Does elastography change the indication to biopsy?

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Ultrasound Detected Cancers

- Physician-performed ultrasound increases cancer detection yield by 2.7 -4.6 cancers per 1000 women screened.
- Although findings visualized by ultrasound examination can easily be biopsied in a minimally-invasive way, risk assessment should take into consideration the psychological strain due to a false-positive ultrasound result.
- PPV of biopsies prompted by ultrasound varies between 8.8% -13%.

Berg WA, et al. Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. JAMA. 2008
Monika Nothacker et al. Early detection of breast cancer: benefits and risks of supplemental breast ultrasound in asymptomatic women with mammographically dense breast tissue. A systematic review. BMC Cancer. 2009

Ultrasound Detected Cancers

- The consequence of a false-positive result in diagnostic imaging is the performance of an unnecessary biopsy.
- A false-negative result has an even more serious implication as the diagnosis of malignancy is delayed.
- In order to prevent excessive biopsies and to guarantee the highest level of patient safety, diagnostic methods should be continuously refined.

Breast Ultrasound Elastography

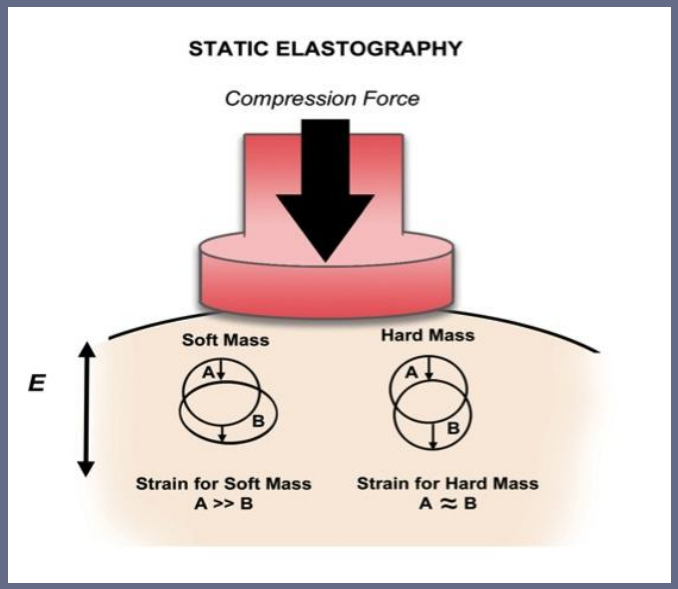
- The combined use of B-mode ultrasound +elastography can improve diagnostic performance in the differentiation of benign and malignant breast lesions.
- B-mode alone: AUC = 0.851
- B-mode + shear-wave elastography: AUC = 0.964
- B-mode + strain elastography: AUC = 0.965
- BI-RADS 3 and 4a lesions

Chang JM et al. Comparison of shear-wave and strain ultrasound elastography in the differentiation of benign and malignant breast lesions. AJR Am J Roentgenol. 2013

Two types of Elasticity Imaging

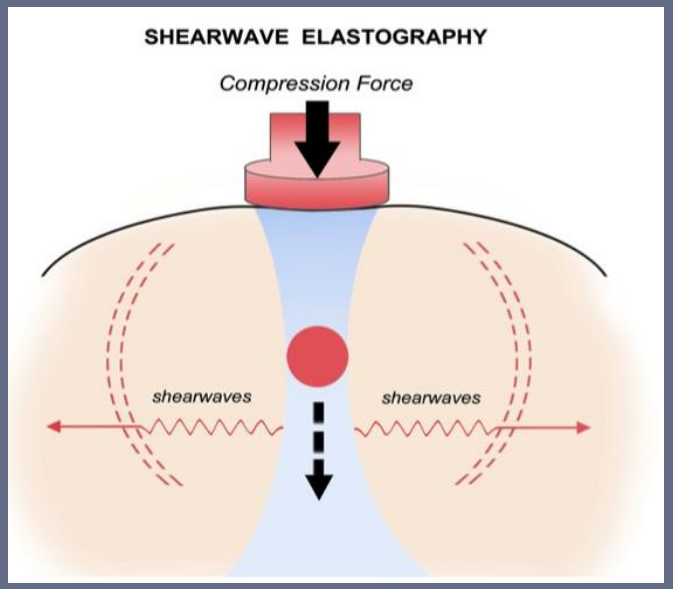
Strain elastography

- Compression elastography (strain) produces an image based on the displacement of the tissue from an external source.



Shear wave elastography

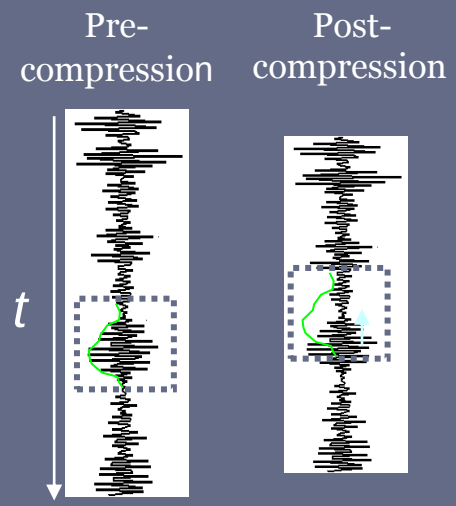
- Shear wave elastography applies a special "push pulse," which results in shear wave propagation inducing tissue displacement.

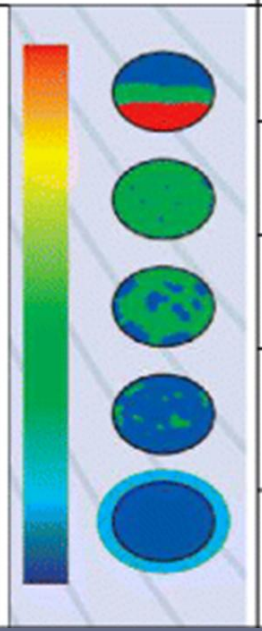


https://iame.com/online/breast_elastography/content.php

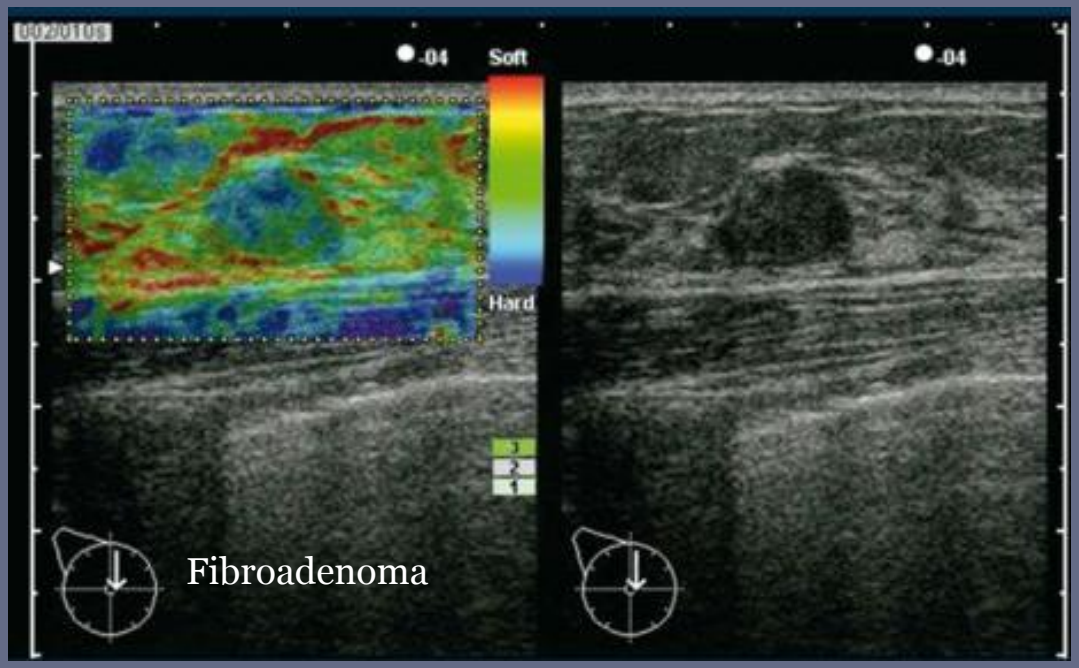
Strain elastography

- Cross correlation algorithms are used to process RF data from two frames to produce a strain image.
- Soft lesions → Easy to deform → High Strain.
- Hard lesions → Hard to deform → Low Strain.



