Research article

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Role of elastosonography in the differentiation between benign and malignant neoformations of the breast and possibility of reducing the number of FNACS for tissue characterization

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Abstract

Introduction. Background The aim of the paper is related to our experience defining the diagnostic accuracy of breast elastosonography.

Objective. The aim of our study is therefore to define the diagnostic accuracy of breast elastosonography in the differential diagnosis of nodular breast neoformations to improve the characterization of the solid lesion and reduce the number of needle aspiration unnecessary for benign formations.

Material and methods. A total of 88 patients were enrolled, who came to the Department with an ultrasound diagnosis of a breast lesion. Each lesion was subjected to mammography and B-mode ultrasonography with an evaluation of size, echogenicity, and vascularization presence or absence. The use of the ultrasound machine and the respective probe has made it possible to make the measurements. All nodules were subjected to ultrasound-guided FNAC. These data were compared with the results of elastosonographic examination.

Results. FNAC results were as follows: CIN 1 in 18 nodules, CIN 2 in 22 nodules, CIN 3 in 36 nodules, CIN 4 in 6 nodules, and CIN 5 in 6 nodules. The sensitivity and specificity of elastosonography found in our case series reported values in line with data reported in the literature, confirming the method's high reliability.

Conclusions. The elastosonography could become a complementary technique to mammography and ultrasonography in the future, reducing the costs and risks of additional examinations. Therefore, we believe it is essential to contribute with this additional finding to increasingly accredit this pathway and reduce the discomfort to patients of more invasive methods. ***Clin Ter 2021; 172 (4):305-314. doi: 10.7417/CT.2021.2334***

Key words: *elastosonometry, breast cancer, FNAC*

Introduction

Breast cancer is one of the most common cancers worldwide and has a meaningful social impact. Besides being the most frequent malignant tumor in women, it represents the first cause of death in women under 50 years of age.[1] On a worldwide level, it is mainly diffused in North America and Western Europe, with a lower incidence in Africa and Asia. This distribution is due, in all probability, to industrial development and the resulting lifestyle and in particular to the dietary habits that characterize the populations in industrialized countries where cancer is widespread. In Italy, the incidence of breast cancer is equal to 27,000 new cases/year (27% of all female cancers), and it is responsible for about 11,000 deaths/year (18% of all deaths from cancer), with a probability of women to fall ill with this disease equal to 1/13. The incidence typically has two peaks: the first is around 50 years of age, and the second is around 70. The incidence varies between North and South, resulting in more industrialized cities such as Genoa (142/100,000 cases) than that of southern cities such as Ragusa (64/100,000 cases).[2,3] Among the main risk factors, in addition to the environment and dietary habits of the woman, including age (the risk of finding breast cancer increases at the age of 50 years and 70 years of age);

Familiarity and heredity (i.e., first degree relatives affected by breast cancer or syndromes associated with it); previous breast disease; peri-menarcheal and peri-menopausal period: the higher frequency of anovulatory cycles, according to the "estrogen window" theory, would expose the breast to a more prolonged estrogenic stimulation, and the presence of shorter menstrual cycles, according to the "estro-progestinic" theory, would cause a more prolonged progestinic stimulation on the breast, resulting in a more significant proliferation of the cells that make up the glan-

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dular tissue; early menarche and/or late menopause: a more significant number of menstrual cycles assumes increased hormonal stimulation; reproductive history: age of first pregnancy (with protection conferred if the woman has her first pregnancy at an age younger than 18 years);

1. number of pregnancies (with protection conferred if the number of pregnancies exceeds 10);
2. prolonged breastfeeding (a factor that appears to be protective, with opinions still conflicting);

- oral contraceptives;
- hormone replacement therapy in the menopausal period (a factor that would increase the risk, particularly in women with a family history or history of previous breast disease).

The aim of our study is therefore to define the diagnostic accuracy of breast elastosonography in the differential diagnosis of nodular breast neoformations and to establish its specificity and sensitivity concerning the cytological data taken as "gold standard", to improve the characterization of the solid lesion and reduce the number of needle aspiration unnecessary for benign formations.

Material and methods

The diagnosis of breast cancer

The early diagnosis of breast cancer is carried out thanks to Diagnostic Imaging, adequately integrated with the clinical examination. The methods currently in use, both for the early diagnosis of cancer and its subsequent staging, are Mammography, Ultrasound, Magnetic Resonance Imaging.[4,5] The traditional methods are flanked by new technologies: Tomosynthesis, Contrast-Enhanced Digital Mammography and Elastosonography. The diagnosis of a carcinoma in an early stage (defined as carcinoma in situ and invasive carcinoma <15 mm) is made through first level methods (in particular mammography, with ultrasound integration) and requires histological confirmation. This confirmation represents only the initial step of an adequate pre-operative diagnosis; more detailed information be needed for surgical planning and oncological management.

