RADY 5002

BREAST SONOGRAPHY

CONTENTS

OVERVIEW OF BREAST ULTRASOUND

AIM

The aim of this course is to enable the student to acquire the knowledge and develop the skills required to perform practical procedures in breast ultrasound.

OBJECTIVES

On completion of this course, you should:

- Detail the anatomy, physiology, and pathology of the breast with specific reference to ultrasound.
- Relate the role of ultrasound in diagnosis of breast pathology to other diagnostic tests.
- Demonstrate comprehensive& advanced knowledge of ultrasound equipment, emerging technologies and quality management of equipment and diagnostic images.
- Demonstrate a comprehensive and advanced knowledge of breast and axillary scanning techniques.
- Correlate mammographic and ultrasound images.
- Understand the moral and ethical considerations involved in breast ultrasound.
- Relate the role of other imaging modalities such as MRI to breast sonography.

HOW TO USE THIS STUDY GUIDE

This Study Guide is intended to assist you in your study of Breast Ultrasound and help direct you to interesting and relevant texts and journals. The topics pertaining to this course have been broken down into 11 modules, each module covering approximately one week's work. Module 6 is quite comprehensive, so this module may require more time than the others as it involves the pathology of the breast, and the corresponding sonographic appearances.

The topics are presented in the order that we think will best facilitate your study. From time to time, however, you may wish to jump to a different topic to enhance your understanding.

Each module is presented in the same format:

- A module overview introduces the topic.
- A list of learning objectives gives you a summary of the ideas you should focus on.
- A list of key concepts assists you to focus on precise terms, phrases and concepts you will encounter. You will be expected to become familiar with these.

The Online Text will direct you to the relevant sections pertaining to that module in the suggested online 'core' texts that have been used in the formation of this study guide. These texts are all available to you online, in the full version with high quality ultrasound images, via the library.

The e-readings has interesting and relevant articles for each topic. So, if you find other interesting articles, please feel free to contact me and we can then make them available to all students doing the course. You may find it useful to keep a journal of your learning, which could include the following:

- The notes you make while you are reading the text and notes for the topic
- Any areas of difficulty, so you have a reminder to check with other reference sources or your tutor

The learning resources advised in this Study Guide are by no means exhaustive and you are encouraged to seek out other resources. These could include your colleagues or your own experience. Remember that you will quite often find conflicting points of opinion, so please do not hesitate to ask if you need advice. If you come across a resource that you have found helpful to your studies, please let us know so that we may make it available to other students.

Assignments are set at incremental periods during the course. You will have to submit these for assessment. These assignments will help you and your course coordinator assess your understanding of the course. Please read the instructions in the Course Information before you complete the assignments.

Before you start to work through the Study Guide, you should first read the Course Outline carefully. It contains information about the teaching staff, how to contact them for assistance, topics to be covered, learning resources, details of assessment, and key dates.

ONLINE TEXT

It is recommended that you use the following text in your study of this course as it is classified as the current 'gold standard' with regards to breast ultrasound.

Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins
Also, very useful is:

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins
- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins,

These texts have been chosen because of their comprehensive coverage of breast imaging and they are all available to students of UniSA as a fully electronic on-line version.

INTRODUCTION

Breast ultrasound is the most important adjunct to mammography. Its main applications are:

- Palpable lesions or lesions detected on mammography may be further evaluated
- Diagnosing cysts (provided the proper technique is used, ultrasound is able to differentiate between cystic and solid masses in almost 100% of cases)
- Identifying lesions in mammographically dense tissue (eg. young breasts)
- Evaluating palpable masses in all age groups, particularly the young (under the age of 30), and in pregnant and lactating women
- Follow up of lesions previously seen on ultrasound
- Identifying an abscess in a patient with mastitis
- Evaluating non-palpable abnormalities for which the mammographic diagnosis is uncertain (such as asymmetry of breast tissue)
- Confirming, or better visualising, a lesion seen incompletely or on only one mammographic projection
- Guided pre-operative marking and percutaneous biopsy/aspiration
- Evaluation of patients with suspected rupture of implants
- For patients who refuse to have mammograms

THE CONTEXT OF BREAST SONOGRAPHY

Sonography should never be used to rule out a malignant process without corresponding mammographic studies. Benign sonographic findings in the presence of mammographic or clinical signs of malignancy do not exclude malignancy (and vice-versa).

- For lesions that are not simple cysts, further diagnostic evaluation such as mammography or percutaneous biopsy may be required.
- Benign sonographic findings in the presence of suspicious mammographic findings do not exclude malignancy.
- If any doubt exists at all concerning the benignity of a solid lesion, then biopsy should be performed.
- Important information can be provided by sonography to confirm the presence of palpable carcinomas in radio-dense tissue. The accuracy of ultrasound in detecting malignancies depends both on the surrounding tissue and on the lesion, itself. Accuracy is limited for small carcinomas pre-invasive carcinoma.

MODULE 1
BREAST EMBRYOLOGY, ANATOMY AND PHYSIOLOGY

MODULE OVERVIEW

Anatomy and physiology are part of the 'basics' in learning ultrasound. I am sure that you will have been through all of it before; but the understanding of these areas, particularly anatomy, is vital for understanding an ultrasound scan. Embryology is also very important as it explains how the breast happens to be there in the first place and it also helps in the understanding of why certain types of cancer occur in the breast.

The mammary glands are accessory organs of the female reproductive system, secreting milk for the nourishment of the infant. Both men and women have breasts; however, they are normally only well developed in women. In men, the glands remain rudimentary, consisting of only a few small ducts.

LEARNING OBJECTIVES

On completion of this section, you should be able to:

- Draw and label the anatomy of the adult female breast.
- Explain the embryology of the human breast
- Describe the changes in histology from adolescence to involution.
- Discuss the arterial supply, venous drainage, nerve supply and lymphatic drainage of the breast.
- Have a basic understanding of lactation

KEY CONCEPTS

Use these terms to guide you in your learning:

- Glandular tissue
- Primary bud
- Mammary ridge
- Epidermis
- Secondary bud
- Lactiferous ducts
- Puberty
- Oestrogen
- Progesterone
- Lobes
- Lobule
- Alveoli
- Lactiferous sinus
- Lactation
- Nipple
- Areola
- Cooper's Ligament
- Superficial fascia
- Follicle Stimulating hormone (FSH)
- Luteinising hormone (LH)
- Prolactin
- Oxytocin

ONLINE TEXTS

Any good Anatomy and Physiology textbook will help to enhance your understanding of this subject. Below is a good basic account of the covered topics (even though the reference material has been sourced from older texts, embryology and anatomy doesn't change!).

You can source more information for your research from the on-line version available to you of:

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 1 (Anatomy of the Breast)
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 4 Review e-Readings for any relevant articles.

EMBRYOLOGY

The mammary ridges appear during the fourth week of gestation. These extend from the axillary to the inguinal regions, normally persisting only in the pectoral region. At about six weeks gestation, the mammary glands begin to develop along the mammary ridge. A solid growth of epidermis, known as the primary bud, grows into the underlying mesenchyme.

Each primary bud gives rise to secondary buds by about twelve weeks gestation. These secondary buds develop into lactiferous ducts and their branches. As placental sex hormones enter the foetal circulation, canalisation of these buds occurs, and by term, 15 - 20 lactiferous ducts have been formed. The fibrous connective tissue and fat of the mammary gland develop from the surrounding mesenchyme.

During late gestation, the epidermis at the site of origin of the mammary gland becomes depressed and forms a shallow mammary pit. In the newborn, the nipples are poorly formed and depressed, but proliferation of the connective tissue in the areola surrounding the mammary pits soon causes the nipples to rise. The mammary glands of newborn males and females are identical and are often enlarged. They will often secrete fluid because of the influence of the maternal hormones.

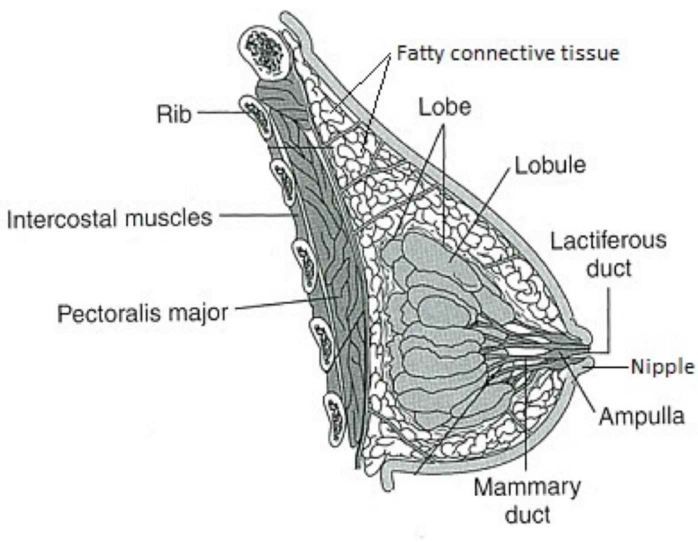
Only the main lactiferous ducts are formed at birth, and the mammary glands remain undeveloped until puberty. During puberty, the female glands enlarge rapidly. Raised levels of oestrogen and other hormones lead to growth of the duct system. The mammary glands only complete their development if pregnancy occurs, due to raised oestrogen levels and an increase in the level of progesterone. In the breast, the intralobular ducts rapidly form buds that become alveoli. The mammary glands in males do not normally undergo any further development after birth.

ANATOMY AND PHYSIOLOGY

The breasts are the most prominent structure of the anterior chest wall. The position of the breast is anterior to the pectoralis major, serratus anterior and external oblique muscles and the sixth rib. It is bordered laterally by the axilla and medially by the sternum. The size of the breasts varies markedly and depends on the amount of fat surrounding the glandular tissue. However, their roughly circular bases are constant - vertically from the 2nd-6th rib, laterally from the edge of the sternum to the mid-axillary line. Two-thirds of the breast rests on the pectoralis muscle, one-third covers the serratus anterior. The inferior border overlaps the superior part of the rectus sheath.

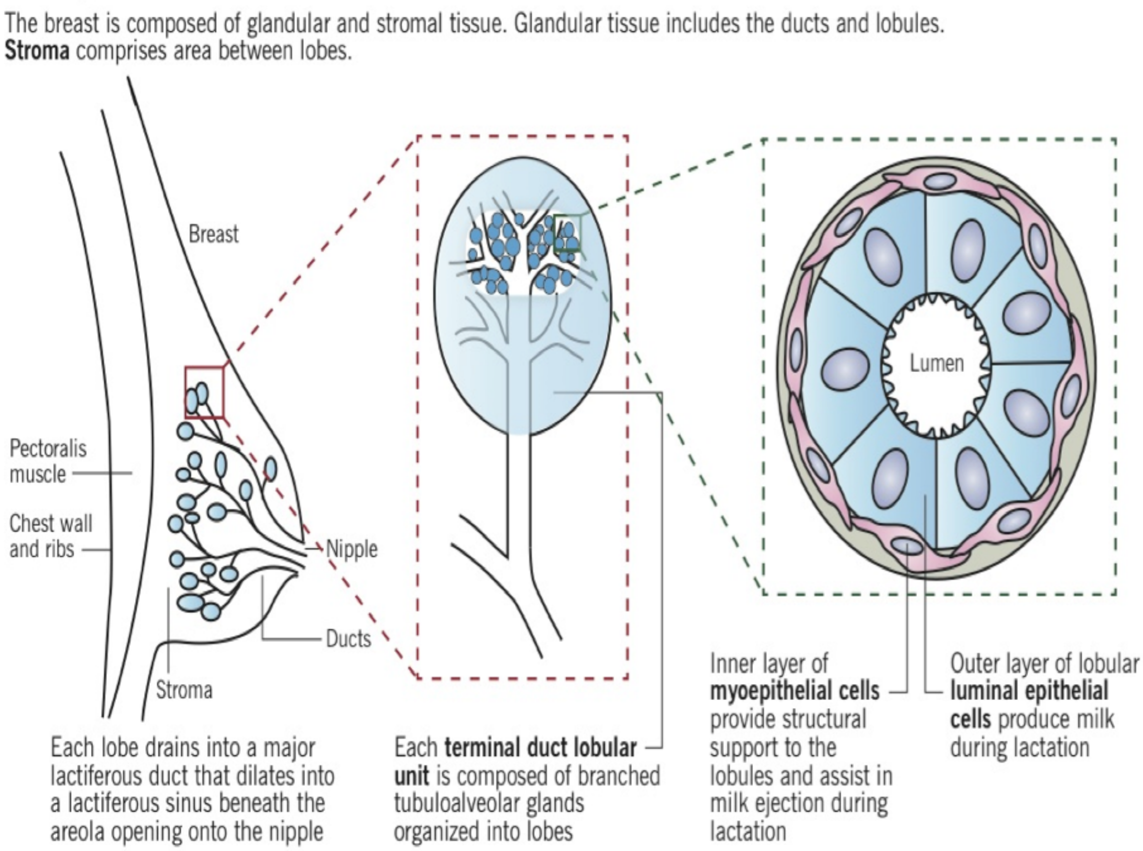
The female breasts normally grow during puberty (12-15 years), and the areolae enlarge. The glandular tissue is made up of lobes, ducts, lobules, and alveoli (acini). One lobule is formed by 10-100 alveoli. Lobules join to form lobes, of which there are about 15-20 in the breast. Each lobe drains by the lactiferous duct into the nipple. Behind the areola, the ducts have a dilated portion called the lactiferous sinus that accumulates milk during lactation. The areolae contain sebaceous glands which secrete an oily substance during pregnancy and lactation, which helps to protect the nipple and areola during breast-feeding. There is no fat beneath the areola.

The nipples are conical or cylindrical prominences that are in the centre of the areolae. There is no fat in the nipples. In nulliparous women, they are usually located at the fourth intercostal space, but, as position varies, this cannot be used as a general guide. The top of the nipple is fissured and contains the openings of the lactiferous ducts. The nipples are composed mainly of circularly arranged smooth muscle fibres that compress the lactiferous ducts and erect the nipples when they contract.



(Curry & Tempkin 2011, p. 458)

The mammary gland is a modified sweat gland, which explains why it has no special capsule or sheath. It lies in the superficial fascia. The glandular tissue of the breast is separated from the pectoral muscles by the deep fascia. Between the breast and the deep fascia, there is an area of loose connective tissue that does not contain much fat. This area, known as the retromammary space, allows the breast to move freely on the deep fascia covering the pectoralis major muscle. Although easily separated from the deep fascia, the mammary gland is firmly attached to the skin by suspensory ligaments known as Cooper's ligaments. They run between the skin and deep fascia and serve to support the breast. The rounded contour and most of the bulk of the breast is produced by fat lobules, except during pregnancy and lactation, when the mammary glands enlarge. The shape of the breast varies considerably in different persons and races, and in the same person at different ages.



Normal functional unit of the breast (Wong, E, Chaudhry, S & Rossi, M 2011, 'Breast cancer', Clinical Obstetrics and Gynaecology, vol. 51, no. 1, pp. 91-95)

During puberty, the lactiferous glands branch, and there is an increase in the amount of fat deposition leading to progressive enlargement. In some women, the breast size varies slightly during the menstrual cycle, owing to the effect of the gonadotrophic hormones - follicle stimulating hormone (FSH), and luteinising hormone (LH).

The breasts enlarge greatly during pregnancy due to the formation of new glandular tissue. The alveoli, or milk secreting cells, are arranged in grapelike clusters or lobules. Milk production or absence is controlled by hormones from the hypothalamus and anterior pituitary gland. The hypothalamus produces prolactin-inhibiting factor, which prevents the release of prolactin until milk production is necessary following childbirth.

LACTATION

After childbirth prolactin is produced by the anterior lobe of the pituitary gland and stimulates the secretory cells. The first secretions that the baby receives are a thin liquid known as colostrum. This is a different composition from milk and is very nutritious.

Secretion of milk begins within a few days and can continue for many months until the infant stops suckling. Milk is synthesised by the epithelial cells of the alveoli. It is then secreted into the alveolar lumen and from there it drains into the ductal system which transports it to the nipple.

Oestrogen levels decrease following expulsion of the placenta, and two hormones are responsible for milk production, prolactin - which promotes the secretion of milk, and oxytocin which promotes milk ejection. These hormones are released by suckling. Milk ejection occurs only as long as the infant nurses due to the action of suckling on the hypothalamus. This assures that the infant only has enough milk to feed off. Eventually, this stimulus may be conditioned by the infant's hungry cry. Conversely, psychological stress may inhibit milk ejection.

There are many benefits of breast-feeding which include:

- Avoidance of Transmitted Infections
- Maternal Antibodies Contained in Both Colostrum and Milk
- Nutrients Perfectly Suit the Infant
- Psychological Benefits to Infant and Mother
- Hastening of Uterine Involution
- Ovulation Suppression

Cessation of suckling at weaning results from a lack of suckling -induced stimulation of both prolactin and oxytocin.

ARTERIAL SUPPLY

There is an abundant blood supply, mainly from the internal thoracic artery. There are also several branches from the axillary artery, mainly from the lateral thoracic and thoraco-acromial branches and lateral and cutaneous branches from the intercostal arteries.

VENOUS DRAINAGE

Veins from the breast drain into the axillary, lateral thoracic and intercostal veins. The chief drainage is to the axillary vein.

LYMPHATIC DRAINAGE

Most lymph passes from the mammary gland along the interlobular vessels to a sub-areolar plexus. From here and other parts of the breast, most lymph vessels follow the veins of the breast to the axilla. 75% of the lymphatic drainage is to the axillary lymph nodes, mainly the pectoral group of nodes. They are located along the inferior border of the pectoralis minor muscle, which lies deep to the pectoralis major. From the deep surface of the breast, the lymphatics pass through the pectoralis major and drain into the apical group of axillary lymph nodes. Lymph from the medial part of the breast drains into the parasternal lymph nodes, which are located within the thorax along the internal thoracic vessels. Lymph from the skin of the breast may pass to the abdominal wall and the opposite breast.

NERVE SUPPLY

Lateral and cutaneous branches of the 2nd-6th intercostal nerves supply the breast. These nerves include both sensory and sympathetic fibres, which supply the skin, smooth muscle of the nipple and areola, blood vessels and mammary glands.

HISTOLOGY

ADOLESCENT: The prepubescent breast consists of lactiferous ducts with adventitial alveoli comprising primarily of connective tissue and small amounts of fatty tissue. During puberty, the ducts increase in length and the terminal alveoli increase in number. These later develop into lobules. Ductal growth triggers mesenchymal metaplasia and formation of connective tissue.

MATURE: Under the influence of oestrogen, progesterone, prolactin, STH and ACTH and corticoids, the ductal system becomes increasingly branched. A tree-like structure with glandular lobules develops. This process of growth and differentiation continues until about age 30. The highest proportion of lobules are located far from the nipple along the periphery, particularly in the upper outer quadrant.

INVOLUTION: As ovarian function decreases, involution of the glandular body sets in. Lactiferous ducts, lobules and parenchyma become atrophic and fatty and fibrous tissue dominate. Often ectasia of the large excretory ducts occurs.

ANOMALIES

Complete absence of one or both breasts and/or the nipple is rare. Rudimentary or accessory breasts can be seen in up to 2% of the population and can involve either the nipple, areola or fibro-glandular parenchyma.

Polythelia (accessory nipples) is the most common anomaly, occurring in both sexes. Common location of an accessory nipple is just below the normal breast, but they can occur anywhere along the milk line.

Inversion of the nipple or flattening can also be an anomaly, but it needs to be differentiated from retraction of the nipple due to an underlying carcinoma or ductal ectasia. Generally speaking it is when a normal nipple becomes inverted over time that the concern is increased as to the cause.

Often seen on mammograms is the evidence of accessory breast tissue, appearing as asymmetry. Most commonly the axillary segment is involved, but like the accessory nipple, it can occur anywhere along the milk duct line.

MODULE 2
BASIC PHYSICS PERTAINING TO BREAST ULTRASOUND

MODULE OVERVIEW - ARTEFACTS

As you have studied ultrasound physics and instrumentation before, it is not necessary to cover these areas in this Study guide. However, some points do need to be reiterated. Artefacts are a common phenomenon in ultrasound, and although some are useful in aiding diagnosis, some can degrade an image quite markedly. It is important to be able to recognise and understand each artefact as you come across it.

LEARNING OBJECTIVES

At the end of this module, you should be able to answer the following questions:

- What are artefacts?
- Why do artefacts occur?
- What are the assumptions about ultrasound that lead to artefacts?
- Which artefacts can aid in a diagnosis?
- What are the common artefacts?

KEY CONCEPTS

Use these terms to guide you in your learning:

- Acoustic shadow
- Edge effect
- Acoustic enhancement
- Dropout
- Beamwidth
- TGC
- Side lobe
- Slice thickness
- Movement
- Noise
- Focal zone
- Reverberation
- Comet tail
- Ring down
- Velocity
- Refraction
- Reflection
- Mirror image

ONLINE TEXTS

You will already have access to one of the good physics texts because of your study of the ultrasound physics courses. The use of this is recommended for the revision in this module.

The current suggested core textbook for Ultrasound Physics and Instrumentation is:

- Gill, R 2012, The Physics and Technology of Diagnostics Ultrasound: A Practitioner Guide, 1st edn, TBA.
- Necas, M 2012, Artifacts in Diagnostic Medical Ultrasound: Volume 1, 1st edn, TBA.