CHROMATIC CODE	ELASTOSONOGRAPHIC SCORE	ITALIAN TEAM OF STUDY
	**SCORE 1:** Presence of chromatic tri-stratification (blue /green / red)	Prevalently in the liquid forms
	SCORE 2: Prevalence of green, with in case some blue point, inconstant seat	**PREVALENTLY ELASTIC:** prevalently in the benign forms
	SCORE 3: Prevalently green, but with some blue spot.	
	SCORE 4: Almost completely blue, with in case some green point, most of all in periphery	**PREVALENTLY RIGID:** prevalently in the malignant forms
	SCORE 5: Completely blue, also with a blue peripheral glow around the nodule	

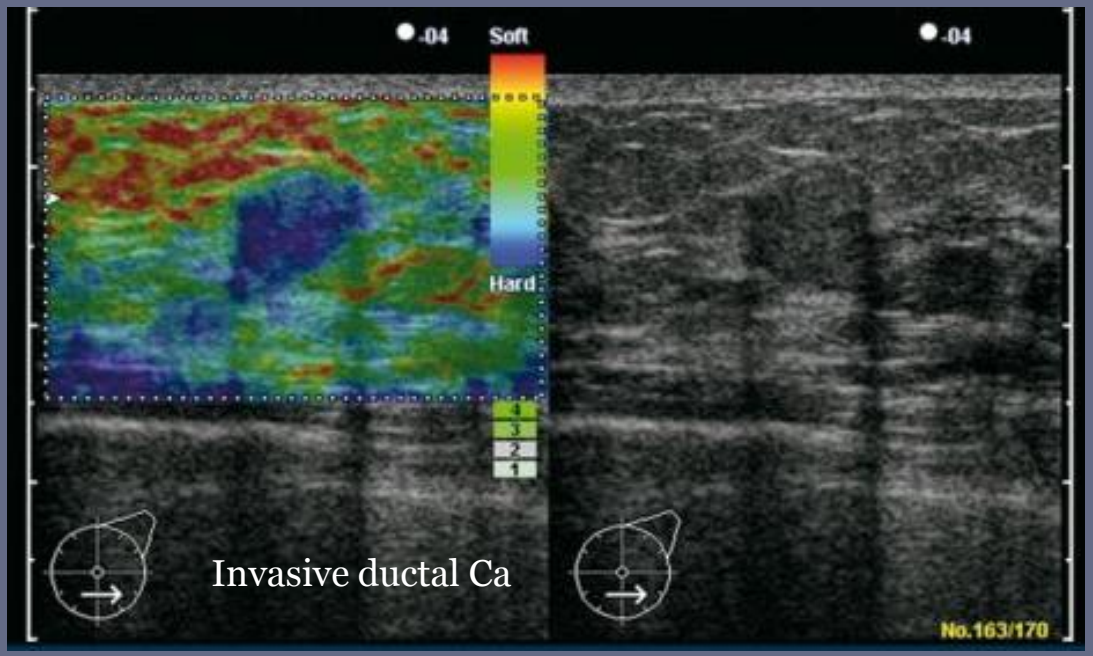
Scaperrotta G, et al. Role of sonoelastography in non-palpable breast lesions. Eur Radiol. 2008
Itoh A, et al. Breast disease: clinical application of US Elastography for diagnosis. Radiology 2006



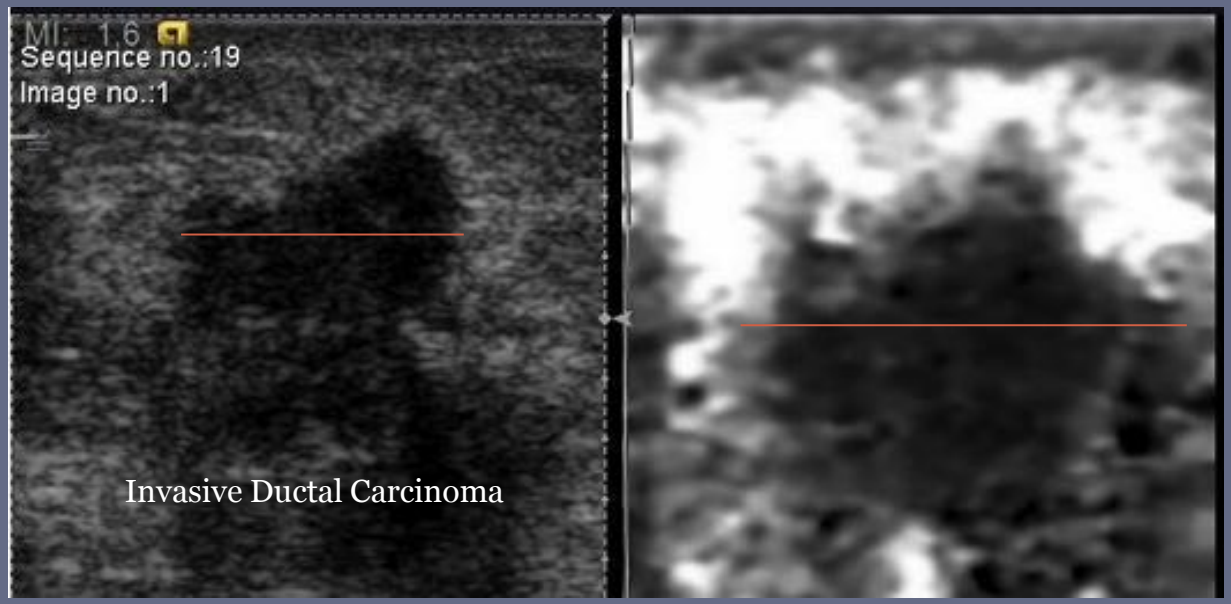
Cut-off between scores **3-4**

Sensitivity: up to 87%

Specificity: up to 89%



Tardivon A, et al. Elastography of the breast: a prospective study of 122 lesions. J Radiol. 2007

