ROLE OF DIGITAL TOMOSYNTHESIS IN IMAGING OF BREAST CANCER

Essay

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In Radiodiagnosis

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INTRODUCTION

Breast cancer is the most frequent malignancy among women; the chance of developing breast cancer in some time in women's life is little less than one in eight (12%). Breast cancer in women is the leading cause of death ***(Baker, 2009).*** Death rates from breast cancer have been declining since about 1990 with larger decrease in women younger than 50. That decrease is believed to be the result of earlier detection through screening and increased awareness, as well as improved treatment ***(American Cancer Society, 2009).***

Early detection of breast cancer can save time and reduce treatment cost. This has been successfully proven over the years ***(Tabar et al., 2007).***

In the past decade breast cancer screening programs have helped to reduce mortality of breast cancer patient by 20 percent but still determined to find new technologies that have potential to even further improve breast cancer statistics ***(Saslow et al., 2006).***

As mammography is considered the most effective screening and diagnostic tool for early detection of breast cancer, about 10%-30% of cancer may be missed. The nature of 2D mammography makes it difficult to distinguish a cancer from overlying breast tissue. A higher rate of false positive and false negative test results exist because the dense tissue interferes with identification of tumors ***(Pisano et al., 2005)***.

Advances in techniques for imaging the breast continue to drive the rapid development of modalities for diagnosis and screening.

A team of researchers at ***Massachusetts's General Hospital [MGH] (2003)*** has developed a new weapon for fight against breast cancer: (Breast Tomosynthesis)

Breast tomosynthesis is one of most exciting research developments in radiology in recent years. It is a 3 dimensional imaging technique that acquires images of a stationary compressed breast ***(Poplack et al., 2007)*.**

Breast tomosynthesis should resolve the tissue – overlap reading problems that are a major source for recalling women for additional diagnostic mammograms with 2D mammography after abnormality detected in the first one ***(American Roentgen Ray Society*, *2009)*.**

Digital breast tomosynthesis offers a number of exciting opportunities including the possibility of reduced compression, improved diagnostic and screening accuracy. New digital technologies in tomosynthesis will advance the diagnosis of breast cancer even further ***(Smith, 2005)***.

AIM OF THE WORK

The purpose of this essay is to describe digital breast tomosynthesis and its value in imaging of breast cancer, highlighting its advantages over digital mammo-graphy.

ANATOMY OF FEMALE BREAST

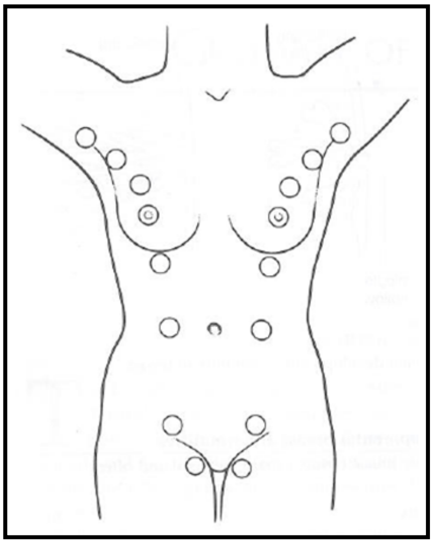
General Anatomy

Development:

The mammary line (crest) is ectodermal thickening that appears during 4th-5th week of development. It extends from axilla to groin, on each side of body (Fig 1). Only a small portion of the line persists in thoracic region ***(Slader, 2004)***

Invasion of the underlying mesenchyme (dermis) in the 6th week gives rise to the mammary buds. These lengthen, branch and canalise to from the lactiferous ducts. The lactiferous ducts come together in a depression on the surface of the skin called the mammary pit. Shortly after birth the pit is converted to the nipple ***(Moore and Persuad, 2003).***

Fig. (1): Supernumerary nipples are sometimes mistaken for skin tags or moles ***(Quoted from Hindle, 1999).***



Breast Anatomy

The breast lies on top of the pectoralis major muscle. Fibrous stroma provides the background architecture of the breast. Cooper's ligaments are attached to both the fascia of the skin and the pectoralis major muscle. Carcinoma invading these ligaments may result in skin dimpling which could be subtle or obvious during visual inspection (Fig. 2) ***(Maxwell and Gabriel 2009).***