Also, you can source more information for your research from the on-line version available to you of:

- Brant, William E 2001, Core Curriculum, The Ultrasound, 1st Edition, Lippincott Williams & Wilkins, Chapter 1 under the sub heading of Artifacts
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 2 (Breast Ultrasound Equipment Requirements). This is extremely detailed, so just read to refresh some of the important aspects required for breast ultrasound.

Review e-readings for any relevant articles.

ARTEFACTS

Artefacts occur on images because of several assumptions relating to the dimensions of the ultrasound beam and its interaction with the patient. If these assumptions had not been made, ultrasound imaging could not have been developed. These assumptions are:

- The propagation of ultrasound in tissue in tissues is always in a straight line.
- The ultrasound beam is infinitely thin and are small in both thickness and lateral directions
- The velocity of sound in tissue is constant at 1540m/sec.
- That there is an even attenuation of sound in tissue along the beams path
- The detected echo originates from the last transmitted pulse
- The detected echo has arrived by way of the shortest path between the probe and the tissue.
- The amplitude of the echoes is derived from the object scanned alone and directly relates to the object's reflective characteristics

The assumptions are incorrect, leading to the following artefacts:

- Diffraction and refraction can occur at intersections causing duplication, triplication, edge shadowing.
- The dimension of the ultrasound beam and the transducer array are the origin of slice thickness and beamwidth, side lobe and grating lobe artefacts.
- Different sound velocities in tissue cause refraction and false distance artefact.
- Echoes of deep lying structures do not always come from the latest sound pulse, causing aliasing (more relevant in Doppler).
- If the acoustic impedance of the two adjacent tissues is greatly different, the ultrasound beam "reverberates" between them so that the echo detected does not come from the shortest sound path - reverberation and mirror artefacts.
- If the decrease in the echo amplitude is not in relation to the penetration depth because of inhomogeneous tissue layers, or fluid, or air-filled areas, enhancement, shadowing and interference artefacts occur.

MODULE 3
SONOGRAPHIC APPEARANCES OF THE NORMAL FEMALE BREAST

MODULE OVERVIEW

Before we can begin to understand or recognise any pathology in the breast it is essential to be able to recognise normal sonographic appearances of the breast. These change throughout life from childhood to old age and from one individual to another.

LEARNING OBJECTIVES

At the end of this module, you should be able to answer the following questions.

How many layers of the breast are described sonographically?

What factors determine the visualisation of these layers?

How does the breast change sonographically through the years?

How does the breast change with pregnancy and lactation?

KEY CONCEPTS

Use these terms to guide you in your learning:

- Retromammary
- Chromosome Abnormalities
- Anterior Layer
- Hormone Replacement
- Middle Layer
- Involution
- Parenchyma
- Immunosuppression
- Posterior Layer
- Turner's Syndrome
- Fascia
- Menarche
- Cooper's Ligaments
- Perimenopause
- Subcutaneous
- Post-Menopause
- Menopause
- Pregnancy

ONLINE TEXTS

- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins, Chapter 17 under subheading of: Anatomy of The Breast As Delineated by Ultrasound
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 4 under subheading of Sonographic Breast Anatomy

INDICATIONS FOR BREAST ULTRASOUND

Indications for breast sonography include, but are not limited to:

- Evaluation and characterization of palpable masses and other breast related signs and/or symptoms
- Evaluation of suspected or apparent abnormalities detected on other imaging studies, such as mammography or MRI
- Initial imaging evaluation of palpable masses in women under 30 years of age who are not at high risk for development of breast cancer, and in lactating and pregnant women.
- Evaluation of problems associated with breast implants.
- Evaluation of breasts with microcalcifications and /or architectural distortion suspicious for malignancy or highly suggestive of malignancy in a setting of dense fibro-glandular tissue, for detecting an underlying mass that may be obscured on a mammogram
- Guidance of breast biopsy and other interventional procedures
- Treatment planning for radiation therapy
- Identification and biopsy guidance of abnormal axillary lymph nodes, for example in patients with newly diagnosed or recurrent breast cancer or with findings highly suggestive of malignancy or other significant etiology

OVERVIEW

The breast is often described as having three layers, from the skin surface to the chest wall, these being:

Anterior layer

Subcutaneous layer contains skin and fat lobules.

Middle layer

Breast parenchyma with fat lobules in between. This layer is most affected by age and functional state of the breast.

Posterior layer

Retromammary layer contains fat lobules and connective tissue and lies on the pectoralis major muscle.

These areas may not be seen well in all patients depending on several factors:

- The age of the patient
- The functional state of the breast
- Size of the breast
- Machine settings and techniques.

However, a good ultrasound machine combined with the correct technique, will generally depict all the layers of the breast and their varying features:

- Skin
- Subcutaneous fat
- Cooper's ligaments
- Superficial fascia
- Breast parenchyma
- Lobules
- Lactiferous ducts - in particular, the subareolar lactiferous sinuses.
- Deep fascia
- Retromammary fat
- Pectoralis fascia
- Ribs
- Pleura

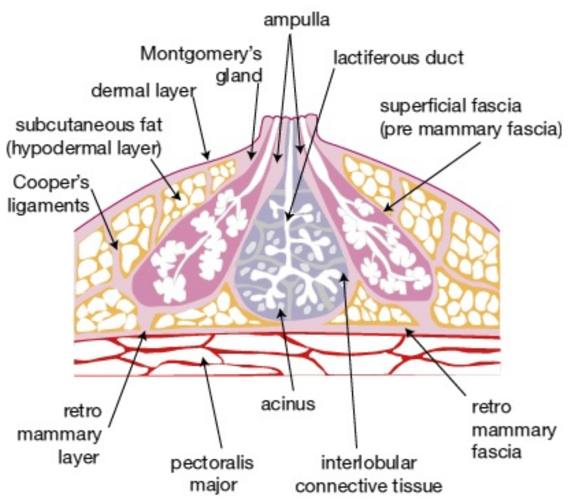


Fig 1. Anatomy of the breast

Fig 2. Ultrasound image of breast

Image showing the correlation between anatomy and ultrasound appearances

CHILDHOOD: In childhood, the breast grows as the rest of the body, but 2-3 years before menarche the mammary gland visibly enlarges. The lobules will begin to differentiate, and the ducts start branching. On ultrasound, the breast parenchyma shows as an island of retroareolar tissue. The lobules are not yet fully formed.

ADOLESCENCE: Development commences at menarche and continues until about 20 years of age. The lactiferous ducts enlarge within the connective tissue and replace most of the fatty tissue. It is almost all glandular tissue and very little fat. The lobules will not be fully developed until the first ovulation begins. A relatively echogenic homogeneous glandular region is seen on ultrasound, in which the parenchyma and connective tissue are barely distinguishable. The subcutaneous and retromammary fat layers appear thin and hypoechoic. Occasionally, some areas may be more mature than others leading to a more hypoechoic region which could be mistaken for a mass.

Cysts may develop because the ductal system is not fully developed. Also, excess proliferation of intralobular connective tissue can lead to development of fibroadenomas, which may spontaneously regress.

SEXUAL MATURITY: After 20 years of age, the interlobar connective tissue gradually regresses and is replaced by fat. At this stage, the breast is about 30% fat, 50% connective tissue and 10-35% parenchyma. The glandular cone, consisting of hyperechoic connective tissue with more hypoechoic interspersed glandular tissue is normally either moderately or greatly hyperechoic. The surrounding and interspersed fat is hypoechogenic. Interspersed fat may be differentiated from hypoechoic tumour by rotating the transducer. A fatty lobule will appear oblong and sometimes be seen to be connecting with subcutaneous fat. Small tubules which are ducts can be seen. These often appear larger centrally on multiparous women.

Skin appears as a hyperechoic line/double line. The thickness should not exceed 3mm except at the areola. Cooper's ligaments are hyperechoic and permeate the layer of fatty tissue, appearing as fine linear structures. Occasionally, there is shadowing behind these which can be eliminated by transducer pressure or by changing the orientation of the transducer.

Subcutaneous tissue is hypoechoic and is variable in thickness. Retromammary fat is hypoechoic, the thickness varying with age - generally becoming thicker as women approach menopause.

PREGNANCY: During pregnancy, the mammary glands prepare for lactation. The fat layer becomes thinner, and the ducts enlarge. The breast can be difficult to assess as there is a high fluid content - leading to hyper echogenicity, heterogeneous tissues and generally thickened and enlarged breast parenchyma. Any suspicious lesion must be followed up.

LACTATION: The ducts are dilated, and the fat content of the breast is decreased. Just before nursing, the lobules can be so distended that they appear as cysts. The breast can be difficult to examine during lactation and it may help to examine the breast directly after nursing.

PERI-MENOPAUSE AND POST MENOPAUSE: At about 40 years of age, the lobules and lobes start to atrophy and undergo fibro-fatty change, the timing varies with individuals. At this stage, the breast is approximately 20% fat, 60% connective tissue and 10-35% parenchyma. On ultrasound, islands of residual parenchyma can be seen as small hypoechoic regions within dense, very hyperechoic fibrotic connective tissue.

The Cooper's ligaments become thickened and eventually the breast pattern will take on a honeycomb appearance. Because of the physiological hormone imbalances that can occur at this age, small retention cysts may occur. These are often very small and normal, but they can be difficult to distinguish from fibro-cystic change.

At about 50 years of age, fat will make up about 40% of the breast tissue, connective tissue will make up to 55% and breast parenchyma 5-20%. About 35% of women will still show a breast pattern which is comparable to a woman of reproductive age.

From about 60 years of age, involution of the lobules progresses rapidly. The fat and connective tissue will each make up about 50% of breast tissue, which will be less than 10% parenchyma. Islands of breast parenchyma may remain in the upper outer quadrant and are the last to involute. Ductal cysts may appear at this stage.

The fatty involuted breast appears hypoechoic on ultrasound. The remaining parenchyma appears hyperechoic - the connective tissue, with hypoechoic "pores" of involuting lobules. Hyperechoic Cooper's ligaments can be seen traversing the fatty tissue.

By the age of 80, the breast parenchyma will have completely disappeared in about 70% of women, having been replaced largely by fat. Involution is generally classified as predominantly fat (lipofibromatous), or predominantly connective tissue (fibrolipomatous).

HORMONE REPLACEMENT

Hormone replacement will delay involutional changes in the breast. A woman on hormone replacement will frequently have a higher content of breast parenchyma due to hormonal changes. This can sometimes cause discomfort as the lobules proliferate in amongst connective tissue that has undergone fibrotic change.

ACCESSORY BREAST TISSUE

Accessory breast tissue appears the same as breast tissue in the usual place. It is most often found in the axillary region.

IMMUNOSUPPRESSION

Patients who have been taking immuno-suppressive corticosteroids show complete fatty breast involution after taking the medication for several years.

TURNER'S SYNDROME

Patients with Turner's syndrome who have been taking hormone therapy will not show a typical breast pattern. Mammary lobes will only form if there is a complete set of chromosomes (regardless of the sex).

MODULE 4
SCANNING TECHNIQUE & MORAL, LEGAL AND ETHICAL CONSIDERATIONS IN ULTRASOUND

SCANNING TECHNIQUE

A scan of the breast can be almost useless and can have dangerous implications if not conducted properly. This module aims to direct you by giving you some scanning facts. Try to put these into practice every time you scan.

LEARNING OBJECTIVES

On completion of this module, you should be able to answer the following questions:

- What type of transducer do I need?
- How will I set up the machine?
- What do I ask the patient?
- What care do I take of my patient?
- What do I take note of before I start scanning?
- How do I position the patient?
- What different techniques may be used?
- How do I describe a lesion?

KEY CONCEPTS

Use these terms to guide you in your learning.

- Linear Array
- Skin Changes
- Power
- Documentation
- Focal Zones
- Patient History
- T.G.C.
- Patient Care
- Stand Off Pad
- Consent
- Scout Scanning
- Skin Thickening
- Clock Face
- Radial
- Mammographic Correlation
- Anti-Radial
- Contrast Resolution
- Field of View
- Symmetry

ONLINE TEXTS

Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 3

Review the eReader for any relevant articles

EQUIPMENT

Use of a high frequency (7-15MHz) linear array transducer is essential, to give the best possible spatial and contrast resolution. The flat surface of the transducer will also flatten out the tissues slightly to reduce refraction artefact.

To penetrate larger, highly glandular breasts, you may need to use a lower frequency probe for the deepest portions of the breast adjacent to the chest wall.

- Power settings should be set as low as possible. This will ensure the smallest sound pulse and minimise 'noise' and distortion.
- Multiple focal zones give the best resolution of the breast from superficial to deep. However, this will slow down the frame rate and may also give rise to transducer focal zone artefact and loss of diagnostic artefacts.
- Single focal zone is necessary for the specific examination of one lesion.
- Time gain compensation should be used to compensate for the attenuation of the sound in tissue and is very important.
- Contrast resolution is very important in the breast. Regions that differ only slightly in their echogenicity must be recognised. This is influenced by adjustment of dynamic range and post-processing.
- A stand-off pad may be used for very superficial structures.
- Use of a small field of view when imaging focal areas and lesions is advised in order to provide better spatial resolution.
- Use of 'write zoom' when scanning a lesion will further enhance resolution.
- Harmonic and real-time compound imaging may improve the image (Take care when using real-time compound imaging as it may mask diagnostic artefacts).

Accurate depiction of breast lesions can only occur when all scan parameters are optimised.

PATIENT CARE

- It is essential that the examination is explained to the patient before proceeding and that the patient understands and gives verbal consent.
- Care should be taken to respect the patient's privacy by making sure that the door is not opened during the examination.
- Covers should be placed over the patient, and only the breast being examined at the time should be exposed.
- The patient may like to have a chaperone present, or departmental policy may require the sonographer to have a chaperone present.
- If the patient is presenting with a palpable lump, you MUST ask for the patient's permission to palpate the lump – do not just feel the lump without asking if it is ok to do so.

PATIENT DETAILS

A full history should be taken from the patient including:

- Previous test results pertaining to the breast.
- History of surgery or radiotherapy.
- History and location of biopsies, FNA
- Recent history of pregnancy, breast feeding or HRT.
- If post-menopausal – what age did, they cease their periods
- Reason for ultrasound – breast lump, nipple discharge, pain or tenderness and how it relates to their menstrual cycle, etc.

Any position of surgical scars, palpable lumps, region of scanning interest, etc., should be documented and drawn on the worksheet.

OBSERVE AND DOCUMENT ANY FINDINGS WITH RESPECT TO:

- Breast size and symmetry (ask the patient if they have ever noticed a difference in the size of their breasts – most women already know when there is a discrepancy)
- Contour.
- Skin changes.
- Nipples –inverted (if so, is this normal or a change)
- Scarring from previous surgery.
- Breast size and symmetry

Small breasts are generally easy to examine, large breasts are more difficult - in fact, and very large breasts should never be examined by ultrasound alone.

It is important to determine whether asymmetry in breast size is an indication of normal individual variation, post-operative, or due to disseminated tumour.

CONTOUR

Normal contour is convex. Note any flattening or dimpling which may be due to surgery or underlying tumour. This may be particularly noticeable when you roll the patient into the scanning position, especially if there is any change to the outer quadrants.

SKIN CHANGES

These may be generalised or localised.

Generalised

- Erythema (mastitis, inflammatory breast cancer, acute radiation reaction)
- Skin thickening
- Skin thickening with obvious pores indicating lymphedema

- Prominent veins (mass causing vein compression)
- Hyperpigmentation or telangiectasia (dilated capillaries) as a result of radiation therapy.

Localised

- Warts
- Naevi
- Atheroma
- Fibroepitheliomas
- Sebaceous cysts
- Scars
- Retraction

NIPPLE

Inversion of the nipple can be:

- Congenital
- Acquired because of surgery
- Result of breast inflammation or malignant tumour
- Associated with retraction
- Deviation of the nipple or lack of symmetry when compared to the opposite side can be an indication of the beginning of retraction
- Asymmetric depigmentation of the nipple can be the result of radiation therapy.
- Crusty deposits on the nipple can be a sign of pathologic discharge
- Eczematous changes in the nipple can be a sign of Paget's disease of the nipple.

All changes should be noted and precisely documented.

POSITIONING

The patient should lie supine on the bed with the arm of the side you are examining raised above the head and resting on the pillow. (Note – always check with the patient that they can place their arm above their head, as some patients will have shoulder limitations, so never force their arm into this position)

Roll the patient into a contralateral posterior oblique position. This allows the breast to flatten over the chest wall and create an even thickness of breast tissue. A small pad or pillow should be placed under the patient's shoulder on the side that is being examined to help support them in this position.

- By rolling the patient as above, it thins out the breast tissue, ensuring that the highest frequency transducer can be used to penetrate to the chest wall but still maintain excellent resolution
- It also pulls the tissue planes of the breast into a plane which is parallel to the skin surface, producing less artefacts and better focusing

Be aware that it may be better to image the medial aspect of the breast with the patient in a truer supine position. Patients with larger breasts may require more obliquity. The patient should be made as comfortable as possible. Adequate amounts of warmed gel should be placed on the skin.

SCANNING TECHNIQUE

You must know your anatomy well to recognise what is normal. Know the layers of the breast and their ultrasonic appearance.

SCOUT SCANNING

This is an important part of the scanning process. It is not about just taking representative images. The breast should be scanned in a systematic way from quadrant to quadrant to ensure that all parts of the breast are scanned.

- This should include the axilla and all margins of the breast tissue.
- Both breasts should be scanned in this way and compared to each other.
- Particular attention should be paid to any palpable lump or area of focal thickening - these lesions should be found and held between your fingers and scanned while the lump is localised in this way. Localisation of some lumps may require scanning the patient in an alternate position (e.g. upright), as the patient may not be able to localise the lump whilst in the supine position.

SUGGESTED SCANNING TECHNIQUE FOR A WHOLE BREAST SURVEY

Please be aware of your department's protocol and follow it.

There are 2 main thoughts on the scanning planes used to scan the breast to optimise visualisation of normal anatomy and pathological changes.

- The first accepted method is when the breast is scanned in both the longitudinal and transverse planes
- The second method is the radial technique, in which the breast is scanned in a clockwise manner

With either technique, ensure that the area deep to the nipple has been assessed, as well as the axilla for the presence of abnormal lymph nodes.

SUGGESTED IMAGES DOCUMENTED FOR A WHOLE BREAST SURVEY

This method employs the "clock-face" technique.

- Each breast is divided as a clock-face and scanned with each image clearly labelled as to its number on the clock-face and its position to the nipple.
- Split screen technique should be used to enable more information on one image.
- Orientation is such that the nipple is always to the left of the screen (you will find that each department varies with this though. It may be the case that it does not matter which side the nipple is on **as long as it is consistent and annotated on the screen**)
- This technique enables the lobes to be scanned radially, as is their position in the breast.
- A "body-marker" is a useful tool to use.
- Some practices ask that all locations of the clock are documented (1 o'clock, 2 o'clock, 3o'clock etc.) along with deep to the nipple and axilla images
- Some only require 6 radial images (12 o'clock, 2 o'clock, 4o'clock etc.) along with deep to the nipple and axilla images
- If a specific lesion is found, you need to take extra images (see below)

SUGGESTED SCANNING TECHNIQUE AND IMAGE DOCUMENTATION FOR A BREAST LESION

- Lesions, especially solid ones, should be scanned in the radial and anti-radial positions
- The angle of the ducts is from the nipple and radiate towards the breast periphery, so scanning in the plane of the duct (radially) shall help to show any ductal involvement of the lesion and any subtle projections along the duct
- The lesion needs to be scanned in 2 planes (radially and anti-radially) with sizes in at least 2 planes, and the distance from the nipple needs to be annotated on the image. This is particularly important for non-palpable lesions
- Colour or Power Doppler should be used to assess any unusual vascularity and effects on surrounding vasculature (is lesion distorting adjacent vessel)
- On finding a lesion, it is important to palpate the area of suspicion, and to confirm that this area is correlated with any mammographic findings if available

MASS CHARACTERISATION

The lesion should be described by:

- Location
- Number
- Size
- Shape - round, oval, irregular
- Margins - smooth, micro/ macro lobulated, irregular or spiculated, well or poorly defined
- Compressibility
- Internal contents - solid, cystic, or mixed
- Echogenicity - anechoic, hypoechoic, or hyperechoic
- Heterogenicity - homogeneous, heterogeneous
- Parenchymal interface - thin linear, echogenic rim or irregular
- Posterior sound transmission - enhancement, shadow or no change
- Associated secondary findings - skin changes, ductal dilatation, cooper's ligament straightening or thickening, and compressibility
- Doppler characteristics

There is a form of classification that goes beyond using just the clock face for specific location of breast lesions. It involves not just the distance from the nipple but also the depth of the area of interest. This is called a quasi-grid pattern, and you can find information pertaining to this in:

Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins Chapter 3 under sub heading of: Identification of scan planes and lesion location

LOCATION OF A MASS SEEN ON A MAMMOGRAM

- The craniocaudal mammogram (CC) delineates if the mass is medial or lateral to the nipple
- The mediolateral oblique (MLO) delineates if the mass is superior or inferior
    - because this is not a true lateral image, lesions on the lateral breast will in reality be slightly lower than how they appear on the image
    - for the same reason, lesions in the medial breast will appear in a slightly higher position on the image compared to their actual location in the breast

When correlating the breast ultrasound with the mammogram, it is the craniocaudal view that best correlates with the transverse view of the ultrasound. This is because the shape of the lesion on the CC view will be easier to reproduce on the ultrasound if they are taken in similar projectional planes.

