Introduction

Breast cancer is the most common undoubtedly prevalent malignant tumour among women globally ***(Zawilla, 2011).***

In Egypt, it is the most common cancer among women, representing 18.9 % of total cancer cases (35.1% in women, 2.2 % in men). However, a positive diagnosis is not necessarily a death sentence yet the lack of public awareness and the financial shortage that impede screening and diagnostic services render chances of survival low and mortality rates high ***(Salem et al., 2010).***

Moreover, the only way to decrease mortality and morbidity from breast cancer is to detect the disease before the patient presents the symptoms. In Egypt a national breast-screening program to improvr early detection was launched by ministry of health offering free breast-screening to Egyptian women over the age of 45 years ***(Sinha and Sinha, 2009).***

Focused research efforts over the last decade have helped establish breast magnetic resonance imaging (MRI) as an important tool for the detection and characterization of breast cancer ***(Zawila, 2011).***

The American cancer society has established guidelines for screening with breast MRI as an adjunct to mammography.

For breast MRI, the guidelines indicate that screening can potentially identify cancer in patients of specific risk groups ***(Saslow et al., 2007).***

The value of breast MRI is derived primarily from the high sensitivity of contrast material enhancement in the detection of breast cancer. The current consensus is that MRI is an excellent tool for determining tumor extent, and should especially be performed in dense breasts. However, due to low specificity, it becomes necessary to perform biopsy of additional lesions detected on MRI. The results of multiple studies show that preoperative MRI is recommended in patients with breast cancer who are scheduled for breast conserving surgery. Breast MRI offers a multi-contrast approach which, combined with morphological features, may provide the optimal approach to diagnosis and management ***(Sinha and Sinha, 2009).***

Dynamic contrast enhanced MR imaging (DCE-MRI) is the most routinely used MR imaging technique for the assessment of breast lesions. It has shown the most promise for discriminating between malignant and benign tumors; however even with this technique, specificity is in the range of (37% - 97%). In DCE-MRI, a dynamic imaging is performed after injection of a contrast agent and the signal intensity on T1WI has specific contrast uptake patterns for malignant and benign, with malignant lesions the applications of DCE-MRI extend beyond diagnosis to therapeutic monitoring and for breast screening. The non-invasive nature of MRI makes it an ideal candidate for monitoring and increases the potential for detection of early response and for treatment optimization ***(Sinha and Sinha, 2009).***

MR Spectroscopy (MRS) is a biochemical marker that allows the non-invasive detection of proton metabolites, cancerous lesions demonstrate elevated composite choline levels arising from increased cellular proliferation. Several groups have demonstrated that MRS either alone or in conjugation with MRI improves the specificity of breast MR. the consensus is that MRS is useful in larger tumors (> 1 cm); however it may be limited in its ability to discriminate benign breast lesions from phyllodes tumor of benign and borderline malignancy. MRS imaging has recently produced the highest spectroscopic resolution and offers the potential for mapping choline distributions across the lesion ***(Hu et al., 2009).***

Magnetic Resonance Elastography (MRE) is a relatively new approach and measures the elastic properties of tissues. It is a phase-contrast –based MRI imaging technique that can directly visualize and quantitavely measure propagating acoustic strain waves in tissue-like materials subjected to harmonic mechanical excitation. There have only been a few preliminary studies using this teqnique; initial studies have indeed confirmed that MRE could be a non-invasive palpation that breast tumors revealed higher shear elasticity than normal breast tissue ***(Siegmann et al., 2010).***

Aim of the Work

The present study aims at discussing new MRI techniques like MR Spectroscopy and MR Elastography which can be used in early detection and diagnosis of breast masses for better management and prognosis aiming to decrease the mortality rate resulting from breast cancer.

Chapter One

Gross and MRI Anatomy of the Female Breast

Gross anatomy of the female breast:

The breasts form a secondary sexual feature of females and are the source of nutrition for the neonate. They are also present in a rudimentary form in males ***(Standring, 2008)***.

