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Learning Diagnostic Imaging

100 Essential Cases

With Contributions by

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To my daughters
Rosario and *Reyes*

Ramon Ribes

To all
my *teachers*
especially to the most motivating ones

Antonio Luna

To all
my *teachers* and *students*,
for enriching me with energy and
enthusiasm. Among my teachers,
a special mention to
my *parents*
(for my father, in memoriam),
my *brother*, my *children* and my *wife*

Pablo R. Ros

Preface

In my first days as a Radiology resident I remember myself in dire need of a book in which I could begin to study the specialty. In those days I was thirsty for radiological knowledge and was recommended a classic manual on conventional chest X-ray which was the very same the oldest radiologist of the staff had studied when he was a beginner. Unfortunately the book I was recommended covered less than 5% of the specialty as it is conceived nowadays.

"Learning Diagnostic Imaging. A Teaching File" is intended to provide medical students, residents of Radiology, and anybody else beginning to be involved in the radiological world, with a useful tool that gives them a quick and comprehensive overview of Radiology. With this book, written in a user-friendly format, Radiology residents, nurses, technicians, and medical students would see their first radiological images in a sort of introduction of what will become their professional activities in the rest of their lives.

One of the main problems that Radiology residents face throughout their residency is that in rounds and clinical sessions they receive information they cannot apprehend because they lack the essential background needed to integrate what they are taught. For example, when, in a radiological session, a resident is looking at an angiogram and has no prior interventional radiology education, he/she inevitably misses the opportunity of learning by being exposed to a great deal of information without the necessary tools to assimilate it. Whenever a mammogram is shown at the radiological session, a first year resident, who has no prior training on breast imaging, knowing beforehand that he is not supposed to be asked about it, loses interest in the subject and it is likely that his mind drifts away until the next case is shown. In clinical sessions, the level of concentration of residents is optimal only in the cases they have prior education on.

With this book, residents independently of their year of residency, would count on the foundations of the specialty as a whole and optimize their time in rounds and clinical sessions. Although initially aimed at Radiology residents, the book would be useful, on the one hand, for medical students, Radiology nurses and technicians and, on the other hand, for senior radiologists and residents and referring physicians of other specialties. As a way of example, the breast imaging senior radiologist would have a basic overview of cardiac imaging at his disposal in just a few pages that otherwise would be impossible for him because no mammographer is supposed to be interested in classic cardiac imaging books as no cardiovascular radiologist has any interest in breast imaging manuals.

The scarcity of books of this sort is easily understandable taking into account that Radiology is divided up in many subspecialties that constitute a universe of their own. To convey an overall view of the specialty is extremely difficult nowadays and will be even more difficult in the future because, due to the fragmentation of the specialty, the old-days only Radiological session, which was attended by the whole Department, has been replaced by a myriad of subspecialty sessions that, by definition, cannot be attended by the entire Radiology Department.

Cordoba, November 22, 2007 Ramon Ribes

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Breast Imaging

1

Marina Alvarez Benito and Julia Camps Herrero
Melcior Sentis Criville and Maria Martinez Galvez (Contributors)

Introduction

A breast imaging unit performs a variety of diagnostic techniques and image-guided interventional procedures. Mammography, ultrasound, galactography, and magnetic resonance imaging (MRI) are some of the most widely used modalities in breast imaging. Common image-guided interventional procedures in the breast are percutaneous biopsies guided by stereotaxy, ultrasound, or MRI, preoperative marking of non-palpable lesions, and the injection of radioactive substances in sentinel node biopsy.

The widespread use of mammography as a screening method for breast cancer in asymptomatic women has introduced many improvements in both the technique itself and in radiologists' reading skills. The BI-RADS (Breast Imaging Reporting and Data System) categories are now widely used in mammographic interpretation and reporting, allowing for uniformity in reports and improving communication between radiologists and clinicians. The latest edition includes a section for breast ultrasound and breast MRI, reflecting the progressively extensive use of these imaging modalities in breast imaging.

After mammography, ultrasound is undoubtedly the most widely used imaging technique in breast imaging: it is the only imaging modality employed in young patients and is a complementary method to mammography in older patients, as well as a crucial technique in image-guided procedures.

Breast MRI has recently been acknowledged to have the highest sensitivity for breast cancer. The main indications for breast MRI are local staging in patients with breast cancer, searching for the primary tumor in cancer of unknown origin, assessing the integrity of breast implants, monitoring the response to neoadjuvant chemotherapy for breast cancer, and screening in high-risk patients. The use of MRI by experienced professionals has been demonstrated to influence the therapeutic approach in breast cancer patients.

One of the most important improvements in recent years is perhaps the introduction of percutaneous breast biopsy procedures. Percutaneous breast biopsies enable histological study of a lesion with lower costs and less morbidity than a surgical biopsy. Various systems, gauges, and methods of approach enable us to biopsy almost any type of breast lesion. Breast interventional procedures are not limited to obtaining material for histologic diagnosis or placing markers for surgical guidance: percutaneous excision or radiofrequency ablation of breast cancers are promising techniques that are currently in the developmental stages.

The diversity of therapeutic approaches to breast cancer, such as breast-conserving surgery, sentinel node biopsy, or systemic treatment with chemotherapy entail important consequences for radiologists, because we are expected to provide accurate information on the size, number, and distribution of tumors, the condition of regional lymph nodes, as well as the outcome of systemic or surgical therapies.

Digital imaging also poses new challenges and opportunities, enabling us to improve our diagnoses through better image quality and the introduction of new imaging algorithms.

In summary, the breast imaging unit is at present a dynamic and wide-ranging section that assumes great responsibilities in the diagnostic and therapeutic process of breast cancer, working together with the rest of the specialist physicians dedicated to breast diseases.

