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A NEW CAD SOFTWARE FOR EVALUATION OF BREAST LESIONS IN CONTRAST –ENHANCED MR MAMMOGRAPHY

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ABSTRACT

The aim of this study was software designing for the detection and diagnosis of breast lesions in contrast enhanced MR mammography. In this study MR mammography was performed in 31 women with 54 suspected breast lesions consisting of 34 malignant and 20 benign entities. Every lesion was evaluated through multiple diagnostic parameters such as morphologic and physiologic lesion traits by designed software. Final results from the physiologic and morphologic assessments for each lesion were compared with the pathology reports. Designed software could show easy reading colored view of each image and it was able to show the margin and internal architecture of lesions. Final results showed that software sensitivity for lesion detection was 94.1% and its specificity was 85%. In this study, efforts have been made to design software for the assessment of physiologic and morphologic breast lesion traits simultaneously. Relatively high sensitivity and specificity is due to this contemporary assessment.

KEYWORDS: *Breast MR, computer aided diagnosis (CAD), contrast enhanced, intensity –time curve, Region of interest (ROI).*

INTRODUCTION

Breast cancer is one of the most common cancers that afflict women and it can lead to death in a number of patients. Breast cancer risk in United States is 1 in 8 and in British is 1 in 12[1]. There is no comprehensive statistics on this subject in Iran. But regional statistics shows high prevalence of breast cancer in these regions[2]. The average five years survival rate for breast cancer in developed countries is 73% and in developing countries is 57%. This average survival depends on early differentiated diagnosis, stage of disease, patient´s age and treatment protocols[3]. Physical examination, conventional mammography and ultrasonography are the most common diagnostic modalities. Each of these methods has limited sensitivity and specificity for detection and diagnosis of breast cancer. Sensitivity of conventional mammography varies from 63% to 98% and only 30% to48% of sensitivity has been reported for dense breasts. Unfortunately, small cancer lesions diagnosis in mammographic images is so difficult for patients with dense breasts. In breast cancer patients, early diagnosis and appropriate staging can leads to good prognosis and accelerating to treatment procedure[4-6]. Breast magnetic resonance imaging is a powerful modality for detection and characterization of breast cancer. MRI systems are able to image in three dimensions and provides morphological and physiological information of lesions. Contrast–enhanced MR mammography is a relatively comprehensive breast imaging modality that depicts morphologic and physiologic traits of breast lesions. Other conventional imaging modalities such as mammography and sonography are able to show only morphological traits. During the past decade a wide range of imaging protocols for MR mammography has been developed. These protocols can present lesions with high spatial and

temporal resolutions. Lesion detection sensitivity in breast MR is above 90%. In contrast of high sensitivity the reports of literature show varying results concerning specificity (36-86%)[7]. In the past decade many imaging protocols, interpretation criteria and CAD methods have been suggested to improve the diagnostic specificity of MR mammography[8]. Usually MR mammography is performed for lesion detection, staging, evaluation of the treatment procedure and so on. One of the most important goals of MR mammography is lesion detection and differential diagnosis (benign vs. malignant lesions)[9]. Early reliable differential diagnosis can prevent unnecessary biopsies and help in speedy start of treatment procedure[10]. Sometimes differential diagnosis of benign vs. malignant lesion is harder because the enhancement kinetic of benign and malignant lesions often overlap or are equivocal and morphologic features are often ambiguous[11]. Many diagnostic parameters have been offered for differential diagnosis such as morphologic traits (shape, margin, heterogeneity) and physiologic traits such as intensity –time curve. But some of these parameters are seen in both malignant and benign lesions[12]. The hypothesis of the present study was whether considering both morphologic and kinetic traits of lesions, would improve the specificity. The study was aimed at expanding data of Breast MR images and approximate lesion imaging traits to reader's eye.

MATERIALS AND METHODS

Patient

MR imaging was performed in 31 female patients with 54 suspected lesions. Every patient filled an informed consent form and imaging procedures were explained to them for optimum cooperation achievement, throughout the procedures.

MR imaging

Breast MR was performed on a 1.5 T scanner (Symphony, Siemens). We used dedicate breast coil, with following parameters of Scanning Sequence: GR fl3d, TE 1.76 ms ,TR 5.20ms, matrix image 512*512, slice thickness 1.41mm, fov 350, six acquisition with 95 slices for each acquisition were obtained. Gadopentetate dimeglumine (Magnevist) was used as contrast agent with a dose of 0.1mmol /kg.

