3D Mammography: The Latest Developments in the Breast Imaging Arena

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Learning Objectives
• Highlight the basics of the technology behind breast tomosynthesis (DBT) and the C view
• Understand the indications and potential uses of DBT
• Understand the potential benefits of DBT as well as some of criticisms
• Discuss future directions, including tomosynthesis-guided biopsies and localizations

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• I have no financial disclosures

Background
• Screening mammography saves lives.
  ◆ Potential to reduce breast cancer related deaths by 30% (Tabar L et al)
• Frequently and highly visible disputed topic, in the literature and in the newspapers.
• As digital mammography generates a 2D image of the 3D breast, superimposition of normal breast tissue may hide masses, distortion and other features of malignancy (Roth R et al; Park JM et al).
• Criticisms of screening digital mammography include (Bleyer and Welch):
  ◆ High false positive rate
  ◆ Limited sensitivity
  ◆ Potential for “overdiagnosis”
From The New York Times…

**Background**

- Long standing quest for a modality for screening that will:
  - Lower the false positives
  - Increase the true positives that are “worth treating”
  - Improve sensitivity

**Generating the images**

- Take a group of low dose exposures from different angles (projection images)
Generating the images

• Take a group of low dose exposures from different angles (projection images)
• Projection images reconstructed through software into a series of high resolution slices (approximately 1 mm in thickness)
• Number of slices determined by the breast thickness
• Additional slices generated due to paddle tilt
A few examples.....

Example 2....
Example 4....
Image Interpretation

- Each generated image depicts the objects (breast tissue, mass, microcalcifications) that are in focus in that particular plane.
- Objects that are above or below the plane will appear blurry to varying degrees (depending on their distance from the plane imaged).
- Microcalcifications will rapidly become blurry and out of focus as the reader scrolls through the stack of images away from plane of the microcalcifications.

Roth R et al. Radiographics 2014

Invasive Lobular Carcinoma

C-view

- Synthesized 2D image from the 3D tomosynthesis data
- Goal is for the C-view to replace the conventional digital mammographic image
- Currently, our plan is to still obtain conventional digital images along with the C-view and tomosynthesis images: the “combo mode”
C-View

- Idea is that 2D and 3D images complement one another in mammographic interpretation
- Helpful for comparison with prior 2D conventional digital images
- C-view intended to preserve the important details from the tomosynthesis images

What about the radiation??

- Current radiation from DBT combined with the standard bilateral 2 view conventional mammography:
  - Results in 2 x the current digital mammography dose
  - Approximately 2.65 mGy-Below the limits defined by the FDA (< 3 mGy)
  - Dose will be cut in half if we abandon conventional 2D for the C-view

The Oslo Study....
Comparison of Digital Mammography Alone and Mammography Plus Tomosynthesis in a Population Based Screening Program

- Skaane P et al. Radiology 2013
- Prospective trial of over 12,000 examinations
- 27% increase in cancer detection rate utilizing DBT plus mammography (8.0 per 1000) vs mammography alone (6.1 per 1000)
- 15.1% decrease in the false positive rate for the DBT plus mammography arm
- PPV for recalled patients with cancers was similar for the two groups
- 40% increase in detection of invasive cancers for the DBT plus mammography arm (25 additional cancers)
- Mean interpretation time was 91 seconds for DBT plus mammography versus 45 seconds for mammography alone.

Breast Cancer Screening Using Tomosynthesis in Combination with Digital Mammography
JAMA 2014
Friedewald SM, et al.

- Objective: To determine if mammography in combination with tomosynthesis is associated with better performance of screening programs in the USA
- Retrospective analysis of 13 academic and nonacademic centers’ metrics of screening performance
- Examined 2 periods of time for each center:
  ◆ Period 1: digital screening mammography 1 year prior to implementation of tomosynthesis
  ◆ Period 2: Digital mammography + DBT from start dates of implementation of tomosynthesis
- Over 280,000 digital mammograms, over 170,000 digital mammograms + DBT

Friedewald SM, et al.

- Overall decrease in recall rate by -16 per 1000 screens
- Decreased model adjusted biopsy rate for women screened with combination vs mammo alone (16.1 vs 19.3 per 1000)
- Overall increased cancer detection rate of 1.2% combined mamm + DBT compared to mamm alone (Cancer detection rate for combination group: 5.4 per 1000)
- Increase in detection of invasive cancers utilizing the combination technique (1.2%) with no change in DCIS detection rate (1.4 per 1000).
- PPV for recall for mamm + DBT: 6.4% (vs 4.3% for mamm alone)
- PPV for biopsy for mamm + DBT: 29.2% (vs 24.2% for mamm alone)

Authors concluded that the addition of DBT to conventional digital mammography is associated with a decreased recall rate and an increase in cancer detection rate.

Speculate that possibly the relative yield for each recall will increase

Infer that increased cancer detection rate may optimize patient outcomes from mammographic screening

Which patients will benefit most from tomosynthesis?

- Fatty or dense breast tissue or both groups?
Clearly, mammographically dense breast tissue will benefit.

Who will benefit from tomosynthesis?

