Emerging New Technologies

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Overview

- Mammography:
  - Contrast Enhanced Digital Mammography (CEDM)

- Ultrasound:
  - Ultrasound Tomography (UST)

- MRI:
  - “FAST” scanning
  - Background parenchymal enhancement & density evaluation
**Contrast-enhanced Digital Mammography: Initial Clinical Experience**

**Purpose:** To investigate the potential of using intravenous contrast material with full-field digital mammography to facilitate the detection and characterization of lesions in the breast.

**Materials and Methods:** Twenty-two women scheduled for biopsy because they were suspected of having abnormalities at breast imaging underwent imaging with contrast material-enhanced digital mammography. Six sequential images of the affected breast were obtained, with a contrast agent injected intravenously between the time the first and second images were obtained. Image processing included registration and logarithmic subtraction. Lesions were evaluated for the presence, morphology, and kinetics of enhancement. Lesion type, size, and pathologic findings were correlated with the findings at contrast-enhanced digital mammography.

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**Dual-Energy Contrast-enhanced Digital Subtraction Mammography: Feasibility**

A technique for demonstrating breast cancers, dual-energy contrast agent-enhanced digital subtraction mammographically occult. Digital subtraction angiography of the breast with fluoroscopic equipment was performed for evaluation of breast tumors almost 20
Contrast enhanced digital mammography

- Iodine attenuation has k-edge at 33keV
- Exposures taken below and above 33keV
- Background suppressed: this highlights the contrast uptake in tumour
HIGH ENERGY - LOW ENERGY = IODINE IMAGE

Images courtesy of Dr John Lewin
Contrast enhanced digital mammography

- Adapted to perform low and high energy exposures
- Produces “iodine image”
- Inject iodinated contrast Omnipyque 350 1.5ml/kg
- Radiation dose 20% > routine screening mammo
- Equivalent to one extra image

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Contrast enhanced digital mammography

• Unilateral CEDM + mammo: compared to
  • Mammo alone and mammo + US

• 74/80 (92%) cancers enhanced
• 13/50 (26%) benign lesions enhanced

• CEDM+ mammo > mammo alone and mammo+US
Contrast enhanced digital mammography

MRI and CEDM both depicted 50/52 (96%) of index tumours
FFDM depicted 42/52 (81%)

2 false positive findings with CEDM
13 false positive findings with MRI
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Ultrasound Tomography (UST)

- Novel whole breast 3D ultrasound imaging technique
- Radiation free
- Inexpensive, faster and more comfortable compared to MRI
- Measures breast density through the measurement of the speed of sound through tissues*
- Volume averaged speed of sound (VASS)**

Ultrasound Tomography (UST)

Breast density measurements with ultrasound tomography: A comparison with film and digital mammography

Neb Duric, Norman Boyd, [..], and Teri Albrecht

Abstract

Purpose: To investigate the use of the whole-breast sound speed measurement as a marker of breast density (BD), a known risk factor for breast cancer.

Methods: As part of an ongoing study of breast cancer detection, 249 patients were scanned with a clinical prototype that operates on the principles of ultrasound tomography. Typically, 40–100 sound speed tomograms were reconstructed from the scan data, corresponding to the entire volume of the breast of each patient. The data were used to estimate the volume averaged sound speed (VASS) of the breast for each patient. The corresponding mammograms were used to calculate mammographic percent density (MPD) using CUMULUS software. Film mammograms were available for 164 patients while 85 digital mammograms were available for the remaining
SoftVue system
SoftVue system image acquisition

2000 transducer elements within a uniform ring configuration

Each transducer element emits ultrasound signals in a sequenced 360° circular array surrounding the entire breast, scanning automatically from the chest wall to the nipple

2mm incremental acquisition
Images

Images courtesy of Delphinus medical technologies.

