Chapter 5
Breast Imaging
Breast Cancer is the most frequent cancer in women in western countries where it accounts for 27% of all female cancers. Imaging techniques play a major role in early diagnosis, evaluation and lookout for treated breast. Early detection of breast cancer allows a decrease in the mortality rate by 20 –30 % in women aged 50 or older. Current screening practice is based on conventional or digital mammography. Ultrasound may be complementary to explore masses. MRI plays a major role in the detection of breast cancer recurrence in treated patient, in the diagnosis of homolateral multifocality extension or contralaterality and in the screening of women with high risk of breast cancer BRCA1 and 2. Biopsy under stereotactic, ultrasound or MRI guidance have been developed in order to optimize the diagnosis and to organize the best treatment.

**BREAST IMAGING MODALITIES**

**MAMMOGRAPHY**

**Techniques**

High quality mammography requires efficient equipment and trained radiologic teams. All mammographs need approximately the same designed generators (tungsten anod system, molybden target or rhodium target for dense breast photo-timing, small focal spot sizes) but there are two types of signal reception: Classical Screen Field Mammography (SFM) that requires scatter-reducing grid, and high definition films, and more recently Full field digital mammography (FFDM); this technique is divided in CR (Computed radiology) where ERLM Screens receive the signal that is then read by laser spot or DR (Digital Radiology); in this former the detector transmits the signal to a numerical reading system. FFDM permits acquisition, storage and facilitates the comparison. It has been demonstrated that FFDM offers quite the same accuracy in terms of detection and diagnosis of breast pathology, especially for the examination of dense breast tissue and for the microcalcifications. FFDM and SFM offer the same specificity (almost 92%) and quite the same sensibility except in the sub-group of dense breasts (BIRADS 3-4) of women under 50 years old. FFDM is now also available for the Breast cancer screening, subject to quality control as in SFM. Physical examination should always precede mammography.

Mammography in every technique uses compression of the breast between parallel rigid plates, permitting projection of the breast unto the surface film. The dose delivered to the breast should remain within acceptable limits and seems to be lower with FFDM. Usually crano-caudal and oblique views of both breasts are obtained. For the crano-caudal view the breast must be well drawn, centered, the nipple perpendicular projecting out of the breast. The oblique view compresses the breast along a 45 to 60 axis (the beam parallel to the pectoralis muscle extending from the axilla to the lower quadrants of the breast) and projects more breast tissue than straight lateral view. Addicional views are obtained completing the check: Mediolateral side view permits to localize an abnormality. We will choose mediolateral or lateromedial access depending if the image is in the outer or in the inner quadrant (minimal distance between the image and the receptor); the magnified views in SFM and high resolution, if possible magnified views in FFDM complete microcalcifications analysis. For the examination of a densification or a mass it could also be useful to rotate the breast or to use a small compression plate to differentiate normal breast tissue from a true mass. The analysis of microcalcifications require magnified views in high resolution to identify the morphology and shape of the group.

Some techniques are developing like Digital Breast Tomosynthesis: In Tomosynthesis the breast is compressed in the same manner but the X-ray tube allows the acquisition of many low dose images rather than only one on FFDM. Then these slices are reconstructed by 3D software. This new technique is in evaluation for analysis of densification and geometry of clusters of microcalcifications.
Normal mammographic pattern
On mammography, breast parenchyma is separated from the skin by a radiolucent layer of subcutaneous fat. The glandular elements are prominent in the upper outer quadrant with the ductal structures converging to the nipple. The parenchymal cone of the breast is delineated from the chest wall by the retromammary fat. Curvilinear dense structures coursing through the breast are seen and correspond to connective tissue and vessels. In premenopausal women, the breast appears dense on mammography. After menopause, the breast is often more radiolucent and it could become easier to detect abnormalities.

Diagnosis in mammography
In mammography, mass developed in the three following locations are more suspicious for malignancy: Internal quadrant, Retroglandular lipomatous region and no man’s land. The main etiologies of round opacities are given in table.

