Breast Imaging and BI-RADS

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Breast Cancer

- The spread of breast cancer has become one of the health challenges in human societies.
- Breast cancer is the most common type of malignancy in women, and one of the three most common cancers worldwide, along with lung and colon cancer
- Breast cancer is the second leading cause of death after cardiovascular diseases.
- About one out of eight women (about 12%) suffer from this disease during their life in the USA and European countries.
- The overall prevalence rate and mortality rate has increased in developing countries.
- However, mortality of breast cancer in North America and the European Union (EU) has decreased, and this is mostly attributable to early detection and efficient systemic therapies

Breast Imaging

- Early detection of breast cancer plays an important role in the treatment and control of the disease.
- If breast cancer is diagnosed early, it has a very high survival rate. To this end, countries have developed some prevention programs.
- There are currently 3 clinical breast imaging modalities, although manual examination is used as the primary diagnostic tool

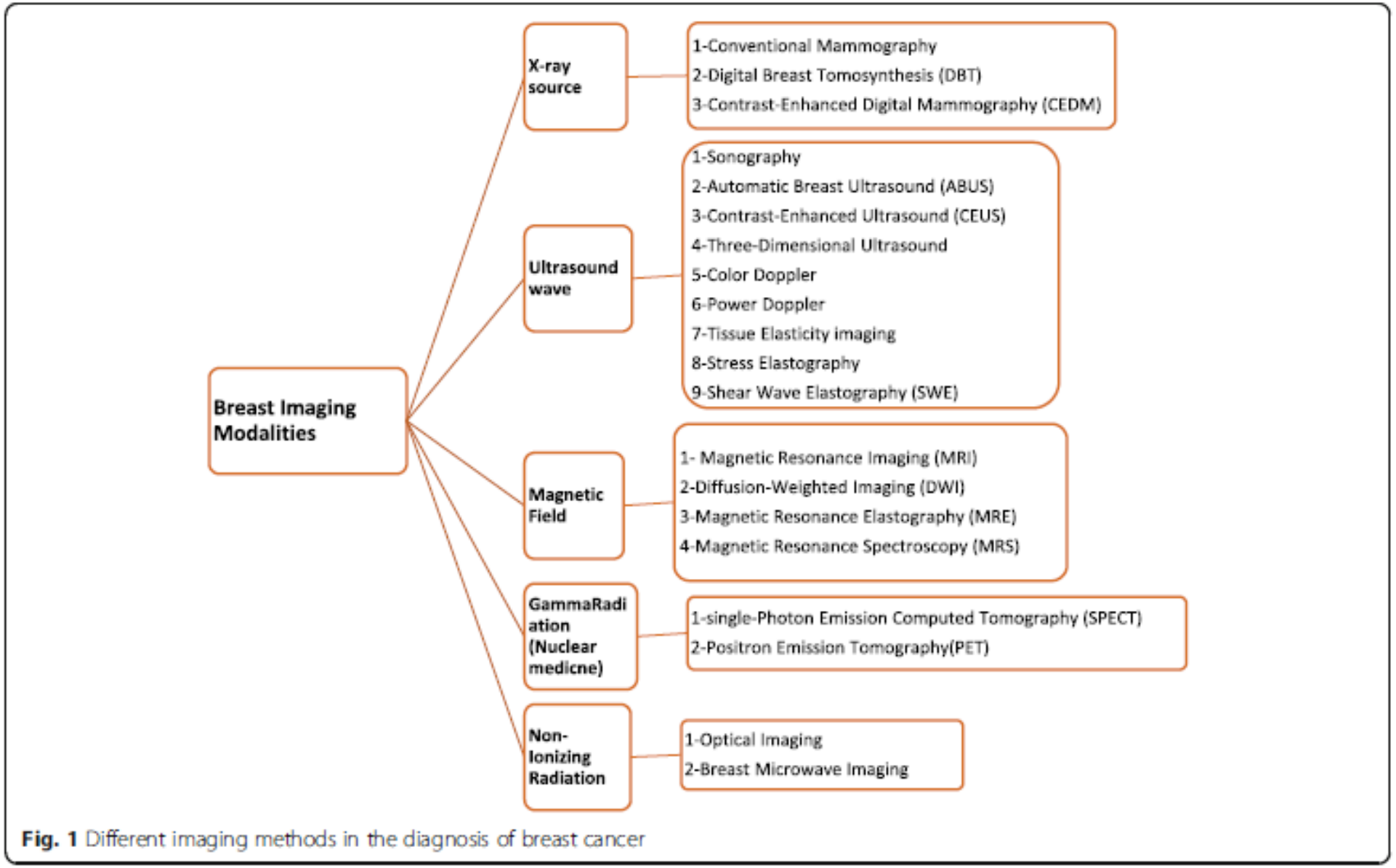


Fig. 1 Different imaging methods in the diagnosis of breast cancer

Mammography

- A mammogram is a two-dimensional image that helps to identifying morphologically suspicious findings in breast cancer.
- These findings include masses, asymmetric calcifications, and deformed breast areas.
- In this method, the breast tissue is pressed by a plate, and then 2D radiographic images are produced by penetrating low-energy (20–32 kVp) X-rays through the tissues.
- A standard screening mammogram is obtained in the oblique views (MLO) and craniocaudal (CC) of each breast

