Ultra-sensitive Microvessel Imaging for Breast Tumors: Initial Experiences

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Principle of Ultra-sensitive Microvessel Imaging

High frame rate = High ensemble count = High Doppler sensitivity

Ultrafast plane wave imaging frames (500-4000 ensembles/second)

Advanced Tissue Clutter Filtering [1-4]


4. P. Song et al., "Improved Super-Resolution Ultrasound Microvessel Imaging With Spatiotemporal Nonlocal Means Filtering and Bipartite Graph-Based Microbubble Tracking," in *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, vol. 65, no. 2, pp. 149-167, Feb. 2018
Conventional Color Doppler VS Ultra-sensitive Microvessel Imaging

Fibroadenoma

Invasive Lobular Carcinoma, grade II
Histopathology of masses (n=29)

<table>
<thead>
<tr>
<th>Type</th>
<th>Count</th>
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</thead>
<tbody>
<tr>
<td>Benign</td>
<td>10</td>
</tr>
<tr>
<td>Fibroadenoma</td>
<td>6</td>
</tr>
<tr>
<td>Fibrocystic breast changes</td>
<td>4</td>
</tr>
<tr>
<td>Malignant</td>
<td>17</td>
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<tr>
<td>Invasive ductal carcinoma</td>
<td>13</td>
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<tr>
<td>Ductal carcinoma in situ</td>
<td>1</td>
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<tr>
<td>Invasive lobular carcinoma</td>
<td>4</td>
</tr>
<tr>
<td>Invasive mammary carcinoma</td>
<td>1</td>
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</tbody>
</table>
Microvessel Distribution Patterns for Different Mass Types

Fibroadenoma

Fibrocystic breast changes

Carcinoma

Grade I

Grade II

Grade II
Quantify Ultra-Sensitive Microvessel Images with Commonly Used Parameters

- **Number of Vessels**
  - Avascular-Hypovascular
  - Hypervascular

  \[
  \text{vessel density} = \frac{\text{vessel pixels}}{\text{overall tumor pixels}}
  \]

- **Distribution of Tumor Microvessels**
  - Central
  - Peripheral
  - Both

Overall Vessel Density %

Vessel Density Ratio (Periphery/Center)
Use microvessel morphology to upgrade/downgrade mass BI-RADS scores

Microvessel morphologies of different masses

- **Fibroadenoma**
  - Continuous vessel flow along the mass boundary

- **Fibrocystic breast changes**
  - Avascular at center
  - Hypovascular at periphery: dot or linear

- **Carcinoma**
  - Disordered, irregular branching, penetrating, chaotic morphology

### Regrading BI-RADS based on Microvessel Morphology

<table>
<thead>
<tr>
<th>Agreement with Benign or Malignant Tumors</th>
<th>Score</th>
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<tbody>
<tr>
<td>Agree well with benign tumors</td>
<td>-2</td>
</tr>
<tr>
<td>Partially agree with benign tumors</td>
<td>-1</td>
</tr>
<tr>
<td>No obvious benign or malignant features</td>
<td>0</td>
</tr>
<tr>
<td>Partially agree with malignant tumors</td>
<td>+1</td>
</tr>
<tr>
<td>Agree well with malignant tumors</td>
<td>+2</td>
</tr>
</tbody>
</table>
Ultra-sensitive Microvessel Imaging Allows More Accurate BI-RADS

After regrading

Unnecessary Biopsy reduced by 4 cases
Potentially useful for *early* evaluation of medical therapy response

Baseline

After 1st chemo
Adriamycin
Cytoxan

B-mode  Color Doppler  Ultra-sensitive Microvessel Imaging
Questions & Discussion