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A Survey of New Diagnostic Techniques for Breast Cancer Detection

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ABSTRACT: Mammography is one of the most efficient imaging techniques for the early detection and diagnosis of breast cancer in woman. This study compares the clinical performance of three digital mammography system types in a breast cancer screening programme. 28 digital mammography systems from three different vendors were included in the study. Full-field digital mammography optimizes the lesion-background contrast and gives better sensitivity, and it is possible to see through the dense tissues by altering computer windows; this may be particularly useful in younger women with dense breasts. Computer-aided detection systems may help the radiologist in interpretation of both conventional and digital mammograms. MRI has a role in screening women at high risk for breast cancer. Newer diagnostic techniques such as sestamibi scans, optical imaging and molecular diagnostic techniques look promising, but need more investigation into their use. Other upcoming techniques are contrast-enhanced mammography and tomosynthesis. These may give additional information in indeterminate lesions, and when used in screening they aid in reducing recall rates.

KEYWORDS: Breast Cancer, Mammogram, Computer-aided detection, MRI, Full-field digital mammography

I. INTRODUCTION

Detection and diagnosis of breast cancer in its early stage increases the chances for successful treatment and complete recovery of the patient. Screening mammography is currently the best available radiological technique for early detection of breast cancer [1]. Calcifications are deposits of calcium in breast tissue. Calcifications detected on a mammogram are an important indicator for malignant breast disease but are also present in many benign changes. Benign calcifications are usually larger and coarser with round and smooth contours [2]. Malignant calcifications tend to be numerous, clustered, small, varying in size and shape, angular, irregularly shaped and branching in orientation [1]. Calcifications are generally very small and they may be missed in the dense breast tissue. Another issue is that they sometimes have low contrast to the background and can be misinterpreted as noise in the in- homogeneous background [2].

II. LITERATURE REVIEW

Computer-Aided Diagnosis (CAD) is a technology used for detection and characterization of cancer. Although CAD is not limited to a single type of cancer, a large number of CAD systems to date have been designed and used for breast cancer. The aim of this review is to discuss the current state of the CAD systems for breast cancer diagnosis. Clinical trials have shown that CAD can improve the accuracy of breast cancer detection. Preclinical studies have demonstrated the potential of CAD to improve classification of malignant and benign lesions. An increased number of CAD systems are being developed for different breast imaging modalities.

III. SCREEN FILM MAMMOGRAPHY

The largest number of applications of CAD currently is for the lesion detection on screen film mammography. Clinical trial of a noncommercial CAD system developed at the University of Michigan for screening mammography. A total of

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2389 screening cases were read by 13 MQSA-qualified radiologists in two academic institutions. Twenty one cancers were detected both by the CAD and the radiologists, six were detected only by radiologists and 2 were detected only by CAD. Radiologist reading with CAD resulted in 7.4% increase in the cancers detected. The increase of the recall rate because of CAD was 7.6%. Study design compared the changes in breast cancer detection rate and recall rates between two periods of time, before and after the CAD system was introduced into their screening mammography practice. The CAD system was reasonably consistent in the overall number of cancers identified at different runs. Greater variability was observed for the false-positive marks compared to true-positive marks.

IV. FULL FIELD DIGITAL MAMMOGRAPHY

Full field digital mammography (FFDM) is becoming important imaging modality. The proposed a multistage CAD for detection of masses on FFDM. They reported a case-based sensitivity of 70%, 80%, and 90% at 0.85, 1.31, and 2.14 FP marks/image. Developed a method for noise equalization in FFDM images and showed that the proposed square root noise model improved the performance of their CAD algorithm for detection of micro calcification clusters on FFDM images.

In recent years there has been a continuing adoption of digital mammography for breast imaging, and a number of comparative studies of screen film mammography (SFM) and full-field digital mammography (FFDM) have been published as screening programmes and practices make the transition to digital imaging [2]. In addition, there have been a number of physical evaluation studies, investigating the technical performance of individual FFDM systems [2]. These studies have provided evidence for the benefit of digital mammography in respect of objective image quality as well as clinically, through improved cancer detection. The installed base of mammography systems at the BreastCheck programme represents three distinctive technologies and thus offers the opportunity to analyse the comparative performance, in terms of cancer detection, of the digital mammography systems used.