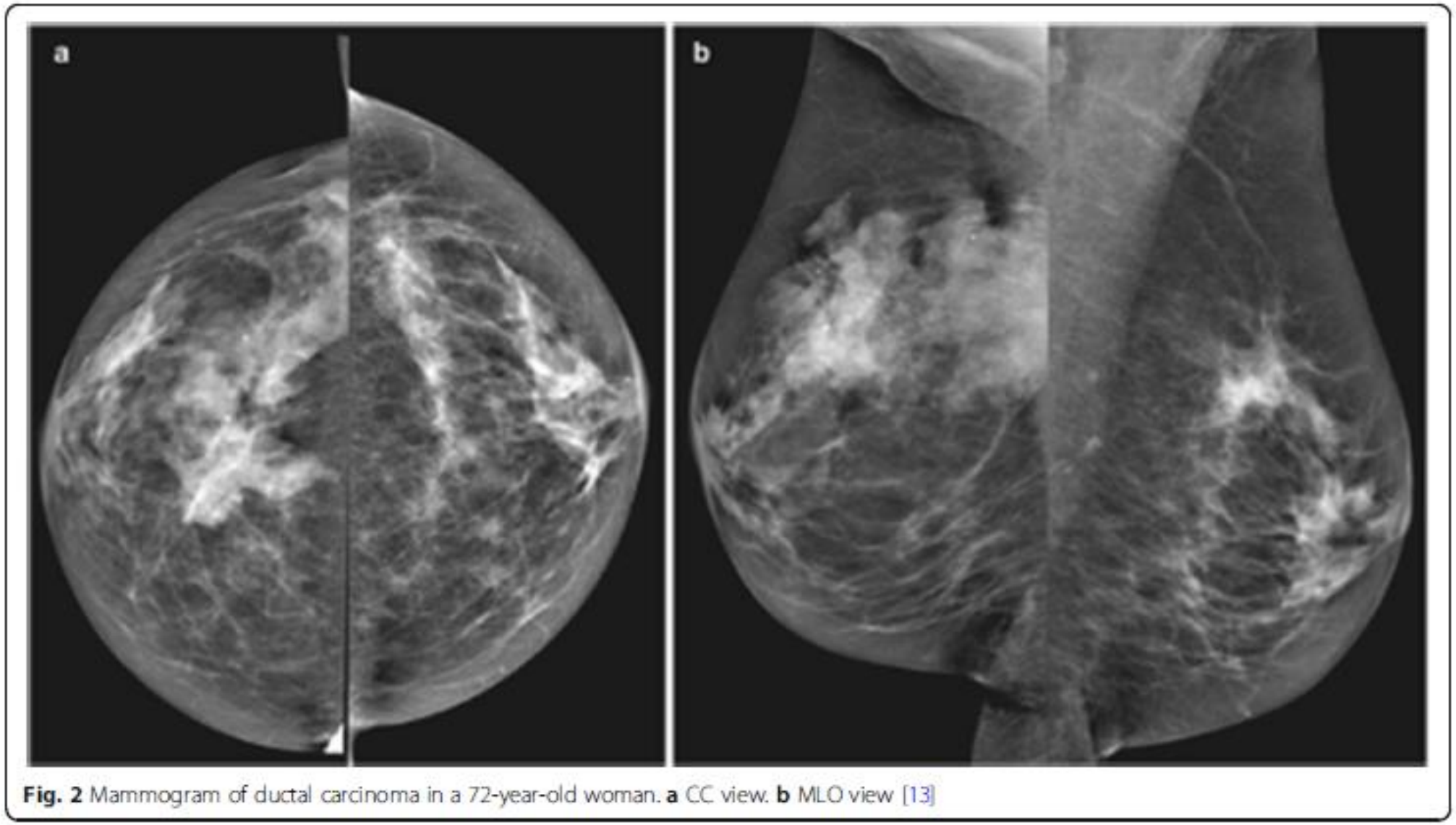
