ABSTRACT

Objective

To study the utility of DWI and ADC in increasing the specificity of MRI in differentiating benign from malignant solid breast lesions

Patients and methods

20 female patients were included in our study. All patients referred to MRI unit -Radiology department –Ain Shams University hospitals to do bilateral breast MRI using conventional sequences ,DWI ,ADC calculation and post contrast dynamic study with time /intensity curve using Philips super conductive magnet at 1.5 T with breast coil. All the patients were subjected to clinical examination , sonomammography as well as written consent also the histopathological results were recorded

Results

20 lesions were detected , 12 were malignant and the rest lesions were benign . The sensitivity of DWI was 83.33% while the specificity 87.50%. The ADC values for the benign lesion were 1.3-2.2x10-3mm2/sec, while the malignant lesions showed the ADC values of 0.4-0.97x10-3mm2/sec. The ADC value of 1.0 x10-3mm2/sec can be used as the cut off value in differentiating the benign from malignant lesions.

Conclusion

DWI and ADC calculation are short unenhanced sequence that can be inserted easily in to MRI protocols to accurately differentiate between the benign and malignant breast lesions

Key word

Magnetic resonance imaging (MRI); Diffusion weighted imaging (DWI); Apparent diffusion coefficient (ADC).

INTRODUCTION

Registry of the National Cancer Institute in Cairo reported breast cancer to represent 35.1% of female cancers in Egypt ***(Salem et al., 2008).***

Both mammography and MRI demonstrate malignancy; however, concordance with the pathological determination of the extent of disease was found to be considerably higher for MRI: 98%, as compared with 55% for mammography ***(Esserman et al., 1999).***

Despite improvements in DCE-MR imaging acquisition techniques, overlap in morphologic characteristics and kinetic features of some benign and malignant lesions still causes improper classifications ***(Brandão et al., 2013)***.

Diffusion-weighted imaging is a technique that is showing promise for improving diagnostic accuracy as an adjacent to DCE-MR imaging. DWI is a short scan available on most commercial MR scanners that does not require any exogenous contrast ***(Brandão et al., 2013).***

Diffusion-weighted imaging is a technique that involves the exchange of water molecules (diffusion) between breast tissue compartments. Diffusion rates vary between normal and pathologic tissue.The value of diffusion of water in tissues is called apparent diffusion coefficient (ADC) and it is calculated

in the MRI machine by using (ADC) mapping. The (ADC) vary in different breast masses. So application of DW sequence to the breast MRI showing promise in improving the specificity of the MRI ***(Woodhams et al., 2005).***

Using Diffusion-weighted imaging (DWI) combined to MRI in distinguishing benign versus malignant breast lesionsmay reduce the number of unnecessary breast biopsies ***(Barker and Salkowski, 2009).***

AIM OF THE STUDY

Our purpose was to study the diagnostic value of diffusion-weighted MRI and ADC in differentiating benign from malignantsolid breast lesions. and to correlate the results with histopathological dataand /or follow up and /or clinical data.

MRI ANATOMY OF THE BREAST

Anatomy of the breast can be exquisitely demonstrated with magnetic resonance imaging. Areas of the breast that have been previously the beyond the limits of conventional imaging, such as the extreme posterior breast and chest wall musculature, can be evaluated ***(Morris, 2005).***

MRI provides a sectional image that can display skin, areola, nipple, subcutaneous fat, parenchyma, muscle, connective tissue andvessels. The relationship of breast tissue to the skin and muscular structures is easily appreciated. The distribution offibroglandular tissue and fat tissueis easily seen and the wide variation in breast composition is more easily appreciated (***Dash and Lupetin, 2005).***

On T1 weighted non-contrast enhanced images, aqueous tissues includingfibroglandular tissue, skin, lymph nodes and muscle have moderately low signal intensity when compared to the higher signal intensity of fat, which has a short T1 relaxation time. In absence of any surgery or pathology, a layer ofretromammary and subcutaneous fat completely surrounds the mammary gland tissue except where it enters the nipple- areola complex. The mammary gland itself is composed of a mix of high signal fat lobule andlow signal fibroglandular tissue. The mix and distribution of afibroglandular tissue and fat vary greatly between patients from dense, uniformly glandular tissue

with almost novisible fat, to heterogeneous, to predominantly fatty tissue separated by thin septaor strandsof fibroglandular tissue ***(Daniel and Ikeda, 2004).***

T2non contrast enhanced images reveal heterogeneous fibroglandulartissue that is usually higher signal intensity than adjacent muscle but still not as bright as the small subcutaneous blood vessels commonly seen at the periphery of the breast or pure fluid ***(Daniel and Ikeda, 2004)***.

