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%.

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.
Strain elastography

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

Fibroadenoma

Cut-off between scores 3-4

Sensitivity: up to 87%
_specificity: up to 89%


Strain Ratio $\geq 1$
suspicious for malignancy

Sensitivity: up to 98%
Specificity: up to 87%
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 \( E = 3 \pi \rho cS^2 \)  
Quantitative values in kPa.

Shear Wave Elastography

- Homogeneous versus heterogeneous color map.
- \( E > 50-80 \text{ kPa} \) indicative of malignancy.
- \( E < 50-80 \text{ kPa} \) indicative of benign lesion.
- Specificity improved: 61%-83%
- Highly reproducible.

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?

<table>
<thead>
<tr>
<th>Histopathologic Result*</th>
<th>No. of Masses</th>
<th>Median $F_{\text{max}}$ (kPa)$^\dagger$</th>
<th>IQR$^\ddagger$</th>
<th>$P$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyst$^\S$</td>
<td>104</td>
<td>23</td>
<td>7–53</td>
<td>&lt;.001, vs fibroadenoma</td>
</tr>
<tr>
<td>Fibroadenoma</td>
<td>176</td>
<td>42</td>
<td>28–73</td>
<td>&lt;.001, vs any malignant$^t$</td>
</tr>
<tr>
<td>Other benign$^t$</td>
<td>351</td>
<td>44</td>
<td>25–90</td>
<td>&lt;.001, vs any malignant$^t$</td>
</tr>
<tr>
<td>Risk lesions$^{**}$</td>
<td>17</td>
<td>74</td>
<td>30–165</td>
<td>&lt;.001, vs any malignant$^t$</td>
</tr>
<tr>
<td>Abscess</td>
<td>2</td>
<td>133</td>
<td>87–180</td>
<td>.72, vs any malignant$^t$</td>
</tr>
<tr>
<td>Ductal carcinoma in situ</td>
<td>12</td>
<td>133</td>
<td>72–180</td>
<td>.053, vs invasive breast carcinoma</td>
</tr>
<tr>
<td>Other malignant$^{††}$</td>
<td>6</td>
<td>175</td>
<td>137–180</td>
<td>ND</td>
</tr>
<tr>
<td>Invasive breast carcinoma$^{††}$</td>
<td>271</td>
<td>179</td>
<td>143–180</td>
<td>ND</td>
</tr>
<tr>
<td>Overall</td>
<td>939</td>
<td>65</td>
<td>30–168</td>
<td>...</td>
</tr>
</tbody>
</table>

* Cyst$^\S$, Fibroadenoma, Other benign$^t$, Risk lesions$^{**}$, Abscess, Ductal carcinoma in situ, Other malignant$^{††}$, Invasive breast carcinoma$^{††}$

Mucinous Carcinoma

Invasive Ductal Carcinoma

To biopsy or not to biopsy?
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

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
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