Mammography, US and MRI: review of normal anatomy and variants

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Learning objectives

To thoroughly describe the breast anatomy and its correlation in the different imaging methods.
Background

A good anatomical knowledge is a basic requirement in the field of Radiology. It is essential for understanding and interpreting the results of the different imaging methods.

As in other areas of Radiology, the accurate study will serve as a guide for achieving a good evaluation of the explorations in the radiological study of the breast.

BREAST ANATOMY

The mammary gland is a modified cutaneous gland that develops from apocrine cutaneous glands. It is the organ - one of the secondary sexual characteristics - responsible for secreting milk during the lactation period.

During its development - around the 5th or 6th week of gestation, the ectoderm thickens on both sides of the ventral surface of the embryo's body - the mammary ridge-, which extends from the axillary region to the inguinal region: the "milk line".

If the breast develops normally, an area of this mammary ridge will develop preferentially, and the other foci will regress.

The breast is located on the anterior thoracic wall, between the 2nd and the 7th intercostal spaces, over the pectoral musculature. It may extend laterally toward the midaxillary line and medially toward the sternum, frequently expanding toward the axillary region: the tail of Spence (Fig 1).

Anomalies may occur while the breast develops (regression errors) owing to which mammary tissue might appear at any point of the 'milk line'. This tissue is known as accessory or ectopic mammary tissue.

The most common location for accessory tissue is the axilla. This accessory tissue will appear either as a continuation of the main mammary tissue or as a separate structure.
It is essential in the radiological study of the breast to be able to identify the presence of accessory mammary tissue because it can also suffer from pathologies.

ANATOMICAL STRUCTURES OF THE BREAST. Fig.2

I. Tissues that make up the breast

a) The skin and the areola-nipple complex.

- The **skin** of the breast is 0.5 to 2 mm thick, except in the region of the areola-nipple complex and the decline region, where it is thicker. It has sweat and sebaceous glands and hair follicles.

It is worth highlighting that the image shows certain elements - the 'caves of Kopans' - which were previously thought to be skin 'pores' and are now known to correspond to small subcutaneous adipose columns which rise toward the dermis (they frequently appear in mammograms).

- The **areola-nipple complex**, which is located in the anterior-central area of the breast, is a specialised skin region which is highly pigmented and is thicker than the rest of the breast's skin.

The **areola** has a discretely irregular surface having small projections - the Morgagni tubercles - which are the outlets of specialized sebaceous glands: the Montgomery glands. Hair follicles are restricted to the periphery of the areolar surface.

The skin of the **nipple** is irregular and has multiple indents into which the **lactiferous ducts** flow.

The nipple and the areola have many nerve endings, collagen fibres and smooth muscle fibres, which facilitate the nipple's erectile function during lactation.
b) **Adipose tissue**, which lies immediately underneath the cutaneous plane: Subcutaneous adipose tissue. It is also located in the retromammary space and between the fibroglandular tissue: Interlobar adipose tissue.

c) **Glandular parenchyma**, which consists of mammary lobules - about 15-20 in each breast - which drain via the main lactiferous ducts, each defining a segment of the breast.

Every segment consists of groups of lobules whose ducts confluetly drain into the main duct.

Each lobule is defined by a final branching of the terminal duct, which causes saccular dilations or blind ductules forming the acini.

The lobule and the terminal duct form the **terminal duct lobular unit (TDLU)**, which is the mammary gland's most important structure from a diagnostic standpoint is given that most metaplastic, hyperplastic and neoplastic processes take place there (Fig 3).

The breast's segmentary anatomy is not divided into histologically defined territories; unlike lung lobules, breast lobules do not have clearly delimited, recognisable limits.

There are usually less principal lactiferous ducts than glandular lobules since some anastomose before they reach the nipple. Some of these lobules generally anastomose before reaching the nipple and share a single main duct when they flow into it.

As they near the nipple, the ducts form dilations underneath the areola - the **lactiferous sinuses**, which will act as reservoirs for the secreted milk.

d) **Connective tissue**, which gives the breast its shape and consistency. There are two types of conjunctive tissue:

- **Stromal or interlobular connective tissues**, which includes the superficial fascia, which unfolds into two sheets forming a sort of envelope around the breast. The superficial sheet, which underlies the subcutaneous adipose plane, and a deep sheet, which is posterior to the retromammary fat and anterior to the pre-pectoral fascia. These sheets are **crossed and crisscrossed** by lymphatic and blood vessels, making it possible for glandular tissue to migrate through them.
This tissue includes Cooper's ligament system, which comprises sheets of fibrous tissue which cross the entire mammary plane from the deep fascial sheet toward the superficial sheet and up to the skin, which they enter via the "retinacula cutis". **Fig. 4.**

- Lax, **specialised conjunctive tissue** intimately associated with terminal ducts and lobules. **Fig. 3 b.**

These elements form a unified structure that supports the breast.