Intramammary lymph nodes are present in up to 47% of breasts. Although they are usually located in the upper outer quadrant, they may appear anywhere in the breast. They are identified by MRI, and other imaging modalities, on the basis of morphological criteria ***(Millet et al., 2012).***

The lymph nodes show characteristic reniform shape with fatty hilum. The cortex is usually hyperintense on T2. Normal vessels may enter nodes via hila. On the dynamic study, they often demonstrate physiologic rapid inflow and washout enhancement curves ***(Kettler, 2006).***

Visualization of the pectoralis major muscle is as important in MRI as it is in mammography to ensure that the breast is maximally imaged. With adequate penetration to the chest wall, portions of the pectoralis major and minormuscles, are reliably visualized. Complete visualization of the entire breast parenchyma is essential ***(Morris, 2005).***

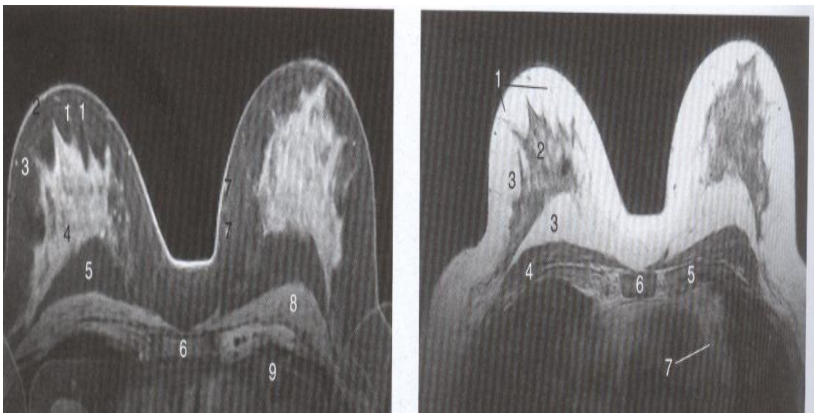
Vessels are easily recognized by their course, which should be assessed in cine-view mode, by their topography (they are often localized at the parenchyma and fat junctions or within fat layers) and by their high signal intensity on *T*2 sequences, although this may be lost in high-velocity vessels..***(Millet et al., 2012).***

After intravenous gadolinium, the blood vessels, nipple and lymph nodes normally enhance. The glandular parenchyma can also enhance especially in the second half of the menstrual cycle, reflecting normal hormonal-induced glandular proliferation. This enhancement is often diffuse and rather patchy ***(Michell et al., 2005).***

The breast imaging should be performed during the second week of the menstrual cycle due to minimize the risk of false-positive diagnosis. The parenchymal enhancement can also be found in menopausal females with hormone replacement therapy. Progesterone can be cause abnormal enhancement in 50% of cases. Where possible, hormone replacement therapy should be discontinued four to six weeks before performing breast MRI ***(Millet et al., 2012).***

Nipples enhance normally to varying intensities in breast MRI. This enhancement of nipple is due to the rich blood supply in the nipple–areolar complex. The normal nipple may be misinterpreted as a mass when it is flattened or invertedagainst

the anterior surface of the coil due to the large size of the breast. To determine that an enhancing lesion is actually a nipple, comparing with the other side, viewing the anatomic image without contrastand performing three-dimensional reformatting can be helpful ***(Millet et al., 2012)***



A **B**

Fig.(1):(A) T1-weighted, fat-saturated, gadolinium-enhanced Note- fat is dark and muscles are bright, enhancing breast tissue. B) T2-weighted image. Note- fat is bright, fibroglandular tissue is dark.