A- Ducts
B- Lobules
C- Dilated duct to hold milk
D- Nipple
E- Fat
F- Pectoralis major muscle
G- Chest wall (ribs)

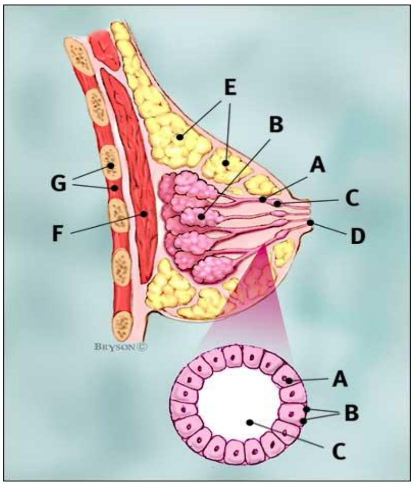


Fig. (2): Anatomy of the breast ***(Quoted from Moore, 2003)***

Microscopic Anatomy

The breast is composed of lobules or glands; milk ducts; connective tissue, and fat, with most of the benign and malignant pathology arising in the duct and lobular network (Fig. 3). Specifically, most breast cancer is thought to originate in the terminal ductal lobular unit (TDLU) ***(Bostwick, 2000).***

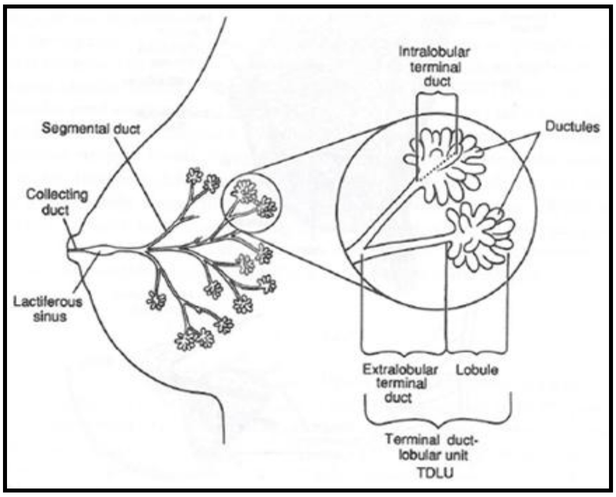


Fig. (3): The breast is composed of 15-20 lobes each with many small lobules. The tobules end in tiny duclules. It separated by connective tissue which radiate out from nipple ***(Quoted from Love and Barsky, 2004)***.

About 50% or more of this glandular tissue is located in the upper outer quadrant; therefore, nearly one half of all breast cancers occur in this area. Glandular tissue and fat vary with a woman's age and weight. Lobes, lobules, and acini serve to produce and secrete milk—the primary function of the breast mammary glands. Ducts and lactiferous sinuses are tubular connections between the lobes and nipples to allow milk to exit the breast. The lactiferous sinuses (located beneath the nipple) may contribute to feeling granularity under the areola on physical examination. The parenchyma of the breast is composed of these ductal/glandular structures. Adipose tissue is present throughout the breast. A high ratio of ductal/glandular breast tissue to adipose and fibrous tissue makes detection of abnormalities during clinical breast examination (CBE) and mammography more difficult, especially in premenopausal women ***(Klein et al., 1995; Heggie, 1996; Jamal et al., 2004).***

All women, regardless of breast size, have the same number of lobes, approximately 15-25. Six to 10 major ducts exit the nipple.

Areola

The nipple and areola are separate structures. Careful inspection of a mature human female nipple will reveal several small openings arranged radially around the tip of the nipple (lactiferous ducts) from where milk is released during lactation. Other small openings in the areola are sebaceous glands, known as Montgomery's glands which provide lubrication to protect the area around the nipple and assist with suckling and pumping of the lactation· About 18% of malignant cancers are found in the subareolar region, a location not easily palpated unless using a technique that permits palpation to the chest wall (Fig. 4).