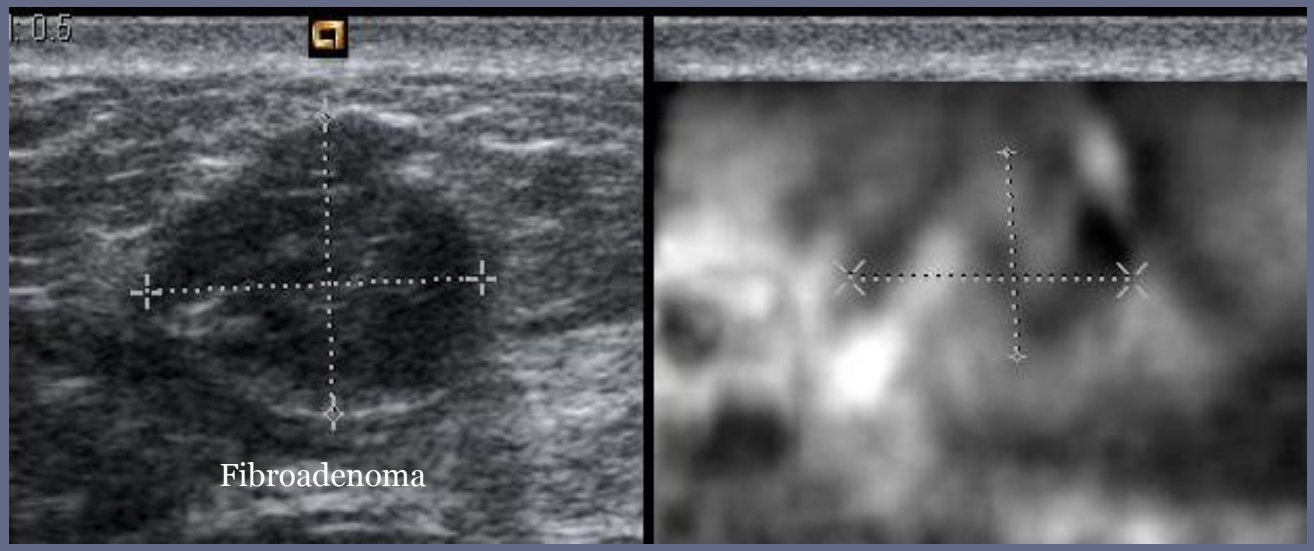


Strain Ratio ≥**1**

suspicious for malignancy

Sensitivity:up to 98%

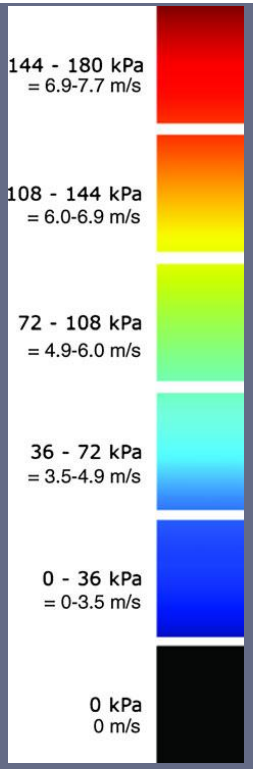
Specificity: up to 87%

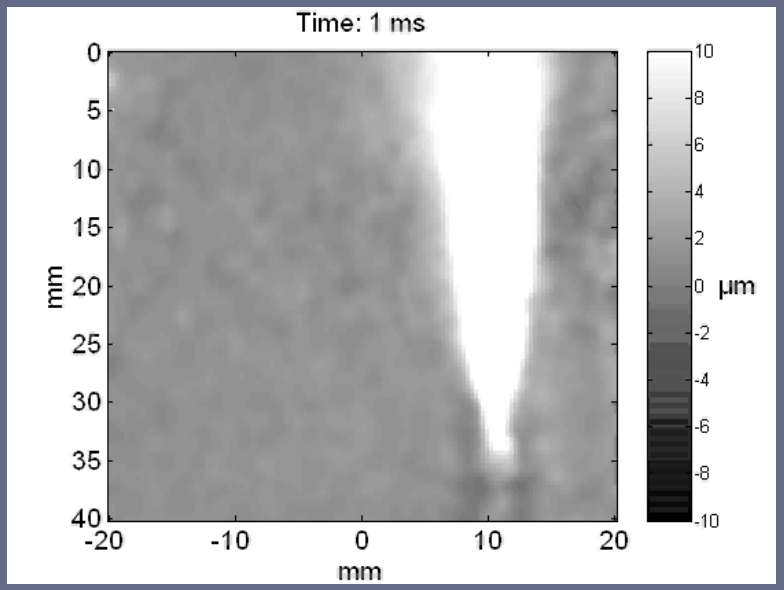


Burnside ES, et al Differentiating benign from malignant solid breast masses with US strain imaging. Radiology. 2007.

Barr RG et al. Evaluation of breast lesions using sonographic elasticity imaging: a multicenter trial. J Ultrasound Med. 2012

Shear Wave Elastography

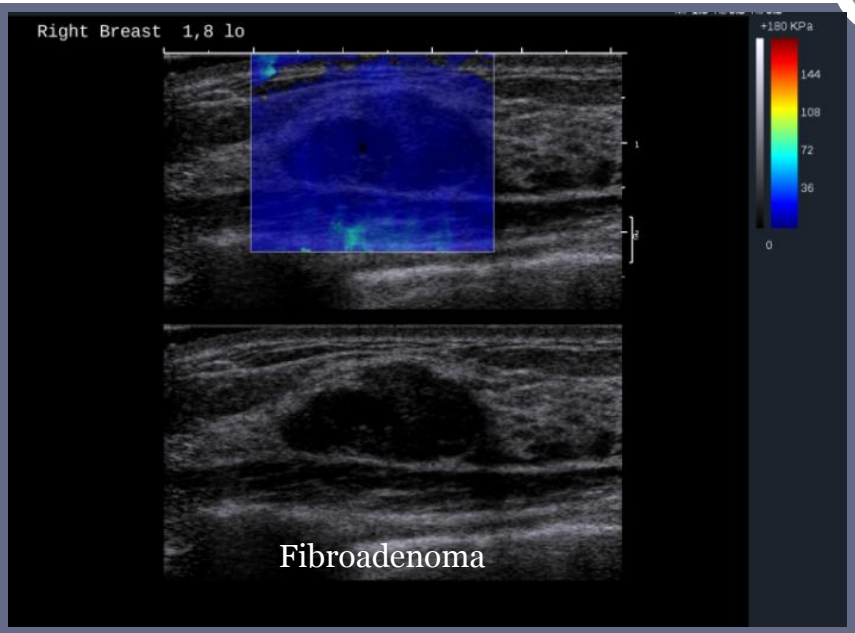


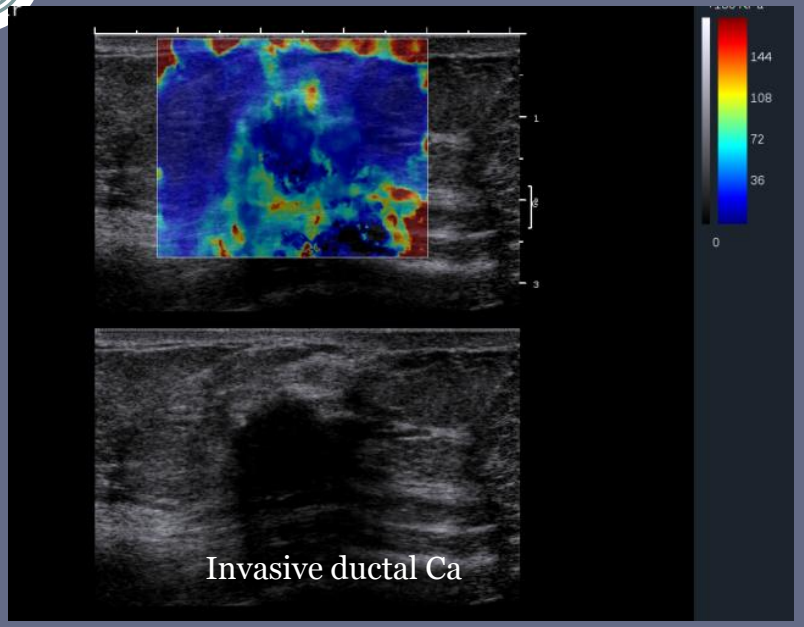


- Shear waves induce tissue displacement.
- Ultrafast imaging system registers shear wave propagation.
- Inversion algorithms are used to recover Young's modulus map.
- Shear wave velocity is proportional to stiffness $\mathbf{E = 3\ r\ cS^2}$
- Quantitative values in kPa.