Opacities can be masses and density, or architectural distorsion. A mass is a lesion that occupies a volume. It can be qualified by its shape round, oval, lobular or irregular. The Density of a mass is important only when lipomatous composant is seen permitting the diagnosis of intramammary lymph node, hamartoma, lipoma, galactocele, steatonecrosis. Small cancer is often not very dense. The margin (FIG 1) is also pejorative when not circumscribed but microlobulated, obscured by adjacent tissue, indistinct or spiculated. The margin of the mass is often obscured by surrounding tissue and localized view with small compression can be useful for a better analysis. Benign lesions often provide well-circumscribed margins but this former can also be seen in 8% of malignant tumors especially in medullary or mucinous carcinomas. The margin of a mass is the most important factor in breast diagnosis: PPV for cancer increases from circumscribed (less than 10%) to spiculated (VPP more than 95%). Architectural distortion is rupture of normal architecture with no visible mass.

![Figure 5.1: Margin of a Mass](image)

Microcalcifications are the best tool for the diagnosis of infra-clinical cancer in the in situ form (that is contained in the duct without breach of the basement membrane). The microcalcifications are described by their distribution in the breast tissue (diffuse ou grouping), their number, their morphology and their size. Numerous calcifications throughout the breast with a a diffuse distribution are usually due to benign nature. Regional, segmental or linear distribution is often suspicious for malignity (FIG 2). Fine pleiomorphic calcifications and fine-linear or branching calcifications are the most suspicious for malignity. Mme Le Gall described a classification based on the morphology of the microcalcifications in relation to the risk of cancer.
Type I Microcalcifications (rim-like and tea-cup calcifications) are always associated with benign lesions. The type V corresponds to intraductal linear or branching microcalcifications and is associated with carcinoma in more than 90% of cases. Histologically, they represent intraductal calcifications of necrosis. The other types of microcalcifications are associated with variable risk of carcinoma. Another important criterion is the shape of the cluster as described by Lanyi: linear, triangular oriented towards the nipple or angular outline are suspect of cancer. Associated signs can be useful like macrocalcifications, skin abnormalities, nipple retraction.

**ULTRASONOGRAPHY**

Ultrasound is an important complementary imaging technique to physical examination and mammography. Mammography will always be first acquired for breast diagnosis. The only exception can sometimes be the case of a young woman with no past history, whose prior ultrasonography shows a palpable cyst or a mass typical of fibroadenoma. But one must always keep in mind the possibility of breast cancer also in very young women.

High frequency linear array transducers must be used (from 7 to 14 MHz) to correctly explore this superficial organ. New sonography units are performing with new software like Spatial or Frequency compound, Doppler imaging and Harmonic Imaging and Elastography. The examination is performed with the patient in supine position, sometimes slightly oblique to permit the lateral part of the breast to be scanned with the arm raised. The major indications of breast ultrasound are the differentiation between cyst and solid mass, the exploration of a palpable abnormality not clearly visible on mammogram (dense breast, protheses, mammographic opacity seen on only one incidence) or when the lesion cannot be radiographed (axillary or submammary locations). Guided aspiration, biopsy, or needle localization can be performed under ultrasound guidance.

**Diagnosis in Ultrasonography**

Ultrasound is essential for diagnosis of masses. It enables to characterize a cyst as simple, complicated or complex (FIG 4). When this mass is not a cyst, Ultrasound permits to evaluate the degree of suspicion with description of shape, margins, orientation, boundary, internal echo pattern and posterior...
acoustic feature. It will appreciate the shape which can be oval, round or irregular. The margins can be circumscribed, angular, microlobulated or spiculated. The orientation of the mass is parallel or non-parallel to the cutaneous surface, parallel axis of the mass being an argument for benignity. The boundary of the lesion is also important, abrupt interface is often benign, but more or less hyperechogenic halo can be seen in malignant lesions or abscess. The type of internal echo pattern is also important as posterior acoustic feature (no features, enhancement or shadowing). Shadowing is not a specific sign of malignant lesions and enhancement can also be observed. Macro or microcalcifications can sometimes be seen especially if they are included in a mass but ultrasonography is not a good exam for calcifications.