Cytohistologic diagnosis is achieved through:

1. Fine Needle Aspiration Cytology: allows the study of cells taken by fine-needle aspiration. In some cases, it may not represent a valid aid for a definitive therapeutic choice;
2. Percutaneous biopsy with a 14 G needle (Core Needle Biopsy): allows to obtain micro-histological tissue samples and is a widely used technique;
3. VABB (Vacuum Assisted Breast Biopsy) uses a computer-assisted probe to biopsy non-palpable lesions of the breast previously found through radiological or ultrasound examinations. Radiological or ultrasound examinations. It allows the frustules of tissue to be harvested for histologic analysis. VABB is a minimally invasive surgical technique and can be performed on an outpatient basis. Tissue harvesting is performed by ultrasound, radiographic, or MRI guidance (Magnetic Resonance Imaging). A high level of experience is required to choose which of the sampling mentioned above techniques is useful (depending on the case) to obtain a detailed diagnosis and continue with the subsequent therapeutic procedure and establish the appropriate follow-up. Finally, a systematic correlation between the radiologist and the pathologist is necessary, essential for sample preparation, section analysis, and interpretation of findings.[6]

Experimental study

Real-time Elastosonography (HI-RTE)

Elastosonography is an imaging technique that allows detecting the physical properties of tissue using ultrasound. This new ultrasound method aims to perform a real-time tissue characterization: it is correct to speak of real diagnostic innovation.[7] In recent years, several studies have been conducted using this technique, which has proved particularly useful in characterizing focal and nodular areas of the thyroid,[8,9] in the diagnosis of prostate cancer and the staging of liver fibrosis. Recent studies have also evaluated the application of elastosonography for the characterization of breast lesions.[10-15] The advantages of elastosonography are numerous: the non-invasiveness of the examination guarantees more excellent tolerability by the patient; the speed of execution, as the duration of the examination is a few minutes and generally is performed during the conventional ultrasound examination in a targeted manner on any nodular formations highlighted. Elastosonography is also easy to perform, but its reliability depends on the manual skill and experience of the operator who performs it. This new method represents a significant advantage, especially for the study of small doubtful lesions (5-10 mm), because it allows a better characterization, reducing the number of patients who must continue the diagnostic process using more invasive and traumatic methods (needle aspiration or needle biopsy) and therefore reducing false positives.[16] Tissue characterization has always been a goal of ultrasound diagnostics; however, until now, it was impossible to achieve this goal without using complex off-line analysis systems. The fundamental problem has always been related to the computational power and the analysis capacity required to acquire and manage the very high number of information needed. The new digital platforms allow to integrate directly and in real-time the classical information of B-Mode, CFM/Power, and eventually of the contrast medium with those of elastosonography. Elastosonography is a new method that allows a better tissue characterization without the use of a contrast medium.

This method exploits two basic concepts: there are significant differences in the mechanical properties of the various tissue components; in many pathologies, the elasticity of the tissue is modified in a rather significant way.

In practice, elastosonography highlights with a chromatic scale the changes in elasticity of the structure under analysis. The standard ultrasound probe is used to obtain this, and a vertical compression is applied to the tissue, which can be obtained manually or automatically by the probe if a new transducer is used. A new generation transducer is used. In this way, the tissues undergo a deformation, more or less relevant in relation to their elasticity, returning different

signals. Therefore, the elastosonographic image is the consequence of the analysis of the mechanical/elastic properties of the tissue traversed by the ultrasound. Tissues of different nature have very different mechanical properties and, therefore, when adequately stressed, respond differently.[17] The diversity of elastic coefficients allows differential analysis of the tissues and lesions under examination. Therefore, this method's evaluation of mammary nodules allows quantifying the extent of stiffness or rigidity of the nodule itself concerning the surrounding glandular parenchyma. Our study aims to define the diagnostic accuracy of Elastosonography in the differential diagnosis of nodular breast formations and to establish its specificity and sensitivity about cytological data taken as "gold standard". The elastosonographic study is conducted concurrently with the ultrasound examination. The elastosonographic technique is based on the analysis of radiofrequency (RF) modification from a structure before and after the application of compression on the structure itself.[17,18] Two elastosonographic techniques can be differentiated concerning the type of stimulus used to cause the deformation of the investigated structures: free-hand compression and mechanical compression (shear-wave elastography). The latter operated automatically by the transducer and obtained by the emission of low-frequency RF pulses.[19] Currently, the most used and studied type of elastosonography is the free-hand ultrasound elastosonography in real-time with gradual manual compression utilizing ultrasound transducer. This method, developed mainly by Hitachi elastosonographers (Esaote-Hitachi Medical Systems), has two significant limitations: it only measures relative stiffness and is significantly operator-dependent. These problems have been largely overcome by the most recent Philips Healthcare elastosonographs, which, using mechanical compression mediated by a sequence of RF pulses, measure absolute stiffness and objectify the measurements, making them non-operator-dependent and repeatable. The latter type of elastosonographs also provides a numerical quantitative assessment of tissue stiffness. It has quantitative indices based on the ratio between the values of deformability (Strain Ratio) of two different areas of interest and that, according to recent studies, would improve the accuracy of the method.[20,21,22] Regardless of the method in use, during elastosonographic scanning, the operator employing the probe or the probe automatically exert rhythmic movements of compression and release; the pressure applied during the compression phase must be constant and in the axial direction, perpendicular to the proximal plane of the lesion; lateral movements should be avoided as they can produce artifacts. Other factors that may alter examination results are gross calcifications, out-of-plane displacement of the examined lesion due to compression. The elastosonographic box's size must occupy almost the entire field of view of the transducer for proper analysis of parenchyma-related elasticities. The dual-mode display allows to obtain at the same time on the monitor both the elastosonographic scan and the corresponding B-mode; this is very useful to check in real-time the lesion's position for the scanning plane. The region of interest (ROI) for the elastosonographic calculation is then selected, including the area of the lesion and the surrounding tissue; the ROI must be placed to include sufficient tissue surrounding the lesion since elasticity values are displayed relative to the average deformation within the ROI. The speed and intensity of the compression and release movements, which in the case of manual application must be modulated case by case with the speed and intensity of compression and release movements, which in the case of manual application must be modulated case by case to the depth of the tissues and their consistency, are instead decided automatically by the probe in the most recently introduced machines. Once the images have been acquired, the value of the elasticity distribution is evaluated in post-processing for each pixel, and the histogram of the analyzed tissue's stiffness is calculated on a logarithmic scale using special software. Different elasticity values are indicated with different colors, and the elastosonographic information is shown superimposed on the conventional grayscale image to visualize the tissue elasticity patterns. The system is calibrated on a color shade map (red-green-blue), where stiff tissue areas are marked in dark blue, medium stiffness areas in light blue, intermediate areas in green, medium soft areas in yellow, and soft areas in red.[23-25] Consistency of elastosonographic chromatism over the entire sampling area indicates the right technical quality of examination performance. According to a recent study conducted applying elastosonography for the differential diagnosis of breast neoplasms,[26] based on the color map, it was possible to classify five Elasticity Scores (Fig.2):