**II. The muscular plane** on which the breast sits includes the pectoralis major and minor muscles. **Fig. 5**

- The **pectoralis major muscle** extends from the mid region of the anterior thoracic wall - originating in the medial half of the anterior edge of the clavicule, the anterior face of the sternum, the first six costal cartilages, and the aponeurosis of the external oblique muscle - to the lateral margin of the bicipital groove of the humerus.
- The **pectoralis minor muscle** lies deeply in relation to the pectoralis major, and extends from the top edge and external face of the third, fourth and fifth ribs and ends in a flattened tendon which enters the anterior part of the internal edge of the coronoid apophisis.

**III. The chest wall** in the mammary region includes the ribs, intercostal muscles, and serratus muscle.

**IV. The breast's arterial vascularization** (**Fig. 6**) depends mainly on the following:

- The central, mid portion of the breast is fed by perforating branches of the **internal mammary artery**, which starts in the subclavian artery and is responsible for approximately 60% of the arterial blood flow to the breast.
- **Branches of the lateral thoracic artery** (a branch of the **axillary artery**) which primarily feed the breast's external superior quadrant. They account for 30 percent of the arterial blood flow to the breast.
- **Posterior intercostal branches** supply blood the lateral mammary tissues.
V. Venous drainage. The breast has two venous circulation systems: Fig. 7

- The superficial venous network, which anastomoses with the deep venous network from the areola-nipple complex at the plexus of Haller.
- The deep venous drainage, which returns toward the lateral thoracic, internal mammary and intercostal veins. These are the three main paths for haematogenous metastasis.

From there, the breast's blood drains into either the subclavian vein or the vertebral veins. These venous connections allow the breast's blood to reach the vertebral territory without going through the lung filter, so they provide a way for vertebral metastases to appear without affecting the lungs.

VI. The lymphatic drainage system, which runs parallel to the deep venous system, goes from the deep mammary tissues to the cutaneous lymphatic vessels, which head to the subareolar plexus and from there mainly to the axilla. There are two main drainage path:

- The axillary path - the most important one - is anatomically divided into three levels according to their relationship to the pectoralis minor: Fig 8
  - Level I, which is located at the base of the axilla, sits below and to the side of the lateral edge of the pectoralis minor muscle.
  - Level II, which is located between the lateral and medial edges of the pectoralis minor muscle. The lymph nodes are disposed between the pectoralis minor and pectoralis major muscles - interpectoral or Rotter lymph nodes - or deeper than the pectoralis minor.
  - Level III, which is located medially and superiorly to the medial edge of the pectoralis minor muscle, toward the mediastinum, and corresponds to the infraclavicular lymph nodes.

The lymphatic drainage usually takes place in a staggered way: from Level 1 to Level 2, and from there to Level 3, which is the last level: the last step of the axilla’s lymphatic drainage. Then they extend inside the thorax toward the subclavian lymph trunk and the supraclavicular lymph nodes.

- The internal mammary path, which accounts for a small percentage (3-22%) of the breast’s lymphatic drainage.
**Fig. 1:** Spence tail

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Fig. 2: BREAST ANATOMY

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**Fig. 3:** Segmentary anatomy. a. Lobe: Major duct, and branches. b. Terminal duct lobular unit (TDLU): Lobule and terminal duct

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Fig. 4: Cooper’s ligaments can be identified as they cross the subcutaneous adipose tissue as triangle-shaped structures with their base facing the parenchyma and their apex pointing toward the skin.

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**Fig. 5:** Pectoral muscles

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Fig. 6: Breast's arterial vascularization

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Fig. 7: Breast venous’s drainage.

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**Fig. 8:** Axillary levels

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Findings and procedure details

Having gone over the breast's anatomy, we will now connect these structures to the different imaging methods - mammography, ultrasound scanning, and MRI - with regard to both the 'standard' breast and its variants, including all potential pitfalls.

RADIOLOGICAL BREAST ANATOMY

MAMMOGRAPHY

The breast differs from other regions of the body in that it has a structure that is composed of 'soft' tissues (glandular, fibrous, and adipose) having similar densities. This results in very small differences in X-ray attenuation, which lead to low tissue contrast.

The differences in the absorption of X-ray beams by normal and pathological tissues are also very small.

This is why high-contrast resolution images are necessary to be able to distinguish between the small differences in X-ray attenuation in healthy tissues and lesions.