SPECIFICATIONS FOR INDIVIDUAL EXAMINATIONS

IMAGE LABELLING should include a permanent identification label that contains:

Facility name and location

Examination date

Patient's first and last name

Identifying number and/or date of birth

Designation of right or left breast

Anatomic location using clock face notation or a labelled diagram of the breast, transducer orientation and distance from the nipple to the abnormality, if present, are required.

Sonographer's and/or physician's identification number, initials, or other symbol.

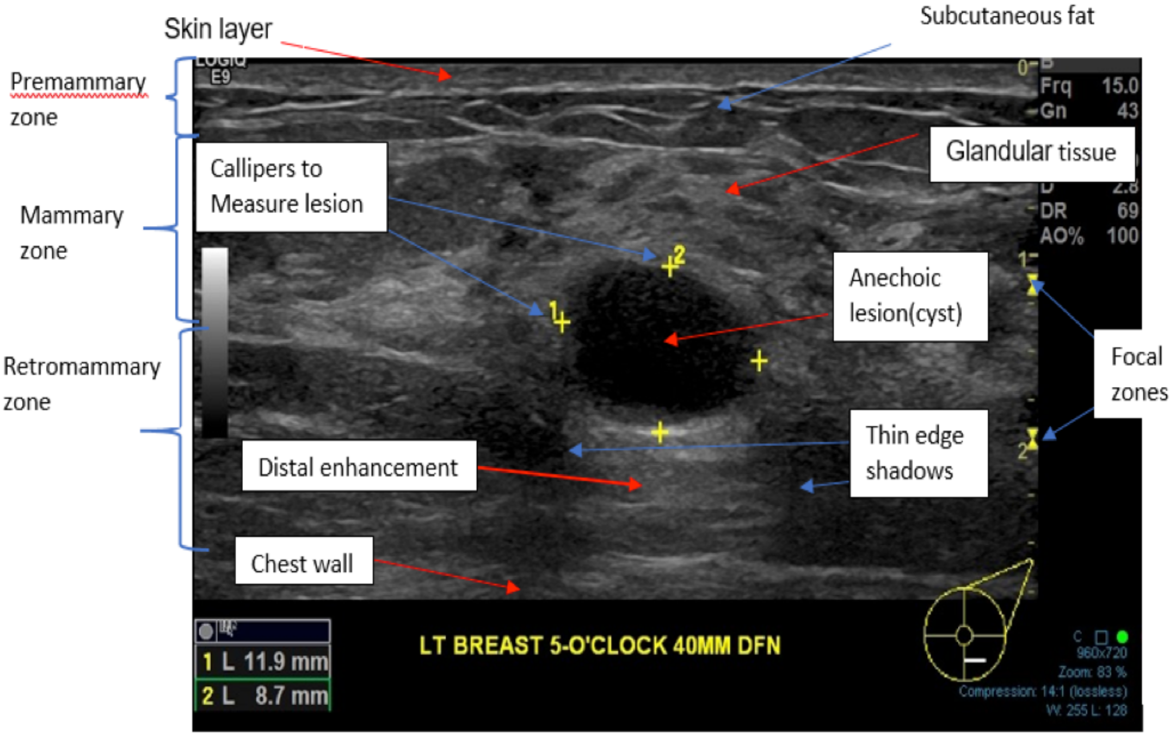


Image used with permission from Author's workplace

MORAL, LEGAL AND ETHICAL CONSIDERATIONS IN ULTRASOUND

MODULE OVERVIEW

You will not be studying the scanning technique or learning about the technical considerations when encountering certain pathologies. Nor will you be learning to recognise the sonographic appearances of an abnormality. Rather, you will be dealing with all the other aspects of the ultrasound examination and with your duties as a sonographer apart from the technical.

In society, today there is an increasing awareness of a person's rights, and when these rights are not respected, someone has to be held accountable. The legal system is increasingly being burdened with cases where financial compensation is being sought when something has gone wrong. Many health workers feel vulnerable. They are uncertain of what is expected of them, what their responsibilities are, and how they can protect themselves from being held accountable by patients who feel that they have been ill-treated.

Hopefully, the study in this module will help you increase your understanding of the key legal issues associated with sonography and your awareness of the more complicated moral and ethical concerns that are raised during the ultrasound examination.

The main objective of this module is to make you think about what you perceive to be your duties as a sonographer. This is quite a complex topic. As you work through these materials, you will find that very few of the issues raised can be set in black and white.

LEARNING OBJECTIVES

When you have completed this module, you should have given some thought to the following questions. Try and let them direct your studies for this module. You may not have any clear-cut answers to them, but aim to have instead a series of alternative tactics ready to solve the problems that they represent.

- Should a sonographer obtain consent from the patient before performing an ultrasound examination?
- What is an informed consent? Do you think obtaining one eliminates the risk of litigation against you?
- Does your patient have the right to expect a truthful answer to a question posed to you?
- Is it okay to lie to a patient?
- Do you know whether your employer accepts vicarious liability?
- What do you perceive is a patient's right to privacy?
- What is the importance of correct documentation?

ONLINE READINGS

Review e-readings for any other relevant articles.

BEST STANDARD PRACTICE

In relation to negligence, the finding of negligence is based on the decision that a physician has not fulfilled his/her duty to a patient by performing as a reasonable physician in the same situation would have performed at the time the breach of duty is alleged to have occurred. In simple terms a jury finds a physician guilty of negligence if the physician failed to live up to the standard of care. The problem lies in the fact that there is no book that delineates the standard of care or best standard practice. There is no medical body that determines the standard of care.

In the introduction to this module, it was mentioned that as health workers we often feel quite uncertain about our position, because we don't know for sure, what exactly is expected of us, what we are liable for, and how we can protect ourselves from being held accountable by patients who feel that they have been ill-treated. Sonographers are especially vulnerable due to the decisional latitude usually delegated to them. The various associations for sonographers have addressed this uncertainty over the years by holding educational seminars in their branches that have focused on both the legal aspects of liability, and the need for everyone to have professional indemnity insurance.

Apart from insurance, as sonographers, we need to have an awareness of what we are doing every time we are performing a scan. We must make sure that we are continuously striving to perform the examination to the best of our ability, not only in a technical sense (that is, achieving the optimal scan), but also from a humanistic point of view. We must take responsibility for all of the patient's needs while they are in our care.

We can only effectively protect ourselves against the risk of disrespecting our patients' rights and thus, the risk of litigation, by performing the ultrasound examination to our best standard of practice every time. In this way, we also uphold the current standard of the profession and set the benchmark that future generations of sonographers will base their minimal standards on and guarantee the future development of the profession.

But what is our 'best standard practice'? Is it as simple as to follow procedure protocols as stated by our professional bodies? Is that how 'we take the responsibility for all of the patient's needs while they are in our care'? Do we put enough emphasis on the non-technical aspects of examination? Or too much? Should sonographers behave like technicians, merely concentrating on obtaining the best possible technical result?

Below is a list of points that a group of fellow sonographers came up with at a tutorial when we were discussing what a sonographer should regard as best practice.

Always:

- Introduce yourself
- Explain the procedure to your patient
- Explain your role in the setting of the examination
- Create good contact with the patient
- Obtain informed consent
- Communicate what you are doing and intending to do
- Let the patient be your focus of attention (avoid interruptions)
- Behave as a professional
- Show empathy and compassion
- Refrain from offering personal opinions
- Respect patient privacy

USE THE BEST POSSIBLE ULTRASOUND TECHNIQUE:

- Always optimise image and scanning technique
- Use colour Doppler and spectral Doppler when needed
- Document conscientiously on hard copy or other
- Know your limitations and ask for assistance when needed
- Make sure there is follow-up for the patient (caring dispatch protocol)
- Be up to date with your knowledge
- Attend conferences, workshops, training sessions and so on
- Adhere to departmental or practice protocols
- Obtain postgraduate qualifications and accreditation

Most sonographers use 'best practices' most of the time. Documenting incidences every time that something goes amiss during an examination, will enable us to have a record to fall back on later if our perceived carelessness or negligence has any adverse repercussions. This documentation should be noted in a logbook (personal or departmental) which is especially designated for that purpose. The kind of cases we would document could be like the following examples:

- 'During Mr X's scan, we were interrupted numerous times by people popping their head in with messages. I could feel that the patient was getting annoyed despite my apologies ...'

- 'Mrs What's-her-name and I just couldn't hit it off. Every time I asked her to do anything; for example, to turn over, or to hold her breath, she panicked and thought I had found something seriously wrong with her. This was regardless of my repeated explanations that I would not be able to answer her questions ...'
- 'This was how I performed the examination when Ms XY-and-Z terminated the examination because she had had enough ...'

A very important aspect of making a patient feel comfortable and cared for is the level of communication offered to the patient at the time.

Most sonographers are good communicators, and they usually have a compassionate nature. After all, they chose a career in the health profession, and most sonographers learn with experience how to conduct themselves. But what if this learning doesn't occur? Also, do we have to have these 'learning experiences' first to feel the need to change our behaviour? What about the patients on the other end of these 'bad experiences'? Can you learn to communicate and to show compassion? I believe you can, and I believe sonographers must, to survive in the profession. To develop good communication skills, you really need to learn to recognise how you are already communicating.

The following examples from everyday situations are provided to give you some food for thought. A useful philosophy is to always treat your patients how you would like to be treated yourself if you were in their situation.

COMMUNICATION

What is it we do when we communicate with our patient? We interact. We do this not only by the things we say but also as much with the things we don't say and with the actions we use. We use verbal and non-verbal communication.

Verbal communication

The quality of your verbal communication depends on:

- The way you present the message or material
- Your attitude
- The tone and volume of your voice
- Effective listening, by both you and your patient
- Presentation of the message or material

Vocabulary

Here you enter a conflict as a health professional. On the one hand, you must develop precise, accurate descriptions in ultrasound terminology to communicate with the other health professionals, such as radiologists, colleagues, and so on. It is an important part of your training to be able to communicate what you are imaging in concise terms. On the other hand, when you are talking to patients, then technical terms and medical jargon will tend to go straight over their heads! Not only don't they understand your message; you are also causing a distancing of yourself from the patient—and you are no longer interacting.

In short, you need to be able to develop appropriate vocabulary for different situations. This is not so hard to do, as we do it every day from early on in our lives. For example, children speak differently to their parents and teachers than they do to their friends in the schoolyard. But in terms of our working life our choice of words must be a conscious development—we must know how to think in professional terms and translate it into lay terms as we speak. Some patients, however, are either health professionals themselves or have read many books and know all the terms, but these patients are sure to communicate that message to you early on, and so you adjust your level accordingly. It is good practice to be sensitive to the level of the patient's understanding of the scan.

Give the patient an opportunity to communicate their level of understanding and knowledge to you—be sensitive to their level and adjust your vocabulary accordingly.

Organisation

If you realise that your speech can 'ramble on' in a disorganised fashion, then you must also realise that this can confuse a patient. You can’t 'afford' to be disorganised in your speech when you are explaining the procedure to the patient. To obtain informed consent you must inform in the first place. There are ways to practise this:

- break down the procedure into component parts for yourself
- practise describing the procedure
- try it out on a friend who is not familiar with the procedure; they will usually tell you if you make sense or not!

Clarity

This mainly relates to your delivery speed. Make clear what you are trying to say. Remember, often the patients absorb just one word and are totally preoccupied with taking that in. Slow down so they don't miss anything; you can often see when you lose them by observing their eyes as you speak. You may need to repeat your message. If, for example, the patient you are scanning has just suffered a miscarriage, you may be in the unfortunate position of having to explain the situation. It is important to remember that on the receipt of bad news, most people will only remember a very small percentage of what has been explained to them, so be gentle and compassionate in your explanation, but also be concise and succinct.

ATTITUDE

Your attitude towards the patient has an enormous impact on your level of communication and I'm sure that most sonographers most of the time maintain a caring attitude towards their patients.

How do you show a caring attitude???

The following is an extract from "Talking with patients: a guide to good practice" by James Calnan (1983); it gives food for thought. See what you think.

The first contact with your patient should be a smile, the second touch, the third a question 'What can I do for you?' By using the three senses of sight, touch and speech by way of greeting, the patient will realise that you are prepared to give him warm, courteous attention, and he will react favourably. The proper attitude calls for an awareness of patients, the human context of medicine, and not just their diseases. You must go deeper. You must talk with the patient outside the line of duty.

You can't fake attitudes—your real attitude will always show. But I believe that even on a bad day you can deliberately change your attitude by reminding yourself whom you are there to serve before you go to greet a patient.

However, sometimes your best attitude will be tested by a totally non-responsive patient. We've all met the obnoxious obstetric patient who starts off with' now. I want five photos of my baby and a videotape, and I want to know what sex it is, so don't tell me you can't see it...' and so on.

This is when your professionalism is tested.

You must take one step back from the abusive or obnoxious patient, so that you don't let your own anger hurt you. Just as patients have rights to be treated as humans, so have you! But if you can find it in yourself to show patience to this kind of patient, you may find that the facade of aggression hides quite different emotions.

Don't always judge a book by its cover. This is just one example; you have probably all had a similar experience with a patient for a mammogram or breast scan, who is terrified of having cancer because her mother and sister both died of it.

ADDRESSING THE PATIENT

When talking to older patients, never address them by the endearment's 'love' or 'dear', as this tends to show a measure of condescension and therefore disrespect. Always address older people by their proper title until invited to do otherwise.

Voice tone and volume

Tone: Often, it's not what you say, but how you say it.

An example: In the sentence 'what are you doing?' you can stress different words and achieve totally different meanings:

What are you doing?
What **are** you doing?
What are **you** doing?
What are you **doing?**

So be aware that the tone of your voice can reverse the meaning of the spoken word.

Volume

If you speak very loudly it soon becomes irritating for the listener. You yourself would instantly back away normally, when spoken to in a loud voice, but your patient has not got that option! When you speak too softly, you run the risk of the patient not absorbing the meaning of your words in their striving to listen to them.

Please don't assume that everyone over sixty years of age has a hearing problem. If they do have one, get their attention by touch or name (eye contact) before you start to talk, and remember that they may be able to hear quite well if you just lower your pitch. Be sensitive to your patient's reactions to your tone and volume and adjust them accordingly.

EFFECTIVE LISTENING

Most of us lack the skills to listen effectively. The words hit our eardrum, but the message becomes distorted.

Much is written in psychology books about listening skills. It's too big a topic to go into in detail here and certainly to teach you any techniques and skills, but as a sonographer you should have two goals clear in your mind:

- To develop your listening skills, so you hear the patient accurately
- To learn to ascertain how accurately your patient has heard you

You must listen, because:

- You need information from your patient
- You want your patient to feel properly treated.

For example, when you are obtaining clinical information from your patient, you are often at the same time typing in the patient's name, setting your scanning program up, changing transducers, and so on. This is not good practice, as it is difficult to concentrate properly on more than one thing at a time.

Instead, sit back in your chair for those thirty seconds, have eye contact with the patient, show them that you are paying attention and listen to what they are saying. This gives you a 'stress break', and it also leaves the patient with a much better impression of their importance to you.

NON-VERBAL

Now we'll be discussing the more subconscious part of our communication, the non-verbal content. Just think how much we can express without words using pantomime or charades.

The non-verbal messages we give our patients are expressed in:

- Facial expressions
- Positions, postures, and gestures
- Physical appearance
- Touch

We all know how much our faces give us away, from the first day we tried to tell mum we didn't do it, when in fact we did, but she wasn't fooled!!

FACIAL EXPRESSIONS

With a facial expression, you can express:

- anger
- pity
- disappointment
- teasing
- pleasure
- boredom
- disbelief etc.

An example of the subtlety of facial gestures is how many ways you can smile. The following passage is quoted from the book, "Health professional/patient interaction", by Ruth Purtilo, (1984, page 118):

Although it is usually interpreted to mean friendliness, a smile does not always communicate that. Consider for instance the following five kinds of smiles:

- The 'I-know-something-you-don't-know' smile. A patient asks, 'Am I going to be here very long with this injury?' The health professional smiles.
- The 'poor-poor-you' smile. The patient labours for five minutes to transfer himself from his bed to a wheelchair but fails to complete the move and must ask the health professional for help. The health professional smiles.

- The 'don't-tell-me!' smile. The health professional asks, 'How are you today, Mr. Carlson? Is everything OK? Good!' Before Mr. Carlson can say whether everything is in fact OK, the health professional smiles.
- The 'I'm smarter-than-you' smile. The patient says, 'I'm sorry, I forgot again when I am supposed to return for my next test.' The health professional smiles.
- The 'I-don't-like-you-either' smile. The patient shouts, 'I hate you!' The health professional smiles."

Note that your facial expression can send the opposite message to what your words are saying.

POSITIONS, POSTURES, AND GESTURES

The way you stand or sit in relation to another person and the way you move while communicating have a significant effect on how your words are perceived. Some active gestures to think of are:

Eye contact: this is the start to communicating a positive message. You have got your listener's attention and they have got yours.

Body posture; Relax!! If you're tense, it gets communicated very quickly to the patient.

Height difference

Once you are standing or sitting and the patient is lying, you have established that you have authority. I do think at times there are patients that need to become aware of 'who's in charge', but the majority of patients come into your department with expectations of being treated as equally worthy a person as yourself. So, establish that feeling in them before they lie down by talking to them as you greet them; introduce yourself while they are still standing, explain what you are going to do, ask them about preparation etc. You are not wasting precious time; you are practising respect. When this is not possible, (for example, if the patient is in bed or in a wheelchair) then sit yourself down and talk to them.

Gestures

Be aware of what your extremities are doing. Avoid

- The clenched fist
- The tapping foot
- The shrugging shoulders
- The folded arms

I think we all know that our body and face give us away in sonography, and it is incredibly but sadly, true, that we must act a lot of the time in ultrasound to be in control of our gestures. I don't know where in our job specification that comes in. I am not sure that there is enough emphasis on this aspect in our initial clinical training towards becoming sonographers!

It can be incredibly difficult to learn to remain expressionless, if you are the type of person who wears your heart on your sleeve. I don't know if everyone can learn to control their body language to conceal messages. I don't know if it would be such a good thing either—we are humans too, we have feelings to cope with as well. But I still hate it, when a patient says to me: 'I knew there was something wrong when you lost your smile and started frowning at the screen'.

THE UNCONSCIOUS OR INADVERTENT GESTURE

Whether or not this last category comes into verbal or non-verbal communication it is difficult to say but be very wary of the inadvertent sigh or groan if a particular section is difficult to image and try not to swear under your breath if the patient moves at the wrong time or the camera jams up. Patients are usually very sensitive to this, and frequently imagine the wrong reason for it.

Physical appearance

There is no doubt that we form opinions about each other based on appearance. As a sonographer, you can assume that, rightly or wrongly, your patient will react to your appearance. You are communicating messages with your choice of appearance. You need to be aware of this aspect of non-verbal communication.

Touch

Touch is a very strong method of non-verbal communication. We live in a non-touching society these days, but once our patient enters a health facility, they allow themselves to be palpated, squeezed, supported, and lifted, and so on. However, they are still protected against non-consensual touching, and we must recognise that.

A comforting touch is a legitimate touch in that context and a reassuring hand resting on a patient's shoulder or arm speaks more loudly than the kindest words. As far as touching your patient goes, you must do what you find natural. However, you need to keep in mind that there are some people who consider that it invades their personal space. In my opinion, sometimes that is worth risking in order to gain the positive effects in the majority of cases.

Sometimes the touching is actively sought by the patient. For example, elderly people will often reach for your hand. Take the opportunity to show that person that you care. Supporting a patient to get off the table is often a welcome touch, even if it is just a touch on the elbow. It concludes the examination and shows that even after you as the technologist have completed your task, you still care.

And that's the message we want the patients to take home with them—that we care!

MODULE 5
OVERVIEW OF BASIC PATHOLOGICAL PROCESSES

MODULE OVERVIEW

This module will give an overview of the basic pathological processes of inflammation and neoplasia that can occur on a systemic level.

LEARNING OBJECTIVES

By the end of this module, you should be able to answer the following questions:

- Why does inflammation occur?
- What are the classic signs of acute inflammation?
- What are the consequences of acute inflammation?
- What happens in chronic inflammation?
- What role does the lymphatic system play in inflammation?
- What is the definition of neoplasia?
- What are the two categories of neoplasia?
- What are the features of a benign and a malignant tumour?
- How do malignant tumours spread?

KEY CONCEPTS

Use these terms to guide you in your learning.

- Acute Inflammatio
- Chronic Inflammation
- Rubor
- Tumor
- Fibrosis
- Local Invasion
- Abscess
- Suppuration
- Ulceration
- Neoplasia
- Granulomatous
- Malignant
- Benign
- Metastases
- Staging
- Lymphatics
- Blood
- Seeding
- Dysplasia

GUIDE TO STUDY

You will need to revise this area quite thoroughly. If you have any problems accessing a pathology book, the UniSA library has many useful texts. Unlike technology, the process of pathology does not change over time, so even though some of the basic information in this section has been sourced from older text, it is just as accurate and concise today as it was when first written.