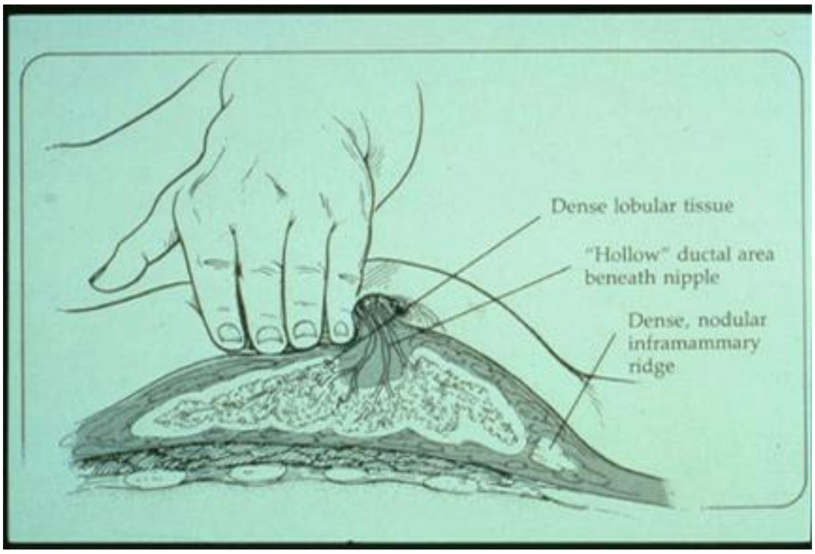


Fig. (4): Subareolar region ***(Quoted from Maxwell and Gabriel, 2009).***

Histology

A gradual epithelial transition is seen, from stratified epithelium in the lactiferous duct, to columnar or cuboidal cells for the rest of the duct system. Change in the epithelium of duct system of the breast may give rise to breast cancer ***(Bukkitt et al., 1993).***

Shape and support

Breasts vary in size, density, shape, and position on a woman's chest and their external appearance is not predictive of their internal anatomy or lactation potential ***(Chersevani et al., 1998; Sohn et al., 1999)***.

The natural shape of a woman's breasts is primarily dependent on the support provided by the Cooper's ligaments and the underlying chest on which they rest (the base). Cooper's ligaments, also known as the suspensory ligaments of Cooper, suspend the breasts from the clavicle and the clavi-pectoral fascia. As their fibers run around and through the breast, these ligaments support the breasts in its position on the chest wall and maintain their normal shape. The breast is also attached at its base to the chest wall by the deep fascia over the pectoral muscles ***(Drake et al., 2007).***

Blood Supply

The arterial blood supply to the breasts is derived from the internal thoracic artery (formerly called the *internal mammary artery*), lateral thoracic artery, thoracoacromial artery, and posterior intercostal arteries ***(Maxwell et al., 2009)***.

The venous drainage of the breast is mainly to the axillary vein, but there is some drainage to the internal thoracic vein and the intercostal veins. Both sexes have a large concentration of blood vessels and nerves in their nipples. The nipples of both women and men can become erect in response to sexual stimuli to touch, and to cold. The breast is innervated by the anterior and lateral cutaneous branches of the fourth through sixth intercostal nerves. The nipple is supplied by the T4 dermatome ***(Maxwell et al., 2009)***.

Lymphatic drainage

The lymphatic and venous drainages of the breast are of great importance in the spread of carcinoma. About three quarters of the lymphatic drainage is to the axillary nodes: (1) Lymphatics pass around the edge of the pectoralis major and reach the pectoral group of axillary nodes; (2) routes through or between the pectoral muscles may lead directly to the apical nodes of the axilla; (3) lymphatics follow the blood vessels through the pectoralis major and enter the parasternal (internal thoracic) nodes; (4) connections may lead across the median plane and hence to the contralateral breast; (5) lymphatics may reach the sheath of the rectus abdominis and the subperitoneal and subhepatic plexuses ***(Drake et al., 2007)***.