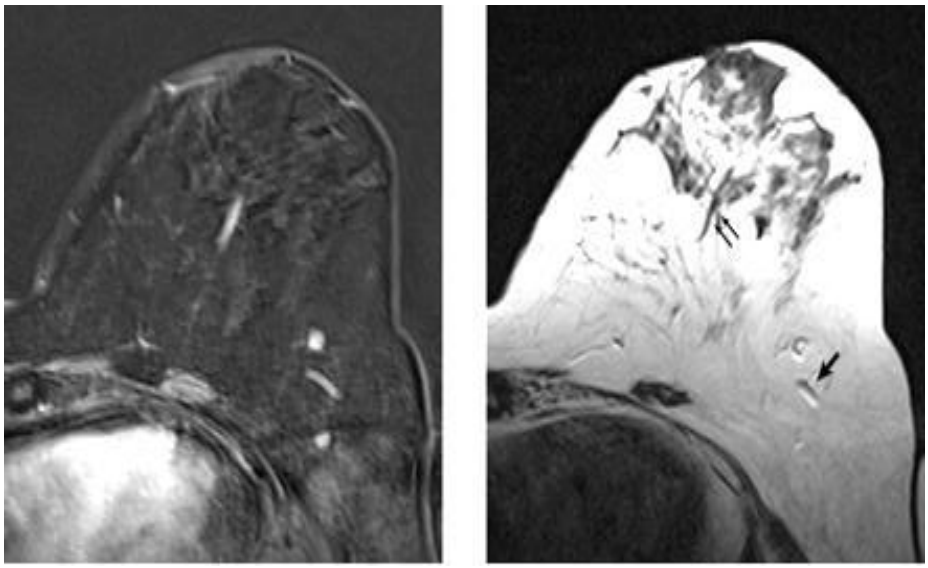
Image (A)

1. Cooper's ligament
2. Skin
3. Subcutaneous fat
4. Enhancing fibroglandular breast tissue
5. Retroglandular fat
6. Sternum
7. Enhancing vessels
8. Pectoralis major muscle
9. Lung.

Image (B)

1. Copper's ligament
2. Fibroglandular tissue
3. Fat
4. Pectoralis major muscle
5. Costal cartilage
6. Sternum,
7. Heart.

(Quoted from Ryan et al., 2004)



A B

Fig.(2): Normal enhancing breast structures (A) On the subtracted axial image of the left breast, four enhancing structures are seen: two are linear and two are nodular (B) On the T2 weighted image, the two nodules have a location within fat and a hypersignal highly suggestive of lymph nodes, and the two linear structures are suggestive of vessels with one in hypersignal (arrow) and the other in hyposignal (double arrows) because of a difference in velocities ***(Quoted from Millet et al., 2012).***

PATHOLOGY OF BREAST MALIGNANT LESIONS

Breast masses have a variety of etiologies, benign andmalignant. Fibroadenoma is the most common benign breast mass; invasive ductal carcinoma is the most common malignancy. However most breast masses are benign.The breast cancer is the most common cancer and the second leading cause of cancer deaths in women ***(Elsaid and Mohamed, 2012).***

Malignant lesions are classified as:

1-Non-invasive Carcinoma of the Breast:

- Lobular carcinoma in situ (LCIS).
- Ductal carcinoma in situ (DCIS) or intraductal carcinoma (Cribriform,papillary,, solid and comedo types)

2-Invasive Carcinoma of the Breast (percentage of total):

- Invasive lobular carcinoma (10-15%).
- Invasive ductal carcinoma:
  - Invasive ductal carcinoma, not otherwise specified -NOS (50-70%).
  - Tubular carcinoma (2-3%).
  - Mucinous or colloid carcinoma (2-3%).
  - Medullary carcinoma (5%).

- Invasive cribriform carcinoma (1-3%).
- Invasive papillary carcinoma (1-2%).
- Adenoid cystic carcinoma (1%).
- Metaplastic carcinoma (1%).

3-Mixed connective and epithelial tumors:

- Phyllodes tumor, benign and malignant.
- Carcinosarcoma.
- Angiosarcoma.

(Iglehart and Smith, 2008)