REFERENCES

Some of the information in this study guide pertaining to this section has been sourced from:

- Kumar, C, Cotran, R & Robbins, S 1997, Basic Pathology, 6th Edition, WB Saunders, Philadelphia
- Stevens, A & Lowe, J 1995, Pathology, Mosby, London

INFLAMMATION

External and internal stimuli can cause injury to the cells. When this happens, inflammation occurs both to protect the cell from microbes or toxins and to eliminate these and to remove the necrotic cells and tissues which occur because of it.

Inflammation dilutes, destroys, or isolates the causative effect, thus setting in motion the sequence of events that heal and repair damaged tissue. The repair process involves the regeneration of the native parenchyma or filling the defect with scar tissue - fibroplastic cells - or a combination of both.

Although inflammation and repair make healing possible, these both can have the potential to do harm, such as, anaphylactic shock, rheumatoid arthritis and rheumatic fever.

There are two forms of inflammation - acute and chronic.

- Acute inflammation lasts for a relatively short length of time from a few minutes to a few days. Acute inflammation involves fluid and plasma exudation and accumulation of neutrophilic leukocytes.
- Chronic inflammation lasts from days to years and involves the influx of lymphocytes and macrophages and tissue destruction and repair associated with vascular proliferation and fibrosis.

ACUTE INFLAMMATION

This is an immediate response to injury. Leucocytes are delivered to the site, where they begin to clean up bacteria and degrade necrotic tissues. The leukocytes themselves may prolong inflammation by the release of enzymes and oxygen radicles. There is an increase in blood flow and structural changes in the capillaries to allow plasma proteins to leave the circulation.

The classic signs and symptoms of acute inflammation are:

- Heat
- Redness
- Swelling
- Pain
- Loss of function

Because changes in vascular flow and calibre begin relatively quickly, local increased blood flow causes redness (erythema) and warmth of the area with increased permeability of the blood vessels. Initially, the fluid that is leaked is mainly blood plasma and known as transudate. However, quite soon, increasing vascular permeability permits the flow of protein rich fluid into the interstitial spaces. This is known as exudate. Eventually, due to differences in osmotic pressure, there is an accumulation of water and ions in the tissues, known as oedema.

Consequences of acute inflammation

Generally, there are four outcomes of acute inflammation, modified by the nature and intensity of the injury, the site of the tissue and the ability of the host to respond. These are:

- Complete resolution. The injury was limited or short lived with only a little tissue destruction. The tissue is capable of regeneration and there is restoration of normality.
- Scarring/fibrosis. This occurs after the inflammation occurs in tissues which do not regenerate, or after substantial tissue damage. Also, fibrinous exudates cannot be completely absorbed and become organised by the ingrowth of connective tissue, resulting in a mass of fibrous tissue.
- Abscess formation. This may happen with infection by certain bacteria or fungi known as pyogenic organisms.
- Progression to chronic inflammation.

CHRONIC INFLAMMATION

In chronic inflammation, active inflammation, tissue injury and healing proceed simultaneously. Although the initial injury to the cells may not be as bad as that which caused the acute inflammation, the failure to resolve may lead to substantially more problems in the long term.

Chronic inflammation occurs because of:

- Persistent infections
- Prolonged exposure to toxic agents
- Autoimmune disease

The patterns of inflammation are:

- Serous - effusion, an outpouring of watery fluid, either from serum or from the mesothelial cells of the pericardium or peritoneum. An example is a blister from a burn.

- Fibrinous - happens because of more severe injuries. There is greater vascular permeability which allows larger molecules such as fibrinogen to pass through the endothelium. These molecules accumulate and can either be degraded by fibrinolysis and the debris removed by macrophages, leading to the resolution to normal tissues; or, if all the fibrin is not removed, to an ingrowth of fibroblasts and blood vessels. This is organisation and leads to scarring.

- Suppurative - purulent inflammation. There is a large amount of pus, which consists of neutrophils, necrotic cells, and fluid. Some organisms e.g., staphylococci, are more likely to produce this type of inflammation. Focal collections of pus are called abscesses. They have a central necrotic area rimmed by neutrophils and surrounded by dilated blood vessels and fibroblastic proliferation. Eventually the abscess may become sealed off and replaced by connective tissue.
- Ulceration- this is the site of an inflammation where an epithelial surface has become necrotic and eroded because of toxic or traumatic injury, or by vascular compromise.
- Granulomatous inflammation - distinct form of inflammation with aggregations of activated macrophages that have acquired an enlarged, squamous -like appearance. These are called granulomas. They only occur in a relatively few states, one of them being tuberculosis. They also occur in a reaction to inert foreign bodies, with one of the most notable being around breast implants.

LYMPHATICS AND LYMPH NODES

This system drains and samples fluid which has accumulated. It forms a second line of defence, along with mononuclear phagocytes. Lymphatics deliver antigens and lymphocytes from peripheral sites to more central lymph nodes, where T-cells and B-cells and antigens will mount an immune response.

Lymph flow increases in inflammation and is important in the resolution of inflammation, helping to drain away oedema, leukocytes, and cell debris. Unfortunately, they also drain away more injurious agents, and secondary inflammation at lymph nodes and lymph channels can occur (lymphadenitis, lymphangitis). If these lines of defence do not work, potentially disastrous bacteraemia can occur when organisms reach the blood stream.

NEOPLASIA

The literal meaning of neoplasia is 'new growth'. All neoplasms begin with a loss of responsiveness to normal growth controls. They act almost as parasites and compete with normal cells and tissues for their needs. They seem to grow almost autonomously, but they are dependent on their host for blood supply and nutrition and sometimes endocrines.

A neoplasm is often referred to as a tumour, the study of tumours being known as oncology. A tumour is, strictly speaking, any swelling at all, and that may include haemorrhage into tissues. Nowadays the term tumour is used almost exclusively for neoplasms. It is most important that neoplasms be divided into two categories - benign and malignant.

Benign tumours are generally slow growing and will only grow locally. They do not invade local tissues but will compress them. Although they are benign, some may cause severe problems, depending on where they are sited. For instance, a thyroid tumour may cause abnormal secretion of thyroid hormones or a brain tumour may actually cause death.

Malignant tumours manifest themselves in different ways from benign in that they invade adjacent structures and will spread to other parts of the body (metastasise). They are often much more rapidly growing.

Malignant tumours can spread to other site by four main routes:

- Local invasion - they will grow into adjacent tissues or along natural pathways such as nerves, blood vessels or mammary ducts.
- Lymphatics - tumour cells may spread by the draining of lymph into local lymph nodes.
- Blood - veins draining the primary lesion can spread tumour cells to distant areas. For instance, a tumour in the gastrointestinal system may spread to the liver via the portal vein, or venous drainage may enter systemic veins and tumour cells carried to brain, lungs, bone marrow, etc.
- Seeding - if the primary tumour is situated in the abdominal cavity or thorax, cells can migrate to the surface of other organs - a process known as seeding.

Certain tumours will spread to one area more frequently, as in breast cancer frequently spreading to bone.

A patient with a neoplasm will usually display systemic symptoms. The most frequent are:

- Weight loss
- Loss of appetite
- Fever
- General malaise
- Anaemia

Once a malignant tumour has spread it will often lead to death due to:

- Cachexia and malnutrition from the effects of the tumour and metastases. The person becomes progressively weaker, and death often results from a secondary infection such as pneumonia.
- A main organ system may be destroyed by the tumour.

DYSPLASIA

This is a histological term that is applied to cells that are showing some of the signs of neoplasia. It is often seen in endothelial tissue that has been subject to chronic irritation. Whilst it is not itself neoplastic, in some areas it is known to become so after time, e.g., the uterine cervix

MODULE 6
BREAST PATHOLOGIES AND THEIR SONOGRAPHIC APPEARANCES

MODULE OVERVIEW

Breast ultrasound has improved dramatically in recent years with modern high-resolution equipment. This has enabled diagnosticians to quantify certain characteristics within specific breast lesions.

LEARNING OBJECTIVES

On completion of this module, you should be able to answer the following questions:

- What are the characteristics of benign breast lesions?
- What features are not characteristic of benign lesions?
- What are the most described benign lesions?
- What are the sonographic criteria for breast malignancy?
- What are the risk factors associated with breast cancer?
- How do metastases develop?
- What are the different appearances of breast cancer that may be encountered?
- Which is the most common malignancy of the breast?
- Why might Colour and Power Doppler be useful in evaluating breast tumours?

KEY CONCEPTS

Use these terms to guide you in your learning.

- Benign
- Fibroadenoma
- Cyst
- Homogeneous
- Anechoic
- Enhancement
- Fibrocystic change
- Phyllodes Tumour
- Fat Necrosis
- Radial Scar
- Lipoma
- Papilloma
- Galactocele
- Scarring
- Abscess
- Mastitis
- Metastases
- In-Situ
- Carcinoma
- LCIS
- Multi-centricity
- DCIS
- Medullary
- Invasive Carcinoma
- Lobular
- Sarcoma
- Ductal
- Occult
- Paget's Disease of The Nipple

ONLINE TEXTS

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 17
- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins, Chapters 17, 18 & 23
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapters 8,10,11,12 (tables 12-4 and 12-5) 13, 14 &15

Review e-readings for any relevant articles.

BREAST PATHOLOGY

Benign

- benign breast changes
  - fibroadenosis
  - fibrocystic change
- benign masses
  - cysts
  - fibroadenoma
  - phyllodes
  - intraduct papilloma
- miscellaenous
  - fat necrosis
  - hematoma
  - Abscess
  - mastitis
  - scars

Malignant

- invasive ductal ca 80%
- invasive lobular ca
- medullary ca
- colloid / mucinous ca
- papillary ca
- DCIS/LCIS

BENIGN DISEASES

Although breast cancer is very common, most of the conditions we will encounter (about 90%) will be benign, but nevertheless, very worrying for the patient.

The most common benign breast conditions (in alphabetical order) are as follows:

ABSCESS

Can be formed due to acute or chronic mastitis, from local infections (infection of sweat glands and Montgomery glands) or through direct extension (arising from chest wall or pleura).

Usually, a bacterial infection is the cause, and patients usually present with a localised palpable lump with possible skin thickening and discoloration over the abscess. Often present in the retro areolar area. If mastitis is suspected, the response to antibiotics can be followed by ultrasound and resolution detected.

SONOGRAPHIC APPEARANCE

- Usually round to oval shape
- Can have smooth or irregular borders
- Mass with thick, indistinct hyperechoic borders and a hypoechoic centre
- Often sedimentation seen in central portion (may be mobile echoes), septations and even gas (dirty shadowing)
- Partial attenuation and limited compressibility
- Surrounded by oedematous tissue
- Colour Doppler may be useful to demonstrate increased blood flow
- May have fistula tracts emanating from central portion as hypoechoic tubular structures
- Look for reactive lymph nodes

CYSTS (SIMPLE)

Breast cysts are extremely common and most women between the ages of 30 and 60 will have at least one at some time. Cysts in the breast are usually formed by expansion in the glands and ducts due to an obstruction or infection; they do not distort the architecture. They can be any size from 2-3mm to 6-7cm and can be multiple or single. Clinically they can be asymptomatic, or exhibit pain or tenderness, and with or without a palpable lump.

SONOGRAPHIC APPEARANCE

- Anechoic
- Posterior enhancement
- Smooth, rounded but often also lobulated, well demarcated borders with thin capsule
- Thin edge effect
- Compressible with transducer pressure

- No internal vascular flow
- Does not breach fascial plane(s)

Cysts that meet these criteria have virtually no chance of containing malignancy.

Simple cysts do not need to be aspirated unless they are causing discomfort. In the breast they will usually appear to be lying horizontally. There are some exceptions to the above criteria. Cysts lying deep in the breast will often not show enhancement and the enhancement caused by very small cysts may not be detectable by eye. It has been noted that if power Doppler is applied to a suspected cyst, movement will be detected within the cyst, thereby proving that the contents are fluid.

CYSTS – COMPLEX/COMPLICATED

If a cyst does not meet the criteria for a simple cyst, it is classified as complex or complicated.

Most non-simple cysts fall within the large spectrum of fibrocystic change.

SONOGRAPHIC APPEARANCE

- Complex/complicated cysts can have echoes internally from infection, abscess or haemorrhage.
- Thick walls, internal thick septations or the presence of mural nodules
- They may also exhibit diffuse low level internal echoes and fluid debris levels
- Possible eccentric wall thickening (which is often actually a solid nodule within a cyst)
- A lack of through posterior enhancement

DUCT ECTASIA

Involves distension of the ducts and occurs primarily in the presence of fibrocystic changes and plasma cell mastitis.

SONOGRAPHIC APPEARANCE

The large subareolar ducts and intermediate-sized ducts become dilated and filled with thick, static secretions. There is inflammation of the duct walls and the surrounding periductal tissues.

- Usually appears as elongated, tubular structures filled with fluid.
- Echogenic matter within may represent old, cellular matter.

FAT NECROSIS

This can occur after trauma, including surgery. It can present as a firm fixed mass with skin dimpling and on ultrasound it may look exactly like a carcinoma.

SONOGRAPHIC APPEARANCE

Early on, it often presents as an area of haemorrhage seen within the fat of the breast, but variable changes occur with time, often leading to increased echogenicity of the fat with cystic degeneration and fibrosis of the affected area.

FIBROADENOMA

A fibroadenoma is the most common benign breast tumour, found usually in young women (due to the influence of oestrogen levels) and composed of dense epithelial and fibroblastic tissue. Rarely are new fibroadenomas diagnosed in postmenopausal women (with or without being on HRT).

SONOGRAPHIC APPEARANCE

- Can be multiple and bilateral
- Typically, oval with the long axis parallel to the skin
- Surface is smooth or gently lobulated and is homogeneous
- Is mobile and compressible and usually measures about 5mm to 3cm in size
- Often exhibit posterior enhancement and do not breach the fascial plane
- However, like cysts, fibroadenomas do not always show typical appearances.
- They can have varying appearances including inhomogeneity and posterior acoustic shadowing due to degeneration and calcification
- Occasionally, they will be missed because they can be iso-echoic with their surroundings
- Impaired compressibility
- There may also be some internal blood flow detected by colour or power Doppler

Differential diagnosis

Complex cyst, normal breast fat, carcinoma

Fibroadenomas with the non-classic presentation cannot be differentiated from malignancies.

Fibroadenoma –Juvenile or Giant

Occurring almost exclusively in young patients, especially around the age of menarche, and is the most frequent breast mass in children. But not all fibroadenomas that occur in adolescents are classified as juvenile fibroadenomas. Consisting of proliferating stroma and epithelial hyperplasia, they typically have rapid growth. Presenting as a well circumscribed, painless mass, and with similar possible sonographic appearances to the adult version.

FIBROCYSTIC DISEASE

This is the most common diffuse breast disorder, and it has been estimated that it could occur in up to 80-90% of women in the 35-55-year age group. Often, no symptoms are observed; however, it can cause breast pain. As it is a condition which is caused by the exaggeration of the normal cyclical proliferation, symptoms and sonographic features are usually more pronounced in the latter part of the menstrual cycle.

Fibrocystic changes generally disappear after menopause. Not generally associated with the future development of breast cancer, the concern with patients with severely affected breasts is that a more sinister underlying lesion could be missed amongst the fibrocystic changes. In amongst this generally disordered appearance, it can prove difficult to detect a focal lesion. Fibrocystic breasts can produce attenuation effects with shadowing, which can also mimic malignant tumours.

SONOGRAPHIC APPEARANCE

- Pattern of fibrocystic change can range from a honeycomb like appearance of small hypoechoic areas against a background of very dense hyperechoic glandular tissue, to frankly cystic.
- Hyperechoic breast parenchyma
- Prominent ducts amongst dense breast glandular tissue
- Proliferative fibrocystic changes may be shown by thick cystic walls and fibrosis of the interlobar stroma
- Circumscribed areas of fibrosis can appear as ill-defined hypoechoic areas (these are poorly compressible and sometimes exhibit posterior shadowing and, thus, easily look like a carcinoma)

Differential diagnosis

mastitis, multiple breast cysts

GALACTOCELE

This is a cystic breast mass containing milk and is due to the obstruction of a lactating duct. Nearly always occur in nursing mothers, they usually present as a painful, palpable retro areolar mass.

SONOGRAPHIC APPEARANCE

- Oval or round hypoechoic mass
- Containing echoes from inspissated milk
- Posterior acoustic enhancement
- Smooth margins

Differential diagnosis

- Fibroadenoma, abscess, complex cyst
- Long standing galactoceles can appear suspicious on ultrasound

HAEMATOMA

A haematoma is a localized collection of extravasated blood, usually due to trauma or post interventional procedure to the breast. Clinically, patients have a palpable and often painful lump or area of thickening, and depending on the age of the haematoma, they may have a visible skin bruise.

SONOGRAPHIC APPEARANCE

- They have a variable appearance depending on the age of the bleed, ranging from isoechoic initially, to hypoechoic, to eventually hyperechoic.
- May appear as complex masses with thick walls and layering debris

HAMARTOMA (ALSO KNOWN AS ADENOFIBROLIPOMA)

This is a proliferation of normal tissues, with the patient presenting with a palpable mass or asymptomatic.

SONOGRAPHIC APPEARANCE

Sonographically

- Complex heterogeneous mass, but often hypoechoic and containing calcifications
- Smooth margins, well encapsulated
- May demonstrate posterior shadowing
- Does not breach fascial planes
- Compresses with moderate transducer pressure

Differential diagnosis

- Fibroadenoma, complex cyst, carcinoma

LACTATING ADENOMA

Breast masses such as focal lobular hyperplasia, galactocele and lactating adenoma in pregnant or lactating patients are common because the gestational hormonal milieu induces ductal proliferation. Lactating adenoma is the most prevalent breast mass in these patients, and it is a benign tumour of the secretory breast epithelium occurring as a palpable mass.

In general, lactating adenoma is well-circumscribed mass measuring 2-4 cm in diameter and it is rubbery or firm, with a lobulated surface. Ultrasound of the breast is recommended as the initial imaging study for patients who are pregnant or lactating.

SONOGRAPHIC APPEARANCE

- Circumscribed border
- Long axis parallel to the chest wall
- Gentle lobulations
- Thin echogenic pseudo capsule.
- Predominantly hypoechoic compared to the normal fat lobules and have a homogeneous central echotexture, but can also be isoechoic, hyperechoic, and heterogeneous
- Colour Doppler sonography detects a hypervascular mass

However, a few have features typically associated with malignancy, such as irregular, angulated, or ill-defined margins, posterior acoustic shadowing, or mixed posterior shadowing and enhancement.

The natural history of lactating adenoma is to regress after the completion of pregnancy or lactation by suppressing hormonal secretion.

LIPOMA

Lipomas are fatty tumours found anywhere in the body. In the breast, they will generally be found superficially at the periphery or in the axilla or chest wall structures. Very occasionally, they may be found in the breast parenchyma. They feel soft and rubbery and are mobile.

SONOGRAPHIC APPEARANCE

- Homogenous mass with similar echogenicity to surrounding fat but can range from hyper to hypoechoic
- Smooth borders, usually well demarcated
- Oval
- May be difficult to delineate from surrounding fat
- Often can help to delineate by moving around with finger whilst scanning – will compress differently to adjacent fat lobules
- Calcification may be present

Differential diagnosis

- Complex cyst, fibroadenoma, glandular breast tissue

Oil Cysts

These are a form of post traumatic fat necrosis.

SONOGRAPHIC APPEARANCE

- well-circumscribed lesions
- May have the sonographic appearance of a simple cyst with good through-transmission of sound
- can contain low-level internal echoes and produce posterior acoustic shadowing

MASTITIS

Mastitis in the lactating woman is generally easily recognisable because of the clinical history and signs. Mastitis in a non-nursing woman can be more difficult, as it can disguise an inflammatory carcinoma. It is due to a bacterial infection in an obstructed lactiferous duct or infected cyst. Patients may present with a spectrum of clinical symptoms, ranging from painful or tender breast(s) to erythema, fever, thick nipple discharge, swelling and associated axillary lymphadenopathy.

Up to one percent of breast cancers are inflammatory carcinomas with patients presenting with similar clinical symptoms.

SONOGRAPHIC APPEARANCE

- May have no sonographic changes
- Hypervascular breast parenchyma seen with colour or power Doppler
- Acute mastitis will show increased thickening and echogenicity of subcutaneous layer
- Dilated lactiferous duct(s) that may be indistinct in outline due to inflammatory reaction
- Echoes may be seen in the ducts due to high protein content of inflammatory exudate
- May have abscess formation

PHYLLODES TUMOUR

This is often called a proliferative fibroadenoma. They are relatively rare, with their peak incidence being in the 50 - 60-year age group. They undergo very rapid growth and malignant transformation is seen in about 10% of these benign fibro epithelial neoplasms. They appear very similar to a fibroadenoma, but often have cystic areas within. Only histology can determine which will become malignant.

SONOGRAPHIC APPEARANCE

- Oval mass with low to medium level echoes
- May demonstrate cystic areas
- Smooth margins
- Width of mass greater than height of mass
- Does not breach fascial planes
- May show some internal vascularity

Differential diagnosis

- Complex cyst, fibroadenoma, carcinoma, normal breast fat.

PAPILLOMA

They are an epithelial neoplasm with two forms – intraductal and intracystic. Intraductal are most frequently located in the subareolar region within the major ducts, but also often occur in the peripheral ducts.

An intraductal papilloma is often associated with a clear, yellow, brown, or bloody nipple discharge. The papilloma will project into a duct and eventually the duct will dilate. Intracystic occurs within cysts located anywhere within the breast parenchyma and are usually asymptomatic. Certain types of papillomas can be associated with an increased risk of malignancy, depending on the presentation and the position.