Case 1
Ductal Carcinoma in Situ

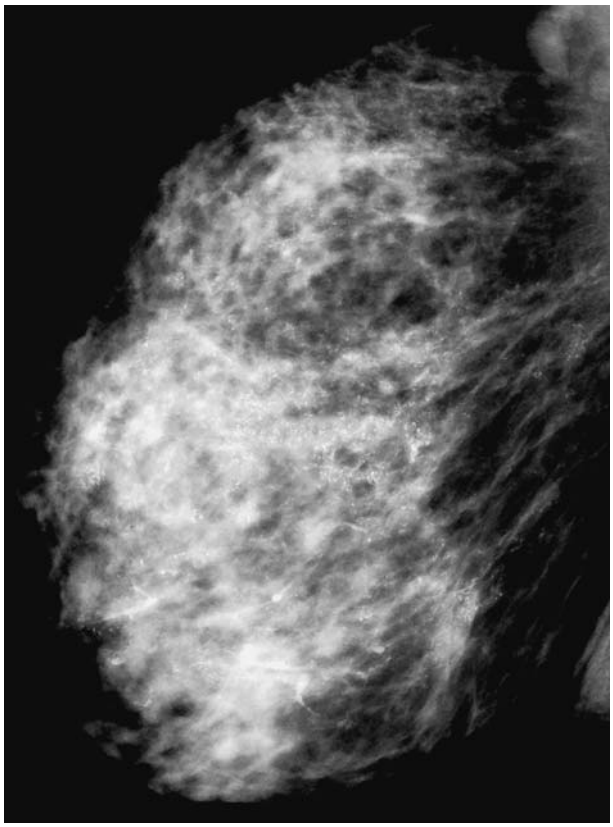

Fig. 1.1.1

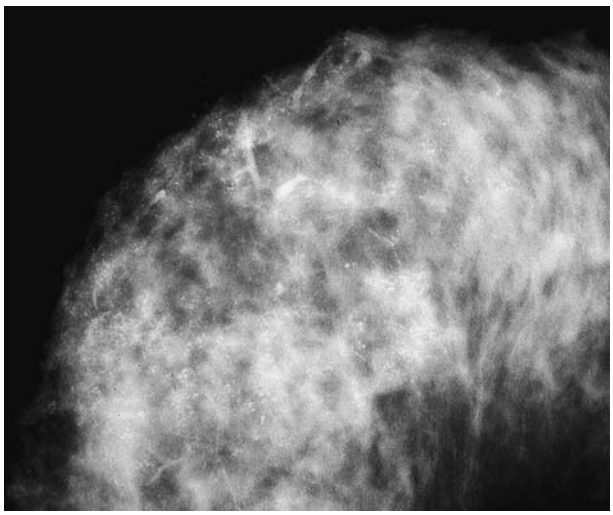

Fig. 1.1.2

Fig. 1.1.3

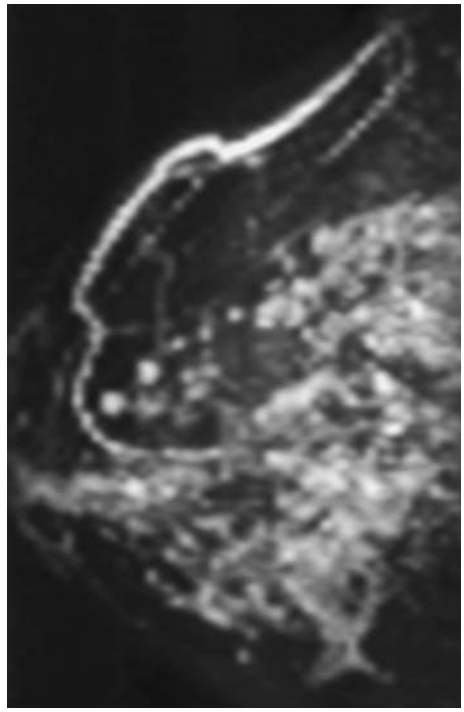

Fig. 1.1.4

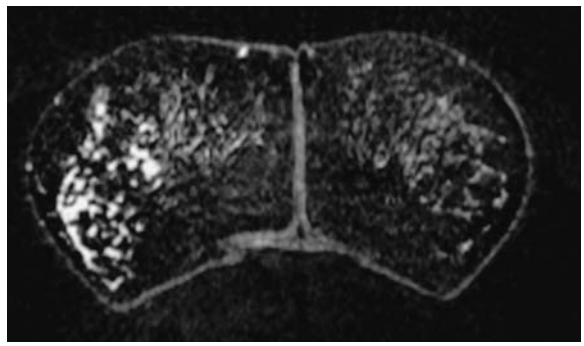

Fig. 1.1.5

A 57-year-old woman presented with spontaneous bloody nipple discharge from the right breast and no palpable abnormalities. The patient had no family history of breast cancer and had already reached menopause but was not on hormone replacement therapy. A mammogram showed extensive microcalcifications in both outer quadrants of the right breast. Ultrasound showed a diffuse area of decreased acoustic through-transmission and an ultrasound-guided biopsy with a 14-gauge needle was performed. Core-biopsy histology revealed a high-grade ductal carcinoma in-situ (DCIS). Axillary ultrasound revealed no suspicious lymph nodes. A breast MRI was then performed to stage the patient's disease and revealed a segmental enhancement distributed in both outer quadrants, but no other suspicious enhancing areas were identified in the rest of either gland. The patient was treated with a right mastectomy due to the extensive and multicentric distribution of the disease and histopathology confirmed high-grade comedo DCIS in all four quadrants and a negative sentinel node biopsy (G3 pTis pN0 pMx).