Athanasiou A, et al . Breast lesions: quantitative elastography with supersonic shear imaging--preliminary results. Radiology. 2010

Shear Wave Elastography

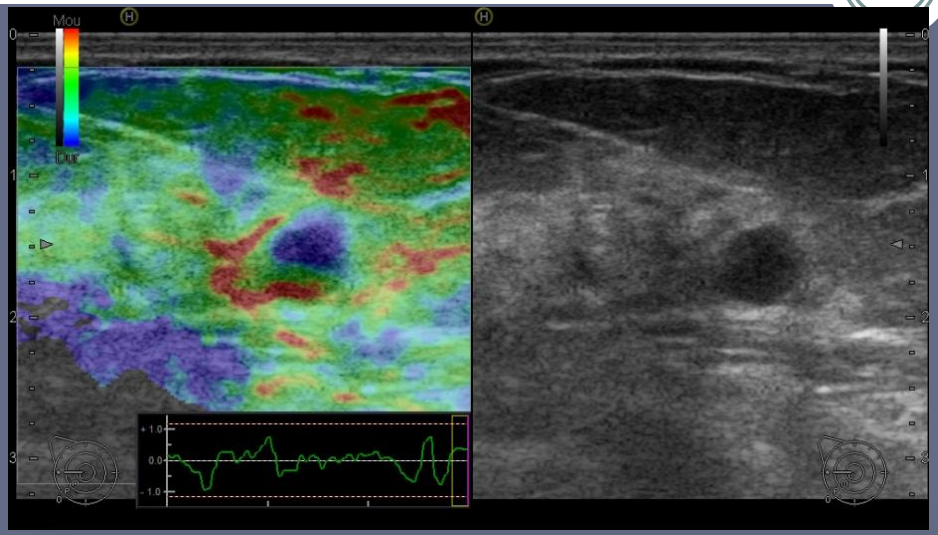


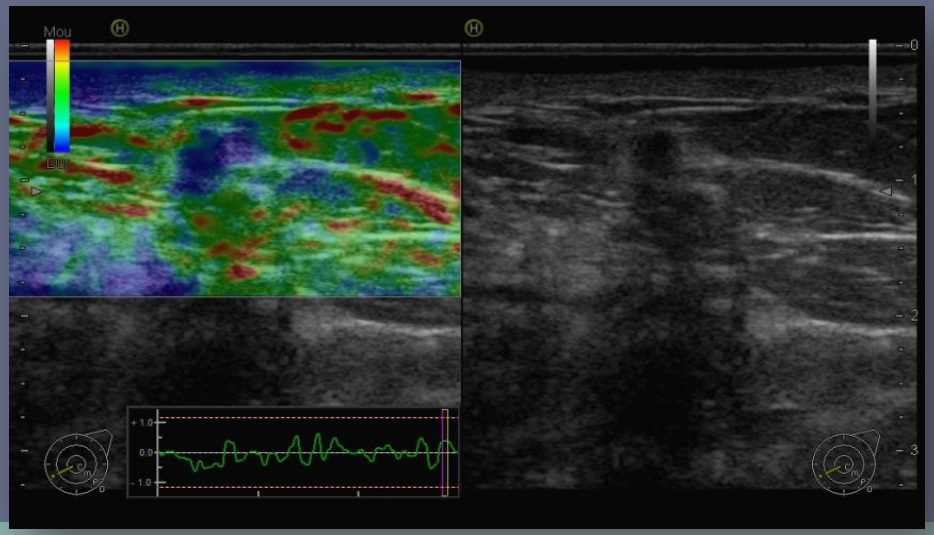


- Homogeneous versus heterogeneous color map.
- **E>50-80 kPa** indicative of malignancy.
- **E<50- 80 kPa** indicative of benign lesion.
- Specificity improved: 61%-83%
- Highly reproducible.

Evans A , et al. Quantitative shear wave ultrasound elastography. Initial experience in solid breast masses. Breast Cancer Res Treat. 2010
Chang JM, et al. Clinical application of shear wave elastography (SWE) in the diagnosis of benign and malignant breast diseases. Breast Cancer Res Treat. 2011
Berg WA, et al. Shear-wave elastography improves the specificity of breast US: the BE1 multinational study of 939 masses. Radiology. 2012
Cosgrove DO, et al. Shear wave elastography for breast masses is highly reproducible. Eur Radiol. 2012

To biopsy or not to biopsy?



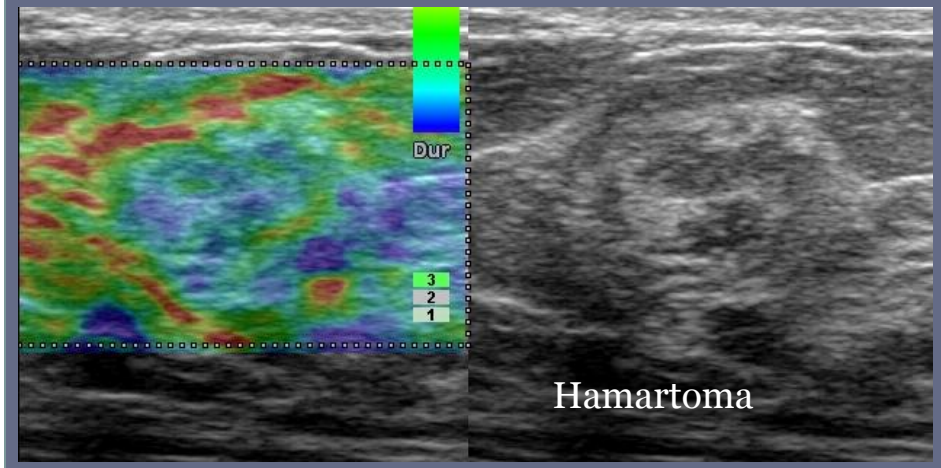


Complicated cyst
versus
Solid nodule

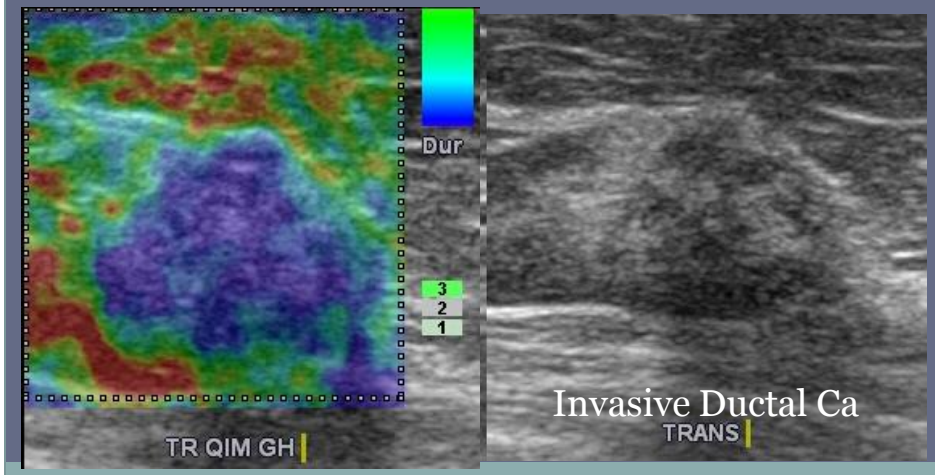
FNA
instead of
Biopsy

To biopsy or not to biopsy?