Therefore, low-energy (low kilovoltage) ionising radiations are used in mammogram tests because they are capable of amplifying the differential absorption of tissues, thereby maximising radiographic contrast.

The basic views in a mammogram are the craniocaudal (CC) view and the mediolateral oblique (MLO) view, which get their name from the point of entry and orientation of X-rays in the breast. These two views allow almost all mammary tissue in most patients to be included in mammograms.

To obtain a craniocaudal view take the following steps:

Fig. 9 and fig. 10

- With the mammograph’s arm at 0°, move the detector until it is parallel to the floor.
- Place the breast looking upward and forward by pulling from it.
• The nipple should sit perpendicular to the edge and tangential to the X-ray beam.
• Push on the top plate downward, making sure the breast’s skin is taut.
• The X-ray beam will arrive from above, perpendicular to the detector.

TIPS AND TRICKS

It is essential to pull and press down the breast before conducting a mammogram; this will allow more mammary tissue from deeper locations to be included. Fig. 11 and fig. 12

To obtain a mediolateral oblique view take the following steps:

Fig. 13 and fig. 14

• Set the mammograph’s arm parallel to the pectoral muscle (40-60°).
• Place the breast facing upward and outward, unfolding the inframammary fold.
• The nipple should lie tangential to the beam.
• Press down on the top plate from the sternum side whilst pulling on the breast and tightening the skin.
• The beam will arrive perpendicularly to the detector and enter the breast from the medial region.

This view includes almost all of the mammary tissue ranging from the axillary region to the inframammary fold.

As already mentioned, it is important to check to see whether there is accessory breast parenchyma present, since it is also susceptible of suffering pathologies. It appears more often in the axillary region.

Fig. 15
In mammograms the **skin** appears as a fine external line which slightly thickens in the breast's periareolar and lower regions as it slopes downward (Fig. 16). Sometimes the **caves of Kopans** may be seen in mammograms. **Fig. 17**

**TIPS AND TRICKS**

It is important to evaluate the skin since any alteration might indicate the presence of an underlying breast pathology either of a benign, such as e.g. inflammation symptoms - mastitis - or secondary changes caused by breast treatments (Fig. 18), or a malign nature, e.g. an inflammatory cancer or the retraction of the skin caused by breast cancer (Fig. 19).

It can also tell us about systemic illnesses such as secondary oedema associated with heart failure. **Fig. 20**

**TIPS AND TRICKS**

Mammography can help us to establish the dependency on the cutaneous plane of different findings when they are tangential to the X-ray beam. **Fig. 21**

The **nipple** is identified as having a 'water' density and protrudes from the skin at the central area of the breast. Sometimes nipples are retracted or inverted; this is usually not a cause for concern, especially when both are inverted. **Fig. 22**

However, sometimes this might indicate the presence of an underlying malign pathology, especially in the case of a unilateral inversion of the nipple. **Fig. 23**

**TIPS AND TRICKS**

When assessing the nipple by mammography, make sure it is arranged tangentially to the X-ray beam, protruding from the skin, as it could otherwise be mistaken for a retroareolar nodule. **Fig. 24**
The lactiferous ducts which drain into the nipple also have a ‘water’ density. They are hard to distinguish from fibroglandular tissue in mammograms of some types of breast (dense breasts, for the most part). Fig. 25

Galactography is a radiological technique used for the detection of lesions within the lactiferous ducts and their possible treatment. Fig 26.

 Conjunctive and glandular tissues also have a ‘water’ density, so it will usually be impossible to tell them apart in a mammogram.

Cooper's ligaments will be seen as intertwining, overlapping curvilinear structures crossing the breast. Occasionally, this will result in images having an irregular - sometimes spiculated - morphology, which often times will make them hard to analyse.

In addition, at the subcutaneous adipose tissue level these sheets can be seen on their journey to the skin as triangle-shaped structures with their base facing the parenchyma and their apex pointing toward the skin.

Fig. 27

Adipose tissue attenuates X-ray beams to a lesser extent than other tissues and has a 'fat' density. Depending on the breast's makeup, there will be more or less of it. Although this is not always the case, fibroglandular tissue frequently regresses with age and is replaced with adipose tissue. Fig. 28

TIPS AND TRICKS

The low radiological density of fat in mammograms allows certain lesions, such as e.g. lipomas (Fig. 29) and hamartomas (Fig. 30), to be diagnosed, because they are fat containing lesions.