Comments

Ductal carcinoma DCIS is a malignant intraductal epithelial proliferation that is confined to the duct by its basement membrane. It manifests with a variety of histologic patterns and can be broadly divided into comedo (high-grade) and non-comedo subtypes. Comedo refers to the plug-like appearance of necrotic material that fills the affected ducts. This necrotic debris results in the typical fine, linear branching pattern of calcifications seen on mammography. Granular pleomorphic microcalcifications are uncommon in comedo DCIS. Comedo DCIS is considered to be the more aggressive DCIS subtype and tends to present more malignant cytologic features and behavior than non-comedo DCIS. It has, therefore, a higher probability of microinvasion. Mammography is the imaging test of choice in DCIS; it shows rod-shaped linear, branching or granular calcifications. Microcalcifications can be very unspecific; therefore, all suspicious microcalcifications are biopsied. MRI is an adjunct to mammography that is used to stage the disease extension and is particularly useful in dense breasts, but although the sensitivity of MRI for high-grade DCIS is relatively high (80–90%), low or intermediate grade DCIS show variable degrees of enhancement.

Imaging Findings

Oblique mediolateral and partial craniocaudal mammographic views (Figs. 1.1.1 and 1.1.2) show a dense breast pattern and diffuse granular and branching microcalcifications extending over both outer quadrants. Maximum intensity projections (MIP) of the corresponding breast MRI (Figs. 1.1.3 and 1.1.4) in craniocaudal and lateral views show diffuse enhancement in both outer quadrants. Coronal subtraction MRI image (Fig. 1.1.5) depicts enhancement in the breast that shows nodular and linear morphology patterns, highly suggestive of DCIS.

Case 2
Invasive Ductal Carcinoma with MRI Staging

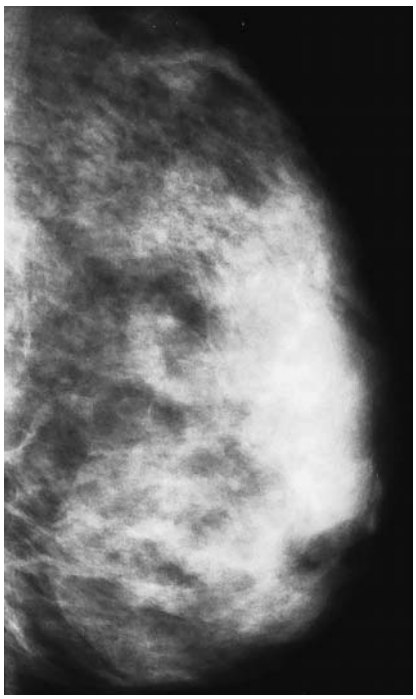

Fig. 1.2.1

Fig. 1.2.2

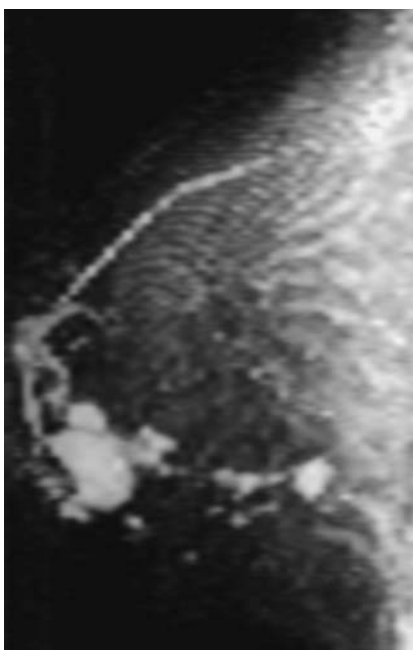

Fig. 1.2.3

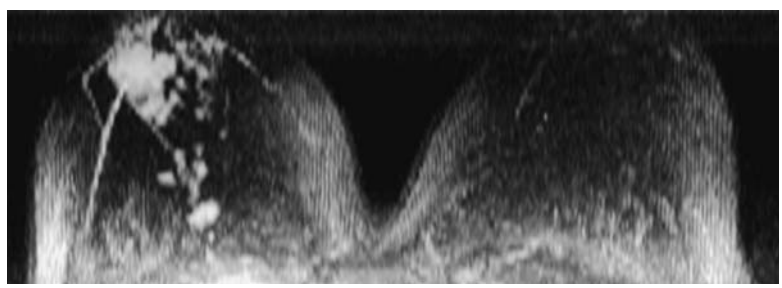

Fig. 1.2.4

A 32-year-old woman without a family history of breast cancer presented with a palpable lump in the lower-outer quadrant of the left breast. Four months earlier, breast ultrasound diagnosed a fibroadenoma in the same location but she had noticed that the palpable lump had become harder and had increased in size. Ultrasound was performed first and showed two ill-defined microlobulated solid masses that were biopsied with a 14-gauge needle because of the morphology and the rapid growth of the palpable lump. Axillary ultrasound showed no suspicious lymph nodes in the left axilla. Mammography showed dense breasts but no other remarkable findings. Core-biopsy histopathology showed an invasive ductal carcinoma (IDC). Breast MRI was performed to stage the disease and a multifocal distribution in the union of both lower quadrants with sparing of the nipple-areola complex was found. The patient underwent breast conserving surgery. Histological study of the surgical specimen confirmed IDC, not otherwise specified, grade II (pT2, pN0, pMx), and all the margins were free of tumor within 10 mm.

Comments

Invasive (or infiltrating) breast cancer can be broadly divided into ductal and lobular subtypes. Invasive ductal carcinoma accounts for the majority (90%) of invasive breast cancers and can be further divided into those "not otherwise specified" (NOS) and "special type" tumors. NOS breast carcinomas account for 50–75% of all invasive breast cancers. Their most distinctive appearance in mammography is that of a spiculated mass, although in women with dense breasts the margins of the tumor may be difficult to identify. Mammography has a 85–90% sensitivity for breast cancer; however, in dense breasts this figure drops to 40–60%. In these cases, palpation and ultrasound play a major role. At ultrasound, IDC shows decreased through-transmission and irregular margins. Breast MRI is increasingly being used to stage invasive breast cancer because its capability to depict tumor angiogenesis is independent of breast density. In expert hands, breast MRI improves breast cancer staging and changes the initial therapeutic approach planned taking only mammography and ultrasound into account in 18–30% of patients.