Hyperechoic Lesions



Hamartoma

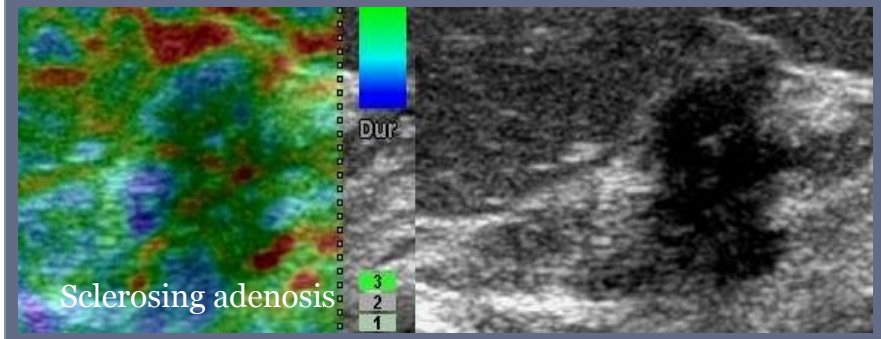


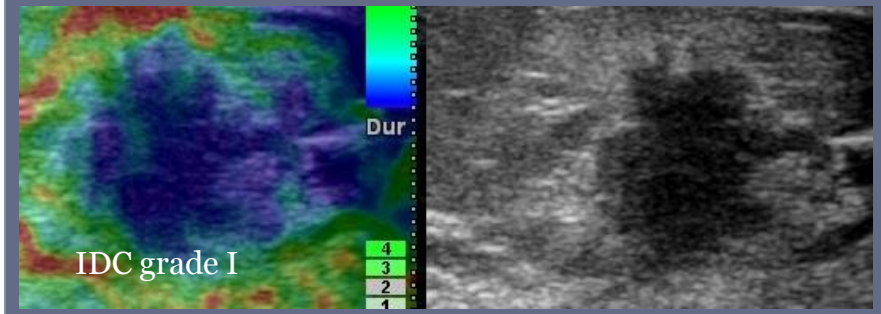
Invasive Ductal Ca

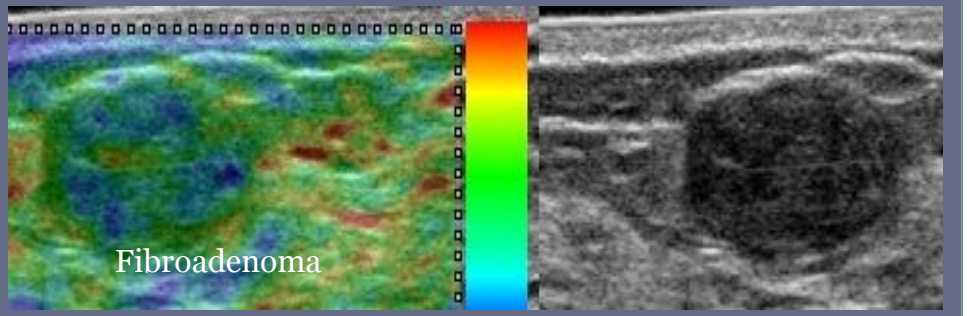
Invasive Lobular Ca

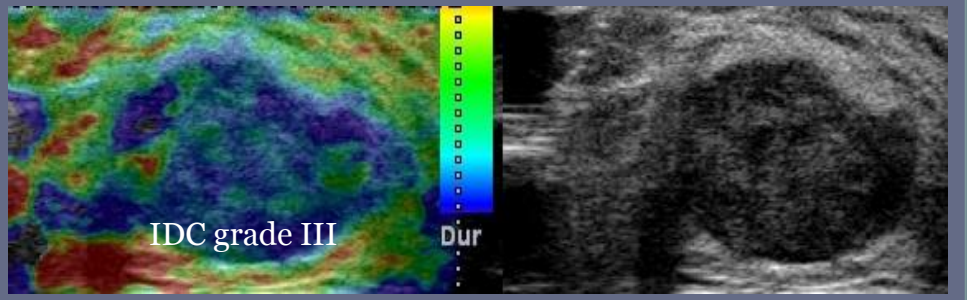
Biopsy instead of follow-up

To biopsy or not to biopsy?



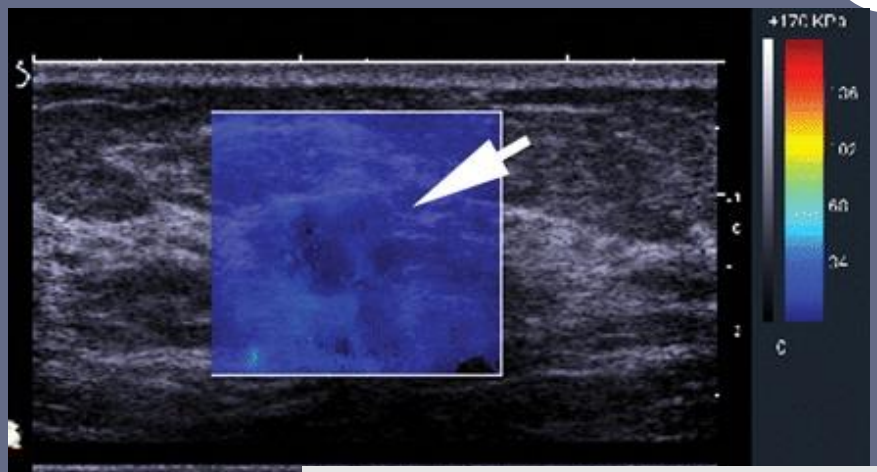


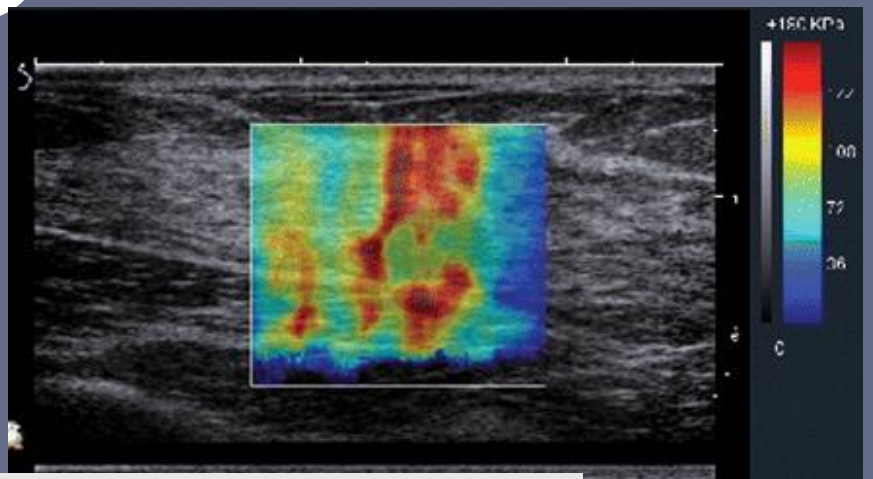




Mechanical properties of stiffness are correlated with tumor cellularity and microvessel density.

To biopsy or not to biopsy?