- Score 1: the presence of appearance of chromatic three-layer (blue-green-red)
- Score 2: prevalence of green with some inconstant blue dots per site.
- Score 3: predominantly green but containing a few blue spots.
- Score 4: almost entirely blue with some green dots preferably at the periphery
- Score 5: utterly blue with a blue halo peripheral to the nodule.

Score 1 has been associated mainly with liquid forms, score 2 and 3 mainly elastic found in benign forms, score 4 and 5 mainly rigid found in malignant forms. The numerous studies carried out have allowed the compilation of guidelines to be followed for accurate analysis and interpretation of elastosonographic data

A group of Italian experts has completed a multicenter study according to which:

– Elastosonography increases the specificity of ultrasonographic study of circumscribed and small breast lesions;
– The interpretation of the elastosonographic image requires a high knowledge of conventional breast imaging;
– Two elastograms should be performed for each highlighted lesion, each lasting at least 5 seconds, centering the lesion well;
– The pressure applied must be constant and perpendicular to the nodular formation (lateral movements produce artifacts), and the pressure applied must be constant and perpendicular to the nodular formation (lateral movements produce artifacts), and the appropriate compression is evaluated by the "feedback bar" placed laterally to the image.

Elastosonographic acquisition can be considered correctly performed when the color on the lesion's healthy tissue is uniformly distributed.[18] Elastosonography has proven to be

a promising technique to improve the characterization and differentiation between benign and malignant neoformations visualized during an ultrasound examination, with good sensitivity (82%), specificity (87.5%), accuracy (82.2%), NPV (90%), and VPP (64%) (28). The use of elastosonographic Imaging in routine could offer additional information that would complement conventional ultrasound imaging, with the potential to reduce the number of FNACs required for tissue characterization. Also, advances in elastosonographic technology and future studies will likely more clearly establish the clinical impact of elastosonographic Imaging in the differential diagnosis of breast cancer.[26] The study was conducted at the Department of Diagnostic Imaging from September 2018 until June 2019. In the course of this study, the degree of stiffness of breast nodules for which FNACs had been indicated on the basis of ultrasound characteristics was evaluated by means of Elastosonography. A total of 88 patients aged 21-85 years (mean age 51.23) were enrolled, who came to the aforementioned Department with an ultrasound diagnosis of a breast lesion. Only breast formations smaller than 2 cm in diameter were included in the study because larger lesions, showing a high structural inhomogeneity, determine atypical alterations of the elastic coefficient. For each patient, history was collected, and the objective examination was performed. Each lesion was subjected to mammography (in consideration of age) and B-mode ultrasonography with an evaluation of size, echogenicity, and vascularization presence or absence. The elastosonographic examination was performed with a Philips model iU22 ultrasound scanner using a multifrequency linear probe (12-5 MHz), at the same time as the ultrasound examination. Measurements were performed by an Operator with high experience in the echotomographic breast technique. The iU22 ultrasound machine and the respective probe have made it possible to make the measurements repeatable and non-operator-dependent. This equipment obtains the axial compression on the tissues is by the probe, not manually by the operator, as in the use of Hitachi elastosonographs. Therefore, the deformation of the structures under examination was caused by exerting a mechanical compression obtained through the emission of low-frequency RF pulses (Fig.1, 2, 3). Using this method, the total amount of deformation used to process the "strain elastogram" is given by the sum of the patient's intrinsic or physiological movements, and the transducer's external compression. During the examination, the system calculates the resulting tissue strain levels, displaying them in the form of a green and gray bar ("feedback bar") at the side of the image, indicating an appropriate (green) or inappropriate (gray) tissue strain for obtaining a good quality elastogram. The bar indicates the instantaneous tissue strain, not the final tissue strain. If the amplitude of the deformation is excessive, the system does not show the corresponding elastosonographic image. The "dual" mode display allows obtaining on the monitor simultaneously both the elastosonographic scan and the corresponding B-mode (Fig. 4). The chromatic