- Waldherr C., et al.: Examined 144 patients
  - Sensitivity and negative predictive value of DBT was superior to digital mammography for women with fatty breasts and women with dense breasts
- Haas BM, et al.: Utilization of DBT with conventional mammography decreased recall rates for all patients and all breast densities
  - Statistically significant decrease in recall rate for scattered, heterogeneously dense, and dense breasts (P < 0.05).
  - Statistically significant decrease in recall rate for women < 40 yrs, 40-49 yrs, 50-59 yrs, and 60-69 yrs.
  - Statistically significant differences for all subgroups EXCEPT those with fatty breast density and those patients > 70 yrs.
  - Greatest reductions in recall rates for patients with dense breasts and those < 50 yrs (less than 20 examinations needed to prevent one recall)

Applications of Tomosynthesis: Screening Mammography

- Rafferty EA et al:
  - Improved diagnostic accuracy compared to 2D digital mammography
  - Decreased recall rate (6%-67%)
  - Improved sensitivity greatest for invasive cancers
- Roth R et al:
  - Reduction in callback rate from 10.4% to 8.8%
  - Odds Ratio: 1.24 \( \Rightarrow \) the probability that a patient would be recalled from screening decreased by 24% with implementation of tomosynthesis + 2D
  - Trend toward increased cancer detection rate
- Rose SL et al:
  - Decreased recall rate: 8.7% \( \Rightarrow \) 5.5% (37% decrease)
  - Increased cancer detection rate: 4.0 per 1000 screens \( \Rightarrow \) 5.4 per 1000 screens (35% increase)
  - Decrease in biopsy rates 15.2 \( \Rightarrow \) 13.5 per 1000 screens (11% decrease)
Applications of Tomosynthesis: Diagnostic Mammography

- Michel MJ et al.: The Area Under Curve (AUC) values for ROC demonstrated statistically significant (P= 0.0001) improvement in diagnostic accuracy in the arm utilizing tomosynthesis with digital mammography (AUC = 0.9671) versus in the arms without tomosynthesis (AUC= 0.8949 and 0.7882).
- Effect significantly greater for soft tissue lesions than for microcalcifications.
- Improved detection of architectural distortion and lesion margins.
- Roth et al.: Several of their “DBT-only” cancers dissipated on standard spot compression views.
- Triangulation: Improved ability to determine the true 3D location of a target within the breast → helpful with target for US.
- May decrease the number of additional diagnostic views needed to triangulate a lesion → may decrease overall radiation dose?
- Helpful with localizing lesions to the skin (Roth et al.).
- Improved ability to estimate the extent of disease within the breast.

Improved lesion characterization

- Patient presenting for diagnostic mammography with a palpable abnormality.
- Conventional CC mammogram demonstrating heterogeneous fibroglandular tissue without mammographic abnormality.

- DBT image demonstrates an oval shaped mass with a possible capsule and containing both fat and dense breast tissue.
Improved lesion characterization

Magnified CC DBT image clearly demonstrates a pseudocapsule surrounded by fat. Classic for a Hamartoma.

Invasive Lobular Carcinoma: Multifocality better delineated with the DBT images

Benefits of DBT

• Increased cancer detection rate
• Decreased recall rate
• Increased PPV for recall from DBT and increased PPV for biopsy based on DBT findings
• From the literature, these benefits hold true both in academic and community settings.

Criticisms/ Disadvantages/ Questions

• Disadvantage: no magnification images possible at this time → currently limits our diagnostic evaluation of microcalcifications
  • Variable data regarding detection and characterization of microcalcifications in the literature
  • Large coarse calcifications create artifacts on multiple slices
• Not intended currently for large breasted women: image may be clipped.
• False positives (Roth et al):
  • Benign masses that would have been concealed by superimposition (lymph nodes, cysts) are detected more easily → may prompt recall and further work up (Roth et al).
  • Architectural distortion from benign lesions (radial scars) is much more evident.
• False negatives (Roth et al):
  • Not everything is detectable by DBT
  • If a cancer does not have classic mass-like features or architectural distortion (ILC), it may not be visualized by DBT. Illustrates importance of additional evaluation with US and MRI.
Criticisms/ Disadvantages/ Questions

- Time to interpret the images
- As with most new imaging modalities, there is a learning curve (Roth et al):
  - Increased recall rate initially
  - Recall of benign masses (LN, cysts) and architectural distortion (radial scars)
- HUGE files for storage: almost 10x greater than a standard 4 view mammogram
- Lack of long term follow up from all of the studies (Pisano E and Yaffe M):
  - Limited ability to accurately determine false negative results rates, interval cancer rate and “overdiagnosis”
- Need for a randomized controlled trial like the DMIST trial (demonstrated superiority of digital mammography to film screen mammography)

Future Directions...

- Tomosynthesis guided biopsy and localization
- Magnification views?
- CAD for DBT
- CPT code?

Tomosynthesis guided biopsy

Conclusions

- A lot of new data supporting the usage of DBT in both screening and diagnostic settings
- There remain several concerns, disadvantages that will hopefully be elucidated with further studies
- DBT is here at Baptist!
References