In young adult females, each breast is a rounded eminence lying within the superficial fascia **(Fig. 1)**. Breast shape and size depend upon genetic, racial and dietary factors, and the age, parity and menopausal status of the individual. Breasts may be hemispherical, variably pendulous, pyriform or thin and flattened. The base of the breast extends vertically from the second or third to the sixth rib, and in the transverse plane from the sternal edge medially almost to the mid-axillary line laterally. The superolateral quadrant is prolonged towards the axilla along the inferolateral edge of pectoralis major up to the apex of the axilla (the axillary tail of Spence). The superficial fascial system splits to enclose the breast to form the anterior and posterior lamellae. Posterior extensions of the superficial fascial system connect the breast to the pectoralis fascia, part of the deep fascial system. The infra-mammary crease is a zone of adherence of the superficial fascial system to the underlying chest wall at the inferior crescent of the breast ***(Standring, 2008).***

Nipple and Areola:

The nipple projects from the centre of the breast anteriorly. In females, its site is dependent on the size and shape of the breasts, but it overlies the fourth intercostal space in most young women as well as in male breast. The skin covering the nipple and the surrounding areola has a convoluted surface and typically darker than the skin covering the remainder of the breast. It contains numerous sweat and sebaceous glands which open directly onto the skin surface, Montgomery's tubercles, around the areola ***(Standring, 2008).***

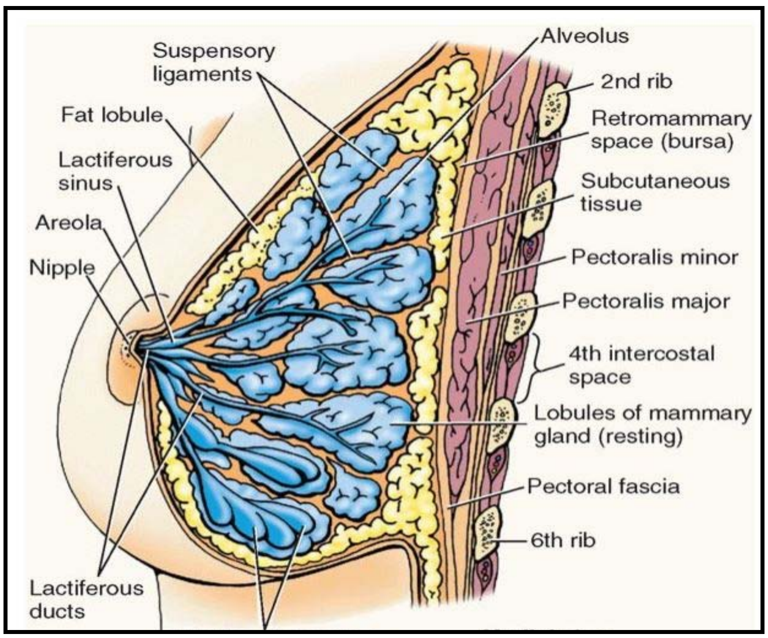

Fig. (1): Showing a normal medial view of female breast ***(Moore et al., 2014).***

Soft tissue and internal architecture:

The internal architecture of the breast varies with age, time in the menstrual cycle, pregnancy and lactation. For most of their lengths, the ducts are lined by columnar epithelium. The bases of these cells are in close contact with numerous myoepithelial cells. Each breast is arranged into 15-20 lobes **(Fig.1)**, each of which is drained by single major lactiferous duct that opens on to the nipple. Each lobe is made up of several lobules, each of which drains several acini. These lobules drain via a branching arrangement of ducts to the single lobar duct. Each lobule drains several acini-these are blind saccules into which milk is secreted during lactation. The terminal duct lobular unit is the functional milk secretory component of the breast and pathologically gives rise to primary malignant lesions within the breast ***(Ryan et al., 2011).***

The fat surrounding the parenchymal structures and the fibrotic framework of the breast constitute the stroma which is dense and fibrocollagenous, whereas the intralobular connective tissue has a loose texture that allows the rapid expansion of secretory tissue during pregnancy. The glanduler tissue of the acini and the ductal tissue draining them comprise the breast parenchyma. Fibrous strands of condensations of connective tissue extend between the layer of deep fascia and the dermis. These suspensory ligaments (of Astley Cooper) support the breast tissues ***(Standring, 2008).***