**Figure:** Vacuum Assisted Breast Biopsy guided by Ultrasonography

**GALACTOGRAPHY**

Galactography is a retrograde injection of water-soluble contrast material (2 ml) into a duct followed by magnified views. This procedure is indicated to explore a unilateral spontaneous serous or bloody nipple discharge localized in a single duct.

The procedure is always performed after an initial mammographic, ultrasonographic study and after samples of discharge for cytologic analysis. The injection provides an opacification of the ductal cavity. Pathologics signs are ectasias, stenosis, cut off, intraluminal defects and rigidity or deviation of the duct. Unfortunately, these signs can be observed in benign and in malignant conditions so that surgery is often required. The main interest of galactography remains in pointing out the causal duct to program pyramidectomy or to identify peripheral lesions that could be missed by standard surgical duct excision.

**Pre-operative needle localization procedure**

When a non-palpable doubtful lesion is detected by mammography, accurate guidance for the surgeon is necessary to permit the excision of this lesion while sacrificing the smallest amount of surrounding tissue (minimal cosmetic defect for benign lesions). Localisation techniques can require the introduction of a needle in close proximity of the lesion. It can usually be performed under mammographic or ultrasonic guidance; sometimes CT or even when available MR can be used. Sometimes with surgeon’s agreement a simple skin marking can be sufficient. When preoperative localisation is made by mammographic procedure, the lesion must be seen on two prior orthogonal views. The view with the shortest mammographic distance to the lesion is chosen. Stereotactic devices permit to work out the space-coordinates of the lesion. Then the needle is passed in the direction of the beam and a wire hook can be left in place. The two next mammographic views control the good position of the needle tip which optimally is within 10 mm of the lesion. After removal of the lesion, an excised breast tissue radiograph must be done to control the complete removal of the abnormal tissue. (FIG 5)
COMPUTED TOMOGRAPHY

Helical computed tomography with iodine contrast injection is often used with success in quite the same indications of Breast MRI, the main limitation of its use being exposition to radiation. However this seems not to be a limitation in examination of the tumoral size and diagnosis of multifocality in breast cancer, in diagnosis of the recurrence in the treated breast, in the pre-operative location of lesion without mammo or ultrasonographic translation. The advantage of CT is the supine position of the patient like in ultrasonography, in opposition to MRI. It allows an easier comparison of the two methods and to complete an eventual positive CT by a targeted ultrasonography. Dedicated breast CT are actually in development.

MRI

Contrast breast MRI has been shown to have very high sensitivity in the detection of breast cancer, superior to 95% but also varying specificity depending on the type of examined breast ranging from 40 to 80%. False positive diagnoses are proliferative fibrocystic disease, adenomatous fibroadenomas, radial scars, fat necrosis, intramammary lymph nodes and breast parenchyma after surgery (during 6 months) or radiation therapy.

Indications

The main indications are screening in high risk women, search for primary breast cancer in patients with metastatic axillary lymph nodes, differentiation between benign post therapeutic changes and local recurrence in a breast treated for cancer, monitoring neoadjuvant treatment efficacy. Sometimes
it is used for the assessment of difficult cases after standard imaging. Diffusion weighted MR or Proton Spectroscopic Imaging following dynamic contrast breast MR are in evaluation for the diagnosis of masses and in monitoring of the tumoral size with neoadjuvant treatment indications.