SONOGRAPHIC APPEARANCE

Intracystic

- Hypoechoic lesions surrounded by echo free cystic fluid
- On moving the patient, the appearance of the lesion stays the same (unlike if debris or sediment in the cyst) was
- If papilloma occupies entire cyst, the hypoechoic to hyperechoic lesion cannot be differentiated from other solid lesions

Intraductal

- Unless there is some ductal dilatation, it will be difficult to show
- Duct contains rounded, hypoechoic to hyperechoic mass
- Involved duct distended and may be cystic

Ultrasound will not differentiate between this benign condition and its malignant counterpart, the papillary carcinoma. Papillomas are usually surgically excised due to the difficult differentiation among papilloma, papillary carcinoma, or other nodular lesions.

POST-OPERATIVE SCARRING

Any interventional procedure in the breast can change the normal sonographic anatomy by causing tissue disruption, a haematoma, or fluid collection in the acute phase, leading to scar formation, fat necrosis, oil cysts and calcification (particularly seen in the post-operative breast).

SONOGRAPHIC APPEARANCE

In acute stage

- May have areas of increased and/or decreased echogenicity.
- May appear as architectural distortion
- May have posterior shadowing
- May have haematoma or seroma formation
- May have areas of fat necrosis

Late changes

- May have scar with acoustic shadowing that can be seen to start at the skin level and interrupts fascial layers
- Can have a range of appearances from hardly distinguishable to causing dense shadowing with dystrophic calcifications seen depending on time after surgery
- Can make looking for a recurrent tumour difficult.

However, scarring does not change over time, but a malignancy will. Ensure that you correlate the region of interest seen on ultrasound with the clinical findings of the surgical site seen on the skin.

RADIAL SCAR (COMPLEX SCLEROSING LESION)

This is another benign condition that mimics malignancy. It is formed by proliferative adenosis radiating outwards and are associated with areas of intraductal epithelial hyperplasia (adenosis refers to epithelial and myoepithelial proliferation of the lobules). There is also stromal sclerosis, and as a result of sclerosis, which develops together with adenosis, the lobules become irregular and distorted.

It is a form of fibrocystic change. It is idiopathic and often found during routine mammogram and often arises in the peri-menopausal period. It is usually not palpable but may determine skin retraction. It can appear as focal or diffuse.

SONOGRAPHIC APPEARANCE

- Looks exactly like a spiculated carcinoma
- Presents as irregularly shaped, hypoechoic, poorly defined tissue

Ultrasound is generally not indicated in the evaluation of a spiculated mass such as this radial scar because biopsy is needed.

SEROMA

A seroma is a localized collection of serous fluid, usually caused by interventional techniques or post-surgery. They can become complicated by secondary infections, especially if they are large collections.

SONOGRAPHIC APPEARANCE

- May appear as simple or complex cysts with diffuse low-level internal echoes
- May also have adhesions that appear as multiple thin, echogenic, or thick septations
- The wall of the seroma may have variable appearance ranging from thick, isoechoic to echogenic, irregular, or nodular

MALIGNANT DISEASES

Breast cancer occurs in 1:9 of the female population. For this reason, arriving at a correct diagnosis is vitally important. Mammography is still the "gold standard" for screening for breast cancer, but ultrasound does have its part to play. However, even with the excellent quality of equipment nowadays, histology is still always required for the final diagnosis.

There are few well established risk factors for breast cancer. Although we know of many factors that contribute to the risk of women getting breast cancer, the cause remains unknown. You can find a recent and relevant article stating the factors and the high and low risk categories associated with these factors in e-readings.

Information on Breast Cancer

- All breast cancers are different. Some are made up of a single type of cell that resembles breast tissue, whilst others can consist of all different types.
- Tumours vary in the rate they grow, but the average breast cancer has probably been present for about nine years before it reaches 1cm in size.
- Breast cancer kills because of the metastases; the metastases can be detected before the primary in some cases.
- Any metastases will have already occurred by the time of surgery, but the deposits may be too small to detect.
- Breast carcinomas arise from the epithelial cells of the ducts and lobules. If they remain confined, they rarely metastasise. These are known as non-infiltrating or in-situ.

For metastases to develop:

- Lymphatics or blood vessels must be penetrated.
- The cancer cells must remain viable in transit.
- The cells must lodge and proliferate at a distant site.
- If cancers have lymph node involvement, they can penetrate lymph vessels; those with distant metastases can penetrate blood vessels. Lymph node spread may not necessarily mean there is spread in the blood stream. However, if a cancer has the characteristics to spread to lymph nodes, it is very likely to have other bad characteristics.
- Cancers spread from breast to lymph nodes and from breast to distant sites, not from breast to lymph nodes and from lymph nodes to distant sites.
- Even with the same cancer, some cells react differently from others to chemotherapy. This happens in much the same way that bacteria become antibiotic resistant.
- There is about a 25% incidence of multifocal growth in the same quadrant with a T1 carcinoma and 40% with a T2. This is known as multifocality. Multifocal carcinomas may also be multicentric.

Multicentricity occurs when there are additional foci of either invasive or in - situ carcinoma outside the quadrant or segment of the breast bearing the primary tumour. From 21% - 75% of tumours may be multicentric. (These figures depend on who is examining the patient, the tumour size when found etc.) Approximately 45% of patients who have a multicentric carcinoma in one breast will already have or will develop a tumour in the other breast

POSSIBLE SONOGRAPHIC APPEARANCES OF MALIGNANT BREAST LESIONS

The sonographic appearances of malignant lesions are, unfortunately, not constant and vary greatly from one type to another, one person to another. Some signs are more consistent than others.

The following appearances may be encountered:

- Irregular outline, hypoechoic with an echogenic rim (frequently seen)
- Spiculated, hypoechoic lesion with an echogenic rim
- Hyperechoic (uncommon) and very hyperechoic (very rare)
- Hypoechoic with shadowing (common)
- Heterogeneous (frequent)
- Homogeneous (not rare)
- Hypoechoic (typical of medullary carcinoma)
- Area of acoustic shadowing (lesion not seen)
- No altered sound transmission
- Acoustic enhancement
- Calcifications
- Partial acoustic shadowing from a lesion
- Broad edge shadow
- Height exceeds width (typical)
- Width exceeds height (very rare)
- Microlobulations
- Ductal extension
- Neovascularisation seen on colour or power Doppler

CARCINOMA IN SITU (CIS)

The cells of these pre-malignant neoplasm's display features characteristic of carcinoma but do not extend across the basement membrane. It is a non-infiltrating carcinoma, but it can recur.

There are two types according to the site of origin - lobular (LCIS) and ductal (DCIS). Ductal carcinoma in situ (DCIS) remains confined to the milk ducts and accounts for approximately 85% of breast CIS. Lobular carcinoma in situ (LCIS) remains confined to the lobules and accounts for approximately 10% of breast CIS.

These two conditions are most often diagnosed during mammography and hence their incidence has increased with increased detection due to more widespread mammographic screening.

DUCTAL CARCINOMA IN SITU (DCIS)

Peak incidence occurs around 50 years of age, with around 1200 women diagnosed in Australia each year. Because DCIS cannot usually be felt as a breast lump or other breast change, most cases are found by routine screening with mammograms due to presence of micro calcifications.

DCIS usually arises within the terminal ductolobular unit (in the terminal duct near to its origin with the lobule).

DCIS can spread extensively by simple intraductal growth throughout one or more quadrants of the breast without invading through the basement membrane.

SONOGRAPHIC APPEARANCE

- Most CIS have no sonographic pattern (cannot be distinguished from normal breast parenchyma)
- May have dilated ducts but many reasons for dilated ducts other than DCIS
- Larger microcalcifications may be seen

Sonography is not a reliable modality for diagnosis of DCIS.

LOBULAR CARCINOMA IN SITU (LCIS)

LCIS is a severe lobular atypia that may be a direct precursor to development of invasive malignancy. Clinically and mammographically difficult to diagnose, they are often found in excisional biopsies performed for asymmetry, or as incidental findings in biopsies performed for other reasons (i.e. fibroadenomas, adjacent microcalcifications).

SONOGRAPHIC APPEARANCE

Not recognisable on ultrasound

INVASIVE CARCINOMA

The term invasive breast carcinoma encompasses a broad spectrum of different malignant lesions that vary greatly morphologically and histologically. The most common types are:

DUCTAL

Most common breast malignancy and accounts for 65 - 80% of all breast carcinomas and is most prevalent at about 50 years of age. Histologically diverse group of lesions, with histological grading having a significant influence on the prognosis. About 30-40% contain microcalcifications. Patient may present with palpable mass, changes in breast or nipple contour, or may be asymptomatic

SONOGRAPHIC APPEARANCE

- Depends on composition and growth pattern – variable patterns
- Can appear scirrhous (hard and fibrous) with some acoustic shadowing and hyperechoic rim
- hypoechoic mass with spiculated outline and associated dilated ducts due to ductal extension
- Height greater than width
- Breaches fascial planes
- Cooper's ligaments may take on a straight path and look thickened
- Sharp angulated outlines, but can have a round, oval, smooth outline
- May have some posterior enhancement (similar to fibroadenomas)
- Small tumours may be isoechoic to surrounding breast tissue
- Non-compressible

Differential diagnosis

- Degenerating fibroadenoma, haematoma, scarring or fibrosis

LOBULAR

This accounts for 10-14% of all breast carcinomas and is most prevalent in the 55 - 70 years age group. This type of cancer infiltrates diffusely and therefore often is discovered late. Due to this, it is usually multicentric or bilateral at stage of diagnosis. Does not contain calcifications so often difficult to see on mammography

SONOGRAPHIC APPEARANCE

- Focal or diffuse locations
- If diffuse, may present like a ductal carcinoma and be difficult to recognise
- Speculated with difficult to define borders due to infiltration of tumour
- May be specific hypoechoic mass with posterior shadowing
- May be no real mass seen but architectural distortion only

MEDULLARY

Belongs to invasive ductal carcinoma. Accounts for 4 - 9% of all breast carcinomas and occurs in all age groups, more in pre-menopausal.

It is characterised by circumscribed margins and is classed as having a good prognosis (even though they are rapid growing cancers). Patient may be asymptomatic or present with soft palpable lump which is usually centrally located

SONOGRAPHIC APPEARANCE

- Usually round or nodular with well demarcated borders
- Can be hyperechoic, but often hypoechoic and can have some posterior enhancement
- Calcifications rare, but may have cystic central component due to necrosis
- Look very much like fibroadenomas

Differential diagnosis

- Fibroadenoma, fibrosis, fibrotic breast tissue, invasive ductal carcinoma

MUCINOUS/COLLOID CARCINOMA

This is prevalent at age 60 -70 years, are slow growing and has a good prognosis. Makes up about 2% of breast cancers. Patient may be asymptomatic or present with soft palpable lump or thickening

SONOGRAPHIC APPEARANCE

- It is sharply demarcated from its surrounds and tends not to distort
- Can appear quite benign with similar appearance to a fibroadenoma (well circumscribed, round or lobulated, usually hypoechoic with good through transmission)
- Can also appear isoechoic, showing little difference compared to adjacent tissue
- Occasionally calcifications can develop

Differential diagnosis

- Complex cyst, fibroadenoma, invasive ductal carcinoma

PAPILLARY AND TUBULAR CARCINOMA

Makes up 1-2 % of breast cancers, are slow growing and more prevalent in the mid 60 age group. Often will present with bloody nipple discharge. Of the palpable tumours, 90% occur in the retroareolar region, with patient presenting with nipple and skin alterations

SONOGRAPHIC APPEARANCE

- Often cannot be differentiated from benign papillomas.
- Grow along the ducts and intracystically, so may see hypoechoic intracystic structure in a dilated duct
- May have microcalcifications

Differential diagnosis

- Complex cyst, fibroadenoma

SARCOMAS

These are made up of fibrosarcoma, lymphosarcoma, and leiomyosarcoma and generally have a very poor prognosis as up to 30% of them have already metastasised when diagnosed. A special form of this type of tumour is the Phyllodes tumour, discussed previously.

OCCULT

A patient may present with an adenocarcinoma in an axillary lymph node, which appears to have been derived from a breast primary; however, the primary in the breast cannot be detected.

PAGET'S DISEASE OF THE NIPPLE

This is a metastatic manifestation of an intraductal carcinoma that involves the epidermis of the nipple and areola. Patient presents with red, thickened, ulcerated area in skin around the nipple and areola

Cancer can often be found elsewhere in the breast as Paget involvement of the nipple is caused by seeding of the initial tumour

INFLAMMATORY CARCINOMA

This is not a histological condition. Arises from any type of breast carcinoma. It occurs when the carcinoma blocks off cutaneous lymph vessels, and the patient presents with the appearance of an infection, without the high white cell count. Once this has happened there is a very poor prognosis.

SONOGRAPHIC APPEARANCE

- Marked skin thickening, thickened Cooper’s ligaments, oedema seen in the subcutaneous space
- May find other tumour nodules as foci within breast tissue

METASTATIC BREAST DISEASE

Considered uncommon but common primary sites are melanoma, ovarian, lung, cervical, prostate, bladder and non-Hodgkin's lymphoma. Occur bilaterally in up to 25 % of cases, and often with associated lymphadenopathy. Diagnosis of the primary is important as treatment plan for metastatic breast cancer is different to that for primary breast cancer

SONOGRAPHIC APPEARANCE

- Discrete masses that usually have smooth or slightly irregular margins
- Often heterogeneous with low level internal echoes, but usually no microcalcifications seen
- Can be impossible to differentiate from other well marginated primary breast carcinomas

TO SUMMARISE

Ultrasound Features of Benign Solid Masses

- Lack of any malignant features
- Intensely hyperechoic or
- Elliptical hypoechoic with a thin echogenic capsule
- Up to two or three gentle lobulations
- Posterior acoustic enhancement (de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Page 638, table 17.2)

Ultrasound Features of Malignant Solid Masses

- Posterior acoustic shadowing
- Hypoechoic
- Irregular contour
- Taller-than-wide configuration
- Spiculation
- Angular or microlobulated margins
- Ductal extension, branching pattern
- Thick hyperechoic halo
- Increased vascularity
- Surrounding edema
- Microcalcifications (de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Page 644, table 17.3)

POST RADIATION THERAPY BREAST APPEARANCES

Oedema caused by acute radiation mastitis is indistinguishable from the oedema caused by mastitis, trauma, lymphatic obstruction, and inflammatory carcinoma.

With the thickness of normal breast skin being 2mm or less, radiation causes the skin to become thicker and less echogenic than normal. The fat and loose stromal tissue becomes hyperechoic. Cooper's ligaments and interlobular stromal fibrous tissues become less thickened and more hypoechoic than would appear normally. These acute changes usually begin to revert after about 6 months and are nearly gone by 12 to 18 months, but in some patients the oedema can progress to fibrosis.

Chronic oedema (usually due to the interruption of lymphatics) usually causes milder changes in the appearance of the breast than does the acute phase of radiation mastitis. In patients with chronic radiation-induced oedema, the fat remains mildly hyperechoic, and the skin remains mildly thickened. Ducts and lobules appear less well defined than before radiation.

PROGNOSTIC FACTORS OF BREAST CANCER

The identification of biologic, molecular, and genetic markers are useful in assessing the prognosis of patients with invasive breast cancer. A large amount of useful information can be obtained from routine pathologic examination of specimens containing breast cancer.

It has also been shown by clinical follow-up studies that features such as axillary lymph node status, tumour size, histological type, histological grade, and lymphatic vessel invasion represent influential and self-supporting prognostic indicators.

Axillary lymph node status: For patients with breast cancer, this is classified as the single most important prognostic factor, with disease-free and overall survival rates decreasing as the number of positive lymph nodes increases

Tumour Size: It has been demonstrated by a variety of studies that the size of an invasive breast cancer is a most strong prognostic factor for both axillary lymph node involvement and clinical outcome

Histological Type and Grade: Certain histological patterns favour positive outcomes for patients, and it has been proven that there is a higher rate of distant metastasis and poorer survival in patients with higher-grade (poorly differentiated) tumours, independent of lymph node status and tumour size.

Lymphatic Vessel Invasion: Its major clinical value at this time is in identifying node-negative patients at increased risk for axillary lymph node involvement and harsh outcome

Other Factors

- invasion of veins and arteries has been reported to have an adverse effect on clinical outcome
- presence of necrosis has been associated with an adverse effect on clinical outcome
- The presence of perineural invasion is sometimes seen and appears to be associated with invasion of lymphatic vessels.

BREAST CANCER STAGING

Staging of breast cancer is based on the TNM (Tumour, Node, and Metastasis) system. "Tumour" refers to tumour size, which is measured in centimetres. "Node" refers to the presence of cancerous cells in regional lymph nodes. "Metastasis" refers to the spread of cancer beyond regional lymph nodes to other organs of the body.

Tumour size (T):

T0: No evidence of primary tumour

TIS: Carcinoma in situ

T1: Tumour <2 cm

T2: Tumour >2 cm but <5 cm

T3: Tumour >5 cm

T4: Extension to chest wall, inflammation, satellite lesions, ulcerations

Regional lymph nodes (N):

N0: No regional lymph nodes

N1: Metastasis to movable ipsilateral nodes

N2: Metastasis to matted or fixed ipsilateral nodes

N3: Metastasis to ipsilateral internal mammary nodes

Distant Metastasis (M)

M0: No distant metastasis

M1: Distant metastasis

Using this classification, cancers are grouped into stages as follows:

- Stage 0: non-invasive breast cancer, including lobular carcinoma in situ & ductal carcinoma in situ.
- Stage I: invasive breast cancer. The tumour may measure up to 2 cm, no lymph nodes are involved.
- Stage II: the cancer measures between 2- 5cm or involves lymph nodes on the same side of the body as the cancer.
- Stage III: the tumour has grown larger than 5cm; there is significant lymph node involvement with "fixing" or "matting" of the nodes; or a tumour of any size has spread to the skin, chest wall, or internal mammary lymph nodes.
- Stage IV: the cancer has spread beyond the breast, underarm, and internal mammary lymph nodes.

"Early" breast cancer refers to Stage I, and some Stage II only. This staging system can be used to work out the prognosis and best treatment options for cancer of different stages.

BI-RADS Classification for Management of Abnormal Mammograms: The Breast Imaging Reporting and Data System (BI-RADS), developed by the American College of Radiology, provides a standardized classification for mammographic studies. This system demonstrates good correlation with the likelihood of breast malignancy. Please see the e-readings for relevant articles describing the BI-RADS system.

MODULE 7
LYMPH NODES
NIPPLE DISCHARGE
THE MALE BREAST

THE LYMPH NODES (AXILLARY AND OTHER)

LEARNING OBJECTIVES

By the end of this module, you should be able to answer the following questions:

- What is the importance of the sentinel node?
- What are the causes of axillary lymphadenopathy – unilateral and bilateral?
- What are the possible sonographic appearances of normal and abnormal lymph nodes?

KEY CONCEPTS

- Axillary Lymph Nodes
- Intramammary Lymph Nodes
- Lymphatic Drainage
- Sentinel Node

ONLINE TEXTS

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 10
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 19
- Whitman, 2011. 'Lymph Node Sonography', Ultrasound clinics, 1556-858X, vol. 6, Issue 3, p 369-380

Review e-readings for any relevant articles.

THE AXILLARY LYMPH NODES are divided into three levels based on their anatomic relationship to the pectoralis minor muscle: level I nodes are inferior to the pectoralis minor muscle, level II nodes are posterior to the muscle, and level III nodes are medial to the muscle.

The majority of intramammary nodes are associated with the upper outer breast tissue, although they can be found in the lower outer part of the breast.

If enlarged lymph nodes are seen in the axilla, it is important to try to determine if there is unilateral or bilateral involvement, as bilateral lymphadenopathy suggests a systemic cause (benign or malignant.)

Unilateral involvement suggests a local abnormality related to the breast or even the arm. Some of these causes include breast cancer, mastitis, or an infection in the arm such as cellulitis.

Although systemic conditions may be associated with nodes that are asymmetrically enlarged, the approach to lymphadenopathy based on unilateral versus bilateral involvement can be an important adjunct to any other sonographic findings.

SOME CAUSES OF UNILATERAL AXILLARY LYMPHADENOPATHY

Mastitis, metastatic breast cancer, site of metastases from non-breast primary, silicone induced adenitis

SOME CAUSES OF BILATERAL AXILLARY LYMPHADENOPATHY

Metastases, lymphoma, rheumatoid arthritis, psoriasis, mononucleosis, HIV, tuberculosis, systemic lupus erythematosus, lymphoid hyperplasia

With primary breast cancer, the presence of lymph node metastasis, maximum diameter, and histologic grade are the three most important indicators of prognosis in breast cancer patients. It has been proven that as the number and level of lymph nodes involved with metastasis increases, the prognosis worsens.

Lymph node metastasis is partially dependent on size and histologic grade. The larger the maximum diameter and the higher the histologic grade of invasive breast carcinoma, the higher are the risks for lymph node metastasis.

Most of the lymphatic drainage of the breast usually converges on the chain of lymph nodes. There are often one or two lymph nodes in the axilla through which most of the lymph drainage from the breast passes. These have been called the sentinel nodes.

The importance of the sentinel node that it is usually the first node that is affected by the spread of the primary breast cancer.