Muscles show ‘water’ attenuation. In MLO views the pectoralis major muscle is seen crossing the posterior region of the breast, in the shape of a triangle, from the axillary region, with its base facing the axilla and its apex pointing downward and sitting more or less at nipple level.
In CC views (if it can be included in the image) it will be seen in the deep region as half-moon shaped. **Fig. 31**

**TIPS AND TRICKS**

The inclusion and correct situation of the pectoralis major in MLO views is an accepted criterion when assessing the technical quality of a mammogram since the latter allows to determine if most of the mammary parenchyma has been included in the study. **Fig. 32**

Occasionally the **pectoralis minor muscle** can be seen in the axillary region, underlying the pectoralis major. **Fig. 33**

**TIPS AND TRICKS**

Please note that the **sternalis muscle** can appear in some views. Thus, you must be familiar with it since you can mistake for a suspicious lesion.

The sternalis muscle is a rare anatomical variant which appears in approximately 8% of the population (both men and women). It is considered to be the cranial extension of the rectus abdominis muscles. It lies parallel to the sternum and is located anteriorly and medially in relation to the pectoralis major. Its fibres end in this muscle’s fascia, on the top margin of the sternum or at the level of the sternocleidomastoid muscle. It may be composed of a few muscular fibres or appear as a muscular belly. In the CC view of a mammogram it is seen as a posteriorly and medially located focal asymmetry having a triangular or round shape. **Fig. 34**

**Vascular structures** have a ‘water’ density and are seen as tubular, convoluted structures. Veins can be distinguished from arteries when the latter are calcified (calcium attenuation). **Fig. 35**

The group of **axillary lymph nodes** which are included in mammograms corresponds to Berg Level I.
Normal adenopathies have an oval-, kidney-shaped shape and a peripheral region (cortex) of 'water' density and a hilum of 'fat' density.

The alteration of the morphology of lymph nodes and the shift or absence of the fatty hilum are potential signs of cancer.

**Fig. 36**

Lymph nodes can also be found in the breast itself. They are most frequently located in the superoexternal quadrant, so we must be familiar with how they are displayed in mammograms.

**Fig 37**

**RADIOLOGICAL DENSITIES**

The different proportions of the elements that make up the breast - fibroglandular tissue and adipose tissue condition the various radiological density patterns.

The **BI-RADS® system** puts the breast into four categories according to its makeup. The nomenclature has been modified in the 5th edition; the four types of density patterns are now designated with letters instead of numbers to avoid confusion with the suspicion categories:  

- **a)** The breasts are almost entirely fatty,  
- **b)** There are scattered areas of fibroglandular density,  
- **c)** The breasts are heterogeneously dense, and  
- **d)** The breasts are extremely dense.  

**Fig. 38**

The description of the different patterns is important, as density can modify the sensitivity of the screening.

Dense mammogram patterns - c and d categories - lower the mammograph sensitivity to lesions, its sensitivity ranging from 98 to 63% - which drops very significantly in the case of very dense breasts (30-48%).

**ULTRASONOGRAPHY**
Ultrasonography is the imaging method that is most commonly used to assess the breast after mammography (usually as a complementary method). It is not advisable to use it as an 'isolated' test during breast cancer screening.

Technical breakthroughs have been made in the past few years which have significantly enhanced the quality of the images, which now have greater axial resolution and contrast. Hence, very small lesions can be detected nowadays.

The standard ultrasound study is carried out using high frequency linear transducers with frequencies equal or greater than 7.5 MHz, which provide good resolution in the surface field and a suitable depth of penetration, resulting in optimal spatial and axial resolution.

The patient should lie in supine position, with her arms in abduction above the head.

The transducer should be positioned perpendicular to the breast to prevent false images or distortions in the planes. More or less pressure on it will be exerted as needed.

The study can be conducted by means of different scans or mappings covering the entire mammary plane; the depth and focus will have to be adjusted in the different regions.

The skin will be displayed as a fine echoic layer between two hyperechoic lines. It will be possible to see slight thickening in the areolar region.

**Fig 39**

The retroareolar region poses an added difficulty for ultrasound assessment. As already mentioned, the areola-nipple complex is thicker than the rest of the breast's skin and is rich in conjunctive tissue. Additionally, the fibroglandular mammary tissue is more abundant in this region. All this can restrict the penetration of ultrasound beams and make it difficult to assess the retroareolar region.

**TIPS AND TRICKS**

In order to study the retroareolar area, keep the probe slightly removed from the nipple, and tilt it a little and press down on the breast with the transducer in order for the beam to be able to penetrate the right distance and the area to be assessed properly (**Fig 40**)
The **nipple** can be seen as an echoic, inwardly convex, oval-shaped structure.