Imaging Findings

Oblique mediolateral view of the left breast (Fig. 1.2.1) shows a dense breast pattern where no distinct breast masses can be identified. Ultrasound image (Fig. 1.2.2) depicts two solid masses with microlobulated margins. The presence of two adjacent masses raises the possibility of multifocal disease but only MRI (Figs. 1.2.3 and 1.2.4) is able to show the distribution of the multifocal tumor along the union of both lower quadrants, providing more accurate information to guide surgical excision.

Case 3
Breast Implant Rupture

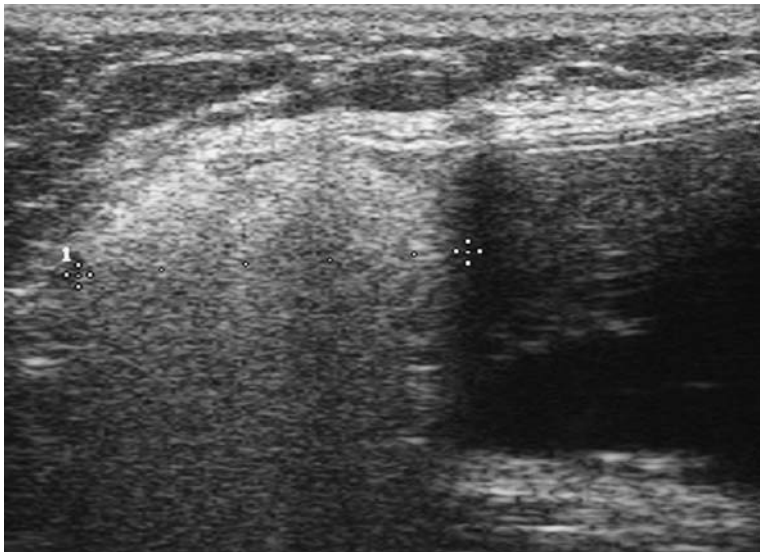

Fig. 1.3.1

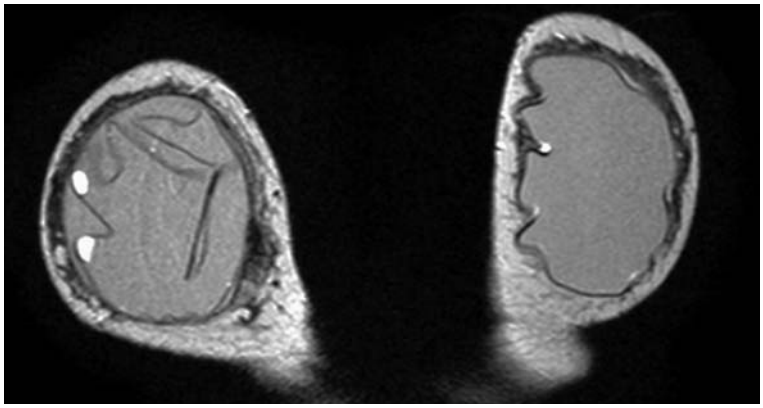

Fig. 1.3.2

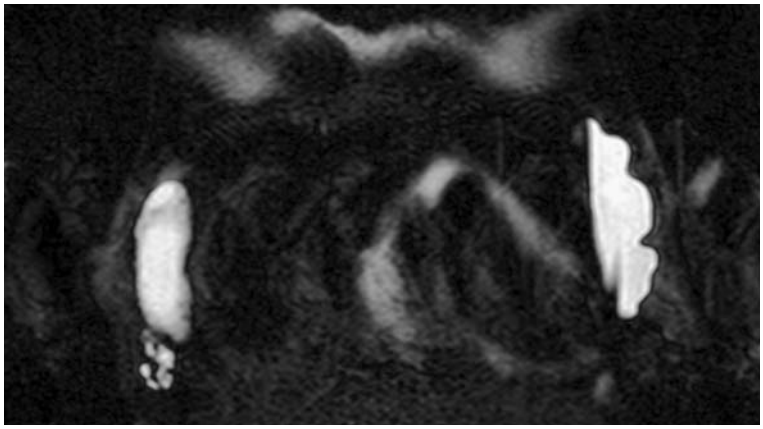

Fig. 1.3.3

A 42-year-old patient presented with pain and a palpable lump in the lower quadrants of the right breast. She had undergone a surgical procedure 10 years prior and had two retropectoral silicone breast implants. Breast ultrasound revealed an area suspicious for extracapsular silicone. Breast MRI was performed and an extracapsular rupture of the right breast implant was confirmed. A new breast implant was surgically implanted.

Comments

Breast implants can be classified as retroglandular or retropectoral depending on their anatomic location. In addition, taking into account the capsule of breast tissue surrounding the implant, breast implant ruptures are divided into intracapsular and extracapsular. This capsule begins to appear immediately after surgery as a natural foreign body reaction. Intracapsular ruptures leave the capsule intact around the implant and there is no extravasation of the implant's contents to the rest of the breast tissue or the lymph nodes. Conversely, extracapsular ruptures produce an extravasation of silicone or saline to the adjacent breast tissue or the lymph nodes. There have been concerns about the possibility of implants producing autoimmune diseases or cancer, but there is no solid evidence for that. Screening mammography is more easily performed in retropectoral implants. Breast MRI is generally accepted as the state-of-the-art technique for evaluating implant integrity, with a sensitivity of 74–100% and a specificity of 63–100%, depending on the technique applied and rupture criteria.