Vascular supply and Lymphatic drainage:

Arteries (Fig.2)

The breasts are supplied by branches of the axillary artery, the internal thoracic artery, and some intercostal arteries. The axillary artery supplies blood via the superior thoracic artery, the pectoral branches of the thoracoacromial artery, the lateral thoracic artery and the subscapular artery. The internal thoracic artery supplies perforating branches to the anteromedial part of the breast; The second to fourth anterior intercostal arteries (perforating arteries) supply the anterolateral part while the second perforating artery supplies the upper region of the breast, and the nipple, areola and adjacent breast tissue ***(Ryan et al., 2011).***

Veins (Fig. 2)

Blood drains from the circular venous plexus around the areola and from the glandular tissue of the breast into the axillary, internal thoracic and intercostal veins via veins that accompany the corresponding arteries ***(Ryan et al., 2011).***

Innervation:

The breast is innervated by anterior and lateral branches of the fourth to sixth intercostal nerves, which carry sensory and sympathetic efferent fibres. The nipple is supplied by the lateral cutaneous branch of fourth thoracic nerve which forms an extensive plexus within the nipple. Secretory activities of the gland are largely controlled by ovarian and hypophysial hormones rather than by efferent motor fibres ***(Moore et al., 2014).***

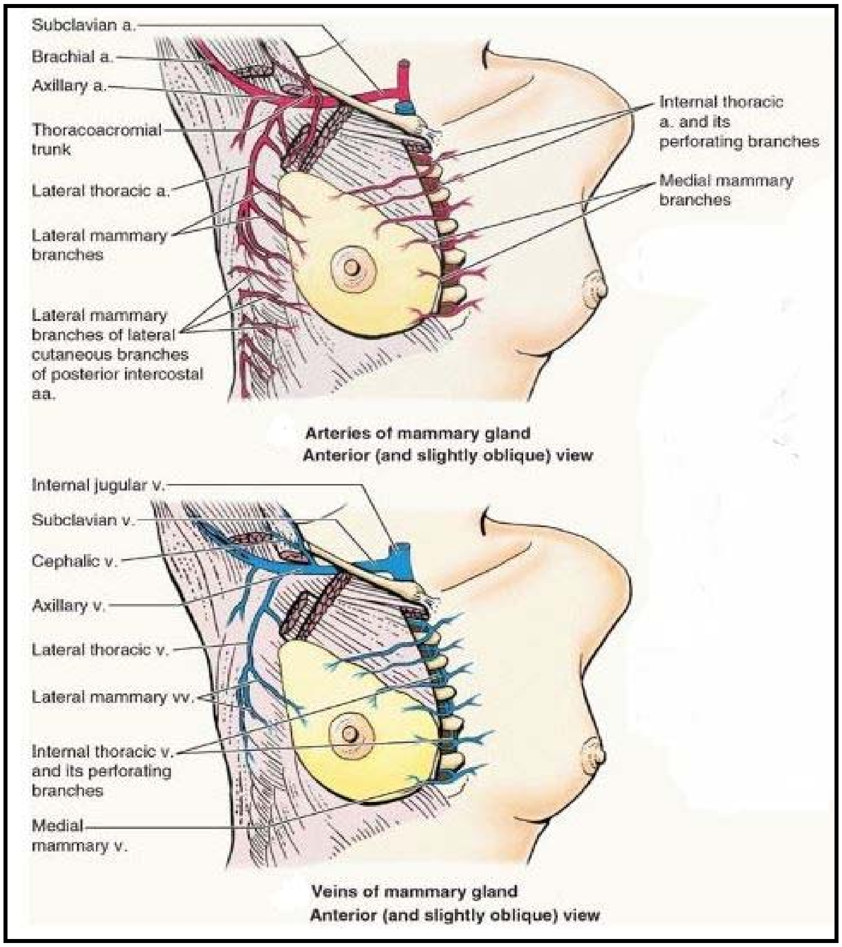

Fig. (2): Showing the arterial supply and the venous drainage of female breast ***(Moore et al., 2014).***