The concept of the sentinel lymph node is also important because of the advent of the sentinel lymph node biopsy technique, also known as a sentinel node procedure. This technique is used in the staging of certain types of cancer to see if they have spread to any lymph nodes, since lymph node metastasis is one of the most important prognostic signs. It can also guide the surgeon to the appropriate therapy.

ULTRASOUND APPEARANCES OF LYMPH NODES

Normal lymph node-

- Usually, hypoechoic solid structure with echogenic fatty hilum
- Margins are smooth and node of elliptical or oval shape
- Internal vascularity following shape of fatty hilum
- Usually measure less than 1-1.5 cm in longest length
- May be seen as single or in clusters

Abnormal lymph node-

- Enlarged hypoechoic mass over 1.5cm in longest length (but size is the least useful criteria when assessing lymphadenopathy)
- Loss of echogenic fatty hilum
- Irregular margins, rounding of shape and overall increase in vascularity suspicious of malignant involvement
- Some malignant nodes are hyperechoic or calcified
- Cortical thickening
- Hilar displacement, indentation, compression or obliteration
- Displacement of surrounding structures
- Variation in right to left symmetry if unilateral involvement
- Relationship and change in appearance between adjacent nodes
- Benign hyperplastic nodes are usually more elongated with echogenic fat in the hilum and these nodes are less numerous and smaller than those involved with malignancy

But remember that - Normal nodes don't completely exclude pathology

NIPPLE DISCHARGE

LEARNING OBJECTIVES

By the end of this module, you should be able to answer the following questions:

- What are the most common causes of nipple discharge?

ONLINE TEXTS

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapters 14 under subheading of Evaluation of Nipple Discharge
- Stavros, A. Thomas 2004, Breast ultrasound, 1st ed, Lippincott William &Wilkins, Chapter 8

Review the eReader for any relevant articles.

The reasons for nipple discharge may not all be due to malignancy.

The usual causes of nipple discharge are:

Normal hormonal nipple discharge

- Nipple discharge is very common and can be obtained from the nipples of approximately 50–70% of normal women when special techniques, massage, or devices such as breast pumps are used.
- This discharge of fluid from a normal breast is referred to as 'physiological discharge' and is usually yellow, milky, or green

Duct ectasia

The discharge caused by duct ectasia may come from both breasts is usually yellow, green or brown, and comes from more than one duct

Duct papilloma

It may cause no symptoms, or it may cause a nipple discharge that is clear or blood-stained. It usually comes from a single duct and is unilateral

Nipple eczema

Eczema or dermatitis which affects the skin of the nipple, particularly if it becomes infected, can cause a weeping, crusty nipple discharge

Breast cancer

Breast cancer is an uncommon cause of nipple discharge. Less than 5% of women with breast cancer have nipple discharge, and most of these women have other symptoms, such as a lump or newly inverted nipple, as well as the nipple discharge

Paget's disease of the nipple

Ulceration and erosion of the nipple skin, and it may be associated with a blood-stained nipple discharge

Hormonal causes

Galactorrhoea is milky nipple discharge not related to pregnancy or breast feeding. It is caused by the abnormal production of prolactin. This can be caused by diseases of glands elsewhere in the body which control hormone secretion, such as the pituitary and thyroid glands.

Drugs and medication

Abnormally high prolactin levels can also be caused by some drugs. These include oral contraceptives, hormone replacement therapy, and medications used for the treatment of nausea, depression, and psychiatric disorders. Drugs such as cocaine and stimulants can also cause high prolactin levels

THE MALE BREAST

Although it is not very prevalent, men do acquire breast disease. Any abnormality of the breast that affects women can also affect men, even though the incidence is lower. As we learnt in embryology, the male breast does not develop after birth; however, the rudimentary lactiferous ducts are there. These are non-branching. A normal male breast will appear on ultrasound as fatty/fibrous tissue crossed by a few duct-like structures under the areola.

LEARNING OBJECTIVES

By the end of this module you should be able to answer the following questions:

- What is the main problem affecting the male breast?
- What are the causes of gynaecomastia?
- Why can it be difficult to differentiate gynaecomastia from cancer in the early stages?
- What is the incidence of breast cancer in males?
- Why do males with breast cancer generally not have a very good prognosis?
- What are the risk factors for males developing breast cancer?

KEY CONCEPTS

- Gynaecomastia
- Pseudo-Fatty Tissue
- Fibrosis
- Haematoma
- Cysts
- Lipoma
- Duct Ectasia
- Fat Necrosis
- Intraductal Papilloma
- Abscesses

ONLINE TEXTS

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 11
- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins, Chapter 19
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 16

Review e-readings for any relevant articles.

MALE BREAST PATHOLOGY

According to Stavros (2004) the male breast is affected by 3 basic categories of disease:

- Gynaecomastia and other benign conditions involving ducts and periductal fibrous stroma

- Primary breast cancer
- And conditions that arise from tissues other than ducts and periductal stroma tissue (such as lesions in the skin, and lesions arising from blood vessels, lymphatics and nerves)

A large proportion of these problems are due to gynaecomastia, and it is also the most common cause of palpable abnormalities in the male breast. There is no proliferation of lobuli in men, like there is in women. So you will not see tumours that start in the lobuli, such as lactating adenomas, fibroadenomas, phyllodes tumours, and also invasive lobular carcinoma are rare.

GYNAECOMASTIA

Gynaecomastia is a benign increase in the growth of subareolar ductal and periductal stromal tissues within the breast tissue. It can be unilateral or bilateral. The degree of stimulation of these tissues varies with the degree and duration of the causative agent and at this point, the process is reversible if the causative agent is removed.

The more pronounced and longer the duration of stimulation, the more likely it is that periductal stroma fibrous tissue will be laid down. Once this starts to occur, the process is irreversible.

There are numerous potential causes of gynaecomastia, but all have a similar underlying mechanism—an imbalance between estrogenic and testosterone effects at the level of breast tissues. This imbalance is due to either physiological or pathological processes.

It presents as a firm palpable lump in the subareolar area. It can occur in the neonate, having received oestrogen from the mother. It most commonly affects adolescent boys and men older than 50 years of age, and accounts for up to 85% of breast masses found in males.

The causes of gynaecomastia include

- Hormonal (either an imbalance in estradiol-testosterone levels which may be seen in the elderly, or dysfunction of pituitary glands, adrenal or thyroid glands)
- Systemic (seen in pathological conditions such as chronic renal failure, cirrhosis, TB, COPD)
- Induced by drugs
- Due to tumours particularly those of the pituitary gland, adrenals, testes, hepatocellular carcinoma of the liver
- Unknown cause

Gynaecomastia must be distinguished from pseudogynaecomastia. Pseudogynaecomastia occurs in obese men in which the breasts become enlarged solely because of fat deposition in the breasts. There is no evidence of benign ductal and fibrous periductal stromal overgrowth.

Sonographically

- Normal appearing fibroglandular breast tissue
- Early gynaecomastia is demonstrated as a focal, homogeneous, hypoechoic triangular area behind the nipple
- Gynaecomastia must be subareolar – any mass that is not subareolar is not gynaecomastia
- Occasional observation of ducts
- As the condition progresses and there is more fibrosis, there is an overall increase in volume and echogenicity
- Early gynaecomastia and early carcinoma can be difficult to differentiate on ultrasound, but gynaecomastia soon becomes diffuse.

MALIGNANCY

Male breast cancer is rare and accounts for just 1% of all breast cancers. The overall prognosis is not as good as in females, most likely because there are longer delays in presentation. The most common age group on presenting is from 60 - 70 years, which is later than in most women with the disease.

There is often a strong family history of cancer, including breast cancer, in the family. The risk is increased in men who have been exposed to ionising radiation of the chest, occupational heat and for those on oestrogen treatment for prostatic cancer. Other causes are Klinefelter's syndrome, testicular injury and infectious orchitis. As for women, advancing age increases the risk.

Clinically, the man will present with a painless hard lump usually in the areolar area. A bloody nipple discharge is present in about 14% and is a stronger indicator of malignancy than when seen in women. As with females, once there are secondary features and lymph node involvement, the prognosis is poor.

Majority of cancers in the male breast (up to 85%) are invasive ductal carcinomas. Because of the absence of lobules in the normal male breast, reports of unequivocal lobular carcinoma, either invasive or in situ, are rare. Paget's disease is comparatively more common in men, and half of these patients have a palpable breast mass with axillary lymph node metastases.

On mammography

- There is a solid suspicious mass
- It may be smooth or spiculated in an eccentric position
- Microcalcifications are rare, and any calcifications seen tend to be round and scattered.

On ultrasound

- Male breast cancers have the same sonographic appearance as seen in the female

- The malignant lesions tend to be hypoechoic, irregular and poorly defined but can have a highly variable appearance
- The sound transmission can be variable
- There is architectural distortion of the breast tissue

GYNAECOMASTIA VERSUS CARCINOMA

The male breast disease either presents as a mass, pain or nipple discharge. Gynaecomastia and invasive ductal carcinoma are the most common lesions, and can usually be differentiated, but biopsy is sometimes necessary to separate them.

All lesions eccentric to the nipple need biopsy unless they are characteristically benign, such as contain fat or are a typical lymph node. The characteristics of gynaecomastia versus carcinoma share many similarities. They occur mostly at the age of 60 and can be soft, mobile, subareolar and unilateral. Carcinoma is usually eccentric, whilst gynaecomastia is never eccentric. Areas of gynaecomastia are usually painful, where as a carcinoma often does not cause discomfort to the patient. Gynaecomastia has to have extensions into the surrounding fat, but carcinoma sometimes have spiculations that can look the same.

OTHER PATHOLOGIES

- Myofibroblastomas – it is the only lesion that is more common in men than in women, and presents as a mobile, solitary firm mass with no calcifications. Average age of presentations is in late 50's.
- Lipomas - these present as a slow growing, soft well-circumscribed subcutaneous mass, separate from the breast tissue
- Pseudo-gynaecomastia - fatty tissue occurring with obese males
- Fat necrosis - this usually occurs after trauma
- Abscesses
- Haematoma
- Duct ectasia
- Papilloma- Benign tumours arising from ducts and periductal stroma tissue of the male breast are rare. Intraductal and intracystic papilloma seen in men have the same sonographic features as those seen in the female breast
- Vascular lesions that have been reported in the male breast include: pseudoaneurysms, arteriovenous fistulas, arteriovenous malformations, cavernous and capillary hemangiomas, venous malformations, and superficial venous thrombosis
- Lesions of neural origin that can involve the breast include neurofibromas and granular cell tumours
- Metastases to the male breast are most frequently due to a prostate primary

MODULE 8
BREAST IMPLANTS

MODULE OVERVIEW

The presence of implants may interfere with routine mammography and therefore has the potential to delay the diagnosis of breast cancer. Ultrasound should not be used as a screening tool for the detection of breast cancer for women with implants. With regards to implants, ultrasound can be a valuable tool in the evaluation of palpable lumps felt on physical examination or for further definition of lesions seen on mammograms.

As for non-implant breasts, it is a great tool for fine needle aspirations and biopsies, to ensure the implant is not damaged during the procedure. It is also used to assess if there has been any leakage or rupture to an implant. But it is often impractical to suggest that ultrasound can assess the entire capsule of an implant – MRI is the modality of choice for the evaluation of implants for possible rupture.

Having said that, due to reduced cost, easy accessibility, and increased patient acceptability, in Australia at least, ultrasound is being used quite frequently for this purpose.

LEARNING OBJECTIVES

At the end of this module, you should be able to answer the following questions:

- What are the different types of implants?
- Where are implants positioned?
- What are the indications for breast implant ultrasound?
- Why may implants be difficult to scan?
- What are the normal sonographic appearances?
- What are the sonographic features of the 2 main types of an implant rupture?
- What are the artefacts commonly seen on scanning an implant?

KEY CONCEPTS

- Silicone
- Saline
- Augmentation
- Reconstruction
- Fibrous Capsule
- Wrinkles
- Contour Deformity
- Implant Failure
- Intracapsular Rupture
- Extracapsular Rupture
- Stepladder' Sign
- Silicone 'Bleed'
- Snow-Storm Effect
- Siliconoma
- Granulomas

ONLINE TEXTS

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 13 under the subheading of: The role of ultrasound Chapter 17 under the subheading of: The role of breast ultrasound – Implant imaging
- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins, Chapters 17 under the subheading of: Ultrasound and implants
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 9

Review e-readings for any relevant articles.

INDICATIONS FOR ULTRASOUND

Apart from the usual indications for performing breast ultrasound, complications arise from the implant itself.

- Breast mass - palpable or impalpable
- Axillary mass - palpable or impalpable
- Change in contour of implant
- Rupture detected on mammogram
- Symptoms - pain, discomfort
- Breast trauma
- Age of implants
- Pre-, intra and post-operative evaluation
- Post removal to evaluate residual silicone or haematoma.
- Evaluation of ectopic silicone

LOCATION OF IMPLANTS

An implant may be placed

- Between the breast tissue and the pectoralis muscle (subglandular)
- Subglandular but deep to the fascia of the fascia of the pectoralis muscle (subfascial)
- Or deep to the pectoralis muscle (submuscular).

Depending on location, there are three possible incisions through which a breast implant can be inserted.

- The most common incision is along the crease beneath the breast where it meets the chest wall (inframammary incision).
- Some surgeons prefer to make an incision around the nipple (periareolar incision).
- Other surgeons may prefer an incision in the armpit through which they can gain access to the chest muscle and place the implant either in front or behind that muscle (transaxillary incision).

TYPES OF IMPLANTS

Breast implants are inserted for cosmetic reasons - to increase one or both breasts (due to an asymmetric breast size, a hypoplastic breast, or a chest wall deformity) or after mastectomy for reconstruction.

There are a variety of augmentation procedures such as the direct injection of silicone or paraffin into the breast; the placement of a variety of types of implants into the breast; and the use of autologous myocutaneous flaps for reconstruction. We will concentrate on the breast implants.

Some of the types of implants used for augmentation have included saline filled, silicone gel, inflatable double lumen, and polyurethane coated. The most common though being saline and silicone gel.

SALINE IMPLANT

- Composed of a silicone elastomer shell that is filled with saline
- Usually have a fill valve for inflation
- Double lumen implants are made up of an outer lumen of saline that encases an inner lumen of silicone gel – but can be reversed order also.
- Saline implants tend to have a slightly heterogeneous density
- The wall of the implant is denser than the contents because the shell is a silicone elastomer that is denser than the contained saline
- Often folds and a fill valve are visible, and these are normal findings

SILICONE IMPLANT

- Silicon is a chemical element occurring in nature; in fact, it is the most abundant element in the earth's crust.
- Silicones are plastics or 'polymers. They are complex man-made substances containing silicon, oxygen, and other chemical elements.
- Depending on their structure, silicones can be liquid, gel or solid.
- The single lumen gel-filled implant is composed of a silicone gel contained within a silicone elastomer shell.
- Can have a smooth or a textured shell (purpose of the textured shell was to reduce the incidence of capsular contraction)
- The density of a silicone implant is homogeneous because the wall and the contents are both silicone, and overall, the silicone implant is denser than a saline implant

When an implant is placed into the breast, the body reacts to the prosthesis by forming a fibrous capsule around it. This fibrous capsule surrounds the implant and can thicken and contract. The capsule can also calcify and is often associated with capsular contraction.

SONOGRAPHIC APPEARANCE OF NORMAL IMPLANT

Because a normal implant tends to have wrinkles and bulges, an implant may be difficult to assess sonographically. However, a normal implant will generally demonstrate the following:

- The normal appearance of implants depends on the type of prosthesis.
- Saline and silicone single-lumen implants have a similar appearance: an anechoic oval structure that has a prominent anterior reverberation artefact which runs parallel to the anterior surface.
- Anterior to this component is an echogenic line that represents the wall of the implant and the fibrous capsule. This line is present, regardless of position or content.
- The port of the saline implant is often visible on ultrasound as an echogenic focus
- Radial folds are often visible as linear bands connecting to the implant wall. Setting the focal zone and depth to an appropriate level to image through the implant and the use of a lower frequency transducer at times is necessary for adequate visualization and assessment of the prosthesis
- Posterior aspects of silicone implants appear deeper than they really are because the speed of sound in silicone is slower than in soft tissue.
- A small amount of fluid may be seen adjacent to the implant.

WRINKLES, FOLDS, BULGES ETC.

Deformities in the contour of an implant are not generally associated with implant failure, and often look like undulations in the surface. Wrinkles and folds can look like membranes within the implant, depending on the position of the transducer. They are very commonly reported.

The echogenic bands that are associated with folds can be proven to be so by being seen to extend from the periphery of the implant. They appear linear and change shape, ie. they appear wider or narrower on orthogonal views (known as radial folds).

If there are many wrinkles, they can be confused with the echoes associated with a rupture. Wrinkles are more common in saline implants than silicone.

Bulges are not associated with rupture and appear as a contour deformity - a bulge - in the surface.

ISSUES ASSOCIATED WITH BREAST IMPLANTS

- Haematoma formation post-surgery
- Necrosis post-surgery
- Implant displacement
- Capsular formation and contracture- extreme hardening of the breast

    Pain—ranging from mild discomfort to severe pain

    Extreme sensitivity to touch

    Wrinkling or distortion of the breast

    Movement or displacement of the implant.

- Implant rupture and gel leakage (covered in below section)
- Gel diffusion

  Rupture of the implant is not the only means by which silicone may escape to the surrounding tissues.

  Silicone may diffuse through the implant envelope in the absence of a tear

  Although it is silicone fluid, not the gel, which passes through the intact implant shell, the name 'gel diffusion' or 'gel bleed' has often been used to describe this situation.
- Granulomas

  Silicone gel leaks into the breast and other nearby body tissues including the lymph nodes, small reactive lumps may sometimes form.
- Changes in nipple and breast sensation

  Any operation on the breast may result in changes in nipple or breast sensation.
- Autoimmune and connective tissue disease
- Implants following mastectomy

The complications are significantly higher in women who received implants following mastectomy for cancer or cancer prophylaxis than among those who received implants for cosmetic reasons. This is because mastectomy patients are generally older, and they have little tissue between the implant and the skin. Also, radiation therapy may affect the skin and underlying tissue.

SONOGRAPHIC APPEARANCE OF IMPLANT FAILURE

Saline implant rupture- saline is absorbed by the body and the size of the implants will visibly reduce. This is a clinical diagnosis and ultrasound is not required.

SILICONE IMPLANT FAILURES:

There are several definitions of implant failure in the literature, ranging from an excessive "bleed or diffusion" of silicone into adjacent tissues, to a total disintegration of the implant. When tears occur in the implant, there may be a range of findings from a small leak to a collapsed envelope with the silicone confined within the fibrous capsule. If there is an associated tear in the fibrous capsule, again, findings can vary, from a small, confined leak to gross extrusion of the silicone into the tissues.

INTRA-CAPSULAR RUPTURE

When silicone implants rupture, the silicone can be extruded into the surrounding tissues. Because many implants are surrounded by a fibrous capsule, the extruded silicone can become contained within this capsule. This is known as intra-capsular rupture.

Sonographically

- The wall of the implant is broken and is floating in the lake of silicone contained by the fibrous capsule that formed around the prosthesis
- The broken segments of implant wall are identified as a "stair step or step ladder" pattern within the silicon (the collapsed implant shell seen as a series of discontinuous parallel lines).
- Diffuse internal echoes may also be present

EXTRACAPSULAR RUPTURE

If the implant ruptures and the silicone leaks through an incomplete or torn fibrous capsule, the result is called an extracapsular rupture. The silicone can extend outside the capsule and into the surrounding breast tissue.

Sonographically

- Disruption of the echogenic line surrounding the implant
- A "snowstorm" of echogenicity with posterior loss of information. This echogenic noise or shadowing is related to the tissue's reaction to silicone.
- Larger globules of silicone appear as echolucent areas within the snowstorm.
- "silicone cysts" may be evident as small, hypoechoic nodules beyond the confines of the prosthesis
- Echogenic foci around the implant with possible posterior shadowing or noise known as siliconoma
- The gel may spread and cause a granuloma or lymphadenopathy.

Both intracapsular rupture and extracapsular rupture can be identified on ultrasound, whereas mammography does not show intracapsular rupture.

Technique of performing ultrasound on implants:

Departments will each have a set routine for scanning of implants; therefore, the following is a guide only.

- Identify patient.
- Explain examination, obtain informed consent.
- Obtain details from patient e.g., what type of implant, age of implants, any lumps, changes, symptoms.
- Palpate any area of concern; feel to detect folds or wrinkles on surface of implant.

- Real-time scan normal breast tissue first -document any abnormal findings. Majority of patients who have implants are having them due to little breast tissue, so ensure that you use the highest frequency possible and that the image is read zoomed up.
- Then you need to scan the implant separately. Scout scan the periphery of the implant, taking special note of any area the patient or her doctor is concerned about.
- It often pays to also assess the internal contents of the implant with the overall gain set quite high – this is to see any abnormal fixed internal contents or septations.
- Taking hard copy images scan the implant in a clockwise direction, radially, using split screen techniques where possible.
- Due to the shape of the implant, it may be necessary to use more than one method to see the whole of the prosthesis and necessary to roll the patient into various positions to even out any wrinkling.
- Ensure the edges of the implant are well seen.
- If the posterior surface of the prosthesis is not seen, it may be necessary to change to a lower frequency transducer, perhaps a 5MHz curved array.
- Keep in mind the sound distortion due to the difference of speed of sound in silicone compared to soft tissue.
- Scan the axilla.