The **main lactiferous ducts** can be seen as anechoic tubular structures converging toward the nipple in the retroareolar region. **Fig 41**

**TIPS AND TRICKS**

Lactiferous ducts will be easier to identify if they are dilated. A diameter is greater than 2 mm, is related to duct ectasia - which old patients usually suffer from - associated with fibrosis of the periductal connective tissue; this does not have pathological significance (**Fig 42**)  

The entire dilated duct should be checked for intraductal lesions (**Fig 43 and 44**)  

During the lactation period women show an increase in the diameter of the lactiferous ducts in the retroareolar region, and is also possible to identify the peripheral ducts. (**Fig. 45**)  

**Fibrous, connective and glandular tissues** are hyperechoic and for the most part cannot be singled out. **Fig. 46**

**TIPS AND TRICKS**

In the case of dense breasts, in order to obtain optimal images press the transducer down against the breast to attain good penetration of the ultrasound beam. **Fig. 47**

The **superficial fascia** and **Cooper's ligaments** are the **conjunctive tissue elements** that will be possible to distinguish from glandular tissues, as they pass through the
subcutaneous adipose tissue towards the skin. As in mammograms, they will be seen as hyperchoic triangular structures with the apex pointing towards the skin, where they enter it. **Fig. 48**

**TIPS AND TRICKS**

Radiologists have to be familiar with the ultrasonic translation of Cooper's ligaments because sometimes they can lead to doubts when diagnosing at the fibroglandular-subcutaneous adipose tissue interface. Cooper's ligaments have to be distinguished from real lesions.

They can appear as hypoechoic structures having a triangular shape and a back shadow - a typical ultrasonic representation of breast cancer.

Advantage of the transducer's motion can be taken because unlike lesions, ligaments usually 'follow' the movement of the probe. Furthermore, other nearly ligaments shown to have a similar behaviour. **Fig. 49**

**Breast adipose tissue** is hypoechoic. It can be seen underlying the cutaneous plane as a hypoechoic band corresponding to subcutaneous adipose tissue. In addition, a hypoechoic band can be seen in the retromammary region, in front of the pectoral muscles, and as hypoechoic islets in the midst of fibroglandular tissue. **Fig. 50**

**TIPS AND TRICKS**

When combined with fibroglandular tissue, adipose tissue can frequently generate false images simulating the presence of intramammary nodules, since fat is hypoechoic, as most nodules are.

All ultrasound findings must be verified by means of a scan in the axial and in the sagittal plane, by rotating the transducer to determine whether the images correspond to real lesions or to islets of adipose tissue.

**Fig. 51**
The **muscular plane** is located deep with regard to the retroglandular adipose tissue. Pectoral muscle bellies show up in ultrasounds as having an elongated shape having the ultrasound characteristics typical of muscles: Hypoechoic bands corresponding to muscular fascicles separated by hyperechoic linear septa corresponding to fibrous septa.

**Fig. 52**

The **pectoralis major muscle** is seen as extending along the anterior thoracic wall from the axillary region and the clavicle toward the sternum. The **pectoralis minor**, which underlies the former and is shorter, will help to delimit the axillary regions. **Fig. 52**

It is possible to see the **anterior thoracic wall** by ultrasounds. The **ribs** are seen as hyperechoic structures having a back shadow in depth. Depending on how the transducer is placed, they will be seen along their longitudinal or their transverse axis. **Fig. 53**

It is also be possible to see the **intercostal muscles**, which lie between the ribs and the **pleura**, as a fine hyperechoic linear structure that produces beam's reverberation and which moves with the movements of breathing. **Fig 53**

**TIPS AND TRICKS**

Breast ultrasound has a potential pitfall:

When making a longitudinal section on the breast, the transverse plane of the rib in the proximal region of the ribs, at the level of the costal cartilage may be accidentalyly included, which might look like a hypoechoic solid nodule with back shadow. In this case, its location behind the muscle and moving the transducer or changing to transverse section, will confirm that it corresponds to the costal cartilage-rib. **Fig. 54**

In the case of patients who have been recently diagnosed breast cancer, the axilla is usually evaluated by means of ultrasound. The **regional lymphatic system** in the breast is generally studied by means of ultrasound.

Ultrasound enables the assessment of will make it possible to assess the **three axillary lymph node levels Fig. 55**
Normal axillary lymph nodes generally appear in ultrasound as oval-shaped nodules with a cortex, seen as a hypoechoic peripheral region and a hyperechoic central hilum, although sometimes the central fatty hilum can be hypoechoic or undistinguishable.