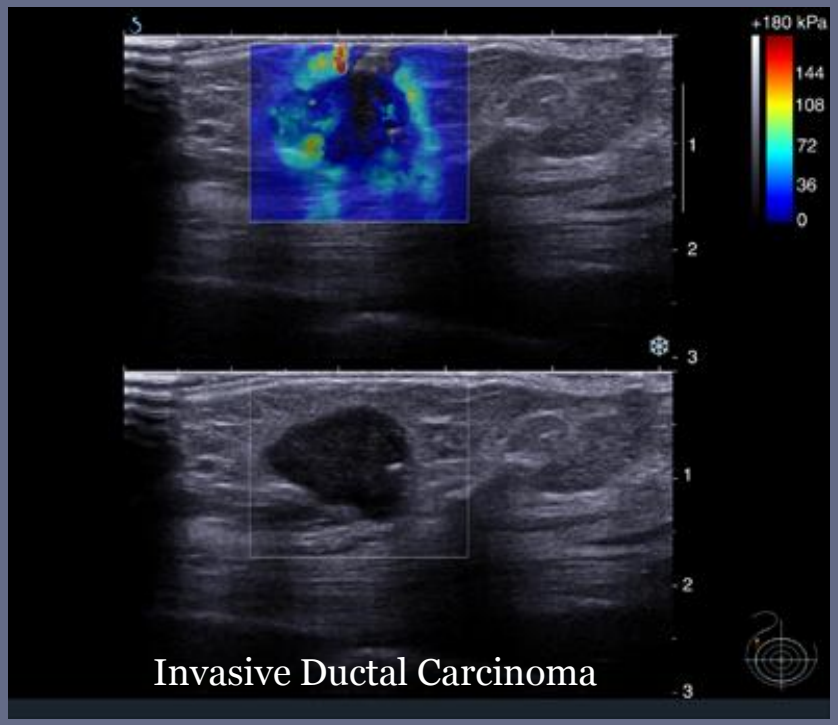


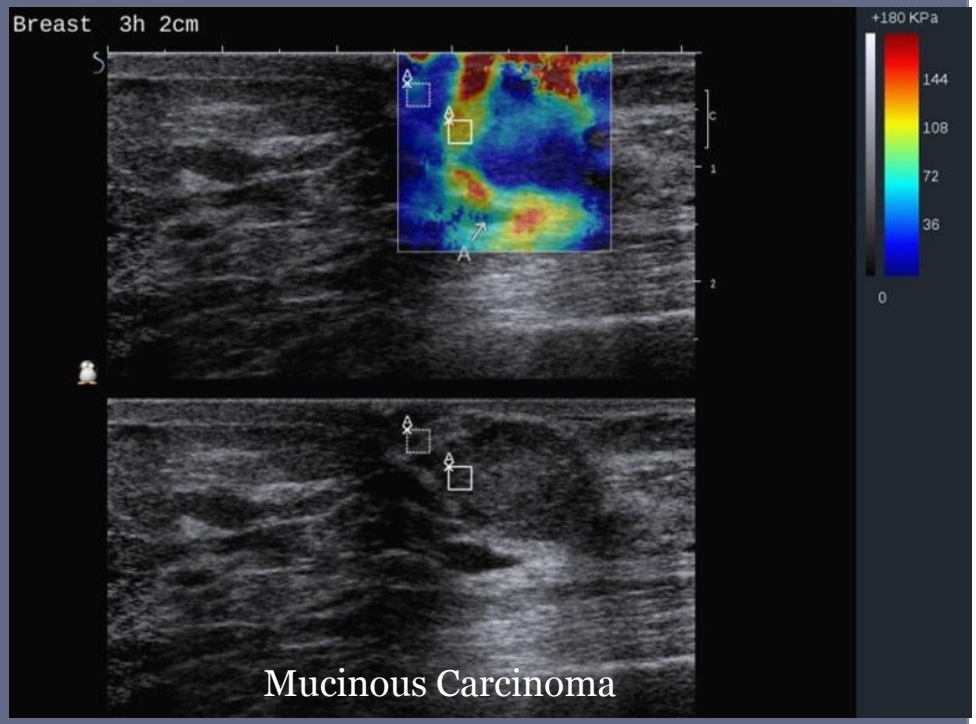
Fibroadenoma

Histopathologic Result*	No. of Masses	Median E_{max} (kPa)†	IQR‡	*P* Value
Cyst§	104	23	7–53	<.001, vs fibroadenoma
Fibroadenoma	176	42	28–73	<.001, vs any malignant‖
Other benign#	351	44	25–90	<.001, vs any malignant‖
Risk lesions**	17	74	30–165	<.001, vs any malignant‖
Abscess	2	133	87–180	.72, vs any malignant‖
Ductal carcinoma in situ	12	133	72–180	.053, vs invasive breast carcinoma
Other malignant††	6	175	137–180	ND
Invasive breast carcinoma‡‡	271	179	143–180	ND
Overall	939	65	30–168	. . .

A Evans et al. Quantitative shear wave ultrasound elastography: initial experience in solid breast masses. Breast Cancer Research 2010

To biopsy or not to biopsy?





Downgrade BI-RADS 4a or Upgrade BI-RADS3

Potential role of SWE in reducing false-positive biopsy of BI-RADS category 4a

- By applying an Emean value of 41.6 kPa or less for downgrading soft BI-RADS category 4a to BI-RADS 3 79 % of unnecessary biopsies could have been eliminated .
- For these patients, follow-up after 6 months would have been appropriate management.
- No cancerous lesions were missed by downgrading according to this cut-off value.

Ji Hyun Youk et al Diagnostic value of commercially available shear-wave elastography for breast cancers: integration into BI-RADS classification with subcategories of category 4. European Radiology 2013

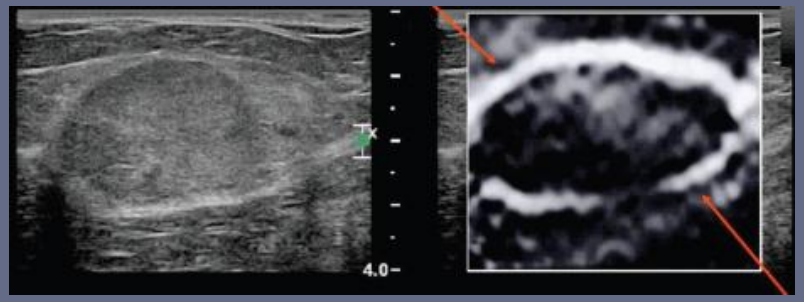
Downgrade BI-RADS 4a or Upgrade BI-RADS3

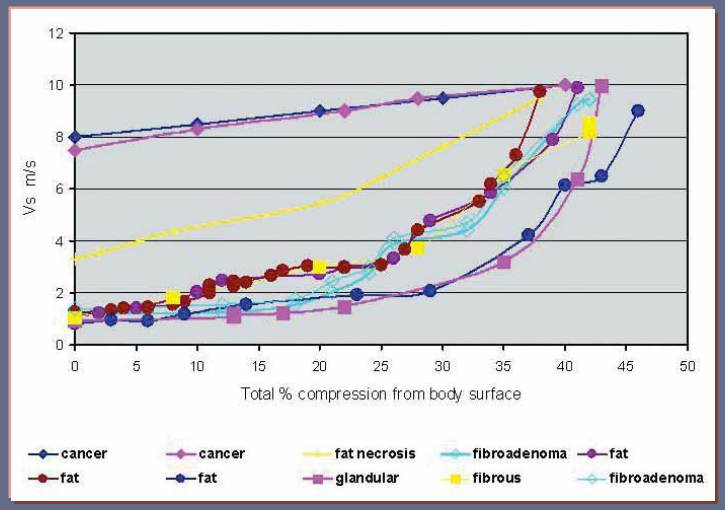
Focusing on the screening population

- BI-RADS 3 lesions occur in about 20% of the women
- Biopsy rate of 3.2% (without E) increase to 4.2% (with E)
- Detection of 62.5% of cancers directly during the first consultation
- Most of the breast cancer patients had a BI-RADS 2 or 3 mammogram
- Further diagnostic steps were initially not indicated and the elastogram alone led to the diagnosis of cancer

Wojcinski S et al. Ultrasound real-time elastography can predict malignancy in BI-RADS®-US 3 lesions. BMC Cancer. 2013

False Positives



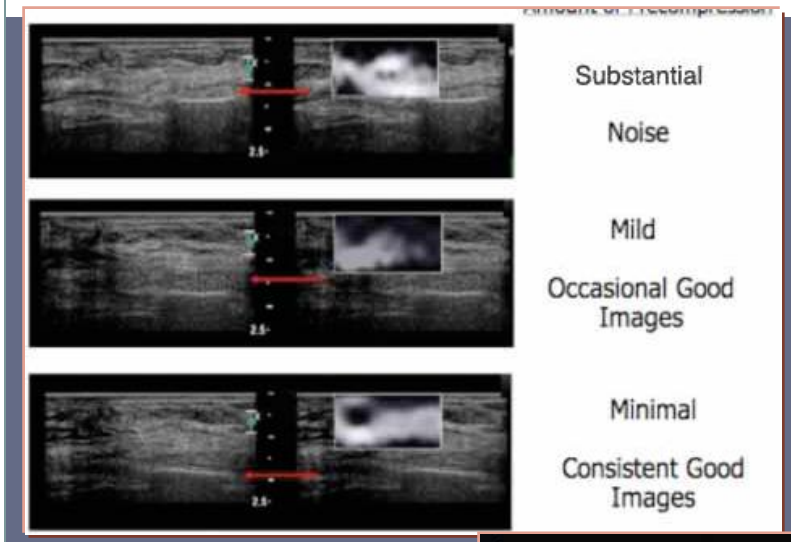


- Poor technique/ sliding artifacts
- Complex sclerosing benign lesions
- « Elastographic contrast »

  Mechanical properties of the surrounding tissue influence the elastogram of the lesion.