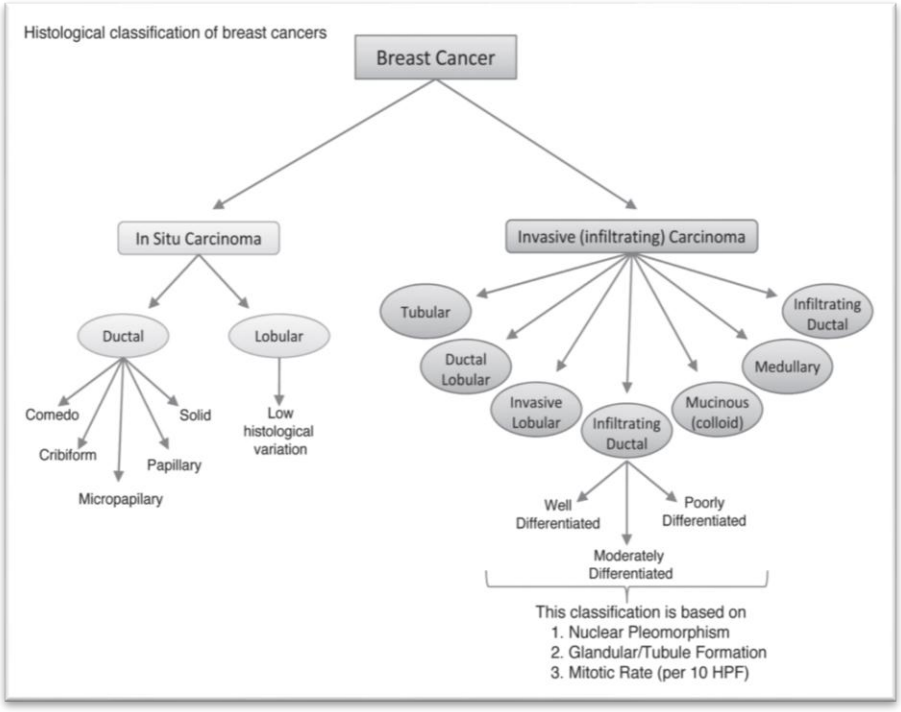


Fig.(3): Histological classification of breast cancer subtypes. This scheme used by clinicians, categorizes the heterogeneity found in breast cancer based on architectural features and growth patterns. HPF: high power field.**(Quoted from Stingl et al., 2007).**

The major invasive tumor types of breast include infiltrating ductal, invasive lobular, ductal/lobular, mucinous (colloid), tubular, medullary and papillary carcinomas. Of these, infiltrating ductal carcinoma (IDC) is the most common subtype accounting for 70–80% of all invasive lesions. Invasive ductal carcinoma is furthersub-classified as either well-differentiated (grade 1), moderatelydifferentiated (grade 2) or poorly differentiated (grade 3) based on the levels of nuclear pleomorphism, mitotic index and glandular/tubule formation (**Stinglet al., 2007)**

Incidence and epidemiology:

I. Incidence by age:

Breast cancer is the second leading cause of cancer deaths **in women today (after lung cancer) and is the most common** cancer among women.

While breast cancer is less common at a young age, younger women tend to have more aggressive breast cancers than older women, which may explain why survival rates are lower among younger women ***(Kumar, 2007).***

II. Incidence by location

Breast cancer commonly affects the left breast more frequent than the right one. Four percent of the cases of breast cancer have bilateral primary tumors. Fifty percent of the breast cancer occur in the upper outer quadrant ***(Kumar, 2007).***

Breast cancer risk factors:

I. Major risk factors

**** Gender:***

The biggest risk factor for developing breast cancer is gender. The lifetime risk for women developing breast cancer is 1 in 8. Approximately half of all women who develop breast cancer have no identifiable risk factor other than being female.

However, the incidence of male breast cancer has increased annually. The reasons are unknown and are not attributable to increased detection, as is generally the case for female breast cancer ***(Evans and Lalloo, 2002).***

*** Age:**

Besides being female, the second greatest risk factor for developing breast cancer is age. Older women are much more likely to get breast cancer ***(Kumar, 2007).***

*** Genetics:**

Although 20-30% of women with breast cancer have at least one relative with a history of breast cancer, only 5-10% of women with breast cancer have an identifiable hereditary predisposition. Breast cancer gene (BRCA1and BRCA2) mutations are responsible for 3-8% of all cases of breast cancer and 15-20% of familial cases **(Pink,2014).**

*** Family history:**

Breast cancer risk is higher among women whose close blood relatives have this disease (mother, sister or daughter). A blood relative can be from either the mother‘s or the father‘s side of the family (***Evans and Lalloo, 2002).***

*** Personal history:**

The woman with cancer in one breast has a greater risk of developing a new cancer in the other breast. Having a history of the following types of cancers may also increase the risk of developing breast cancer: colon, uterine, salivary gland and Hodgkin‘s disease ***(Evans and Lalloo, 2002).***

II. Minor risk factors

*** Childbearing:**

Never having children increases the risk of breast cancer twice over women who have had at least one baby. Also breast feeding has consistently been shown to decrease a woman‘s risk of breast cancer slightly (***Yager and Davidson, 2006).***

*** Menstrual history:**

Women who start menstruating at an early age (early menarche - before age 12) or who went through menopause at a late age (after age 55) are at an increased risk for breast cancer***(Yager and Davidson, 2006).***