Imaging Findings

In Figure 1.3.1, an ultrasound image shows the "snow storm" sign caused by the presence of extracapsular silicone adjacent to the implant. In Figure 1.3.2, a T2-weighted MRI sequence shows the most certain sign of intracapsular rupture that usually accompanies extracapsular ruptures: the "linguine" sign, caused by the infolding of the implant's capsule within the silicone gel, often arranged parallel to the fibrous capsule. Small hyperintense droplets can be seen trapped between the folds of the ruptured implant capsule and are also a sign of rupture in double-lumen implants, where saline droplets mix with silicone gel. In Figure 1.3.3, a silicone-only MRI sequence, silicone droplets appear hyperintense, adjacent to but outside of the right breast implant in a 6 o'clock position. This is a certain sign of extracapsular rupture.

Case 4
Papillary Lesions

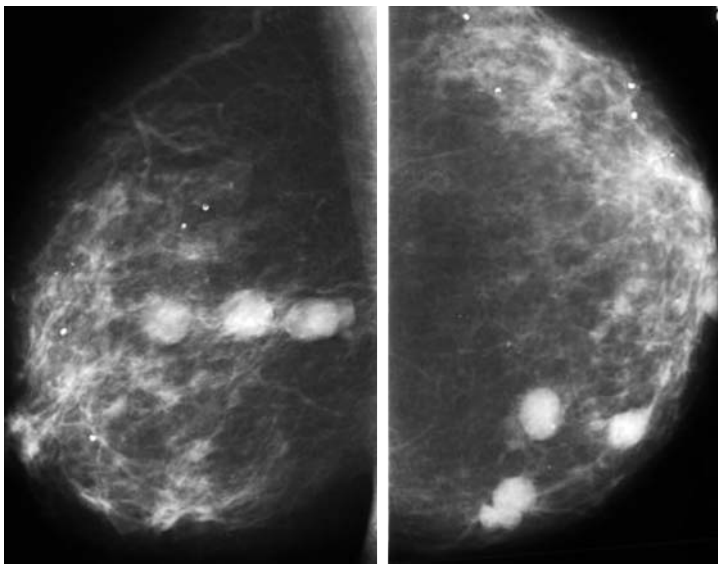

Fig. 1.4.1

Fig. 1.4.2

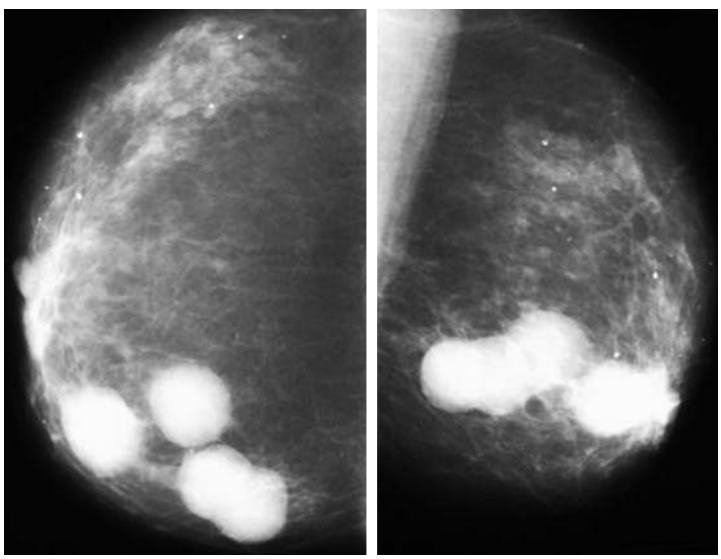

Fig. 1.4.3

Fig. 1.4.4

A 70-year-old woman presented with a right breast lesion adjacent to the nipple-areolar complex.

Physical examination revealed a well-circumscribed, mobile mass of firm consistency.

Bilateral mammography and diagnostic breast ultrasound showed multiple solid nodules with partly ill-defined borders in the right breast. Histological study of ultrasound-guided percutaneous biopsy samples yielded intraductal papilloma, and annual follow-up was recommended.

At follow-up mammography and breast ultrasound 12 months later, an increase in the size of the lesion was observed and surgical biopsy confirmed the existence of intracystic papillary carcinoma.

Comments

Papillary breast lesions constitute a varied and heterogeneous group of lesions, including intraductal papilloma, intracystic carcinoma, and papillary carcinoma, among others.

Except for intraductal papillary lesions, which tend to present clinically with nipple discharge, peripheral papillary lesions tend to appear at midlife, as single or multiple lesions, both synchronically and metachronically. Mammography characteristically shows one or multiple masses, which may be either well- or ill-defined; ultrasound shows mixed lesions with solid and cystic components.

The use of percutaneous biopsy in this type of lesions is controversial because cancer is often underestimated in these lesions with this technique; the false-negative results are probably due to their histological heterogeneity. Although findings of malignant papillary lesion after percutaneous biopsy permits therapeutic planning, surgical biopsy should be proposed in cases with findings of benign papillary lesion.

Some authors think that papillary lesions can evolve to become more aggressive and patients with papillary lesions present a higher probability of developing breast carcinoma. Papillary carcinoma has a better prognosis than other types of ductal carcinoma.

Imaging Findings

Mammography carried out at the time of initial consultation (Fig. 1.4.1) shows multiple rounded and oval-shaped masses with partly ill-defined borders in the right breast. Breast ultrasound (Fig. 1.4.2) confirms their solid nature.

In the 12 month follow-up mammogram and breast ultrasound, an increase in the size of the lesions can be observed. Their ill-defined contours are highlighted in the mammogram (Fig. 1.4.3). The ultrasound image is characteristic, showing mixed lesions, with cystic and solid components (Fig. 1.4.4).

