Combining Automated Image Measurements, Blood Biomarkers, and Clinical Data for Improved Decisions in Diagnostic Mammography

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Introduction

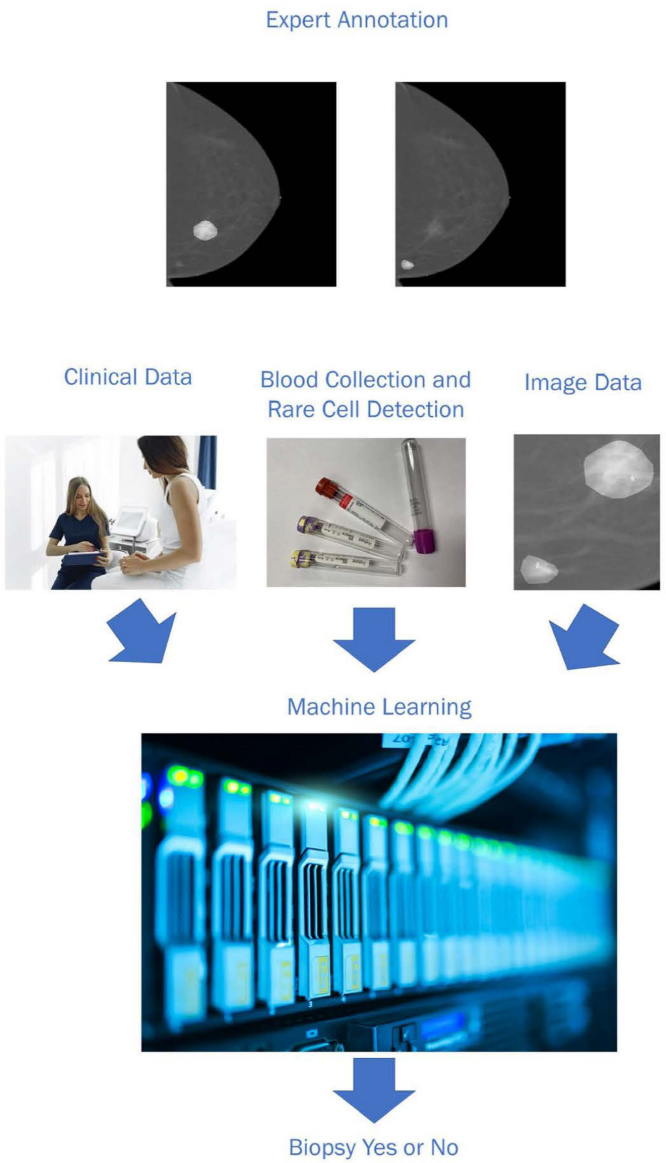
In breast cancer screening, approximately 2-3% of the women are classified as Breast Imaging Reporting and Data System (BI-RADS) 4 by the radiologist's interpretation. These women are recommended for biopsy and about 80% are found to be BC negative. This is a strong indication that computerized decisions could lead to improved specificity for this subset of women.

Background

This is a network collaborative project conducted by the BDL at Duke University (Marks et al.) and the CVC at Moffitt Cancer Center (Heine et al.) that targets BI-RADS 4 women prospectively (n = 1050). This study is comprised of two parts: (1) developing an EDRN central data repository resource supported by the DMCC and JPL; and (2) developing AI based decision models by considering a wide set of variables and automated image analyses to reduce biopsy procedures. The repository includes mammograms (close to the time of diagnosis), blood samples taken at the time of biopsy, an array of data variables (i.e. pathological, radiological, clinical, and demographical data), and complete image annotation. Blood samples are analyzed in real-time for rare cell detection (Creatv MicroTech) and archived for future EDRN use. Image annotation includes translating findings in the radiology report and mammogram to fully annotated overlay images, defined as the truth-files (TFs), at the individual level. Findings for a given woman are annotated by scribing the lesion boundaries that are saved in TFs. In this way, automated image analyses can target lesion areas with confidence. The automated decision modeling includes exploring the measures defined above with sophisticated AI techniques.

Progress and Baseline Results

Progress to date includes patient/data accrual (n = 909), annotation, and developing baseline (BL) models. These BL models are done during the data collection interim, without automated image measurements or blood markers; this provides BL performance metrics for comparison with more sophisticated modeling techniques using wider sets of variables. Performance metrics are cited with 95% confidence intervals (CIs) parenthetically. For women with masses ($n_{positive}$ = 47 and $n_{negative}$ = 218), a three variable logistic regression model with age, BI-RADS margin descriptors, and BI-RADS 4 (a, b and c) ordinal ratings produced significant odds ratios (ORs): OR = 2.10 (1.34, 3.28) for age; OR = 1.67 (1.11, 2.52) for margins; and OR = 4.67 (2.55, 8.55) for the ordinal ratings. The corresponding area under the receiver operating characteristic curve (Az) was Az = 0.89 (0.82, 0.95). Including BI-RADS shape descriptors in a similar model produced two significant measures: OR = 2.09 (1.26, 3.46) for age; and OR = 4.53 (2.33, 8.79) for shape. Although both margins (OR = 2.01) and BI-RADS ratings (OR =1.40) lost significance, the model's predictive capability increased giving Az = 0.94 (0.89, 0.99). These preliminary findings are based on a small sample size as noted in the wide CIs. The shape finding has not been noted in our work previously.



Discussion

Although preliminary, these simple BL findings suggest modeling with more sophisticated techniques including both automated image measurements and blood markers may produce a viable automated tool for further testing in the clinical environment. The repository development has many user-friendly attributes (e.g., querying methods, documentation, data structure, and image file naming conventions), incorporated into its design, in addition to the wide array of data elements, representing a unique EDRN resource.

Three Variable Model: Az = 0.89 (0.82-0.95)	
Measure	OR (95% CI)
Age	2.10 (1.34, 3.28)
Margin	1.67 (1.11, 2.52)
BI-RADS	4.67 (2.55, 8.55)
N=265 Cancer= 47 Non-Cancer=218	

Four Variable Model: Az = 0.94 (0.89, 0.99)	
Measure	OR (95% CI)
Age	2.09 (1.26, 3.46)
Margin	2.01 (0.66, 6.09)
BI-RADS	1.40 (0.86, 2.29)
Shape	4.53 (2.33, 8.79)
N=226 Cancer= 37 Non-Cancer=189	

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