**MRI technique**
Patients are studied in prone position with a dedicated coil and the exam is uni or bilateral. MRI with contrast injection brings to light tumoral neoangiogenesis. The exam includes T2 slices, T1 slices before and after bolus administration of contrast medium, with or without fat supression. Some post-processing techniques can be used like image subtraction, maximum image intensity... High resolution spatial technique is very important for assessing morphological features but kinetic informations about enhancement are also considered.

**MRI diagnosis**
Abnormal enhancement is defined as enhancement of higher signal intensity compared to the normal glandular tissue on contrast-enhanced images. It will be defined as a mass or a non-mass like enhancement. Masses are defined by their shape, margin and internal enhancement. Malignant lesions typically have an irregular shape, spiculated margins and heterogenous or rim internal enhancement. Benign lesions are more often round or oval, with smooth margins homogenous internal enhancement or sometimes dark internal septations. Abnormal enhancement can be a non mass. When its size is less than 5 mm, it is called focus and cannot be taken into account when there is no concordant mammographic or sonographic sign. Non mass enhancement can be described by its spatial distribution as ductal, segmental, regional or diffuse distribution and its internal enhancement pattern (homogenous or heterogenous, punctuate, clustered...).Kinetic analysis includes initial enhancement and time intensity-curve shapes that can be described as three types: a persistent curve (continuous enhancement increasing with time) often seen in benign lesions, a “plateau curve” or a “washout” curve defined as a decrease in signal intensity after an initial peak often suggestive of malignity.

**ISOTOPIC BREAST IMAGING**
Positron Imaging Tomographic Scanning is usually used with 18F-fluorodeoxyglucose (FDG) as early evaluation for neoadjuvant therapy efficacy. Some new markers like FES (16alpha 18 F-fluoroestradiol-17beta ) are in evaluation in some indications. Some teams use PET scan for the initial evaluation of neoadjuvant therapy effect.

**GUIDED BREAST SAMPLING**
Imaging modalities are very useful to guide biopsy of non palpable suspicious lesions. The goal remains to avoid useless surgical approach for many benign lesions but also to prove invasiveness and to specify pathologic and immunohistochimic features of carcinoma. This procedure implies efficient collaboration between clinician, surgeon, radiologist and pathologist. Patient information and acceptance is required before each procedure. After biopsy multidisciplinary consultation is necessary to verify radiologic and clinical comptatibility with the pathologic result and for consensual management of images especially when the result is benign.

The sampling can be simple fine needle aspiration (FNA) for cytologic analysis and core needle biopsy (CNB). FNA provides cytologic information that is often sufficient for palpable lesions especially depending on the experience of pathologic and radiologic teams but in certains types of lesions, the sensitivity is very low. Biopsy provides better sensitivity (more than 95 %) especially with the technique of vacuum assisted breast biopsy.

The modality of biopsy guidance is chosen depending on the accessibility and the best imaging of the lesion. It can be stereotactic guidance which is especially efficient for the diagnosis of microcalcifications, with 11 or 8 vacuum core. Ultrasound-guided biopsy can be performed with 14 G automated gun biopsy but also more recently with vacuum-assisted core 11 and 8 G with very good results. (FIG 6). MR guided needle localization and now biopsy system are developing but it still is a time and machine consuming procedure.
Breast imaging

Breast diagnosis

The Breast Imaging Report and Data System (BIRADS) of the American College of Radiology (ACR) is today largely used in most of the countries where breast cancer screening is implemented. At the beginning, BIRADS was only devoted to mammography but the fourth version of the American edition, published in 2003 is completed by ultrasonographic and MRI lexicon. BIRADS lexicon includes a list of mammographic, ultrasonographic and MRI terms and an atlas containing illustrations of each feature. In France the Societé Française de Radiologie translated the BIRADS lexicon in classification “ACR.” The aim of this classification is to standardize the terminology in each report, to deliver recommendations of the action to be taken, according to the probability of breast cancer risk. It permits also assessment of the findings and audit of screening programs.