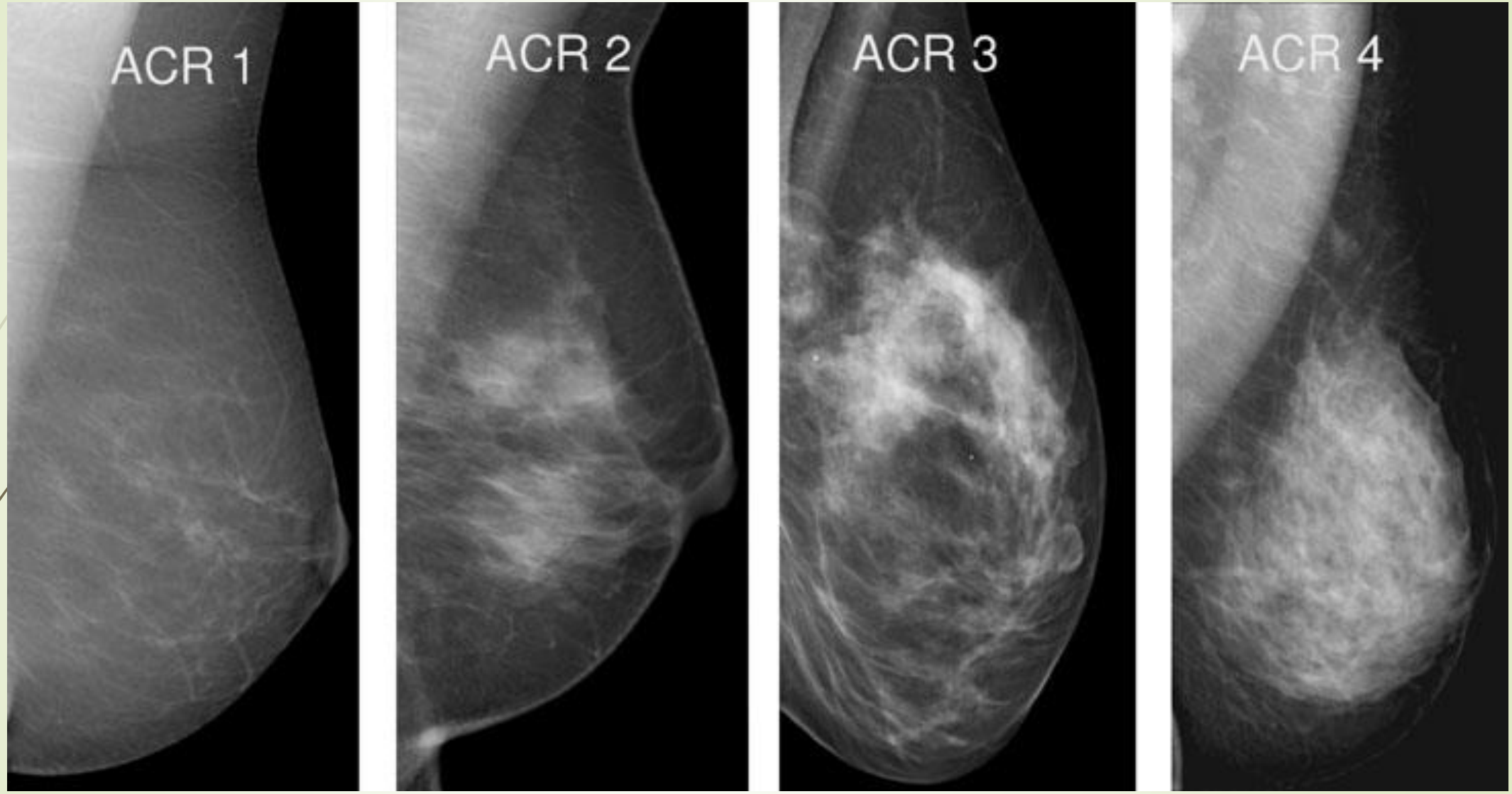