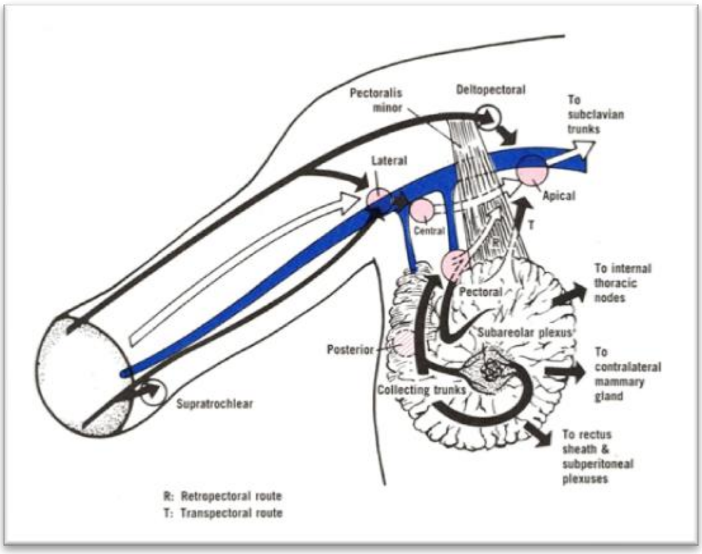


Fig. (5): Lymphatic drainage of the breast
(Quoted from Uren et al., 2001).

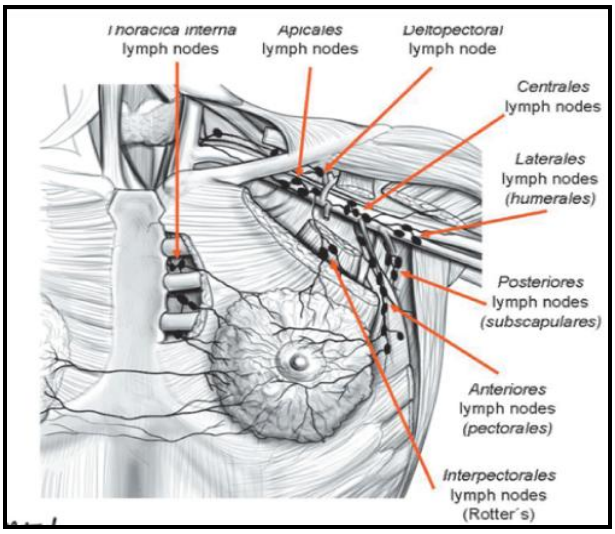


Fig. (6): Lymph drainage of axilla and breast
(Romell and Bland, 2004).

Breast Physiology

All women experience changes in their breasts throughout the life cycle (Table 1). Fluctuating hormone levels during the menstrual cycle can cause changes in the look, feel, and tenderness of the breasts (Fig. 7).

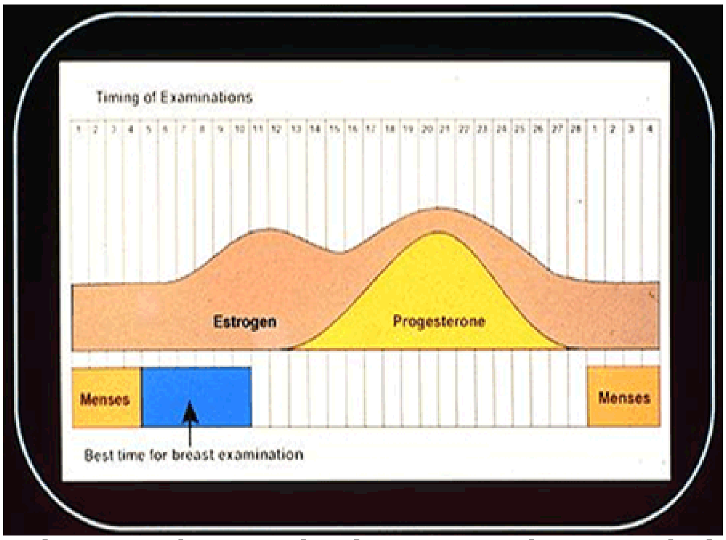


Fig. (7): Fluctuating hormone levels can cause changes in the look and feel of the breasts ***(Quoted from Maxwell and Gabriel, 2009)***.