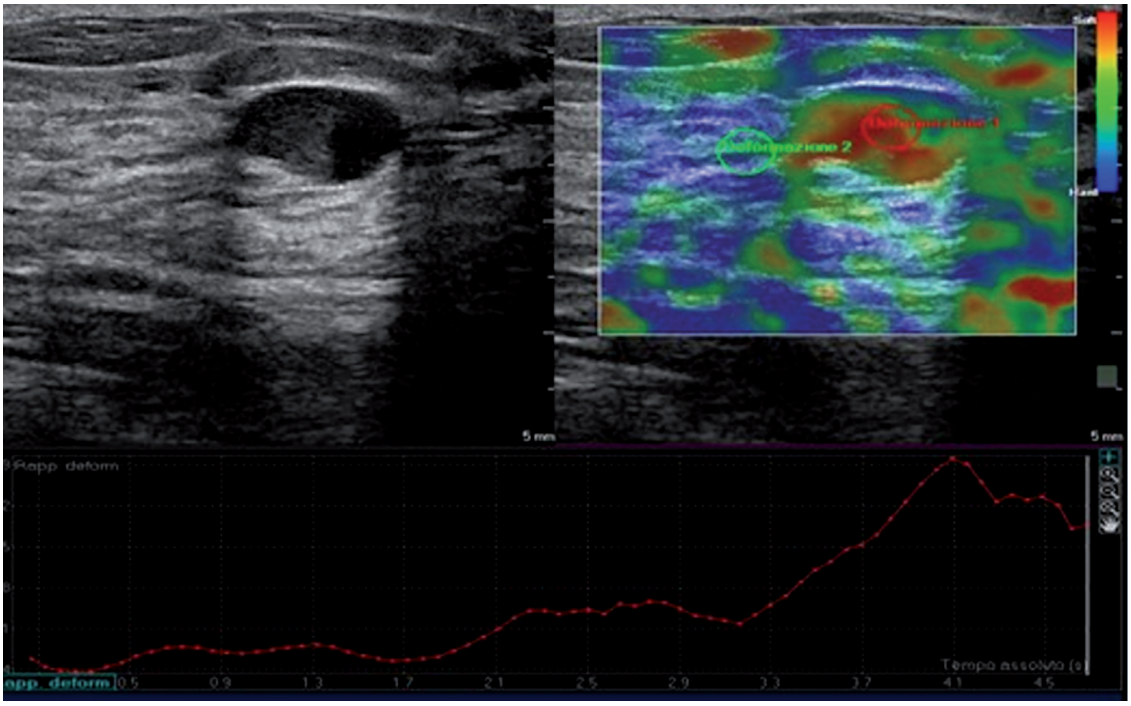

Fig. 1 Score 1: The presence of colorimetric tristratified appearance (blue-green-red) at elastosonographic evaluation typical of cystic formations.