MODULE 9
INTERVENTIONAL PROCEDURES

MODULE OVERVIEW

For sonographically visible lesions, ultrasound guided interventional procedures have become the method of choice. With sonographic guidance, needle localization, cyst aspiration, fine-needle aspiration biopsy, core biopsy, and vacuum-assisted biopsy can be performed. It has been shown to reduce the need for as many open biopsies, especially for benign lesions. Using ultrasound, the needle may be guided directly into the lesion, reducing the risk of accessing the wrong site, inaccurate sampling, puncturing an implant or even the chest wall.

LEARNING OBJECTIVES

By the end of this module, you should be able to answer the following questions:

- Why is ultrasound the procedure of choice to guide interventional procedures?
- What should you always do before commencing any invasive procedure using ultrasound?
- What does the term "Standard Precautions" refer to?
- How do you clean a transducer?
- Describe the ultrasound guided techniques that are commonly used to biopsy a suspicious breast lump that is demonstrated sonographically
- What methods may be used to localise a lesion before surgery?
- What are the possible complications associated with percutaneous needle biopsy?
- What do you understand by the term’s cytology and histology?

KEY CONCEPTS

- Fine Needle Aspiration (FNA)
- Core Biopsy
- Cytology
- Histology
- Cyst Aspiration
- Biopsy Gun
- Freehand Technique
- Indirect Method
- Cross Infection
- Standard Precautions
- Universal Precautions
- Hook Wire
- Carbon Tracking
- Sterilisation Techniques
- Right Angled Technique
- Needle Visualisation
- Informed Consent
- Contraindications
- Aspiration Cytology
- Trocar Technique

ONLINE TEXTS

- de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 15 under the subheading of: Ultrasound guided needle localisation, Chapter 16
- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins, Chapter 24 under the subheading of: Imaging guided needle biopsy
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 17
- Harvey, 2012. 'Ultrasound-Guided Breast Interventions', Ultrasound clinics, 1556-858X, 9781455739462, vol. 7, Issue 3, p 309-323. Available via the library from http://www.sciencedirect.com/science/article/pii/S1556858X12000321

Review e-readings for any relevant articles.

ADVANTAGES OF ULTRASOUND GUIDED BREAST INTERVENTION

- No use of ionising radiation
- Ease of patient positioning and comfort
- Procedure performed as an outpatient service
- Relatively cheap form of biopsy
- High accuracy rate of tissue sampling due to direct imaging as sample being taken
- Can sample multiple areas of the one lesion
- Multiple lesions can be sampled in the one consult
- Availability of having pathologist on site to ensure enough tissue sampling taken for accurate and complete diagnosis
- Can act as therapeutic as well as diagnostic tool (ie in case of cyst aspiration)
- Elimination of unnecessary surgery
- Ultrasound-guided breast biopsy can evaluate lumps under the arm or near the chest wall, which are hard to reach with stereotactic biopsy.
- Recovery time is brief, and patients can soon resume their usual activities.

DISADVANTAGES OF ULTRASOUND GUIDED BREAST INTERVENTION

- Extremely operator-dependent
- Requires good eye–hand coordination
- Small lesions (<1 cm) may be difficult to hit
- Because the breast is not immobilized, the lesion may be pushed out of the path of the needle as it is introduced into the lesion. Because the needle is directed back toward the chest wall, there is the danger of entering structures of the thorax and causing damage.

- Any introduction of a needle into the breast can produce a confusing picture on follow-up ultrasound. Haematomas and oedema caused by needle biopsies can produce effects that when seen by ultrasound are indistinguishable from cancer and may persist for months.

PATIENT PREPARATION

- Ensure patient does not have a bleeding disorder and should not be taking anticoagulants
- Patient should be advised to avoid aspirin and nonsteroidal anti-inflammatory medications for 5 several days prior to, and after the procedure.
- Must have informed consent from the patient (should be in a written form).
- Risk and alternatives to procedure should be explained to the patient
- Patient should understand when the results are available to them, and to how they shall be informed of the results.

TECHNIQUES AND PROTOCOLS

The techniques and protocols for interventional ultrasound vary a great deal between doctors, institutions, and patients. For this reason, I suggest you read the relevant sections in the Online Texts and apply what you read to what you observe in your own department, taking note at the same time of the different methods that are employed by others.

Informed Consent needs to be obtained.

Treatment/Intervention

It is extremely important to know the general guidelines for prevention of cross-infection.

Control

Ultrasound guidance, either free hand or with mechanical guidance, is best performed with the needle shaft parallel with the transducer length so that the full length of the needle and the tip can be always visualized.

Free hand puncture enables the angle of approach to be optimized. Where practical, the angulation between the needle shaft and the transducer contact surface should be keep to a minimum. A horizontal angle of approach, with the needle positioned approximately parallel with the chest wall, is required for safety reasons and for better angulation of the needle to the beam, improving the needle display.

Experience with interventional procedures is required for expertise. According to Stavros (2004), the types of interventional procedures of the breast include

- Cyst aspiration
- Abscess drainage
- Ductography
- Needle localization (pre-operative)

- Fine-needle aspiration biopsy (FNAB)
- Automated large core needle biopsy
- Directional vacuum-assisted biopsy (DVAB; mammotomy)
- Carbon tracking localisation
- Radiofrequency (RF) interventions
- Sentinel node analysis
- Therapy and in-situ ablation

The lesion types that are the exceptions to ultrasound being the modality of choice for guidance of interventional procedures are:

- Microcalcifications that are not associated with a mass
- Very small nodules deeply located in large fatty breasts
- Suspicious mammographic asymmetries that are not reliably identified on diagnostic ultrasound.

In these instances, stereotactic mammographic guidance is necessary.

CYST ASPIRATION

Cysts that are simple on ultrasound do not need to be aspirated unless they are markedly symptomatic. Complicated cysts are typically aspirated when solitary, new, larger, or when associated with other lesions suspicious for malignancy in the same breast. Sometimes multiple simple cysts and complex cysts having a similar appearance are followed at a short interval rather than aspirating all that are not completely clear.

Can observe in real time the complete evacuation of the cyst and ensure that no solid component remains after the aspiration. When cyst fluid is clear, straw-coloured, or green, it is benign fluid and can be discarded, as this is typical of a simple cyst. If the cyst aspirate shows any other signs other than the ones just mentioned, it needs to be sent off for cytology.

ABSCESS DRAINAGE

Complex cysts and fluid collections should be aspirated and drained if there is suspicion of inflammation or infection. In such cases, the fluid will appear grossly yellowish and frankly purulent

PRE-OPERATIVE NEEDLE LOCALIZATION

Used for the localization of non-palpable breast lesions that can be seen on ultrasound, prior to surgery. Means that smaller amount of tissue needs to be excised at surgery, with a positive of this being less postoperative deformity of the breast. Also, the smaller the sample, the easier it is to pathologically diagnose a small focus of CIS. The localization is performed using some form of needle and hook wire combination whereby a wire is left at the site of the lesion.

Complication of this procedure is haematoma formation, infection, wire migration, pneumothorax and the most common one of vasovagal reaction.

BIOPSY

Ultrasound-guided breast biopsy is usually reserved for solid breast lesions, with the 3 most common types being Fine Needle Aspiration Biopsy (FNAB), automated large core biopsy, and mammotomy (Directional Vacuum-Assisted Biopsy).

FNAB

a 22- to 25-gauge needle is placed into the lesion, suction is applied, and the needle is moved back and forth within the lesion. The suction is released, the needle is withdrawn, and the aspirate is ejected from the needle onto the slides and is smeared and fixed

CORE BIOPSY

With core-needle biopsy, specific histology is obtainable from masses, focal asymmetries, and microcalcifications. The diagnostic accuracy of a lesion biopsied using a core-needle technique is improved with an increase in the number of samples as well as increased experience in performing the procedure. Usually requires multiple passes with a large bore (14 gauge) biopsy needle mounted on a gun. Local anaesthetic is required

Major complications of core-needle biopsy of the breast are rare. Due to using the large bore needles, infection can occur uncommonly, as can haematomas. It has been documented that on rare occasions that tumour cells can be displaced during core-needle biopsy

DIRECTIONAL VACUUM-ASSISTED BIOPSY (DVAB OR MAMMOTOMY)

- Local anaesthetic is required
- The device consists of a 9 or 11-gauge needle with a window cut into the side that uses vacuum assistance to obtain multiple larger samples during one needle insertion
- A rotating blade is in the needle which cuts a small sample off and holds it in the needle
- Multiple samples can be taken in succession by directing the window towards the lesion
- Without withdrawing and reinserting the needle, it rotates positions and collects additional samples. Typically, eight to 10 samples of tissue are collected from around the lesion
- Some evidence has suggested that it has been able to completely remove small lesions, but primary use is for sampling purposes
- Complex cysts that have mural nodules, thickened internal septations, or irregularly thickened outer walls can undergo ultrasound-guided mammotomy to ensure that these complex cysts do not contain malignancy

RADIOFREQUENCY DEVICES

- Instrument that uses RF energy to penetrate and cut breast tissue.
- Many of these instruments can be used with ultrasound guidance.
- When the RF energy is applied, it results in some interference (“snow”) in the ultrasound image

SENTINEL NODE ANALYSIS

- A major advance in breast cancer surgery.
- Instead of needing to perform a full axillary node dissection, the patient now only has a few nodes removed after they have been labelled with a radionuclide.
- On the day of surgery, ultrasound guidance is used to place the radionuclide just anterior to the tumour in the plane between the deep subcutaneous fat and the mammary zone containing the lesion. In this way, the radionuclide is placed adjacent to the tumour but is in an anatomic region rich in lymphatics.
- Lymphoscintigraphy is performed about 1 hour after injection of the radionuclide, and the technologist marks the skin overlying the activity in the axilla
- The presumed sentinel node identified by ultrasound is then wire-localized under ultrasound guidance while the primary breast carcinoma is wire-localized

GENERAL GUIDELINES FOR INTERVENTIONAL PROCEDURES

TRANSDUCER CARE PRIOR TO THE PROCEDURE

When performing interventional techniques under sterile conditions (for example, intraoperative sonography), care should be taken to adequately clean the machine and transducer to be used. A probe is rendered sterile by being cleaned and placed in a sterile sheath. The other options are 'gas sterilisation' or 'probe immersion'; although except for some biopsy needle guide transducers, most probes can be sterilised by using a sterile cover. The sheath should extend over the cord of the transducer for the distance for which the cord will be in contact with the sterile area. Coupling gel should be used on the probe footprint before it is sheathed, and the sheath should be secured with a rubber band or pipe cleaner. Sterile ultrasound gel should then be used on the covered sheath.

A 'sterile membrane' may be used to scan over fresh or recent post-operative sites.

For many interventional techniques that pertain to the breast, sterility is not considered necessary as it is akin to having an injection.

It is important to remember that standard precautions should always be used when performing all sonographic examinations, not just for interventional (see below).

PREVENTION OF CROSS INFECTION

Infection control is based on the principles of hygiene, cleanliness and sterility. The primary aims of infection control are to prevent transmission of infection from patient to patient, and to prevent staff acquiring infections from patients or transmitting infection to patients.

Standard precautions are standard operating procedures that apply to the care and treatment of all patients, regardless of their perceived infectious risk.

These precautions include aseptic technique, hand washing, use of personal protective equipment, appropriate reprocessing of instruments and equipment and implementation of environmental controls.

Standard precautions should incorporate safe systems for handling blood (including dried blood), other body fluids, secretions, and excretions (excluding sweat), nonintact skin and mucous membranes.

Standard precautions are the first line of approach to infection control. Visible soiling of surfaces should be cleaned after each patient with soap and water.

Thorough washing of the hands before and after each patient is essential. Protective clothing should be worn where appropriate, aseptic techniques should be followed, and there should be appropriate disposal of sharps and other contaminated waste.

Additional precautions are required when standard precautions may not be sufficient to prevent the transmission of infectious agents (e.g. tuberculosis, measles).

Additional precautions are tailored to the specific infectious agent concerned and may include measures to prevent airborne, droplet or contact transmission (direct contact with dry skin or contaminated surfaces) and health care associated transmission agents.

FOR PROCEDURES

- Sterile surgical gloves should be worn.
- Single use disposable needles are used.
- Appropriate skin disinfection is used.
- If ultrasonic coupling gel is required, a disposable sterile pack is used.
- The ultrasound transducer is covered in a sterile cover.

ULTRASOUND GEL

A further potential risk is possible contamination of the coupling gel and subsequent transmission of infection from patient to patient. Risk of infection is increased in those with a healing wound.

Gel is a potential source of infection. The use of an ultrasonic gel which contains a bacteriostatic agent is recommended. Containers for gel, once emptied, should be either discarded or cleaned with soap and water and disinfected with Milton. Gel should be applied to each patient without contamination of the container.

Small disposable packets of sterile gel are available and should be used when scanning an open wound or a recent surgical incision.

TRANSDUCER CLEANING AFTER THE PROCEDURE

Instruments which come in contact only with the skin can be regarded as low risk instruments. However, cross infection from skin flora can occur. This is of particular importance in a hospital setting where multi-resistant organisms may contaminate the patient's skin and be transferred to others. Furthermore, patients with a wound are at significant risk of wound contamination and subsequent infection.

Once the ultrasound gel has been removed (this may need to be by soap and water), clean with an alcohol wipe. This very simple procedure of using a 70% alcohol wipe to clean the transducers between patients has been shown to render the probe bacteriologically clean. This simple, inexpensive procedure is an essential part of the ultrasound examination. When there is an open wound, in addition to wiping the probe between patients, a sterile disposable transducer cover should be used. If blood or serous contamination of the transducer occurs, the transducer should be disinfected in hypochlorite (Milton). Glutaraldehyde formulations may also be used for transducer cleaning, but care should be taken because glutaraldehyde is an intense irritant. Advice should also be sought from the transducer manufacturer as to what solutions can safely be used. If Biopsy guide and/or gun was used that is not for single use—sonographer or nursing staff must wash with soap and water, using brush to clean grooves. Send to CSSD for sterilisation.

GUIDANCE METHODS

You should be aware of the general procedures and relative advantages and disadvantages of each of the following guidance methods:

Indirect Method

- Used for the aspiration or drainage of large collections (such as ascites in the peritoneal cavity)
- It is a blind technique without the use of real-time imaging during needle insertion

- Puncture site is identified and marked using ultrasound, and the angle and dept. of the puncture ascertained by ultrasound prior to the needle insertion

Freehand Method

- This is performed without the constraints of a needle guide, and the needle is inserted and advanced under the long axis of the ultrasound transducer.
- Needle may be adjacent to or remote from the transducer, parallel or even perpendicular to the plane of the scan
- The optimal direction of needle insertion though is parallel and horizontal to the transducer and chest wall, making the entire needle and its bevel visible
- Advantage is that allows independent movement of either the transducer or the needle during the procedure
- Disadvantage is that may be difficult to keep the needle in the same plane as the transducer (for example, if needle changes its parallel relationship to the probe)

For cyst aspiration or fine-needle aspiration biopsy.

- The smaller the needle, the better the sample
- A vertical approach may be used for needle placement for cyst aspiration or FNAB
- In this manner, the needle is placed the shortest distance from and directly into the mass.
- For this placement, the needle is placed at the midline of the long face of the transducer, and the needle is visualized once it is at the depth of the lesion.
- If a long axis or horizontal approach is used, the needle is placed at the short end of the transducer and is visualized in its entirety as it is advanced toward the lesion.
- The horizontal approach usually requires a longer needle to reach the lesion.

For core-needle biopsy or vacuum-aspirated biopsy;

- A horizontal/oblique approach must be used.
- Because of the forward firing of the needle, it is imperative that an approach parallel to the pectoralis major muscle be used for safety.
- Many of the core needles typically used for ultrasound-guided biopsy advance into the breast about 2 cm on firing. An angled approach could easily allow the needle to penetrate the chest wall.

NEEDLE GUIDANCE SYSTEMS

Using a biopsy guide that is provided by the manufacturer of the ultrasound machine. These attach to the transducer and provide a rigid pathway for the needle. The needle pathway is displayed on the monitor electronically, so the sonographer then needs to change their scanning plane to ensure that the area to be biopsied is situated in the electronic pathway

These devices restrict the angle at which the needle is inserted and do not allow for real-time changes in angle or direction of the needle after it has entered the breast Another disadvantage is that the needle must be placed close to the transducer and cannot be positioned at a location remote from the transducer

NEEDLE VISUALISATION

General principles of ultrasound

- Visualisation determined by factors such as type of tissue needle is being inserted into (if similar echogenicity to needle, it shall be difficult to see)
- Reflection of ultrasound beam – the more perpendicular to the beam the needle is, the better the visualisation
- Larger needles easier to see due to the width of the ultrasound beam – to compensate for needle gauge, try and use the highest frequency probe possible that still gives optimal penetration

Pump action

Technique used to improve visualisation by gently moving inner stylet up and down, scattering the ultrasound beam

Use of colour Doppler

Because colour Doppler shows movement, this technique may show minute movements of the needle. This technique works better for objects in superficial structures. Inappropriate colour settings shall obscure any visualisation though, so use with caution and skill

AFTER CARE

You should be aware of the care required after any procedure, and of the complications that may arise.

MODULE 10
MRI AND CURRENT ADVANCES IN BREAST IMAGING

MODULE OVERVIEW

You may be wondering what this module is doing in this Study Guide for Breast Sonography.

MRI of the breast is not a replacement for mammography or ultrasound imaging but rather a supplemental tool for detecting and staging breast cancer and other breast abnormalities.

This module serves to outline the basis of MRI use in breast imaging; it is not intended that it should be a comprehensive guide.

LEARNING OBJECTIVES

- What are the indications for MRI in breast imaging?
- What is the benefit of using MRI when examining breast implants?
- When is MRI not useful?

ONLINE TEXTS

de Paredes, Ellen Shaw 2007, Atlas of mammography, 3rd Edition, Lippincott Williams & Wilkins, Chapter 17 under the subheadings of: The Role of Magnetic Resonance Imaging of the Breast & The Role of Magnetic Resonance Imaging in screening for breast cancer

Review the eReader for these and any other relevant articles.

DYNAMIC CONTRAST ENHANCED MR IMAGING (DCE-MRI)

This 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 tumours; however even with this technique, specificity is in the range of 37%-97%.

In DCE-MRI, dynamic imaging is performed after injection of a contrast agent and the signal intensity on a T1 weighted dynamic sequence has specific contrast uptake patterns for malignant and benign, with malignant lesions showing a higher 'signal enhancement ratio', larger values of 'maximum slope', and shorter 'time to peak of enhancements'.

MR imaging of the breast is performed to:

- Assess multiple tumour locations, especially prior to breast conservation surgery.
- Identify early breast cancer not detected through other means, especially in women with dense breast tissue and those at high risk for the disease.
- Evaluate abnormalities detected by mammography or ultrasound.
- Distinguish between scar tissue and recurrent tumors post lumpectomy/surgery

- Determine whether cancer detected by mammography, ultrasound, or after surgical biopsy has spread further in the breast or into the chest wall.
- Assess the effect of chemotherapy.
- Provide additional information on a diseased breast to make treatment decisions.
- Search for cancer in a patient with silicone augmentation
- Determine the integrity of breast implants
- Assessment of the contralateral breast in patients with primary breast cancer

Without IV contrast material, an MRI of the breast can show:

- Breast tissue density.
- Cysts
- Enlarged ducts.
- Haematomas.
- Leaking or ruptured breast implants.
- The presence of enlarged lymph nodes.

By comparing breast images taken before and after contrast material injection, an MRI exam can determine:

- If there are breast abnormalities.
- Whether an abnormality looks benign or malignant.
- The size and location of any abnormality that looks malignant.

BENEFITS OF MRI 0F THE BREAST

- Sensitive to small abnormalities
- Effective in dense breasts
- Can image breast implants/ruptures (most effective modality for assessing for ruptures)
- Can evaluate inverted nipples
- Can locate primary tumour in women whose cancer spread to armpit lymph nodes
- Can detect residual cancer after lumpectomy
- Can determine what type of surgery is indicated: lumpectomy or mastectomy
- Can detect cancer recurrence after lumpectomy
- May be useful to screen women at high breast cancer risk

LIMITATIONS OF MRI OF THE BREAST

- High sensitivity but low specificity (Non-specific) - often cannot distinguish cancerous and non-cancerous tumours
- Cannot image calcifications that can indicate early breast cancers

- Expensive and not widely available (MRI costs about 10 times more than a mammogram)
- Some patients who are claustrophobic may not tolerate MRI
- Cannot be used in women with implanted medical devices
- Requires use of contrast agent
- More time-consuming than mammography or ultrasound
- If a suspicious lesion is clinically and mammographically occult and cannot be found on a targeted ultrasound, the biopsy or needle localization needs to be done with MRI guidance. MRI-guided procedures are time consuming and costly
- The overlap in the MRI features of certain benign and malignant lesions decrease the specificity and positive predictive value, which results in an increase in the biopsy rate.
- It also remains unclear if alterations in management plans based on MRI findings benefit patients.

Because of many of the above cited disadvantages, screening MRI will not likely be a replacement for mammography or a generally used study. MRI, like ultrasound, plays an important role in the comprehensive evaluation of women with breast abnormalities, many of which are detected on mammography. MRI's main role is in the assessment of the integrity of breast implants. The gold standard for early detection of breast cancer and the tool proven to reduce mortality for this disease remains mammography.