Case 5
Microcalcifications

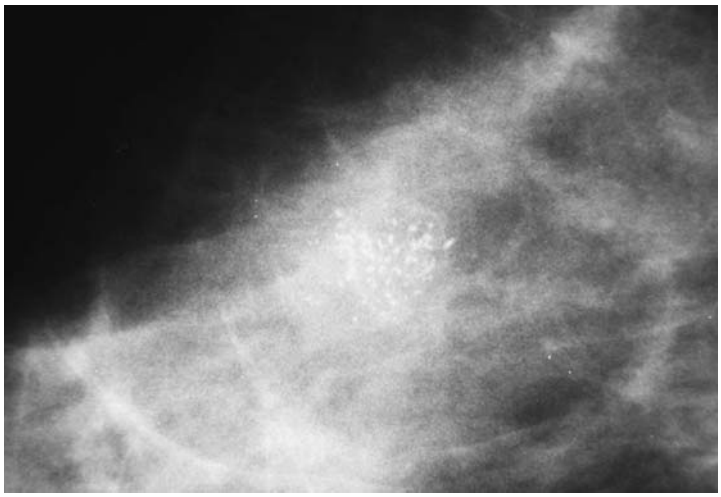

Fig. 1.5.1

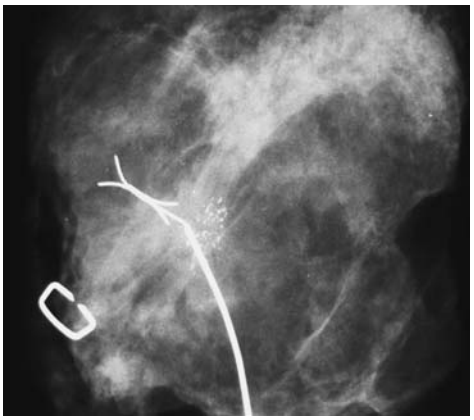

Fig. 1.5.4

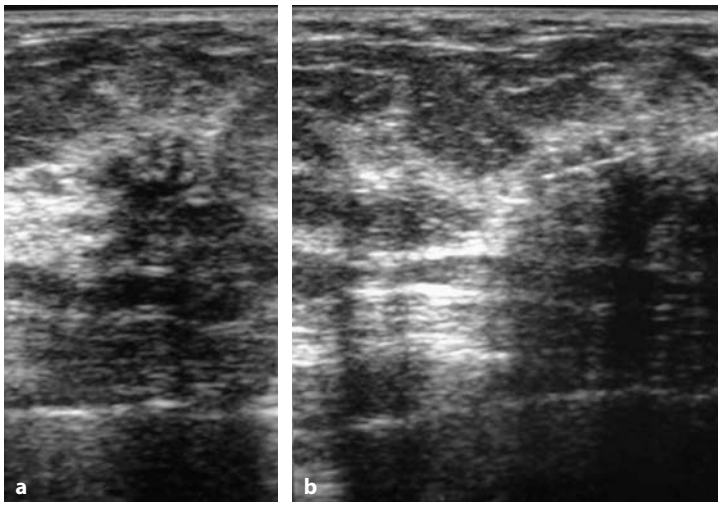

Fig. 1.5.2a,b

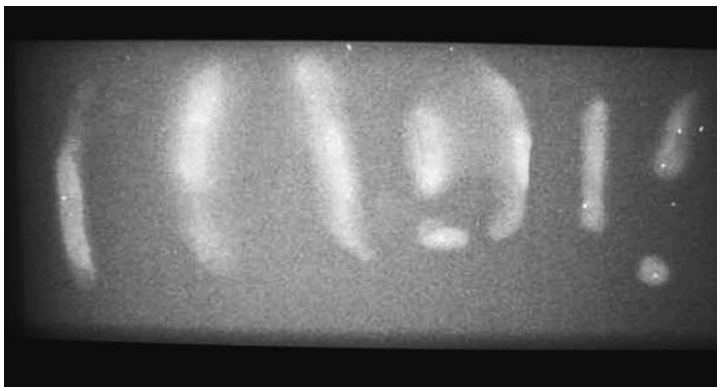

Fig. 1.5.3

A 55-year-old woman with unremarkable history was referred to the breast unit for a newly detected cluster of microcalcifications in the left breast at screening mammography.

Breast ultrasound confirmed the existence of microcalcifications in the upper-outer quadrant of the left breast, visualized as hyperechoic points on a hypoechogenic background. Histological study of material obtained at ultrasound-guided percutaneous biopsy yielded infiltrating ductal carcinoma with an in-situ component. The patient underwent tumorectomy and selective sentinel-node biopsy (SBSN). Definitive pathologic staging was stage I (T1 N0M0).

Comments

Programs for early breast cancer detection have favored the diagnosis of small lesions, without lymph-node involvement. In addition to having a more favorable prognosis, these lesions enable less aggressive treatments, such as conservative surgery as opposed to mastectomy or selective sentinel node biopsy instead of lymphadenectomy for axillary staging.

Microcalcifications are one of the forms of presentation of cancer and other breast lesions. The BIRADS system (Breast Imaging Reporting and Data System) recommends classifying them in relation to their morphology (typically benign, amorphous, heterogeneous, pleomorphic, linear, or linear and branching) and distribution (cluster, segmental, linear, regional and diffuse).

Pleomorphic microcalcifications are suspicious for malignancy and are frequently associated to a carcinoma in-situ. Breast microcalcifications are usually biopsied under stereotactic guidance. On breast ultrasound, pleomorphic microcalcifications seen on a hypoechogenic background may signal the existence of an invasive component that calls for ultrasound-guided biopsy.