A lymph node is potentially metastasised if it has a round shape, a lost fatty hilum, abnormal peripheral vascularisation, a cortical thickness greater than 2.5-3.0 mm or focal cortical lobulation. **Fig 56 and 57**

Intramammary lymph nodes can also be identified by means of ultrasound. **Fig. 58**

**MAGNETIC RESONANCE IMAGING**

In MRI both breasts are examined at the same time using a multichannel phase-array breast coil. The patient has to be lying prone. **Fig. 59**

The protocol includes T2 TSE and STIR sequences, a diffusion study (b = 0 and b = 1000), an intravenous contrast (Gadobutrol) T1 GRE study with fat saturation, a multiphase study with suitable spatial and temporal resolutions, and a late 3D study with high spatial resolution.

In MRI it is essential for both breasts to be arranged properly. The study must include all of the mammary parenchyma, the axillary tail, the inframammary fold, the pectoral musculature, the thoracic wall, and the axillary region.

It is very important for the breasts to be positioned properly by lightly pressing down on them from medial to lateral; too much pressure can lead artefacts, for example to improper enhancement after the injection of the IV contrast for the mammary parenchyma. **Fig. 60**

Let’s begin with the **cutaneous plane**. The **skin** is identified in MRI as in mammography. It has a thickness ranging from 0.5 to 2 mm along the entire perimeter of the breast and has a slight thickening in the areolar region. Normal skin can up being slightly enhanced after injecting the IV contrast. **Fig. 61**
TIPS AND TRICKS

Within breast pathology with alteration of cutaneous plane, it is important to know the
telltale signs of inflammatory carcinoma, a type of breast cancer which characteristically
affects the skin and in which the skin lymph ducts are infiltrated by tumour cells.

MRI is the most sensitive method for detecting this entity since it allows to see the
significant skin thickening and the foci of enhancement in the skin thickness, which
may from skin lymphatic duct involvement. In addition, mass and non-mass-type
enhancement areas can be displayed and Cooper's ligaments enhanced. Subcutaneous
oedemas and even the pre-pectoral region could be depicted. This kind of cancer very
often metastasises in the axilla. Fig. 62

The areola-nipple complex can show significant enhancement after the injection of
the IV contrast owing to its intense vascularisation, although this has no pathological
significance. Fig. 63

The lactiferous ducts can show T2 high signal intensity, and occasionally T1 high signal
intensity due to their haemorrhagic and protein content, this often being so in the case
in duct ectasia.

When studying the ducts it is interesting to conduct highly T2-weighted sequences, such
as STIR, and the multiphase study, with pre- and post-contract subtraction images, in
order to rule out the presence of intraductal lesions. Fig. 64

Fibroglandular tissue usually shows low signal intensity in T1 and T2 sequences.
Adipose tissue follows the fat signal.

Cooper's ligaments, components of the fibrous tissue, have a similar triangular shape
when they go through the subcutaneous adipose tissue and show low signal intensity in
all sequences. Fig. 65

Fibroglandular parenchyma shows 'normal' enhancement after the IV contrast is
injected. Fig 66
BI-RADS® classifies the enhancement level. This enhancement ‘level’ refers to the volume and intensity of enhancement and is classified into four types:

a) Minimal: lack of enhancement or scant enhancement, b) mild: low intensity enhancement, c) moderate: multiple foci of diffuse shape, and d) marked: intense enhancement with multiple bilateral foci.

In general, parenchymal enhancement is more prominent in pre-menopausal patients and during the second phase of the menstrual cycle, so it is advisable to conduct the study between the 6th and the 14th day (second phase) of the cycle. Patients which have been recently diagnosed breast cancer should be subjected to the study regardless of the phase of the cycle.

The muscular plane, which consists of the pectoralis major and minor muscles, is identified in its extension on the anterior costal wall, separated from the fibroglandular plane. It appears as hypointense in the pre-contrast T1 and T2 sequences. Fig. 67

MRI is the imaging method that permits to better assess whether the pectoral muscles and, in general, the thoracic wall - defined as the serratus anterior muscle and the costal wall-sternum (which can also be evaluated by means of MIR) - are affected by cancer.

Fig. 67 and fig. 68.

The vascularisation of the breast can be clearly identified in the dynamic MRI sequence by depicting the path of the lateral thoracic vessels and their branches and of the internal thoracic vessels and its perforating branches. Fig. 69

In the axillary region, the different nodal axillary levels can be evaluated. Normal lymph nodes can generate the typical image of an oval-shaped node with a fatty centre and usually end up being intensely enhanced after the injection of the IV contrast owing to their significant vascularisation.

Bear in mind that MRI is often a technique with low specificity for determining the presence of a metastasised tumour. Fig. 70 and 71
By comparing the three imaging methods we will be able to describe the different types of breast densities according to the amount of fibroglandular tissue. Fig. 72-75
**Fig. 9:** Obtaining a craniocaudal view. Mammograph.