Lymphatic drainage (Fig.3):

The lymphatic flow of the breast is of great clinical significance because metastatic dissemination occurs principally by the lymphatic routes. There are superficial lymphatics under the skin of the breast and a particular concentration in the subareolar plexus, beneath the nipple. Lymph flows unidirectionally from superficial to deep in the breast to the perilobular and deep subcutaneous plexus. Lymph in the deep plexus then drains centrifugally from the nipple to the axillary and internal mammary chains. However the majority of the drainage is to the axillary chain with less than 5% draining to the internal mammary chain. Axillary nodes are 20–40 nodes, grouped artificially as pectoral (anterior), subscapular (posterior), central and apical. Surgically, the nodes are described in relation to pectoralis minor. Those lying below pectoralis minor are the low nodes (level 1), those behind the muscle are the middle group (level 2), while the nodes between the upper border of pectoralis minor and the lower border of the clavicle are the upper or apical nodes (level 3). There may be one or two other nodes between pectoralis minor and major are known as Rotter's nodes ***(Ryan et al., 2011).***

Drainage of the deep parenchymal tissues terminates in the subclavicular lymph nodes. Lymphatics from the left breast ultimately terminate in the thoracic duct and subsequently the left subclavian vein. On the right, the lymphatics ultimately drain into the right subclavian vein. Connecting lymphatics across the midline may provide access of lymphatic flow to the opposite axilla. Efferent vessels pass to the pectoral lymph nodes; some pass to the subscapular nodes or infraclavicular nodes or interpectoral nodes. Most of the remainder drains to parasternal nodes ***(Standring, 2008).***

The Male breast:

The male breast remains rudimentary throughout life. It is formed of small ducts (without lobules or alveoli) or solid cellular cords and a little supporting fibro-adipose tissue. The areola is well developed, although limited in area, and the nipple is relatively small. It is usually stated that the ducts do not extend beyond the areola in a male breast but glandular tissue can be more extensive ***(Standring, 2008).***

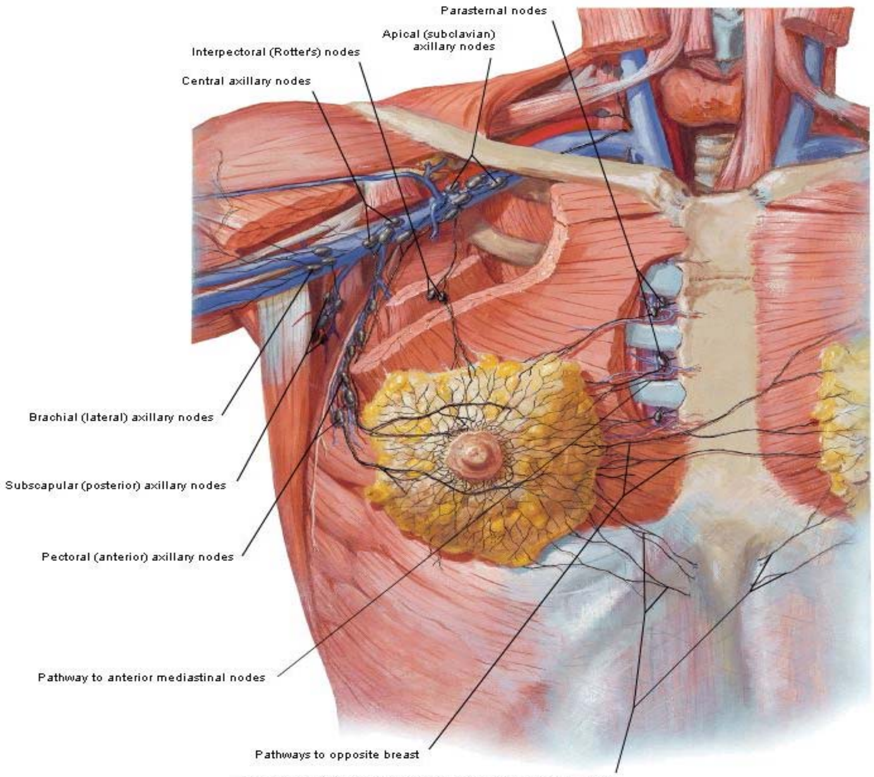

Fig. (3): An illustration showing the lymphatic drainage of the breast ***(Moore et al., 2014).***