CAD[1] Software

The objective was to design software that can automatically specify and read out the dynamic images and subtract post contrast series from pre contrast Series. Subtracted images were the basis of this CAD survey. After a lesion was found by the reader, software allowed additional possibilities for further lesion assessments such as coloring, lesion selecting through free -size ROI, margin, shape and heterogeneity assessments and Intensity –time curve drawing. For these purposes, different panels and buttons were contrived in the software (Figure .1).

Figure 1
Software pane

Coloring

A specific color map was used for this purpose. Software analyzes the mass enhancement and washout rate and allocates cold colors (indigo, blue…) for steady enhancement and late washout, and hot colors (red, orange…) for high-intensities signals, high enhancement and rapid washout respectively (Figure 2).

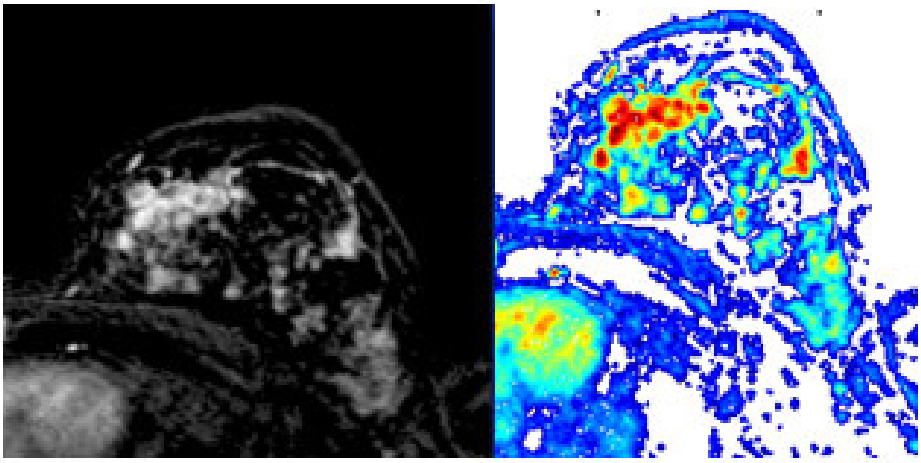

Figure 2
Extensive lesion in the left breast of a 54 year old woman with it's color- coding map. Pathologist reports "invasive ductal carcinoma" for this lesion.

This coloring method allowed the conversion of the gray scale image to a colored format without missing actual value of pixels data. In this way all suspected points of the image are highlighted in a user friendly pattern.

Set ROI[1]

Now the reader can select suspected region for further assessments through drawing a free- size quadrangle around the lesion (Figure .3).

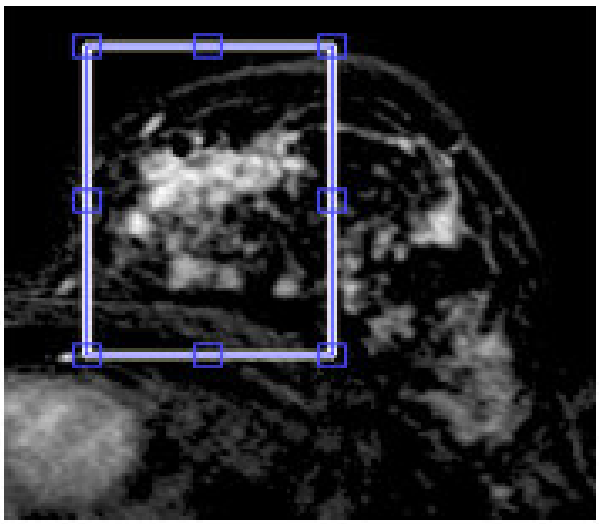

Figure 3
Selecting a region for further assessment

Selected ROI was opened in a new window with a magnified and pixel by pixel colored format. Lesion heterogeneity was assessable in this way. Rate of heterogeneity was determined by a variety of color hue and color intensity in pixels.

Margin, Shape and Heterogeneity assessments

For better margin and shape assessment, the software was enabled to connect pixels with the same intensity through the colored contours. On the other hand heterogeneity was assessable through pixel by pixel lesion color map (Figure 4). Heterogeneous lesion show further color hue and color intensity pixels in their colored format.

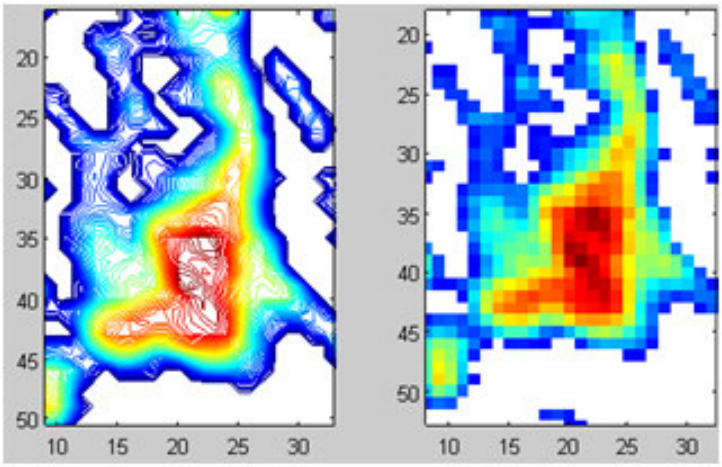

Figure 4
Lesion shape and margin evaluation in the left picture and heterogeneity in the right picture are presented. Pathologist report showed "invasive ductal carcinoma" for this lesion in a 33 year old female.