Fig. 2 Mammogram of ductal carcinoma in a 72-year-old woman. **a** CC view. **b** MLO view [13]


ACR 1
ACR 2
ACR 3
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- Since the introduction of mammography about 30 years ago, breast imaging has improved significantly with this method.

- Initial studies on the clinical function of mammography have shown that this method reduces the mortality rate about 20–40%.

- Mammography, on the other hand, has high false positives due to the overlap of normal fibroglandular tissues in 2D imaging and the appearance of abnormalities resembling cancer and further inducing unnecessary biopsies

- The sensitivity of mammography has an inverse relationship with breast density.
- High-density breast implies more fibroglandular tissue and less adipose tissue.
- The sensitivity of mammography in the breast tissue of 50-year-old women varies from 68 to 90% and in women aged 40–49 is about 62%.
- The specificity of mammography ranges from 82 to 97%

Film vs. Digital Mammography

- Film-screening mammography is the gold standard in breast cancer imaging; Heterogeneous and dense breast parenchyma in digital mammography shows better sensitivity than film-screen mammography, but in general, both methods are less sensitive in dense breasts

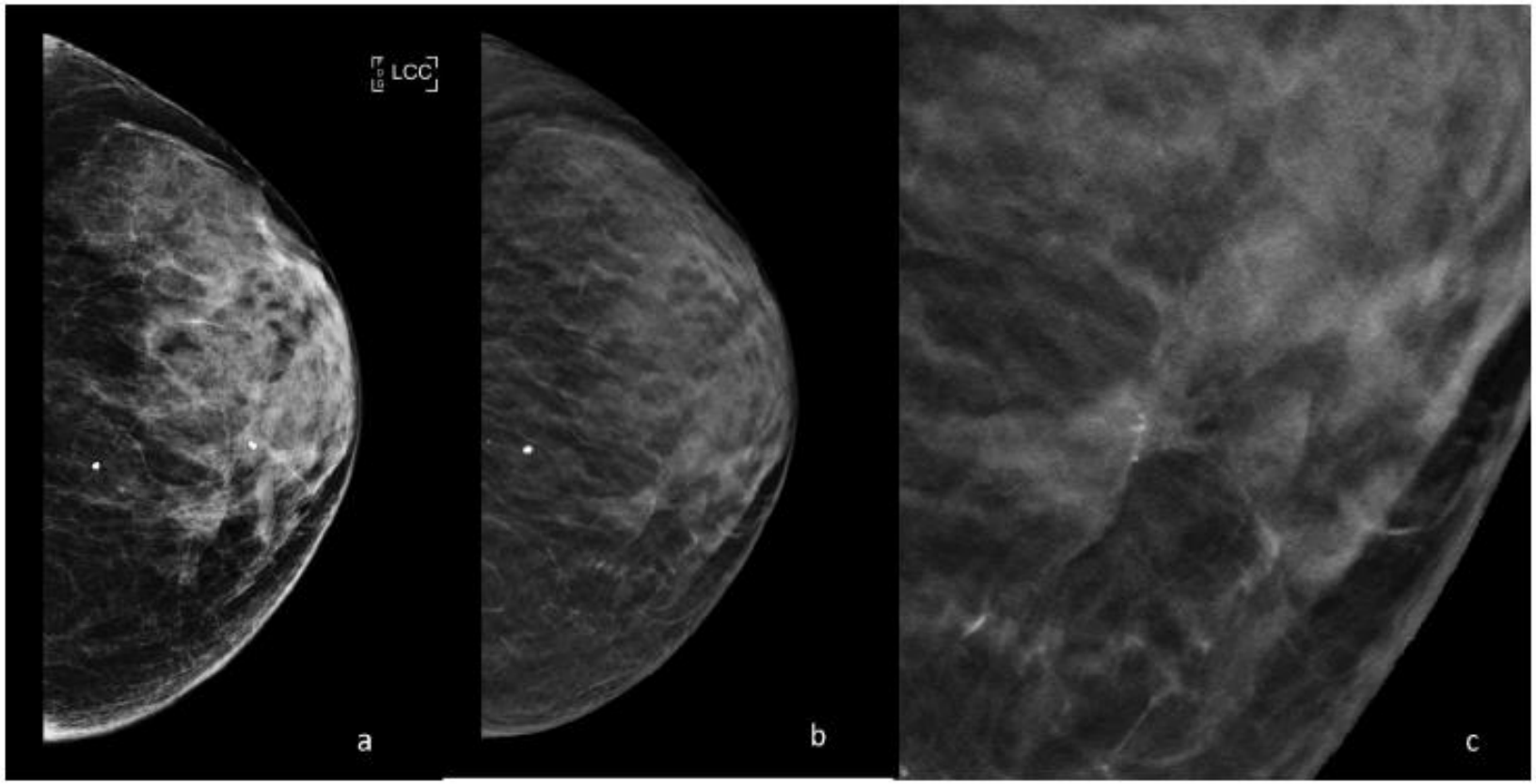


Figure 1. Periodic control with DM and DBT of a 47-year-old patient with a family history of breast cancer. **(a)** DM cranio-caudal left view; breast density BIRADS C; millimetric cluster of microcalcifications in the inner quadrants. **(b)** DBT cranio-caudal left view; in the site of the microcalcifications a parenchymal distortion is appreciated, enhanced by DBT acquisition. **(c)** Detail of the parenchymal distortion at higher magnification. The distortion with microcalcifications was then biopsied, resulting an invasive ductal carcinoma.

Mammography: Breast Cancer risk?

- Concerns about the side effects of ionizing radiation used in mammography are still present, and some studies have shown that mammography may increase the incidence of breast cancer.