Comparison of UST(left) and MRI(right) shows concordance in visualizing breast parenchyma, fibrous stroma, fatty tissues and lesions.
Correlation of VASS with % water density

$r^2 = 0.97, p < 0.00001$
Lesion detection

Full coronal B-mode image shows a ~1.5 cm hypoechoic mass at 2:00.

Full coronal B-mode image overlaid with tissue stiffness map.

Images courtesy of Neb Duric.
Lesion detection

Full coronal B-mode image shows a ~2 cm anechoic mass at 1:00, overlaid by progressive intra-and peritumoral ROI’s.

Full coronal B-mode image overlaid with tissue stiffness map.

Images courtesy of Neb Duric.
Breast MRI

1. “FAST” scanning

2. Background parenchymal enhancement & density evaluation
Accelerated Breast MRI for screening

- “FAST” breast MRI:
  - First post contrast subtracted image (FAST) and MIP

- 433 women (mild/moderate increased risk)
- negative mammograph, 606 breast MR studies

Kuhl et al. JCO 2014
Accelerated Breast MRI for screening

- FAST” + MIP table time 3 mins, full protocol 21 mins
  - Average time to read MIP 2.8 seconds
  - Average time to read FAST 28 seconds

- Results:
  - 11 breast cancers detected
  - NPV MRI (99.6%) + FAST (99.8%)
  - Specificity of FAST equivalent to full protocol (94.4%)
A Novel Approach to Contrast-Enhanced Breast Magnetic Resonance Imaging for Screening

High-Resolution Ultrafast Dynamic Imaging

Ritse M. Mann, MD, PhD,* Roel D. Mus, MD,* Jan van Zelst, MD,* Christian Geppert, PhD,†
Nico Karssemeijer, PhD,*‡ and Bram Platel, PhD*

• TWIST technique: 102 seconds
• Successive MIP’s read
High resolution ultrafast dynamic imaging

With kind permission of Dr Ritse Mann
High resolution ultrafast dynamic imaging

- Read regular dynamic curve and TWIST maximum slope in cohort of 199
  - Regular dynamic curve AUC = 0.692
  - TWIST Maximum slope AUC = 0.829 (p=0.0036)

Mann et al. Invest Radiol 2014
Background parenchymal enhancement (BPE)

- Odds ratio for breast cancer increased significantly with increasing BPE

(odds ratio = 5.1 - 10.1 for moderate/marked BPE)

King et al. Radiology 2011
Background parenchymal enhancement
Background parenchymal enhancement

• Moderate and marked BPE is related to the inaccurate estimation of tumour size on MRI*

• Increased BPE is associated with younger age and higher abnormal interpretation age**

• Initial inter-reader agreement for BPE “fair” amongst breast radiologists***

*Baek et al. EJR 2014; **DeMartini et al. AJR 2012; ***Melsaether et al. AJR 2014
Breast density

- Women with at least 75% density have 4-6 fold increased risk*

- Up to 43% of the population have BIRADS C/D density*

*DCE early subtracted

*T2W

Does MRI Breast “Density” (Degree of Background Enhancement) Correlate With Mammographic Breast Density?

Nienke L. Hansen, MD,* Christiane K. Kuhl, MD, Alexandra Barabasch, MD, Kevin Strobel, MD, and Simone Schrading, MD

• Scores matched in 19%, but differed in 81%

• 468 women density scored on mammography and DCE-MRI
Breast density

• Mammographic assessment: Cumulus™, Quantra™, Volpara™

• MR density assessment:
  • Most MR density evaluation performed on T1W
  • No consensus as to whether fat suppressed* or non-fat suppressed best**

Breast density

• MR Dixon technique proposed as gold standard*

Chemical shift difference between fat and water
Fat and water protons will be in-phase or out-of-phase at certain echo times

The combination of in-phase and out-of-phase images results in fat-only and water-only images → used to derive water fraction of the breast

*Schmidt et al. Phys Med Biol 2011
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Thank you for your attention