The first item concerns the composition of the breast: type 1: fatty breast (less than 10% of dense tissue), type 2: fibroglandular (10-49% dense tissue), type 3 heterogenous dense (49-90% of dense tissue), type 4 dense and homogenous (more than 90% dense tissue). Breast density is an independent risk factor for breast cancer and also decreases mammographic sensitivity.

Additional ultrasonography is often useful to complete the mammographic examination in type 3 or 4 breasts. Then report describes each breast according to breast lexicon in mammography, ultrasonography or MRI when done, and the final conclusion is delivered according to the following BIRADS categories, taking into account the worst classification.

<table>
<thead>
<tr>
<th>BIRADS 0</th>
<th>Incomplete, need for an additional imaging evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIRADS 1</td>
<td>Normal. Normal interval follow up</td>
</tr>
<tr>
<td>BIRADS 2</td>
<td>Typically benign. Normal interval follow up</td>
</tr>
<tr>
<td>BIRADS 3</td>
<td>Probably benign. A short interval follow up is</td>
</tr>
<tr>
<td></td>
<td>recommended: 4 month follow up for masses and 6</td>
</tr>
<tr>
<td></td>
<td>months follow up for microcalcifications</td>
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<tr>
<td>BIRADS 4</td>
<td>Suspicious abnormality: a biopsy should be considered</td>
</tr>
<tr>
<td>BIRADS 5</td>
<td>Highly suggestive of malignancy. Surgery should be</td>
</tr>
<tr>
<td></td>
<td>performed. Sometimes with prior Biopsy for neoadjuvant</td>
</tr>
<tr>
<td></td>
<td>therapy or when sentinel node imaging is included in</td>
</tr>
<tr>
<td></td>
<td>treatment</td>
</tr>
<tr>
<td>BIRADS 6</td>
<td>Histologically proven malignancy. Imaging is</td>
</tr>
<tr>
<td></td>
<td>performed for cancer staging or evaluation after</td>
</tr>
<tr>
<td></td>
<td>neoadjuvant therapy</td>
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</table>

However this classification doesn’t take into account extra-technical elements important in breast diagnosis like the patient’s age, past or familial history, risk factors for breast cancer like BRCA 1 or 2 mutations nor does it give elements of clinical examination. These elements can change the management of an image.

**Mammography:**

**Typical Benign Aspects BIRADS 2**

Some masses and clusters of calcifications may be qualified of typically benign, and necessitate no subsequent control.

**Benign Masses**

Normal intramammary lymph nodes are usually small (less that one centimeter) and located in the upper outer quadrant of the breast, near a vessel. It is typical when it has a central or lateral lucency corresponding to the hilar notch. In sonography it can be an oval mass, normal when large hilar hyperechogenicity and fine homogenous cortex are seen. In MRI it is often an oval mass with circumscribed margin with hilar hyper T1 and T2, hypo T1 with fat saturation. But enhancement can be early and intense. Masses with fatty components (FIG 7) can be identified as benign like Hamartoma (as breast in breast in mammography and in ultrasonography). It can also be oil cyst, lipoma or
galactocele. Architectural distortions can be also classified BIRADS 2 when it is clearly related to prior surgery and not modified on successive mammograms.

For diagnosis of a well circumscribed mass, ultrasonography is necessary to distinguish between cyst and solid mass. Cysts may be round, oval or flat, well circumscribed with abrupt interface with the normal breast tissue and often anechoic with posterior enhancement. A typical cyst can be classified BIRADS 2 (FIG 8). Atypical cyst because complex (association of anechoic and solid parts) or complicated (not anechoic) is classified as suspicious (BIRADS 4) and may necessitate aspiration with cytologic analysis.
TYPICAL BENIGN CALCIFICATIONS, BIRADS 2
Calcifications that can be identified as always benign on mammography are typically large, coarse, round. It can be skin, suture, vascular calcifications, “eggshell type” calcifications in cysts, coarse or pop-corn like of fibroadenoma. Linear Macrocalcification are often associated with ductal ectasia but at the early stage it can be difficult to distinguish them from ductal cancer. Round calcifications associated with lucent centered calcifications, diffuse distribution of punctuate calcifications are also benign in aspect. Deposit of calcic milk in microkystic dystrophy will give the aspect of curvilinear upwards appearance on mediolateral view or tea-cup aspect.