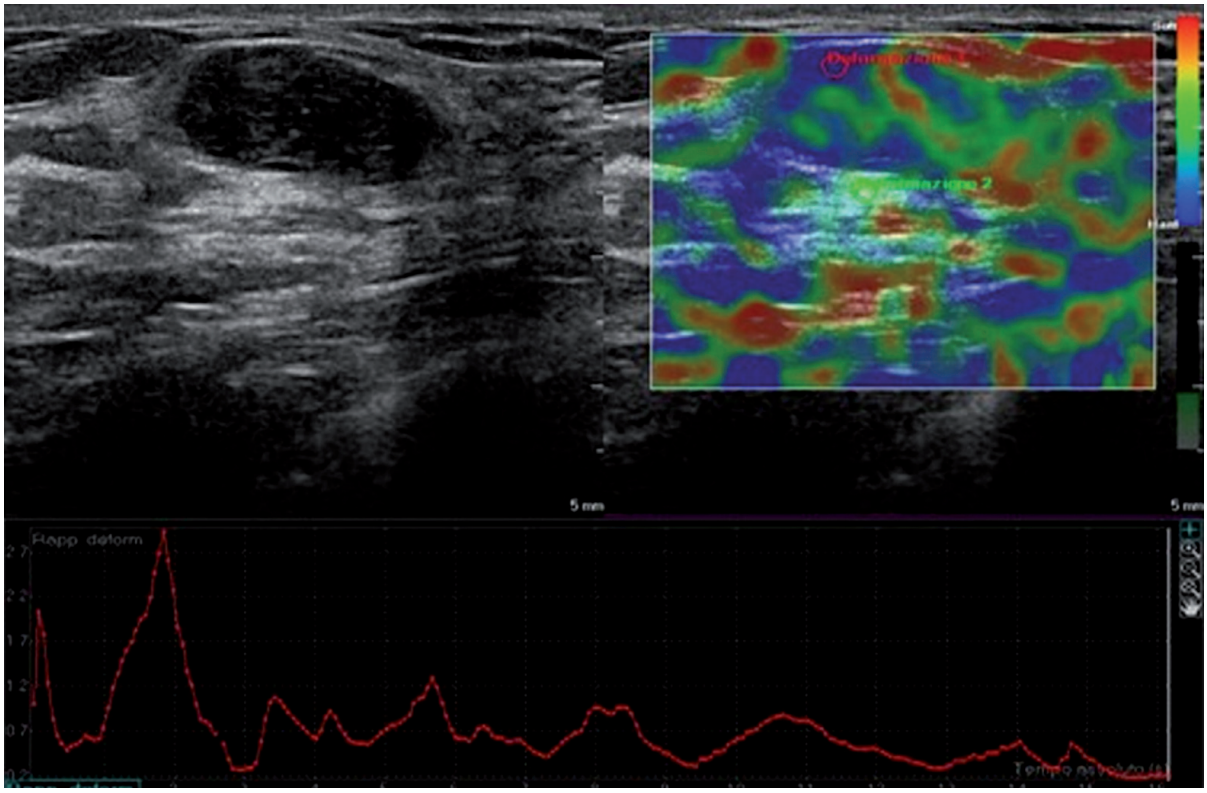

Fig. 2 Score 2-3: Prevalence of green with a few spots of blue (fibroadenoma).

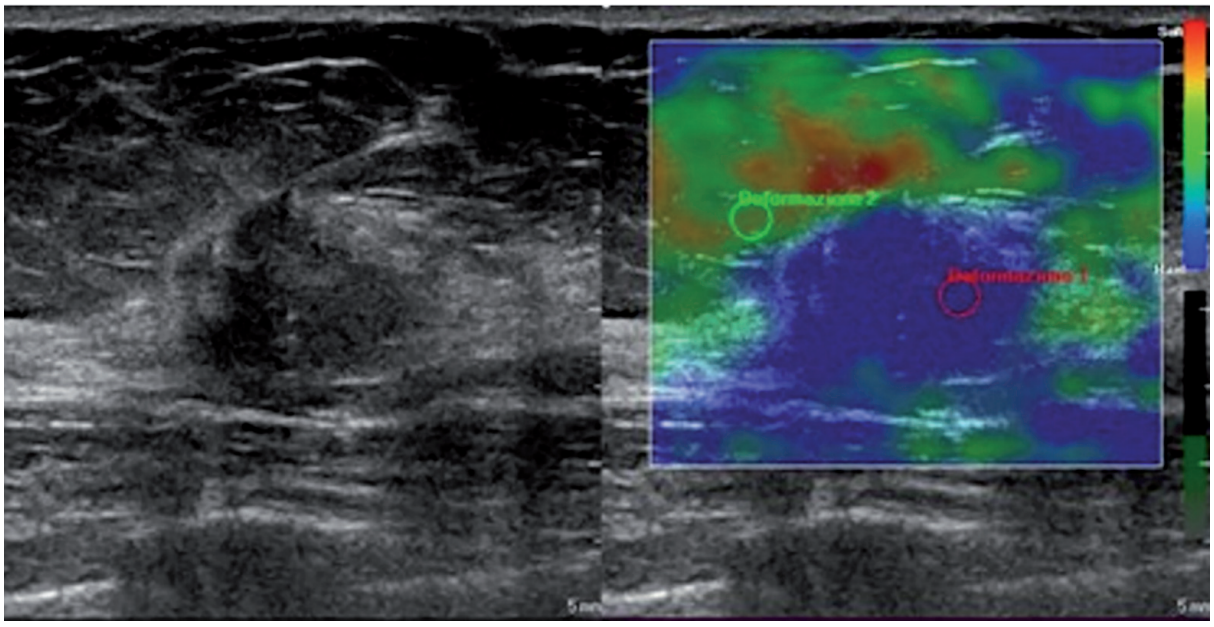

Fig. 3 Score 4-5: The nodule shows a hardness pattern throughout the area examined (the entire nodule is homogeneously blue on elastosonographic evaluation).