Intensity–Time Curve
Intensity–time curve assessment is an important key for differential diagnosis. By this software, the reader is able to draw the intensity-time curve for any region of interest (ROI). For this purpose, software depicts mean signal intensity variation for a ROI in pixels.

Original views of lesion on other sequences
For further lesion evaluations the software can read out and show the same cut of image on other sequences simultaneously for example TIRM, T2 weighted, T1 pre- contrast and etc. This assessment is important for mass lesion(13).Also reader was able, compare lesion location at opposite breast for non-mass like lesions.

Image interpretation
In this study an expert radiologist assessed every lesion by various diagnostic parameters, for example morphologic traits (shape, margin, heterogeneity) and kinetic traits (Intensity-time curve and enhancement patterns) through the software. However the software was still able to show the same-cut image on other sequences for further evaluations for mass lesion. For non-mass enhanced regions software was able to compare its location on opposite breast.

RESULTS

The radiologist's reports were compared with the pathology result. 54 lesions in 31 female patients consisting of 34 malignant lesions and 20 benign were included in the study. After morphologic and kinetic evaluations for every lesion through the software, radiologist decides about the nature of lesions, malignant or benignant. Radiologist's reports were compared with biopsy results. The results are shown in Table 1.

Table 1
32 instances were true positive (TP), 3 instances were false positive (FP), 17 instances were true negative (TN) and 2 instances were false negative (FN).

	Malignancy		Total	Percentage
Software	32 TP	3FP	35	64.8
Result	17TN	2FN	19	35.18

These results show 94.1% sensitivity and 85% specificity for lesion detection and diagnosis. In this study 100% lesions with spiculated margins and 91.6% of lesions with lobular margins were malignant according to pathologist's reports. And 17.6% of all malignant lesions have round margins. We found that 82.3% of malignant lesions had heterogenic internal patterns. On other hand 66.6% masthopathic changes were heterogeneous in pattern..

DISCUSSION

Breast lesions are various depending on their nature, morphology and dynamic kinetic traits. While patients' age and hormonal activity, stage of disease and so on increase this variety. Diagnostic criteria for mass lesions in DCE1 breast MRI include morphologic traits (such as margin, shape and internal architecture) and kinetic traits (such as intensity–time curve and enhancement pattern)15,16. Malignant mass lesions often have irregular shapes and margins and benign lesions often show round shape and regular margins17,18. Although these allocations are not certain principles sometimes they overlap in both malignant and benign lesions. The present study shows this subject too. In breast, mass lesions as early as tumor grows more than a few millimeters, oxygen and nutrient diffusion is not sufficient for their high metabolism requirements. This result in hypoxic stress in their cells and angiogenic hormones are produced13. In this way new vessels are produced in the tumor. Studies show that vessel density in malignant lesions is higher than in benign lesions and natural fibro glandular tissue in breast19. For this reason, often malignant lesions have early enhanced and immediate wash–out, intensity–time curve patterns17. Intensity-time curve is an important tool for mass lesions evaluations. However, different curve types sometimes overlap in both malignant and benign lesions. But type I curves often are seen in benign lesion and wash-out curves are often seen in malignant lesions20. On other hand invasive malignant lesions have more heterogeneous internal pattern. The software results of our study have verified these items. But intensity–time curve assessment for non-mass enhanced regions is misleading. Because in this lesions the angiogenesis procedure is not similar to that of mass lesions9. Important differential diagnostic key for non-mass lesions is to compare its location in opposite breast and enhancement distribution pattern. Symmetry evaluation in both breasts is useful in these cases14,21. For this purpose this item is considered in the software. It was decided to assess relatively all diagnostic parameters through this software.

CONCLUSIONS

For differential diagnosis in mass and non-mass enhanced lesions, two different paths and diagnostic criteria must be considered. Some of these diagnostic items overlap in benign and malignant lesions. Relying on only one diagnostic parameter can be misleading. On the other hand to improve diagnostic specificity both morphologic and kinetic lesion traits must be considered.

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CONFLICT OF INTEREST

Conflict of interest declared none.

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