PROBABLY BENIGN IMAGES, BIRADS 3
The primary rationale behind probably benign assessments is to reduce false-positive recommendations for biopsy while maintaining an acceptably high detection rate of early-stage cancer. The likelihood of malignancy in these lesions is defined to be under 2%. These lesions must be controlled over a period of at least two years. Neither age of the patient nor size of the lesion modify the attitude of surveillance of these images as demonstrated by Sickles. On the other hand if this surveillance may be impossible or difficult (pregnancy, hormonal treatment ..), biopsy may be indicated. The same is true of such lesions for women with high risk for breast cancer. Three types of mammographic lesions can be assessed as probably benign: circumscribed masses, small clusters of round (or punctate) or oval calcifications and focal asymmetry.

Fibroadenoma (FAD) is the main tumor of the young woman (FIG 9). Well circumscribed in mammography and in ultrasonography, the mass will often be homogenous, oval or macrolobulated (3 or less lobulations), the main axis being parallel to the cutaneous surface. This aspect is sufficient to evoke a FAD that should be controled 4 months later. Sometimes MRI is performed for another cause and typical aspect of ADF in MRI must be known: a circumscribed mass with smooth margins hyper or iso on T2 weighted sequence, hypo T1 with homogenous or heterogenous pattern with dark septationsand enhancement. Kinetic analysis of enhancement curve often shows persistent curve (continuous enhancement increasing with time). If a mass suggestive of FAD changes, it should be classified BIRADS 4 and be biopsied in order to permit differential diagnosis of round benign or malignant tumors (FIG 10)

SUSPICIOUS ABNORMALITIES, BIRADS 4
This category groups together many images with various levels of risk for cancer but likehood of carcinoma more than 2 % makes histologic study necessary. This former will be done with percutaneous biopsy. In this class are included: New clusters of few fine pleomorphic calcifications (FIG 11), amorphous or indistinct calcifications, numerous punctate regular microcalcifications which shape of cluster is not round nor oval, coarse heterogenous calcifications, Architectural distortion without known scar, Assymetry of density with convex margins, Non cystic mass with microlobulated margins, obscured or recently increased, Spiculated images without dense center that are sometimes due to a radial scar but which can be associated with carcinoma like tubular carcinoma.
Figure: BIRADS 4 Metaplastic carcinoma

Small cluster of polymorphic calcifications

Figure: Suspicious Image, BIRADS 4, Biopsy: In Situ Carcinoma

HIGHLY SUGGESTIVE OF MALIGNANCY IMAGES, BIRADS 5
In these images, the likelihood of malignancy is high and the biopsy before surgery has strategic interest to precise the pathologic, immuno-histochemic or even genomic characteristics of the tumors. But sometimes such BIRADS 5 aspects can be observed in some benign lesions like FAD. Highly suggestive of malignancy are spiculated masses with dense centers (FIG 12), III defined masses with irregular margins (FIG 13), irregular spiculated masses with associated pleomorphic calcifications. For the calcifications, numerous fine pleomorphic calcifications, fine linear or fine-linear branching calcifications (FIG 14), linear or segmental distribution of calcifications whatever their morphology, are very suspec of malignancy.