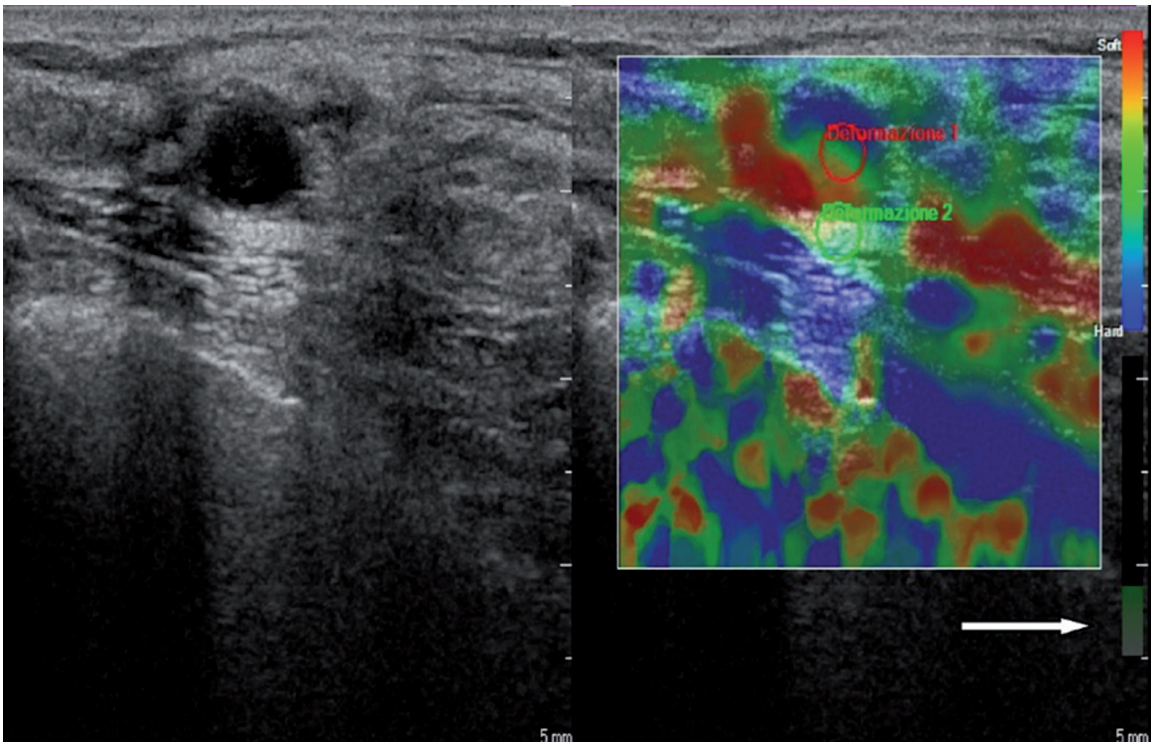

Fig. 4 Display in "dual" mode: The B-mode image is shown on the left and simultaneously the elastogram on the right. It is also displayed the "feedback bar" at the bottom right, necessary to obtain a good quality elastogram.

scale used associates the color red to elastic tissues, blue to inelastic tissues, and green to intermediate elasticity degrees. In our experience, the elastosonographic box was selected to include the nodule and part of the surrounding glandular tissue; sampling was performed by placing the first region of interest (ROI) at the nodular formation-level under examination and a second ROI at the adjacent parenchyma. The data obtained were processed by the system using a dedicated software Q-LAB that allows, through a specific algorithm, to evaluate the degree of distortion of the tissue, processing the information coming from the lesion in the form in a short time of RF pulses. The value that was taken as reference for the comparison with the FNAC result was the strain ratio (M1/M2) calculated between the average value of stiffness detected within ROI 1, corresponding to the nodule and indicated with M1, and that detected within ROI 2, located at the level of the surrounding parenchyma and indicated with M2 (Fig. 5). Following the literature, the strain ratio used as a cut-off in the differentiation between benign and malignant formation was set equal to 1. This value is thus considering elastosonographically suggestive of benignity lesions with M1/M2 value > 1 and suggestive of malignancy those with value < 1.[27] All nodules were subjected to ultrasound-guided FNAC (Fine Needle Aspiration Cytology), using 21-23 G needles with a 20-ml syringe (or with 14-18 G needles for microhistological examination defined as core biopsy). The material collected, preserved in fixative liquid, was prepared with the Thin-prep method (cytology on the thin layer), obtaining a stained slide with Papanicolau method. Each sample was sent to the pathologist accompanied by a card containing the patient's data and the clinical question and the characteristics of the aspirated material and the number of samples taken for each nodule. The results of the cytological-microhistological study were classified into five categories, indicated by the acronym CIN (according to Consensus cytological SIAPEC 2007):

– CIN. 1 Not diagnostic (Inadequate)
– CIN. 2 Negative for malignant cells (Benign)
– CIN. 3 Undetermined
– CIN. 4 Suspected malignancy
– CIN. 5 Positive for malignant cells.

These findings were correlated with data obtained from the ultrasonographic and elastosonographic study.

Patients and methods

Statistical analysis

Patients in the study cohort were divided into three groups according to cytologic classification C II-III (benign), C IV-V (malignant), and C I (doubtful). These data were compared with the elastosonographic examination results, taking the M1/M2 strain ratio index (cut off placed at a value of 1) and the 5-level elastosonographic score as evaluation parameters. The following were calculated to evaluate this method's reliability: specificity, sensitivity, positive predictive value (VP), and negative predictive value (NPV). We