Imaging Findings

Magnified view of the upper-outer quadrant of the left breast shows a cluster of pleomorphic microcalcifications (Fig. 1.5.1). Ultrasound shows multiple hyperechogenic points in the left image (Fig. 1.5.2a) that correspond to microcalcifications on a hypoechogenic area. Figure 1.5.2b (right) shows the microcalcifications traversed by a hyperechoic line representing the biopsy needle (Fig. 1.5.2).

It is essential to perform a radiograph of the specimen to confirm the presence of microcalcifications in the biopsy cores (Fig. 1.5.3). Furthermore, a radiograph of the surgical specimen should be carried out if breast-conserving surgery of nonpalpable lesions is performed. Figure 1.5.4 shows the surgical specimen containing the lesions, which are traversed by the needle localization wire; all have acceptable margins and one is marked with a surgical clip.

Case 6
Architectural Distortion

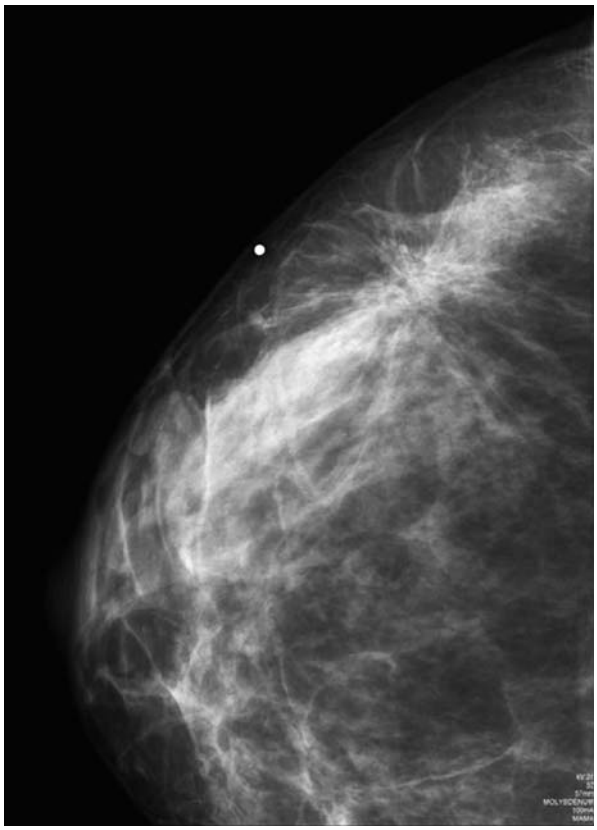

Fig. 1.6.1

Fig. 1.6.2

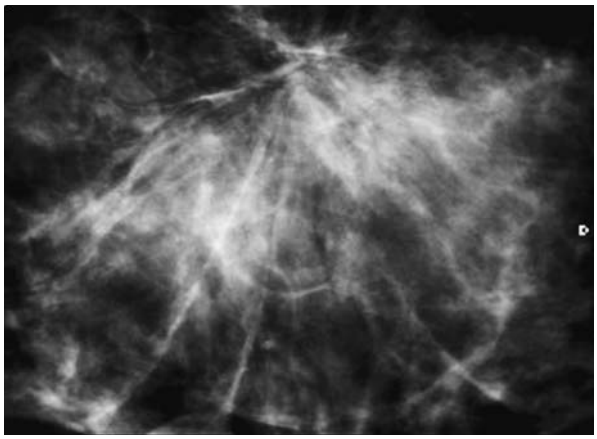

Fig. 1.6.3

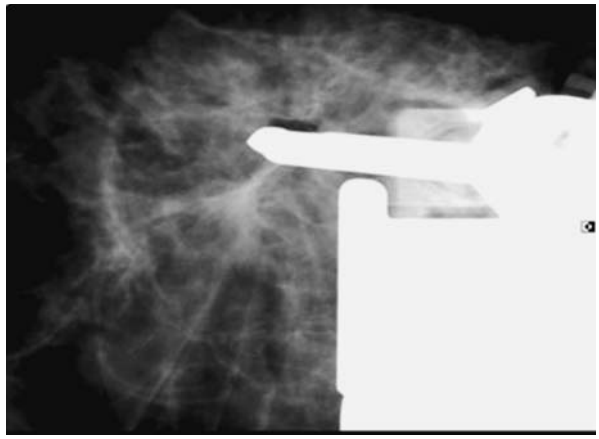

Fig. 1.6.4

A 25-year-old woman presented with a retroareolar mass. Breast ultrasound was initially performed and showed multiple bilateral circumscribed solid masses and a hypoechoic area in the upper-outer quadrant of the right breast.

The diagnostic study was completed with mammography, in which an image of architectural distortion in the upper-outer quadrant of the right breast could be observed. Histological study of material obtained by stereotactic-guided vacuum-assisted percutaneous biopsy found a radial scar, and this finding was confirmed in the surgical biopsy specimen some weeks later.

Comments

In patients younger than 35, or younger than 30 with a family history of breast cancer, breast ultrasound should be the first diagnostic test when there is a palpable abnormality. This test should be complemented with a mammogram when ultrasound does not show any abnormality or shows a suspicious lesion.

Architectural distortion is one type of mammographic presentation of breast pathologies. It is often a subtle finding, described as the reorganization of the mammary tissue toward an eccentric point from the nipple. There are strands of tissue that converge toward a point forming a typical "star" or "whirlwind" shape.

Approximately 50% of cases are malignant, and it is impossible to predict its benign or malignant nature by imaging tests alone. Biopsy should be performed in cases of architectural distortion without previous surgery, injury, or biopsy, although the performance of a percutaneous biopsy in these lesions is controversial, since underestimation of the lesion or false-negative results can be obtained.

Larger gauge needles, such as those used in vacuum-assisted biopsy, improve the accuracy of the technique in comparison to core needle biopsy. Some authors claim that when a minimum of 12 cylinders are obtained with these systems, surgical biopsy can be avoided in the absence of atypia.