MRI anatomy of the female breast:

Magnetic resonance imaging (MRI) of the breast provides a sectional image that can display skin, nipple, areola, subcutaneous fat, parenchyma, muscles, vessels and connective tissue. The relationship of breast tissue to the skin and muscular structures is easily appreciated. The distribution of fibroglandular tissue and fat is easily seen ***(Kopans, 2007).***

Normal anatomical components of the breast can be visualized and distinguished on MR imaging by assessing signal intensity.OnT1WI without fat saturation, adipose tissue is of high signal intensity and breast fibroglandular elements appear relatively intermediate to dark. The presence of fat can be confirmed by assessing the same region on T1WI with fat saturation, where adipose signal would be expected to be nulled **(Fig. 4).** In TIWI with fat saturation **(Fig. 5, 6),** the relative signal intensity of fibroglandular elements then becomes intermediate to bright, given that the fat appears dark. Similarly, on T2WI **(Fig. 7, 8)** without fat saturation, fat appears bright while breast parenchyma appears intermediate to dark ***(Gavenosis, 2011).***

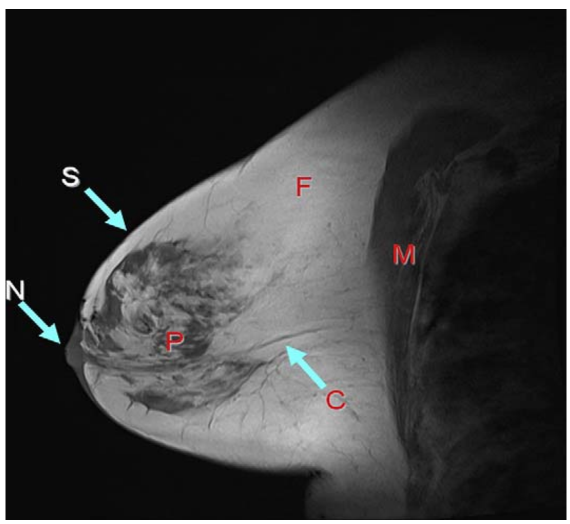

Fig. (4): Showing Sagittal T1WI without fat saturation. Adipose tissue is of high signal intensity, and breast fibroglandular elements appear relatively intermediate to dark. Representative structures are indicated. N, nipple; S, skin; V, vessels; F, fat; P, breast parenchyma (fibroglandular tissue); C, Cooper’s ligament; M, pectoralis muscles ***(Gavenosis, 2011).***

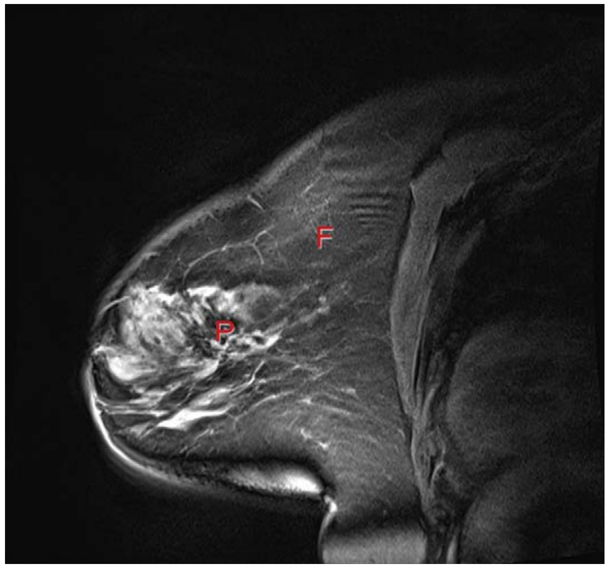

Fig. (5): Sagittal T1WI, with fat saturation. The relative signal intensity of fibroglandular elements is intermediate to bright; given that the fat appears dark (fat signal is nulled). F, fat; P, breast parenchyma (fibroglandular tissue) ***(Gavenosis, 2011).***