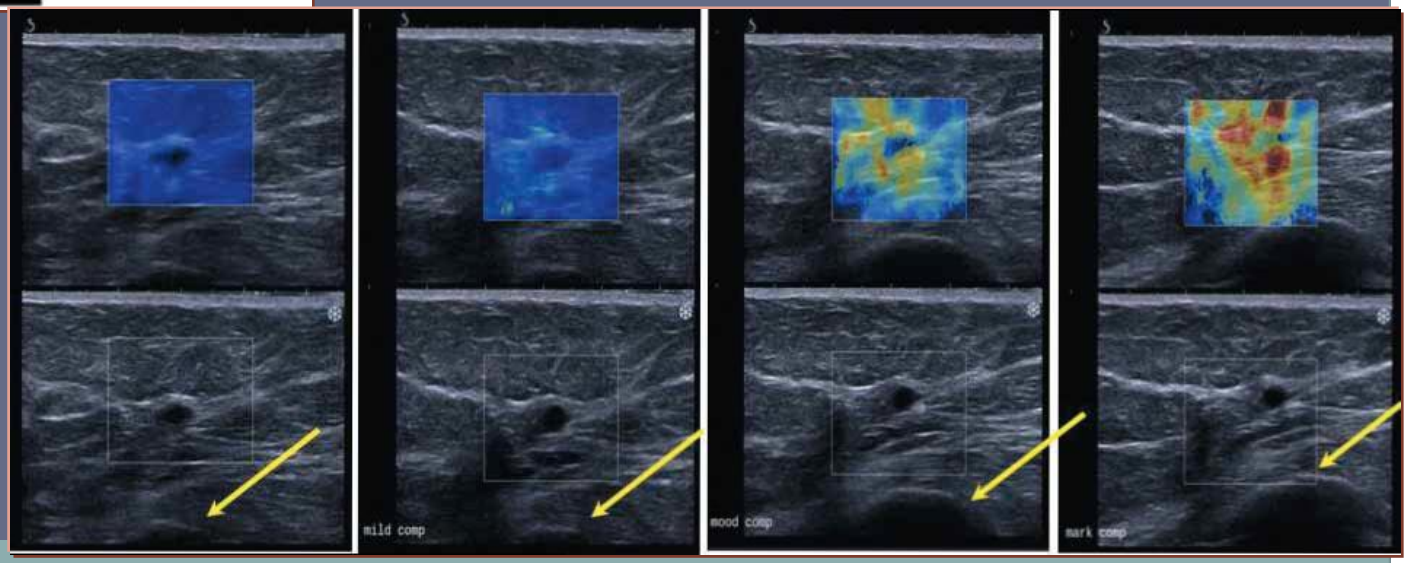
  A benign lesion may appear relatively hard if the adjacent tissue is relatively soft.
- Precompression

False Positives



Precompression ↑

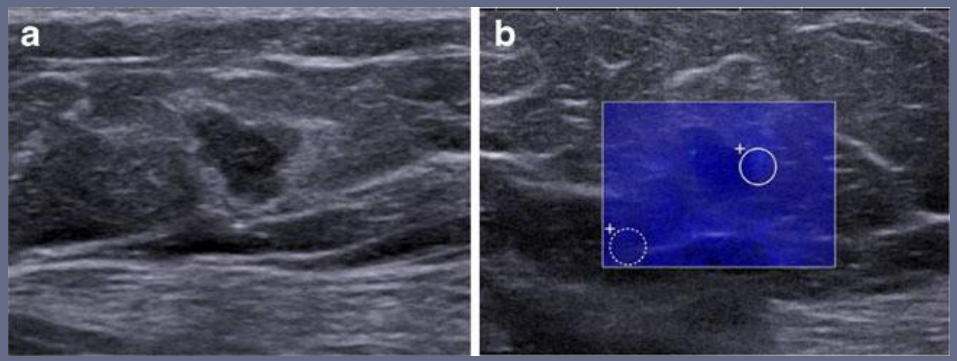
Conspicuity between tissues ↓



Barr RG. Effects of precompression on elasticity imaging of the breast. J Ultrasound Med 2012

False negatives

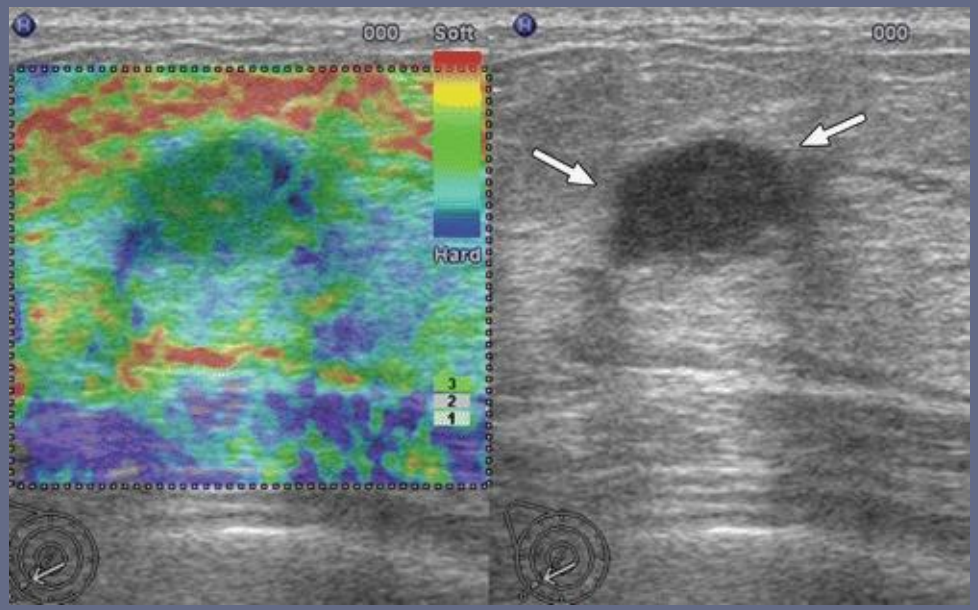
- Histology/ lesion size/depth
- Depth >4 cm.
- Invasive size ≤10 mm
- DCIS, ILC, mucinous/medullary, grade 1, tubular type
- B-mode primes!!