- One of the major disadvantages of mammography is inducing radiation dose in a high sensitive tissue such as breast. Studies have shown that a complete mammography imaging induces approximately 1–3 mGy dose into the breast tissue itself, which can *increase the risk of cancer in the individual !!*

Digital breast tomosynthesis (DBT)

- This method is a subset of the mammography procedure, with the difference that the X-ray tube rotates around a narrow angular angle (15–60°) from the compressed breast tissue and produces 3D breast information.

- DBT images are generated from repeated exposure to the breast tissue at various angles and reconstructed as half-millimeter slices.

DBT: Benefits

- Various studies have shown that this method increases the patient's radiation dose by 20%, but the cancer detection rate increases about 15–30% and the recall rate decrease about 15–20%.
- Helps in detection of masses and lesions that may not be seen in conventional mammography due to overlap with dense breast tissue, But it is less efficient for microcalcifications.
- The sensitivity of tomosynthesis is high and false-positive detections are decreased

Digital breast tomosynthesis (DBT)

- In the USA, combining digital breast tomosynthesis with digital mammography has reduced the recurrence rate by up to 30%. However, the radiation dose in DBT is 8% higher than the standard digital mammography

Breast Ultrasound

- The ultrasound wave is transmitted to the tissue by a probe at frequencies ranging between 3 and 12 MHz.
- The different organs reflect the ultrasound to the probe because of differences in their acoustic impedance. The magnitude of reflected wave intensity produces a gray pattern on the screen.
- Ultrasound along with mammography is used to determine the nature (benign or malignant) of solid masses.
- Also, Doppler ultrasound and contrast media are used to measure tumor blood flow and tumor vascularization.