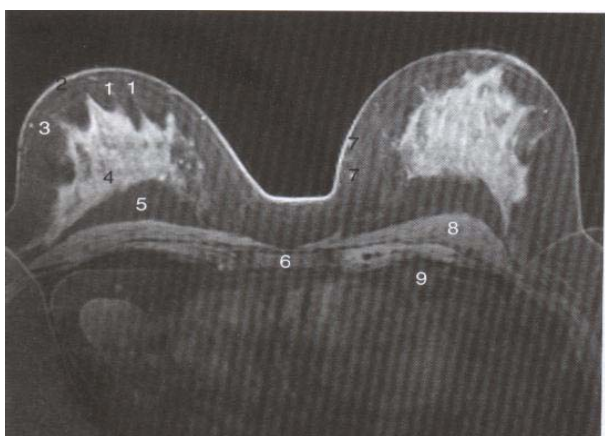

Fig. (6): T1WI axial fat-saturated, gadolinium-enhanced Note- fat is dark and muscles are bright with enhancing breast tissue ***(Ryan et al., 2011).***

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

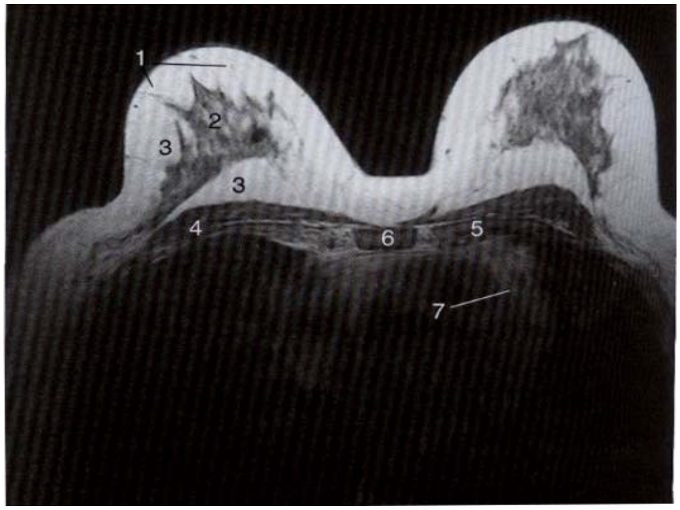

Fig. (7): Breast MR T2WI. Note, the fat is bright, fibroglandular tissue is dark ***(Ryan et al., 2011).***

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

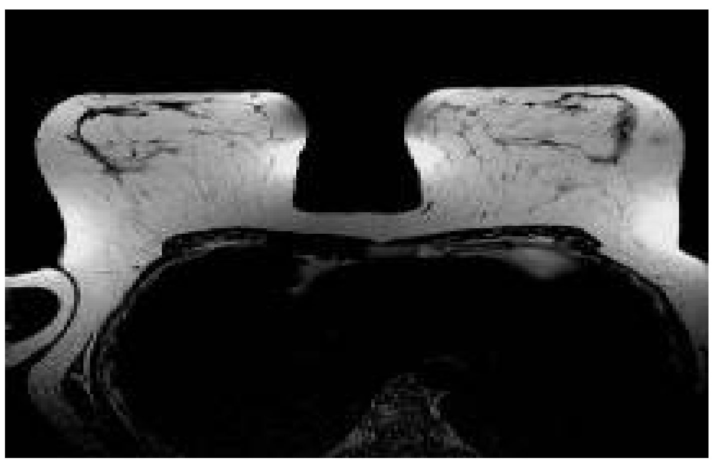

Fig. (8): T2 weighted axial image ***(Kopans, 2007).***

The pectoralis muscle is an important distinction when it comes to staging a patient with breast cancer ***(Morris, 2005).*** The skin appears smooth with intermediate signal and