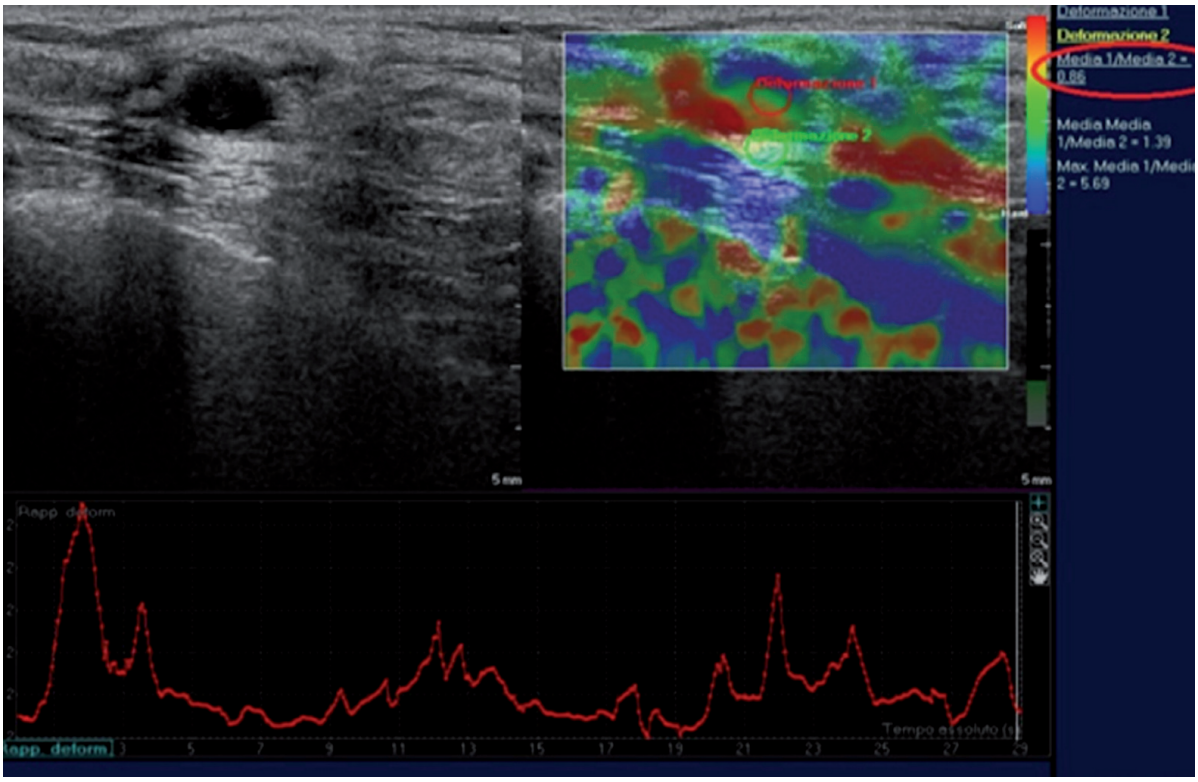

Fig. 5 COMPUTATION OF THE "STRAIN RATIO": The elastogram shows the two ROIs placed respectively on the nodule and the surrounding parenchyma; the graph below represents the strain ratio analysis calculated between the two regions of interest. The numerical result of the calculation is shown in the upper right corner (circled in red).

observe true positives (VP) were those lesions with a strain ratio less than 1 or an elastosonographic score of 4 or 5, and a cytological verification of malignancy; true negatives (VN) were those lesions with a strain ratio greater than 1 or a score of 1, 2 or 3 and were benign at needle aspiration; false positive (FP) lesions with strain ratio less than 1 or score 4 or 5 and verified as benign on cytologic examination; false negative (FN) those with strain ratio greater than 1 or score 1, 2 or 3 and with a definitive diagnosis of malignancy.

Results

FNAC results were as follows: CIN 1 in 18 nodules, CIN 2 in 22 nodules, CIN 3 in 36 nodules, CIN 4 in 6 nodules, and CIN 5 in 6 nodules (Table1).

Elastosonographic features

Colorimetric elastosonographic evaluation showed the following: Score 1 in 20.82% (18/88) of lesions, score 2-3 in 65.9% (58/88) of lesions, Score 4-5 in 13.62% (12/88) of lesions (Table 2). Of 88 lesions 18 (20.82%) were non-diagnostic, therefore score1, 58 lesions (65.9%) were benign, 6 (6.81%) were doubtful and 6 (6.81%) were malignant. Excluding the 18 non-diagnostic lesions, on the remaining 70 we observed a score 2-3 (82.5%) on 58 lesions, of which 57 were benign (98.27%) and 1 malignant (1,72%); while a score 4-5 was observed on 12 lesions (17,14%) of which 10 were malignant (83.3%) and 2 benign (16.6%) (Table 2). The colorimetric score was significantly correlated with the cytologic diagnosis of malignancy (p=0.0002). Elastosonography showed a sensitivity of 87.9%, specificity of 93.1% with a VPP of 85.9% and a VPN of 94.3% 8 (Table 3).

Discussion

The first clinical results on elastosonography were published in 1997- 2001, but only in 2003-2005 with the advent of devices with software for real-time processing of elastosonographic images allowed to obtain results validated by the international scientific community. This study highlights how the combined use of B-mode ultrasound and sonoelastography allows easier distinction of benign from malignant nodules. Our results' most exciting finding is that sonoelastographic criteria, based on an echogenic component's rigidity, were adequate for breast neoformations' characterization. Limitations of the study were related to the operator: the measurements made by different operators. Moreover, they are related to the method: impossibility to objectively evaluate the different pressures exerted during the acquisition of images and, furthermore, related to the structure of the nodule to be analyzed: presence of calcifications in the structure to be analyzed.