CURRENT ADVANCES IN BREAST IMAGING

OVERVIEW

Breast imaging is an ever changing, ever advancing technology. New methods of examination are constantly being evaluated. Sometimes, these methods become a part of everyday imaging. Quite often though, research shows that the method may not be quite as useful as first thought. And there are always differing opinions.

The current gold standard for breast screening is still mammography, with both ultrasound and MRI being important adjuncts to mammography, with each modality offering additional information required for accurate diagnosis. But there is a multitude of imaging techniques out there- some are currently being used, whilst others are still in the experimental phase of their suitability.

LEARNING OBJECTIVES

At the end of this module, you will be able to answer the following questions:

- What is an ultrasound contrast agent and how does it work?
- How may an ultrasound contrast agent help in diagnosis?
- What might be the advantages of 3D ultrasound?
- Understand PET and PEM scanning techniques.
- What is elastography of the breast?

- What are some of the advantages and disadvantages of the myriad of current breast imaging techniques?

ONLINE TEXTS

- Kopans, D 2007, Breast Imaging, 3rd Edition, Lippincott Williams & Wilkins, Chapter 17 under the sub headings of: Doppler ultrasound & Intravenous Enhancement of Breast Lesions for Ultrasound Evaluation and chapters 27 and 28.
- Stavros, A. Thomas 2004, Breast ultrasound, 1st edition, Lippincott Williams & Wilkins, Chapter 20
- Heino Hille 2012, Advances in Breast Ultrasound, Sonography, Dr. Kerry Thoirs (Ed.), ISBN: 978-953-307-947-9, InTech, Available from: http://www.intechopen.com/books/sonography/advances-in-breast-ultrasound
- Specht, 2012. 'Advances in molecular imaging for breast cancer detection and characterization', Breast cancer research: BCR, 1465-5411, vol. 14, Issue 2, p 206, Available from: http://breast-cancer-research.com/content/14/2/206

Review the eReader for these and any other relevant articles. There are a multitude of updated and new articles that can be sourced on the internet pertaining to the techniques found in this module.

TISSUE HARMONIC IMAGING (THI) AND CONTRAST HARMONIC IMAGING (CHI)

High-resolution ultrasound is well accepted for differentiating between cystic and noncystic tumour lesions. Developments such as tissue harmonic imaging (THI) and contrast harmonic imaging (CHI) have enhanced its value, particularly for primary detecting tumours in dense inhomogeneous mammary gland tissue, identifying mammographically occult tumours and appraising abnormalities in tissue architecture. Lesions that are only a few millimetres in size become detectable and tumours can be characterised more precisely.

Compound real-time imaging insonates specular reflectors at multiple angles, limiting image artefacts and noise, therefore improving the definition of the margins of lesions. It is widely available on most equipment.

Harmonic imaging is a procedure in which the ultrasound machine scans images at twice the frequency transmitted. This technique potentially can suppress reverberation and other near-field noise but it may limit depth of penetration and result in loss of resolution. Harmonic imaging allows better visualisation of tissue architecture and facilitates recognition of parenchymal changes with tumour infiltration, making it easier to wire mark small lesions with THI. Tissue harmonic imaging is also widely available on equipment and improves the signal to noise ratio, reduces side lobe artefact and improves lateral resolution.

3D ULTRASOUND OF THE BREAST

There has been increasing attention given to 3D breast ultrasound as an adjunct to mammography. Benefits of accessing more information from the 3D data set and the ability to view the non-traditional scanning planes contribute to the rising interest. In particular, the 3D planar views are said to be helpful when studying tumour margins and ductal structure.

Some of the advantages of 3D ultrasound include:

- It depicts a 3D image of a tumour and its relationship with its surrounds
- Superior definition of borders, margins and tumour extent
- Detailed survey of the internal structure of a tumour is available
- Tumour volume may be calculated
- Skin tumour infiltration evaluation
- Images of planes not accessible to conventional sonography may be constructed (3 planes to define margins, i.e. microlobulation, papillomas)
- Visualisation of coronal plane to view compression versus retraction patterns of tumours
- Assists in breast tumour treatment, planning and monitoring
- The ultrasound criteria for benign and malignant disease may be easier to recognise.

3D volume data and the coronal plane imaging provide more detailed information about lesion characteristics, extent and borders. Multiple findings such as the retraction patterns, spiculations and possible bridging between the masses, along with the ability to interrogate numerous ducts in any plane, has been enabled by volume scanning and demonstrated especially in the coronal views, which could not be displayed in normal 2D imaging.

Researchers report that the use of three-dimensional ultrasound can provide enhanced image information to enable radiation oncologists to better define the treatment region when delivering partial breast irradiation treatment for breast cancer.

DOPPLER IN EVALUATION OF BREAST TUMOURS

Malignant tumours will often cause formation of new (but abnormal) blood vessels in the vicinity of the tumour. Colour/power Doppler may be useful in characterizing breast tumours. Malignant tumours show detectable, moderate to high flow rates with increased vessel densities, as opposed to benign tumours, which have little or no detectable flow rates and low vessel densities.

After a malignant neoplasm achieves a certain size, the tumour must generate its own new blood vessels (or it will cease growing). To enable growth beyond this point, all malignant tumour cells have developed the capacity for the formation of new vessels (tumour neovascularity) to supply nutrients to and remove wastes from the tumour. This aggregation of abnormal vessels produces flow that can be detected using colour Doppler ultrasound.

The formation of neovascularity is typically most pronounced in the periphery of the tumour mass.

Ultrasound contrast agents may or may not help improve sensitivity of Doppler in low grade, less vascular lesions. Although ultrasound contrast will make flow within low-grade lesions with little tumour neovascularity more readily detectable, the contrast will also make flow within normal tissue and benign lesions such as fibroadenomas more easily detectable. Thus, even with contrast, such malignant lesions may not have perceptibly increased flow.

The use of Doppler for detection of abnormally high velocity flow or abnormally low-impedance flow for definitive diagnosis of malignant lesions is also limited.

Low-grade invasive carcinomas generally have little or no internal vascularity on colour Doppler but often have demonstrable feeding vessels in the surrounding tissues. Some complex fibroadenomas are hypervascular. Lactating adenomas, stimulated by the hormones of pregnancy or lactation, typically appear very vascular on colour Doppler evaluation.

One of the most reliable positive predictors of malignancy is a difference that exists in the pulsed Doppler spectral waveform patterns between vessels that lie within the substance of the tumour and those that lie on the periphery.

In many malignant lesions, the waveforms obtained from the centre of the lesion have high peak systolic velocities, sharp systolic peaks, early diastolic notches, relatively lower peak diastolic velocities, and higher measures of impedance such as systolic-to-diastolic ratios, resistivity indices, and pulsatility indices. On the other hand, the waveforms obtained from the periphery of the malignant nodule tend to have lower systolic velocities and more rounded systolic peaks, lack early diastolic notches, and have lower measurements of impedance.

It is essential that very little scan pressure be used with any form of Doppler to assess a breast lesion for tumour neovascularity. Excessive compression pressure can collapse the abnormal vascular spaces within and around the tumour, decreasing or even completely shutting off blood flow to the lesion. Inadvertent compression can greatly affect the Doppler assessment of flow to the tumour.

Aside from all that has been covered in this Doppler section, it needs to be remembered that benign lesions may exhibit increased flow and, more important, a significant number of cancers do not exhibit evidence of abnormal flow -particularly lesions smaller than 1 cm.

Therefore, Doppler is not yet reliable for truly distinguishing benign lesions from malignant lesions. There is the perplexing overlap of benign and malignant characteristics on Doppler analysis that makes it difficult to avoid obtaining cytological or histologic material through interventional techniques.

The sensitivity of Doppler and the number of malignant findings on B-mode imaging vary with the type of breast tumour being imaged. Doppler assessment of breast tumours should not be viewed as a stand-alone assessment of a lesion's risk for malignancy. It is best used in conjunction with the real-time B-mode image

ASSESSING RESPONSE TO TUMOUR THERAPY

Doppler can be used to follow response to available chemotherapeutic agents. In some cases, vascularity decreases before there is a decrease in tumour volume. Doppler could be especially useful in determining the effectiveness of antiangiogenesis therapy. In such cases, a favourable response would likely result in decreased blood nearly immediately, long before shrinkage of the tumour could be detected sonographically.

ASSESSING WHETHER LYMPHADENOPATHY IS CAUSED BY INFLAMMATION OR METASTATIC BREAST CARCINOMA

Not only do the colour Doppler and power Doppler flow patterns within the metastasis-containing lymph node parallel those of the primary lesion, but so does the pulsed Doppler spectral waveform pattern.

Most malignant tumours have high systolic velocities and relatively high resistivity indices in the centre of the tumour. So do the lymph nodes that contain metastases from that primary lesion.

Most lymph node metastases from breast carcinoma have histology identical to that of the primary tumour. If the histology of the primary tumour is associated with hypervascularity, the lymph node metastases from that primary lesion will also be hypervascular. Similarly, if the vessels in the centre of the primary tumour have high peak systolic flows, sharp systolic peaks, and high resistivity indices, then the pulsed Doppler waveforms obtained from the metastasis-containing lymph node will have similar features in most cases.

This pattern of spectral waveform characteristics differs greatly from the waveform characteristics obtained from inflamed or reactive lymph nodes, for which the pulsed Doppler spectral waveforms tend to have lower systolic velocities, more rounded systolic peaks, and lower resistivity indices.

The most specific of all the Doppler findings for lymph node metastases is the presence of transcapsular feeding vessels. The vascular supply of normal lymph nodes enters and exits through the hilar notch. The normal lymph node has no vessels that traverse the lymph node capsule.

In inflamed nodes, the normal hilar vessels enlarge, but transcapsular feeding arteries do not develop (they do not develop neovascularity).

Breast cancer metastases, on the other hand, have the formation of transcapsular feeding vessels. Thus, the presence of transcapsular feeding arteries suggests the presence of lymph node metastases.

Power Doppler is somewhat more sensitive than colour Doppler and is better for demonstrating transcapsular vessels. In cases in which the lymph node is grossly abnormal, the mediastinum of the lymph node may be so compressed, displaced, and distorted that it cannot be identified.

DEMONSTRATING INFLAMMATORY HYPERAEMIA

Doppler can be useful in evaluating thick-walled cysts for evidence of inflammation. The findings that suggest acute inflammation include relatively uniform isoechoic wall thickening, fluid-debris (pus) levels, and hyperaemia within the thickened cyst wall.

RECURRENT TUMOUR

Most recurrent tumour nodes have demonstrable blood flow on colour Doppler. Six months or more after lumpectomy, the presence of blood flow in the lumpectomy cavity or immediately surrounding tissues raises concerns about recurrent tumour.

ASSESSMENT OF VASCULAR CONDITIONS OF THE BREAST

Doppler is essential for evaluating vascular conditions in the breast. These are conditions that are like vascular conditions elsewhere in the body but just happen to occur in the breast. The two most frequently encountered vascular conditions are superficial venous thrombosis and venous malformations.

In superficial thrombosis of the breast, the presenting symptom is a tender cord. Sonography shows a tortuous or beaded hypoechoic structure that has no demonstrable blood flow and is non-compressible.

FULL FIELD BREAST ULTRASOUND (FFBU)

The Full Field Breast Ultrasound system automatically images the whole breast and provides tomographic images of the scanned breast. The tomographic images are displayed to mimic the appearance of the standard mammogram. This provides easier correlation between the ultrasound images and the mammogram which is expected to improve the current ultrasound practice of early breast cancer detection.

The system uses 3 components: a special scan station, image processing computer and a view station.

The scanning procedure is performed in a manner similar to standard mammography. The exam is performed in the standing position with the breast held in the standard mammographic positions, Craniocaudal and Mediolateral Oblique, under light compression.

It uses high frequency, 768 element transducers to acquire 400-800 sagittal ultrasound images with one sweep. The entire scan takes less than 60 seconds to perform.

The images convert into 6 to 8 somograms (tomographic ultrasound slices) which are presented in the CC and MLO projections which are easily correlated with mammography. Each somogram represents a section of the breast approximately 5-10 mm thick. Viewing breast tissues in thinner sections is expected to be particularly useful for breasts with dense tissues.

INTRAVENOUS ENHANCEMENT OF BREAST LESIONS FOR ULTRASOUND EVALUATION USING ULTRASOUND CONTRAST AGENTS (CONTRAST ENHANCED ULTRASOUND – CEUS).

There is some hope that the neovascularity that develops with many cancers can be demonstrated by using intravenous contrast agents that enhance the visibility of vessels on ultrasound.

Several papers have been published suggesting that contrast material can enhance the visualisation of blood vessels under ultrasound observation. The problem lies in whether the use of these agents aids in managing patients with breast lesions.

Ultrasound contrast agents usually employ encapsulated bubbles or solid particles in the 5 to 7-micron range, producing a marked increase in backscatter and making it easy to visualize flowing blood. They also produce moderate tissue enhancement usable for dynamic perfusion studies that look for changes in tissue enhancement over time. When some agents are exposed to a higher power ultrasound beam, the micro bubbles break, releasing acoustic energy that can be detected using colour or power doppler. This phenomenon has been called stimulated acoustic emission and may be useful for detecting contrast agents in tissue when the gray-scale imaging does not clearly show the agent.

The disadvantages of contrast agents are their cost and the requirement for an intravenous injection. Also, with more sensitive Doppler instrumentation, blood flow enhancement may not be as important as it has been in the past. An increase in tissue enhancement can be achieved using an ultrasound contrast agent in experimental tumours implanted in a liver. Whether such enhancement will occur in breast applications remains to be seen.

ELASTOGRAPHY looks at only the elastic properties of tissues by applying a slight compression to the tissue and comparing an image obtained before compression and after compression. The data collected before and after compression are compared, using a cross-correlation technique to determine the amount of displacement each small portion of tissue undergoes in response to the compression applied by the ultrasound transducer. It uses a computer program to analyze ultrasound images of a breast mass and judge how stiff the mass is. An ultrasound done with elastography is no different than that one done without elastography. Masses that are cancer tend to be stiffer than the surrounding healthy breast tissue. The elastography software judges' stiffness of a mass by detecting how much the mass does or doesn't get compressed by the pressure of breathing, or by pushing on the chest wall.

Elastography has been used clinically to examine a variety of breast lesions in patients, and it has been concluded that this modality may be useful for differentiating malignant from benign masses. Results of some studies suggest that elastography is better at judging when a mass is cancer than it is at judging when a mass is benign. Elastography software isn't new but hasn't been used very much to help diagnose breast cancer. The results of various studies suggest that using elastography more often during breast ultrasound could help doctors decide if a breast mass should be biopsied and help avoid some unnecessary breast biopsies.

DIGITAL MAMMOGRAPHY, also called full-field digital mammography (FFDM), is a mammography system in which the x-ray film is replaced by solid-state detectors that convert x-rays into electrical signals. These detectors are like those found in digital cameras. The electrical signals are used to produce images of the breast that can be seen on a computer screen or printed on special film similar to conventional mammograms. From the patient's point of view, having a digital mammogram is essentially the same as having a conventional film screen mammogram.

Digital mammography is significantly better than film mammography in screening women who are under age 50, or women of any age who had very dense breasts, and premenopausal or perimenopausal women.

Digital mammography allows improvement in image storage and transmission because images can be stored and sent electronically. One of the biggest advantages of digital is associated with the wide latitude of the digital signals. Density compensation by CR systems make exposure errors less apparent, meaning less repeats due to incorrect technical factors.

Surveys have shown though, that digital mammography was associated with significantly more recalls than film mammography because of radiologic abnormalities and with significantly less recall than film mammography because of poor technical quality. Digital mammography also had a significantly higher recall rate because of its better capability to detect calcifications than film mammography.

The major disadvantage of digital mammography is the start-up cost.

Computer-Aided Detection (CAD) systems use a digitized mammographic image that can be obtained from either a conventional film mammogram or a digitally acquired mammogram. CAD is used to alert the radiologist to areas of a mammogram where computerised image analysis suggests that abnormalities may be found – thereby increasing the productivity and accuracy of the radiologist's interpretation.

It works by first mapping normally healthy breast tissue that is then stored as a reference. Typically, the CAD tool processes a digitised version of a mammogram and marks it with "prompts" to highlight mammographic features that the reader should examine. The design goal for CAD is to aid in noticing features in a mammogram that might indicate cancer but that may otherwise be missed. Some recent studies have shown though that its effect on the accuracy of interpretation has been unclear.

Digital Tomosynthesis (DBT) produces a three-dimensional image of the breast. It is similar to a CT scan, with many thin images. With this procedure subtle areas of architectural distortion that may lie deep in the breast can be visualised.

The breast is in either the MLO or CC projections, and the x-ray tube is rotated around making multiple exposures at different angles. The result is a 3-dimensional reconstruction of the breast from the multiple images.

DBT provides greater detail and clarity and allows physicians to identify tumours that are easy to miss with the 2D approach. DBT combines the data from eleven low-dose 2D images to create a single 3D composite image, using no additional examination time, X-ray energy and fewer breast compressions.

Studies have been done to design a computer-aided detection (CAD) system for breast mass detection on digital breast tomosynthesis (DBT) mammograms and to perform a preliminary evaluation of the performance of this system. Computer-aided detection (CAD) has been shown to improve breast cancer detection at mammography.

POSITRON EMISSION TOMOGRAPHY SCAN OR IMAGING (PET SCAN) uses a small dosage of a radionuclide combined with a sugar. This combination is injected into the patient. The radionuclide emits positrons.

A PET scanner will rotate around a patient's body to detect the positron emissions given off by the radionuclide. Because malignant tumours are growing at such a fast rate compared to healthy tissue, the tumour cells will use up more of the sugar which has the radionuclide attached to it. The computer then uses the measurements of glucose used to produce a picture which is colour coded.

Different colours or degrees of brightness on a PET image represent different levels of tissue or organ function. For example, because healthy tissue uses glucose for energy, it accumulates some of the tagged glucose, which will show up on the PET images.

However, cancerous tissue, which uses more glucose than normal tissue, will absorb more of the substance and appear brighter than normal tissue on the PET images.

PET scans are used most often to detect cancer and to examine the effects of cancer therapy by characterizing biochemical changes in the cancer. A PET scan can differentiation between recurrent, active tumour growth and necrotic (dead) soft tissue masses in cancer patients.

PET scans can be useful for evaluating people after breast cancer has already been diagnosed, in several different ways:

- To determine whether the cancer has spread to the lymph nodes
- To determine whether the cancer has spread to other parts of the body, and if so, where (metastatic breast cancer)
- To assess whether metastatic breast cancer is responding to treatment

POSITRON EMISSION MAMMOGRAPHY (PEM) is an effective tool for detecting breast cancer. PEM, also known as high-resolution breast PET, has fewer false-positive results than breast MRI.

Dense breast tissue and hormonal status can hinder other breast imaging techniques. PEM shows high sensitivity and is not limited by these factors.

Imaging is obtained on the dedicated breast PET in a manner similar to mammography. The PEM detectors are mounted on the 2 compression paddles. The breast is imaged, similar to mammography with slight compression to immobilize the breast in the MLO and CC projections.

As the detectors are positioned close to the target organ, image acquisition is efficient and there is little attenuation of counts so spatial resolution is much improved over whole body PET imaging.

Molecular Breast Imaging (MBI) is a relatively new nuclear medicine technique that, while more expensive than mammography, is about one-fifth of the cost of breast MRI.

With MBI, patients are injected with a short-living radioactive agent that is absorbed by breast tissue. This agent is tracked with a gamma-camera that can distinguish healthy tissue from breast cancer tumours, as cancer cells absorb more of the radioactive agent than healthy cells.

The procedure is relatively simple to perform. Imaging can be performed within 5 min post injection, with the breast lightly compressed between the two detectors.

Images of each breast are acquired in the craniocaudal and mediolateral oblique projections facilitating comparison with mammography.

Key studies have confirmed that MBI has a high sensitivity for the detection of small breast lesions. Tumour detection does not appear to be dependent on tumour type, but rather on tumour size. Sensitivity was lowest for tumours less than 5 mm in size.

A large clinical trial compared MBI with screening mammography in over 1000 women with mammographically dense breast tissue and increased risk of breast cancer and showed that MBI detected two-to three-times more cancers than mammography.

BREAST-SPECIFIC GAMMA IMAGING (BSGI) is a promising new technology designed to supplement mammography and breast ultrasound examinations when these show suspicious findings.

BSGI images the metabolic activity of breast lesions through radiotracer (99m-technetium) uptake. It uses a high-resolution gamma camera to detect sub centimetre breast cancers even less than 5 mm. Breast cancer is identified based on the differential uptake of radiotracer in cancer cells as compared with normal surrounding breast tissue. This procedure provides an easy, rapid and economic way to perform supplemental breast imaging of women with dense breast tissue, cosmetic implants, post-surgical scars and masses, multiple suspicious lesions, and palpable lesions not detected by mammography and ultrasound.

Although a breast may be imaged in any position during a BSGI exam, it is designed to replicate positions used in mammography, specifically craniocaudal and mediolateral oblique projections. Unlike an MRI procedure, which may acquire hundreds of images, a typical BSGI exam only has 4-16 images, and can be reviewed and interpreted more rapidly by a radiologist.