Full-field digital mammography (FFDM) utilizes digital detectors in place of the screen and film used in conventional mammography, giving more latitude and contrast resolution.[3] Digital detectors absorb x-ray photons and convert them into electric charge, and with the help of analog-to-digital converters, the image is changed to digital value. FFDM also provided easier access to images and use of computer-aided detection (CAD), and easier storage and retrieval of images. The use of FFDM may be justified in the specific subgroup where it showed increased sensitivity. Fischmann conducted a study in 200 women to compare image quality and lesion detection for FFDM and conventional full-screen mammography.[4] No improvement in detection of masses with FFDM was reported, but FFDM was advantageous owing to its contrast resolution in excluding masses and better classified parenchymal density. There was also better depiction of nipple, skin and pectoral muscle. The paper concluded that FFDM was equal or superior to conventional mammography for all image quality and detection parameters studied.

- Digital mammography is FDA approved and thus coverage of digital mammography should be no different from coverage of digital fluoroscopy, chest x-ray, angiography, etc. All of these modalities converted to digital with no change in coding or reimbursement.
- The ACR supports coverage of FFDM at the same rate as film screen mammography.
- The ACR Committee on Coding and Nomenclature has taken the position that if the private payers' system is not set up to recognize HCPCS codes (and therefore the G-codes that have been developed for FFDM)

V. BREAST ULTRASOUND

A number of CAD schemes were proposed for characterization of malignant and benign breast lesions on ultrasound scans. A CAD system for characterization of breast masses as malignant and benign on three-dimensional (3-D) ultrasound scans using 102 biopsied masses. Four radiologists evaluated the 3-D ultrasound volumes in an observer study. The CAD system based on 3-D segmentation method achieved an area under ROC curve, Az, of 0.92 for testing. The Az values of the four radiologists ranged from 0.84 to 0.92. The accuracy of the classifier designed for differentiating malignant and benign breast masses on 3-D US volumes in this study was similar to that of experienced breast radiologists.

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VI. BREAST MRI

Recently MRI is used more frequently for diagnosis of breast cancer. A number of studies have been reported which explored the feasibility of CAD use for characterization of breast lesions as malignant and benign using contrast enhanced MRI. A computer system to estimate the likelihood of malignancy of lesions on contrast enhanced MR images. They used 100 lesions (in 78 patients) to train the computer system. In addition they had the descriptive rating (benign, probably benign, indeterminate, suspicious, or highly suggestive of malignancy) of the lesions on MR images by an experienced radiologists. The scores from the computer system and the radiologist were merged by using the logistic regression analysis in a combined model. The study demonstrated that the complementary information from a radiologist and a computer system has the potential to increase the overall performance for clinically and mammographically occult lesions.

V. BREAST TOMOSYNTHESIS

Digital breast tomosynthesis (DBT) is a promising new modality allowing 3D imaging of the breast. A CAD system for breast masses on DBT mammograms. The CAD system first screened the 3D volume for mass candidates by gradient field analysis. Each candidate was segmented from the structured background. Morphological and texture features were extracted. A feature classifier was designed to differentiate true masses from normal tissues. The classifier obtained an area under the test ROC curve of 0.91 ± 0.03 . The CAD system achieved a sensitivity of 85% at 2.2 false positives/case. The results demonstrate the feasibility of this approach to the development of a CAD system for DBT mammograms.

VI. CONCLUSIONS

Breast cancer is one of the major causes of death among women. Digital Mammography screening programs can enable early detection and diagnose of the breast cancer which reduces the mortality and increases the chances of complete recovery. Computer-aided detection and diagnosis algorithms have been developed to help radiologists give an accurate diagnosis and to reduce the number of false positives. CAD is an active area of research and development in medical imaging and diagnostic radiology. Recently, there are an increased number of CAD applications. To date the largest number of CAD systems have been developed for screening mammography. However, an increasing number of applications for US and MRI breast imaging are being evaluated. Further developments in each algorithm step are required to improve the overall performance of computer-aided detection and diagnosis algorithms.

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