Our data are similar to those of Itoh et al.[28,] whose elasticity score of 5 indicates infiltration of tumor cells in the tissue interstitium (e.g., in scirrhotic carcinomas) or in an

Table 1. Socio-personal characteristics of the sample in asyntomatic patient analyzed in our study with breast nodule and bubdivision of lesions in relation to cytohistological findings.

Age	21-30	31-50	51-66	67-70	71-81
	20(22.72%)	20 (22.72%)	22(25%)	20(22.72%)	6 (6.81%)
Region of residence	Lazio				
Educational Level	No school training	Elementary school	Lower Secondary school	High secondary school	University
	2 (2.27%)	14 (15.9%)	20 (22.72%)	16 (18.8%)	36 (40.90%)
Marital Status	Single	Married	Windower	Divorced	Cohabitant
	11 (12.5)	6 (6.81)	16 (18.8%)	20 (22.72%)	35 (39.77%)
Cytohistological findings	CI	CII	CIII	CIV	CV
	18 (20.45%)	22 (25%)	36 (40.99%)	16 (18.8%)	6 (6.81)

Table 2. A Subdivision of lesions according to sonoelastographic score; B Distribution of elastosonographic score and cyto-microhistological outcome.

	A		B			
			Malignant		Benign	
S1	18	20.8	-	-	-	-
S2-3	58	65.9	1	1.72	57	98.27
S 4-5	12	13.62	10	82	2	16.66
TOTAL	88		11		59	

Table 3. Results of elastosonography

	Elastosonography
Sensitivity (%)	87,9
Specificity (%)	93,1
Accuracy (%)	91,2
VPP (%)	85,9
VPN (%)	94,3

intraductal component (e.g., in DCIS). Score 4 seems to be characteristic of solid tubular carcinomas that are circumscribed and more homogeneous than adjacent normal breast tissue. Score 3 was found mainly in benign lesions. Therefore, all lesions with a 3 or higher score are useful to be examined by cytologic aspiration or biopsy. Thus, a score of 1 indicates that breast lesions have almost the same compressibility as the surrounding breast tissue, whereas score 2 indicates lesions that are slightly harder than the surrounding breast tissue. This result suggests that the cytodiagnostic procedure can be omitted in lesions with score 1, whereas lesions with score 2-3 deserve close correlation between mammography, US, and sonoelastography before deciding to avoid invasive diagnostics.[29] Our study shows that FNACs could be avoided on average in 33.6% (29.6 of 88) of women with suspicious breast lesions. However, in some cases, there were discordances between the elastic properties and the nature of the breast lesion: in 1 lesion, the

Table 4. Sensitivity and specificity values reported in the literature

Comparison of studies	Sens (%)	Spec (%)	VPP (%)	VPN (%)
Thomas[18]	77.6	91.5	84.4	83.1
Giuseppetti[30]	79.0	89.0	-	-
Tardivon[26]	78.7	86.9	85.7	80.3
Regini[15]	88.5	92.7	86.1	94.1
Chang[20]	58.7	81.8	69.2	73.9
Our Experience	87.9	93.1	85.9	94.3

elasticity was higher than expected with a pattern similar to benign lesions (false negative), while in 2 cases, the elasticity was lower than expected with a pattern similar to malignant lesions (false positive). These data have also been reported in the literature Giuseppetti et al.[30] an essential role of histotype has been hypothesized. In fact, ductal tumors could have different elastic behaviors concerning the fibrohyalin component produced by the neoplasm and to the evolutionary stage of the lesion itself; while in lobular lesions, elasticity would be conditioned by the peculiar anatomopathological characteristics, namely the low cohesion between cells, the minimal component of hyaline fibrosis with modest desmoplastic reaction especially in small lesions (3-36-37). All this concludes that a close correlation between mammography and ultrasonographic data and sonoelastographic data is essential. Other elements that may influence the elastic score, as also reported in the literature and as present in our study, are the size and depth of lesions: in fact, lesions with a diameter of fewer than 2 centimeters showed greater sensitivity and specificity as well as lesions with a lesser depth. This can be explained by the fact that larger lesions present a more significant structural inhomogeneity that determines the elastic coefficient's atypical alterations.

In comparison, deeper lesions make it more difficult to compress them correctly, and therefore, the elastogram is altered by the presence of artifacts due to lateral dislocations of the transducer.[31,32] The sensitivity and specificity of elastosonography found in our case series reported values in line with the data reported in the literature (Table 4), confirming the method's high reliability. The lesions at low mammographic and ultrasonographic risk that reported a score less than or equal to 3 were benign. However, some concepts should be stressed, namely the small number of patients who underwent our study and the close correlation between the operator's manual skill who performs elastosonography, the subjective evaluation of the image, and the changes, even if minimal, of the patient with the sonographic data.[33] In conclusion, therefore, elastosonography (when data will improve by more extensive case series and retrospective studies) may become in the future a complementary technique to mammography and ultrasonography, reducing costs and risks of further examinations.

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