Figure: Suspicious malignant mass, BIRADS 5
Invasive ductal carcinoma is the most common breast cancer histologic type (70-80% of all cases). Invasive lobular carcinoma is the second most common histologic type (5-10%). This form is associated with a high rate of multifocality and bilaterality. Other less common cancers are the tubular, papillary, medullary and mucinous cancers. Sarcomas, Phyllod tumors grade 3, Angiosarcomas and Lymphomas are other types of malignant tumors. When basement membrane is intact, the carcinoma is called in situ: ductal in situ (DCIS) or lobular in situ carcinoma (LCIS). 30-50% of DCIS will develop invasive form in the next 10 years. LCIS is considered to be a marker of increased risk for invasive cancer of all forms.

Preoperative staging.
Mammography is always the first exam to be done. In women with dense breasts, the sensitivity of mammography can be low (around 68%). About 10% of cancers are mammographically occult. Ultrasonography is a good complement to mammography especially in the case of dense breasts. Questions to be checked are tumoral size, multifocality or multicentricity and controlaterality.

Tumoral size:
Mammography is performant to determine the tumoral size when the breast is fatty or little dense. The measure is more accurate when the opacity is round than when it is spiculated and in that case the measure must take into account the dense center and the spiculated continuations, where tumor can also
be seen. But mammography fails to determine exact size of a tumor when the breast is dense or when the tumor is inflammatory. In these cases, Ultrasonography gives better correlation for tumoral size with pathologic correlations. MRI is good exam for the evaluation of tumoral size because of good correlations with histologic size. In the case of Microcalcifications, size of focus in mammography is very important but in the in situ carcinoma the tumoral size is often underestimated (especially if for low grade tumors). MRI doesn’t offer better size evaluation because of false negatives for CCIS (low or high grade) and can also overrate lesion extension. MRI will offer informations about pectoral or chest wall invasion.

**Multifocality- multicentricity- Controlateraly**
When mastectomy was performed instead of lumpectomy for unifocal breast cancer; pathologic analysis found that 20 % of cancers had additional focus of carcinoma in less than 20 mm away of the known cancer, 27 % had in situ carcinoma and 14 % invasive carcinoma at a distance superior to 20 mm; for this reason it appears important to search for other lesions. The association of mammography and ultrasonography is sufficient in fatty breasts for this approach and MRI doesn't offer any supplementary aid. But when breasts are dense, MRI is able to detect additional mammographically occult lesions in 30 % of cases permitting the diagnosis of multifocality (within different quadrants) or multifocality (within the same quadrant of the breast), more often when the patient has a familial history for breast cancer or in lobular invasive carcinoma (FIG 15 -16).

Contralateral associated cancer can also be detected in approximately 5-10 percent of cases with normal clinical exam and mammography. However, MRI is a very sensitive technique but not specific enough; so detection of suspicious enhancement must be proved as malignant because it could lead to surgical modification (mastectomy instead of lumpectomy in 17 % of cases). Secondly targeted sonography after MRI can find an abnormality in approximately 30% of cases, allowing a biopsy procedure. When there is no sonographic or mammographic translation, histologic analysis should be done by Biopsy under MRI guidance or by surgical approach after CT or MRI localisation procedure. The population that could benefit of this MRI extension assessment could be when cancer is not correctly analyzed (dense breast) or not seen (palpable masses without mammo or ultrasonographic translation, carcinoma lobular invasive, suspicion of multifocality, when a parietal extension is suspected, when radiotherapy could be contraindicated or before beginning a neo-adjuvant therapy.

**Neoajuvant therapy response**
Response to Neoajuvant therapy is important because a complete pathologic response is a good predictor of long term survival. It can be appreciated with Conventional imaging especially for evaluation of unifocal lesion in fatty breasts. Delineation of the lesion is important and there is a high correlation with the size when more than 50 % of the tumor margin is seen. When microcalcifications due to the association to in situ carcinoma are present, they can persist even in good responders or they...
can appear under treatment secondary to necrosis. The question of surgeons is to identify patients who could have a breast-conserving surgery. MRI is a better exam for the estimation of residual disease than mammography or ultrasonography. But sensitivity for evaluating residual tumor must still be studied because it seems to be perfectible. In some small series, patients without residual enhancement on MRI still had residual lesions on pathologic analysis. On the other hand, MRI is good for detection of non-responder or progression. In broad outline, at the end of the treatment, MRI can depict three types of response: Tumoral stability or progression, Concentric shrinking of the tumor leading to disappearance of the visible tumor, fragmentation of the tumor that is contre-indication for conservative surgery. For predicting early response after initiation of the treatment, MRI, FDG-PET Imaging and MRI Spectroscopy seem to be promising.