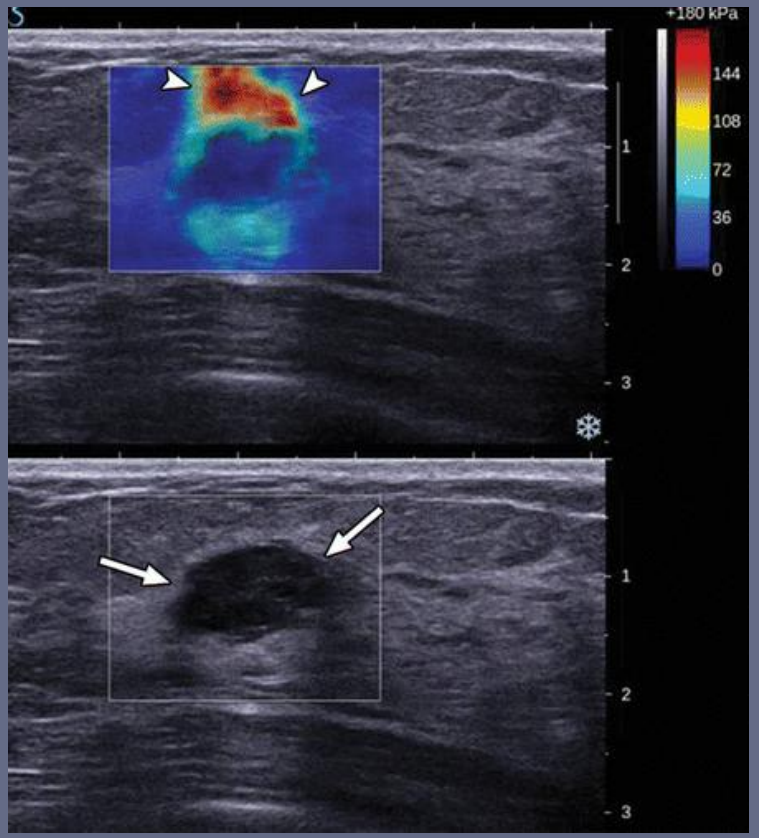


Vinnicombe SJ et al What are the characteristics of breast cancers misclassified as benign by quantitative ultrasound shear wave elastography? Eur Radiol. 2013

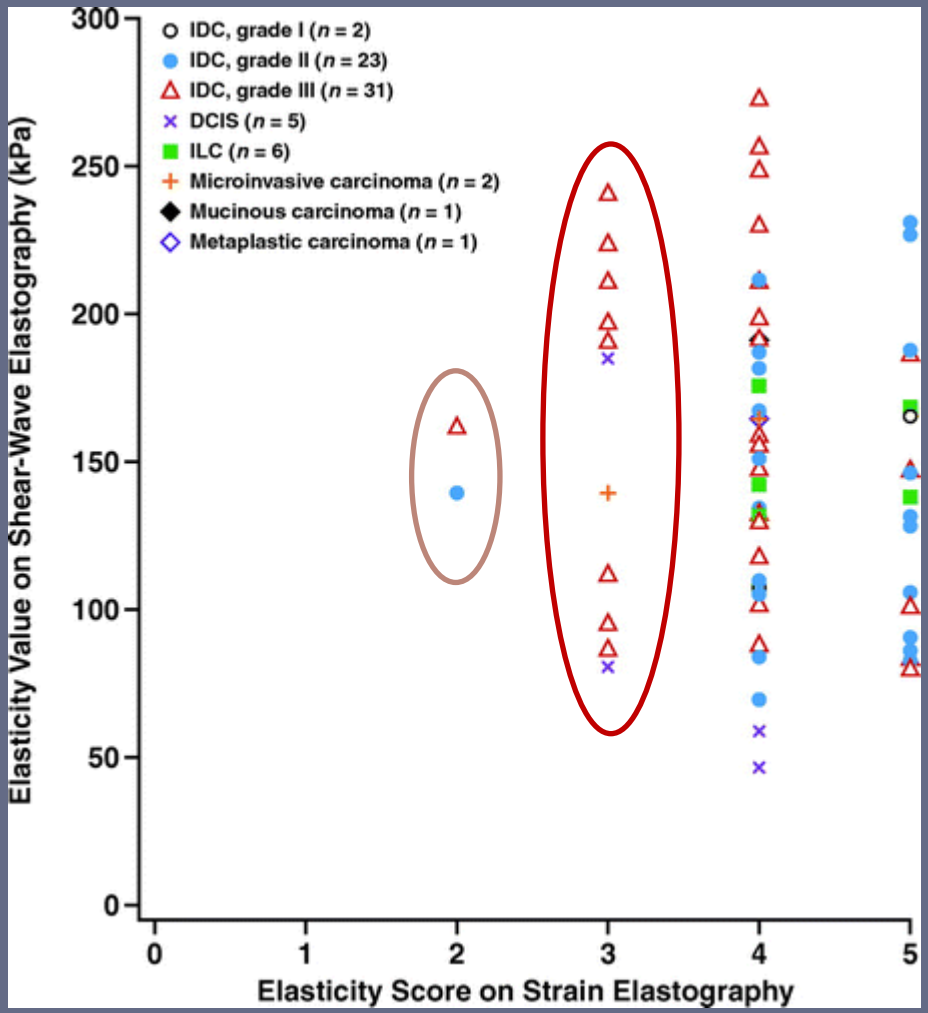
Future may be….

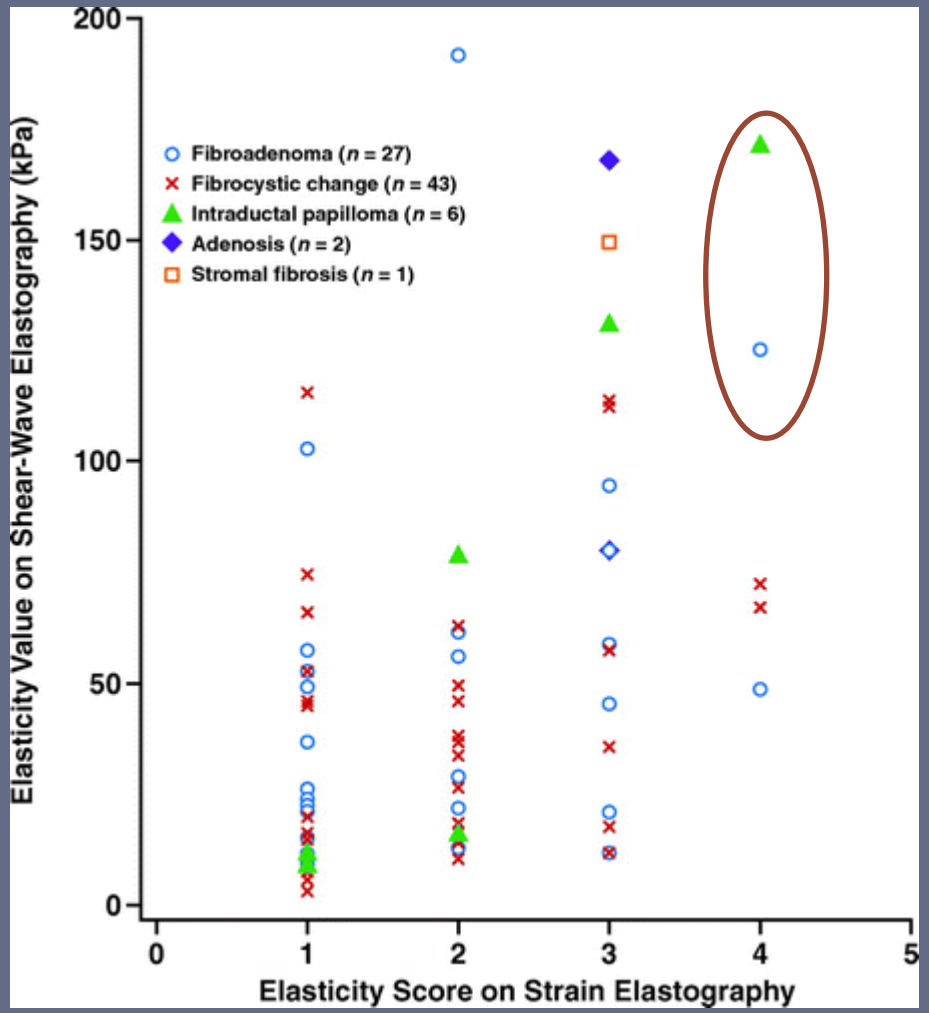
- Combining BOTH strain and shear wave!





Invasive ductal Carcinoma grade II





Chang JM et al. Comparison of shear-wave and strain ultrasound elastography in the differentiation of benign and malignant breast lesions. AJR Am J Roentgenol. 2013

If one is master of one thing and understands one thing well, one has at the same time insight and understanding of many things.

THANK YOU