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Fig. 10: Mammography: Craniocaudal view.

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Fig. 11: The effects of compression and traction.

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**Fig. 12:** Appearance of a deep retroareolar node: The effect of traction. Mammography CC view:

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Fig. 13: Obtaining a mediolateral oblique view. Mammography

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Fig. 14: Mammography Mediolateral oblique view.

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Fig. 15: Accessory axillary tissue. MLO view Mammography of the left breast.

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Fig. 16: Normal skin. Mammography MLO view.

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Fig. 17: Caves of Kopans. Mammography MLO view

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Fig. 18: Skin retraction and thickening in external quadrants of the right breast, secondary to post-surgical changes. Left breast, normal skin. Mammography CC view

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Fig. 19: Slight skin retraction and thickening in the superoexternal quadrant of the left breast, conditioned by a specular nodule with an infiltrating carcinoma diagnosis. Mammography CC and MLO view

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Fig. 20: Patient suffering from heart failure. Evolution, from the absence of skin oedema until a cardiac decompensation episode. Mammography MLO view

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Fig. 21: CC view of a nodule in external quadrants of the left breast. The MLO view shows that it corresponds to a cutaneous appendage lesion. Mammography.

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Fig. 22: a. Normal nipple. b. Retracted nipple without pathology. Mammography CC view

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Fig. 23: Secondary retraction of the nipple due to a retroareolar irregular nodule, corresponding to an infiltrating carcinoma diagnosis. Mammography MLO view.

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**Fig. 24:** Poorly positioned nipple, looking like a retroareolar nodule. Mammography CC view

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**Fig. 25:** Solitary dilactating lactiferous duct. Mammography MLO and CC view

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**Fig. 26: Galactography**

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Fig. 27: Fibroglandular tissue. Cooper’s ligaments crossing the breast from the pectoral muscle to the skin. Mammography MLO view.

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Fig. 28: Subcutaneous adipose tissue, (bracket), fatty islet, (arrow), retrograndular adipose tissue (arrowhead). Mammography MLO view.

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Fig. 29: Lipoma: Oval-shaped, radiolucent nodule with a fine capsule. Mammography MLO view.

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Fig. 30: a. Ovoid in shape nodule with heterogeneous content with thin capsule. Mammography CC view. b. On T2 TSE MRI, had heterogeneous intensities and thin capsule. On DCE-MRI the lesion enhanced gradually.

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**Fig. 31:** MLO and CC views of the pectoralis major muscle. Mammography.

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Fig. 32: a. Pectoralis major muscle barely included in the MLO view. b. Proper position of the pectoralis major muscle, allowing the posterior tissues to be visualised. Mammography MLO view.

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Fig. 33: The pectoralis minor muscle. Mammography MLO view.

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**Fig. 34:** Sternal muscle. Mammography CC view.

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Fig. 35: Arteries (with calcium) on their walls) and veins. Lateral thoracic (arrowhead) and internal mammary branches (arrow). Mammography MLO view.

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Fig. 36: Normal lymph nodes. b. Pathological lymph nodes associated with breast cancer metastasis. Mammography MLO view.

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Fig. 37: Intramammary lymph node. Mammography CC and MLO view.

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**Fig. 38:** ACR BI-RADS® categories of breast density. a) The breasts are almost entirely fatty, b) There are scattered areas of fibroglandular density, c) The breasts are heterogeneously dense, and d) The breasts are extremely dense Mammography MLO view.

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Fig. 39: Ultrasound. a. Normal skin. b. Skin thickening in patient with a history of breast cancer and conservative treatment

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Fig. 40: Ultrasound in retroareolar region. a. Image taken with the transducer located perpendicularly above the areola. b. Tilted transducer exerting greater pressure on the areola: Proper ultrasound passage

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Fig. 41: a. Nipple. b. Lactiferous ducts arriving at the nipple/converging toward the nipple. Ultrasound.

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Fig. 42: Ductal ectasia. Ultrasound.

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**Fig. 43:** US and Mammography. Dilated retroareolar duct: Intraductal lesion

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Fig. 44: Dilation of a single retroareolar duct, showing an echoic lesion inside. Ultrasound.
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Fig. 45: Women in breastfeeding period. Dilation of lactiferous ducts and lactiferous ducts in external quadrants. Ultrasound.

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Fig. 46: Band of hyperechoic, fibroglandular parenchyma (big arrowhead) located between the hypoechoic subcutaneous adipose tissue and retroglandular adipose tissue (arrow). Ultrasound.