Imaging Findings

Craniocaudal and oblique mammographic views of the right breast show architectural distortion or alteration in the distribution of the mammary tissue in the upper-outer quadrant; linear tracts converge toward a point forming the typical "star" shape (Figs. 1.6.1 and 1.6.2).

Localized view (Fig. 1.6.3) of the percutaneous stereotactic biopsy depicts the linear tracts converging toward a central point in greater detail. Figure 1.6.4 confirms the location of the biopsy needle in relation to the lesion.

Case 7
Breast Cancer in Men

Fig. 1.7.1

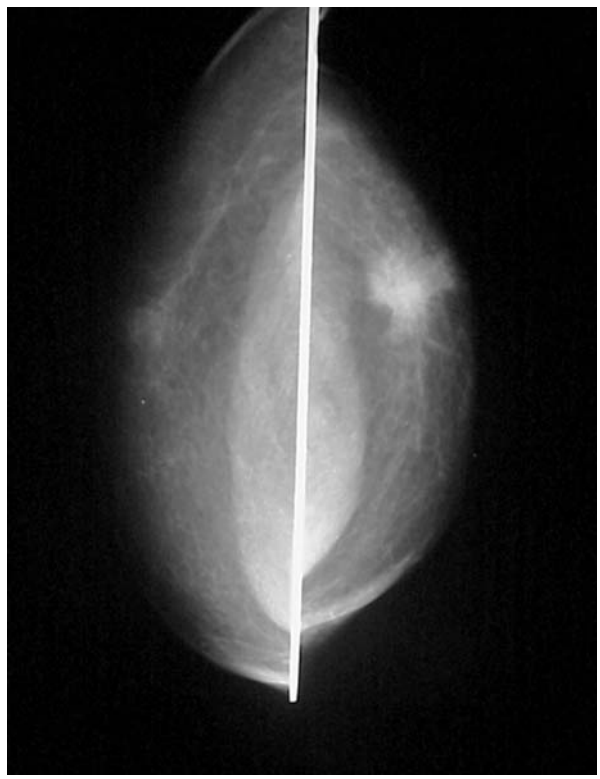

Fig. 1.7.2

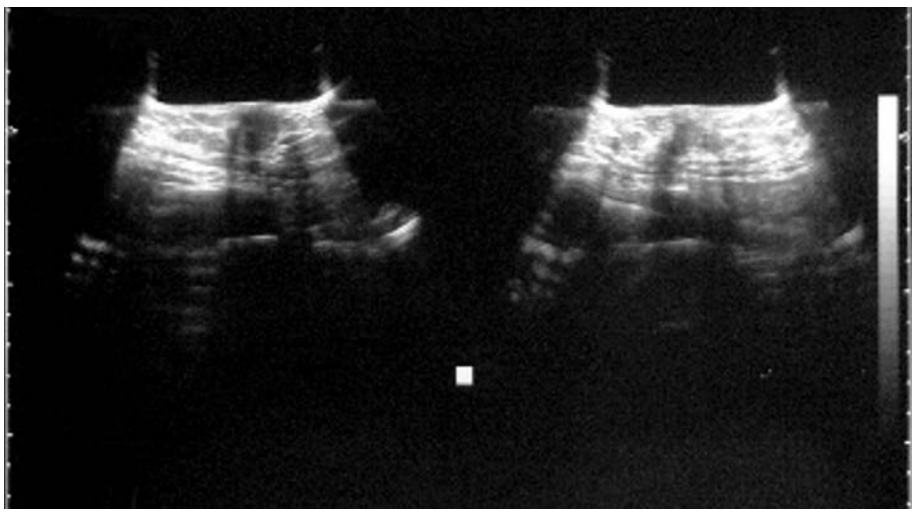

Fig. 1.7.3

A 58-year-old man, with no family or personal history of interest, presented with a mass in the left breast. The physical exam revealed the existence of a hard, fixed mass associated to nipple retraction.

Mammography and breast ultrasound confirmed the existence of a nodule highly suspicious for malignancy in the left breast.

Intraoperative biopsy followed by mastectomy and axillary emptying were carried out. Histopathologic study revealed infiltrating ductal carcinoma with axillary nodal extension.

Comments

Breast pathology in men constitutes less than 1% of all consultations in breast units.

Gynecomastia is clearly the most frequent breast pathology in men. It presents two peaks of incidence, one in puberty and another in the 6th or 7th decade of life. It is clinically characterized by a diffuse unilateral or bilateral increase in breast size or a retroareolar mass of soft consistency. Mammography shows an increase of breast tissue with a triangular morphology, central in relation to the nipple, without signs of malignancy.

After gynecomastia, breast carcinoma is the most frequent breast lesion in men. It constitutes less than 1% of breast carcinomas and less than 1% of malignant tumors in men. Clinically, it presents as a hard mass fixed to the surrounding tissues; it is eccentric to the nipple and may or may not be associated with other signs of malignancy. Mammographically, it is very similar to breast cancer in women but presents less varied forms. Given the smaller volume of male breast, extension to the nipple and the pectoral muscle is more frequent. Infiltration of the nipple favors lymphatic infiltration, and this has been considered one of the factors that worsens the prognosis of these patients.

Other breast lesions, such as cysts, abscesses, or lipomas, are less frequent in men.

Imaging Findings

Oblique (Fig. 1.7.1) and craniocaudal (Fig. 1.7.2) mammograms show a spiculated mass and nipple retraction, highly suspicious for malignancy (BI-RADS 5 category), in the left retroareolar region. The right breast shows fatty predominance with some isolated remains of fibroglandular tissue or rudimentary ducts in the retroareolar region.

Breast ultrasound confirms the existence of a solid and irregular nodule in this location.