Table (1): The Stages of Breast Development

Fetal development	Breast tissue begins to develop around the sixth week in utero.
Prepuberty	Breasts are in resting state with ducts present but nonfunctional.
Puberty	Ducts elongate due to estrogen; breast bud appears and is sometimes mistaken for a mass and removed. Breast buds do not always develop simultaneously.
Young adult	Effects of progesterone are influenced by initiation of ovulation; ducts elongate; side branches of ducts and lobular elements form.
Maturity	Breasts become pendulous after many ovulatory cycles; lobular elements are well formed. Distinct morphologic changes occur with the menstrual cycle. During the first 5 menstrual days, there is minimal edema in the intralobular stroma and no mitoses or apoptosis is seen in the lobular epithelium. Intraluminal secretions are common. During the following 2 weeks, the follicular phase, the lobular acini increasingly develop a distinct double-cell layer appearance with increasing basal layer vacuolation. The stroma remains nonedematous until the third week, the midluteal phase. In the last few days prior to menstruation, the late luteal phase, there is extensive vacuolation and increased inflammation. Breast pain is more common during this part of the cycle. In premenopausal women, the breast is most sensitive to touch, or tender, about 7-14 days following ovulation. Thus, the best times for scheduling any type of clinical or mammographic breast exam are the days immediately following the start of menses (Days 5 to 10). Both require pressure and compression for better quality and may be more tolerable during these days when nodularity at its minimum.
Pregnancy	Distal ducts grow and branch; breasts enlarge to twice their normal weight; increase in mammary blood flow leads to vascular engorgement and areolar pigmentation; sometimes bloody nipple discharge occurs due to hypervascularity.
Lactation	Acini are dilated and engorged with colostrum and then milk.
Menopause	Lobules begin to recede, leaving mostly ducts, adipose tissue, and fibrous tissue; histologically, postmenopausal and prepubertal breasts are very similar. Hormone therapy may delay postmenopausal changes in the breast and mimic a more active physiologic or premenopausal state (ie, cyclic tenderness due to increased nodularity, etc).

(Maxwell and Gabriel, 2009)

The axilla:

The axilla is pyramid in shape. It lies between the arm and the thorax, and communication with the posterior triangle of the neck. It contains vessels, nerves and lymph nodes. It has an apex and base, and four walls, anterior, posterior, medial and lateral. The anterior wall consists of three muscles, pectorals major and minor muscle and subclavius muscle. The fascia extends between the clavicle and pectorals minor muscle. It is pierced by lymphatic, the cephalic vein, the lateral pectoral nerve and branches of the thoraco-acromial axis (a branch of the axillary artery).The posterior wall is formed by the subscapularis, teres major muscles, and tendon of latissimus dorsi. The medial wall with upper portion of serratus anterior. The lateral wall is the humerus. It contains the axillary artery and vein, lymph plexus, the brachial plexus and lymph nodes ***(Lagopoulos, 2007)***.

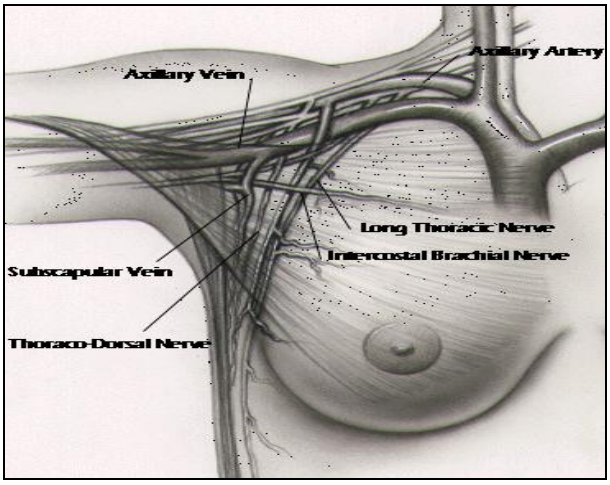


Fig. (8): Blood vessels and nerves of the axilla
(Quoted from Porier and Charpy, 2004).

The axillary lymph nodes (20-30 in numbers) drain not only the lymphatics of the breast, but also those of the pectoral region, upper abdominal wall and the limb, and there is anatomical and surgical classification. Anatomical classification are arrange in five groups:

Anatomical classification

Anterior nodes

The anterior nodes (pectoral nodes, medial nodes; sometimes inferior nodes) are four to five nodes lying along the inferolateral border of pectoralis major, related to the lateral thoracic artery. Afferents drain the skin and muscle of the anterolateral thoracic wall, as well as the central and lateral breast. Efferents pass to the central and apical nodes.

Posterior nodes

The posterior nodes (subscapular nodes, inferior nodes) are six or seven nodes on the lower margin of the posterior wall of the axilla, along the course of the subscapular artery. Its afferents drain the skin and muscle of the posterior thoracic wall as well as the lower posterior neck. Its efferents pass to the central nodes.

Infraclavicular nodes

The infraclavicular nodes (subclavicular nodes) are two or three nodes situated superiorly and posteriorly to the