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Fig. 47: Uncompressed and compressed dense breast. Ultrasound.

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**Fig. 48:** a. Superficial fascia: Superficial sheet and deep sheet. b. Cooper’s ligaments. Ultrasound.

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Fig. 49: a. Nodule with irregular edges and back shadow: Infiltrating carcinoma. b. Cooper's ligaments. Ultrasound.

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Fig. 50: Subcutaneous adipose tissue (bracket), fatty islet (arrow), retrograndular adipose tissue (arrowhead). Ultrasound.

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**Fig. 51:** Hypoechoic nodule with a non-circumscribed (indistinct) edge (corresponding to an adipose islet in the midst of fibroglandular tissue). Ultrasound.

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**Fig. 52:** Pectoralis major muscle and pectoralis minor muscle. Ultrasound.

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**Fig. 53:** a. Ribs (arrowhead), with the transducer arranged in longitudinally to the wall along the short axis of a rib, the transducer in transverse position to the wall following the long axis of a rib, and intercostal muscle between two ribs (arrow). b. Pleura (arrow). Ultrasound.

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Fig. 54: a. Nodule with cancer diagnosis. b. Pseudonodule: Cross section of a costal cartilage-rib. Ultrasound.

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**Fig. 55**: Axillary levels. Ultrasound.

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**Fig. 56: Characteristics of Axillary Lymph Nodes on Ultrasound:**

a. Normal lymph nodes.

b. Lymph nodes suspect of suffering from tumoral infiltration/metastasis.

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**Fig. 57:** US imaging. Normal lymph nodes and lymph nodes suspect of suffering from tumoral infiltration/metastasis. Ultrasound.

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Fig. 58: Normal Intramammary lymph node. Ultrasound.

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Fig. 59: MRI Breast phase-array multichannel coil. Patient lying in prone

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Fig. 60: T2 TSE MRI. a. and b. the same patient. a. Tightly packed breasts with poor compression. b. After placement of the patient the breasts are correctly positioned

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**Fig. 61:** Normal skin. T2 TSE MRI.

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Fig. 62: Right breast inflammatory carcinoma: a. MRI. TSE T2 Marked skin thickening, subcutaneous and prepectoral edema. T1 GRE FS post c. Foci of cutaneous enhancement. b. Mammography. The mammary parenchyma presents alteration of its structure with generalized density increase, subcutaneous edema and tumor lymphadenopathy. C. US. Cutaneous thickening and subcutaneous edema. Normal left breast.

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Fig. 63: a. Areola-nipple complex in T2-weighted sequence. b. Significant enhancement of the nipple after IV contrast.

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Fig. 64: US and MRI. Solitary ductal dilation: Intraductal lesion. Mammography: Ductal prominence and calcifications

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Fig. 65: Fibroglandular tissue. Cooper’s ligaments (white arrow). Subcutaneous adipose tissue, (bracket), fatty islet, (arrow), retrograndular adipose tissue (arrowhead). T2 TSE MRI.

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**Fig. 66:** Background parenchymal enhancement. T1 GRE FS post civ. MRI

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Fig. 67: Pectoralis major and minor muscles. Sternum (arrowhead) and costal wall (arrow) T2 TSE MRI.

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Fig. 68: Invasive ductal carcinoma (arrowhead) following the retroglandular fatty plane and the pectoral musculature plane (arrow) is no tumor affectation.

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**Fig. 69:** a Lateral thoracic vessels and their branches. b. Internal thoracic artery and its perforating branches. MIP DMRI.

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**Fig. 70:** Normal lymph nodes. T2 TSE and STIR MRI

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Fig. 71: Lymph nodes affected by metastasised breast cancer. Mammography MLO view, US and T2 TSE and STIR MRI

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**Fig. 72:** Patterns of breast density. Extremely dense breast. Mammography, US, and T2 TSE MRI

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Fig. 73: Patterns of breast density. Heterogeneously dense breast. Mammography, US, and T2 TSE MRI breast.

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Fig. 74: Patterns of breast density. Breast with areas of disperse fibroglandular density. Mammography, US, and T2 TSE MRI

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Fig. 75: Patterns of breast density. Breast with areas of disperse fibroglandular density. Mammography, US, and T2 TSE MRI

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Conclusion

Having a good understanding of the standard anatomy of the breast and its variants and its correlation to the image in the different imaging methods, is necessary in order to be able to properly evaluate breast diseases.

It is essential to be familiar with the normal structures of the breast and how they are displayed in the different imaging methods in order to be able to detect anomalies.
**Fig. 76:** Breast anatomy: Mammography, US and MRI.

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