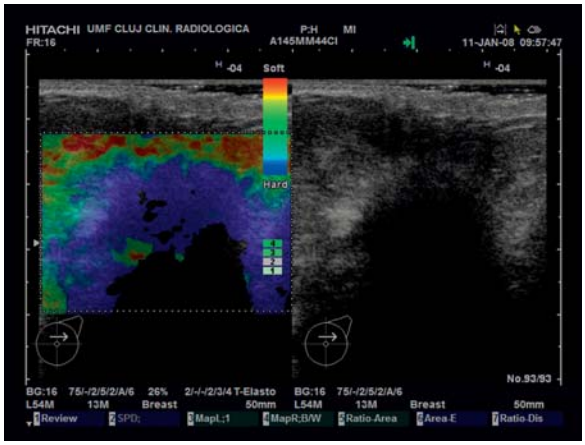


Fig. 10. Malignant lesion, located in the vicinity of the chest wall, in which the evaluation of the elastographic score is more difficult compared with fig 9.

Discussion

Several observations resulting from this study are important not only when examining the breast, but in every situation where elastography is applied.

The general recommendation is that the transducer should be in very light contact with the skin at the beginning of the examination, because, over a certain degree of compression, pressure and strain are no longer proportional [7]. Comparing the images obtained with different degrees of initial compression, the conclusion is that a strong initial compression changes the Ueno score [5] in the case of stiff lesions, leading to false negative results.

From the technical factors that influence the final elastographic score, the ROI seems to be the most important one. In the study performed by Itoh and Ueno [5], the authors defined a ROI with lateral margins that were 5 mm away from the lateral limits of the lesion on both sides. Because elastography measures the relative strain within the ROI, a ROI limited to the lesion or not exceeding 5 mm around it would not allow a correct estimation of the elasticity. When the examination was performed with a "small" ROI, the score was lower in almost all of the stiff lesions (with an elasticity score of 4 or 5). Therefore, the ROI should be as large as possible: in depth, from the subcutaneous tissue to the pectoralis muscle and in width it should occupy the entire screen. In the case of hard malignant lesions, if there is not enough surrounding healthy tissue for a correct comparison, the elasticity score will be underestimated.

However, in benign lesions (lesions with an elastographic score of 1 or 2) the elasticity score is not influenced by the size of ROI because the strain is similar in the lesion and in the rest of the breast.

Another factor which influences the elasticity score is compression during the examination. Regarding the compression, this has two components: the initial compression, applied on the skin with the transducer at the beginning of the examination and the amplitude and frequency of movements during the examination. The two last factors are quantified on the elastographic image on a scale from 1 to 6. While frequency and amplitude of movement do not significantly alter the score, applying a strong initial compression will decrease the elasticity score in lesions with a score of 4 or 5, leading to false negative results. As explained above, this is due to the fact that, when there is strong initial compression, the relationship between pressure and strain is no longer linear [7]. Therefore, too much initial compression should be avoided.

However, it was worth noting that no matter what degree of pressure was used during the examination (as measured on the machine scale), the elasticity score remained unchanged. In other words, if enough pressure was used to actually obtain an elastographic image, the score remained unchanged as long as the pressure was maintained within the six degrees of compression as assessed on the machine scale. Also, if stronger compression was used during the examination, the lesion was frequently pushed outside the ROI and the estimation of elasticity was no longer reliable.

The angle between the scan plane and the skin surface also proved to be very important. Whenever the transducer was angulated instead of being maintained strictly perpendicular to the skin, the elasticity score became lower. This was only observed in malignant masses with a score of 4 or 5 on the perpendicular sections. Angling the transducer changes the pressure applied on the lesion with consequences on the relative strain, which will no longer be measured accurately.

In relation to this, as shown above, the score can be different on sagittal and transverse sections. In this case, both types of sections should be analysed and the highest score should be taken into consideration.

As far as the characteristics of the lesion are concerned, in several cases it was difficult to estimate the elasticity correctly when the lesion was very large. This observation is related to the one concerning the size of the ROI: when a lesion is large (occupying the entire ROI) and there is little or no surrounding healthy breast tissue for comparison, the elasticity score may be inaccurate.

The deeper a lesion is located, the more difficult it is to obtain a correct score. The depth should be estimated in relation to the size of the breast itself and not as just the distance between the transducer and the anterior margin of the lesion. In other words, if a lesion is deeply located in a small breast and it comes in contact with the chest wall,

the elasticity score is more difficult to appreciate than for a mass that is located in a large breast at the same distance from the transducer, but away from the stiff structures of the chest wall. The difficulty in correctly appreciating the score in deep-located lesions is due to the artifacts that appear when the lesions are in the vicinity of stiff structures.

One important observation during the examinations was that, in the case of soft masses (score 1 or 2), no matter how the examination was performed, the lesions did not appear harder than they really were. Therefore, it can be concluded that there is no technique-related risk of overestimating the elasticity score of benign lesions. However, there is an important risk of underestimating the stiffness of a malignant lesion if the examination is not performed according to a certain standard.

Conclusion

Elastography is a useful tool in the noninvasive diagnosis of breast lesions, but it needs specific training, as well as acknowledging technical and pathological factors which may influence it.

The most important factors that influence the final elastographic score are the ROI, the initial compression and the angulation of the transducer, while the frequency and amplitude of movement during the examination are less important.

All these factors influence the results only in cases of malignant lesions, with an elastographic score of 4 or 5 while lesions with a score of 1 or 2 remain unchanged, no matter how the examination is performed. Therefore, an incorrect technique will lead to false negative results.

Large lesions will be classified inappropriately if they occupy the entire ROI because there is insufficient surrounding healthy tissue. If the lesions are located near the stiff structures of the chest wall, the evaluation of the elasticity score will be more difficult.

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