**Tumor recurrence after lumpectomy**

Tumor recurrence after lumpectomy occurs at the rate of 10-15% in 20 years, almost 2% per year during the five first years. Follow up consists in a first mammography 6 months after the end of therapy and then annually. Ultrasonography is useful to precise mammographic abnormalities. The comparison of successive mammographies is a precious aid. Normal Aspect: During the first mammographic controls skin thickening and architectural distortion due to surgical scar can be observed. Ultrasonography may be useful to eliminate mass syndrome but doubtful images can be created by post-therapeutic fibrous tissue. Fat necrosis can appear after treatment and the early form can be confusing. Typically it presents like a densification or architectural distortion associated with a fine limited lipomatous image. Calcification can appear in the periphery, typical when clear at the center macrocalcifications, sometimes ambiguous at the early stage and needing an earlier control.

Abnormal aspect: A mass or microcalcifications emergence are usual aspects but can also only be scar modification or densification increase. In these cases, MRI can be very helpful: Indeed in the treated breast, MRI is more specific than in the non treated breast because with radiotherapy, normal or dystrophic breast tissue often does not enhance anymore. So the VPN and the specificity of MRI is very high and allows not to biopsy treated breast if there is no enhancement. When enhancement is observed, biopsy will be performed according to the best radiologic translation.

**Breast cancer Screening**

Mass screening for early detection of breast cancer is available in many countries. In the general population, the risk of breast cancer is 0.6% per ten-years period before 40 years and 2.8% for the fifth ten years period, so one woman per 8 can be concerned. The aim of early detection is to treat earlier and to decrease mortality. The international quality criterions of a screening campaign are a participation rate up to 70%, a reconvocation rate inferior to 7%, a PPPV of biopsy superior to 50% and a rate of interval cancer inferior to 2%. In the general population, screening procedure rests on high quality mammograms and permanent quality control of the complete chain of mammography from the technical acquisition to the radiologist. Clinical examination improves detection. Sensitivity of mammography is better in breast type 1 or 2 than in type 3 or 4 (respectively 98, 85, 83, and 68%). The use of CAD does not improve detection rate and can’t take the place of second reading. The association of ultrasonography in dense breasts clearly improves sensitivity of mammography. There is no indication of MRI in screening of the general population because MRI is less performant than mammography for microcalcifications and it is sensitive but not very specific and the rate of recall may be to important.

On the other hand, it is now demonstrated that screening in the population of women with a high risk of cancer and with genetic mutations like BRCA1 or 2, rests on association of annual mammogram, ultrasonography and MRI, because these young women, who often have dense breasts, also may have round cancer, high grade cancer or interval cancer (FIG 17). The sensitivity of mammography alone is lower and needs the adjonction of ultrasonography if possible targeted after MRI.
Conclusion
During the past ten years, technical improvements have been essential for breast imaging: Evaluation of digital mammography proved to be competent for breast cancer screening, improvement of sonographic installations, extension and evaluation of Breast MRI, diversification of percutaneous biopsy with all modalities of guidance, new technical developments like tomosynthesis, MRI spectroscopy. If primary senologic evaluation always lies on clinical exam, mammography and ultrasonography, it’s now relatively clear that MRI can be essential in care of breast cancer for preoperative staging, evaluation of neoadjuvant therapy response, supervision of treated breasts, but also for screening of women with high risk for breast cancer like genetic mutations BRCA1 and 2 carriers.