- B-mode (grayscale) is one of the most common ultrasound techniques.
- Ultrasound can evaluate the morphology, orientation, internal structures, and margin of lesions in dense breasts on several plates. Evaluation of these features helps to differentiate benign and solid breast lesions.
- Sensitivity increases to 97.3% and specificity to 76.1% by adding ultrasound imaging to conventional breast cancer screening methods (mammography and physical examination).
- Various advances have been made in ultrasound technology, including 3D ultrasound, color Doppler, power Doppler, automated breast ultrasound (ABUS), and sonoelastography.
- 3D ultrasound and ABUS collect volumetric information from the whole breast.

Breast MRI

- Magnetic resonance imaging has become widely used due to the advances in surface coil technology, the introduction of new contrast agents and fast imaging sequences.
- In this method, the image is produced using the magnetic properties of the hydrogen atoms in the tissues.
- Although MRI is not commonly used for breast cancer imaging, it is a suitable method for screening patients with a high risk of breast cancer (20–25%)

- MRI imaging is more sensitive than mammography and ultrasound in the diagnosis of breast cancer and it is relatively cost-effective.

- Studies have shown that MRI has detected 14.7 new cases of cancer per 1000 people when used as a complementary method in people who have already had mammography and ultrasound.

- Results of 11 previous studies showed that MRI and MG sensitivity were 92% and 75%, respectively, and their specificity was 71% and 70%, likewise.

Imaging of BRCA1/2 mutations?

	Mammogram (MG)	MRI	MG + MRI
Sensitivity	40%	75%	94%
Specificity	93%	81%	73%

- The sensitivity of the MRI method for patients with BRCA1 gene expression was better than those with BRCA2 gene expression which was 92% and 58%, respectively, while the sensitivity was worse for mammography (23% and 50%, respectively)

Breast MRI indications

- Preoperative evaluation (lobular neoplasia, tumor extent in dense breast, DCIS)
- Post neoadjuvant chemotherapy
- Positive surgical margins, post breast conservation
- Metastatic axillary lymphadenopathy, unknown primary malignancy
- Silicone breast implant integrity
- Breast cancer screening

Breast MRI Screening?

- **The ACS has recommended annual screening breast MRI for very high-risk women:**
  - women with *BRCA1*and *BRCA2* gene mutations and their untested first-degree relatives;
  - patients with prior chest radiation between the ages of 10 and 30;
  - Women with certain syndromes associated with propensity for breast cancer; and
  - patients with a lifetime risk for breast cancer of >20% to 25% as determined by risk models.

- **Insufficient evidence was found to recommend for, or against, screening MRI for women at intermediate risk:**
  - Women with a lifetime risk for breast cancer of 15%to 20% defined by risk models;
  - prior diagnosis of atypia or lobular carcinoma in situ;
  - patients with dense breasts on mammography; or
  - patients with a personal history of breast cancer

Table 2. Diagnostic performance of CEM compared to MRI.

Study	MRI		CEM	
	Sensibility	Specificity	Sensibility	Specificity
Jochelson, Radiology, 2013 [69]	96%	n.a.	96%	n.a.
Łuczyńska, Med Sci Monit, 2015 [70]	93%	n.a.	100%	n.a.
Fallenberg, Eur Radiol, 2016 [71]	76%	88%	72%	95%
Li, Diag and Interv Imaging, 2016 [72]	100%	n.a.	100%	n.a.
Ali-Mucheru, Ann Surg Oncol, 2016 [73]	100%	n.a.	98%	n.a.
Lee-Felker, Radiology, 2017 [74]	99%	4%	94%	17%
Jochelson, Eur J of Radiol, 2017 [75]	n.a.	94.1%	n.a.	94.7%
Kim, J Breast Cancer, 2018 [76]	95.2%	73.6%	92.9%	81.1%

BI-RADS: Definition

- **BI-RADS** (**Breast Imaging-Reporting and Data System**) is a risk assessment and quality assurance tool developed by American College of Radiology that provides a widely accepted lexicon and reporting schema for imaging of the breast. It applies to mammography, ultrasound, and MRI.

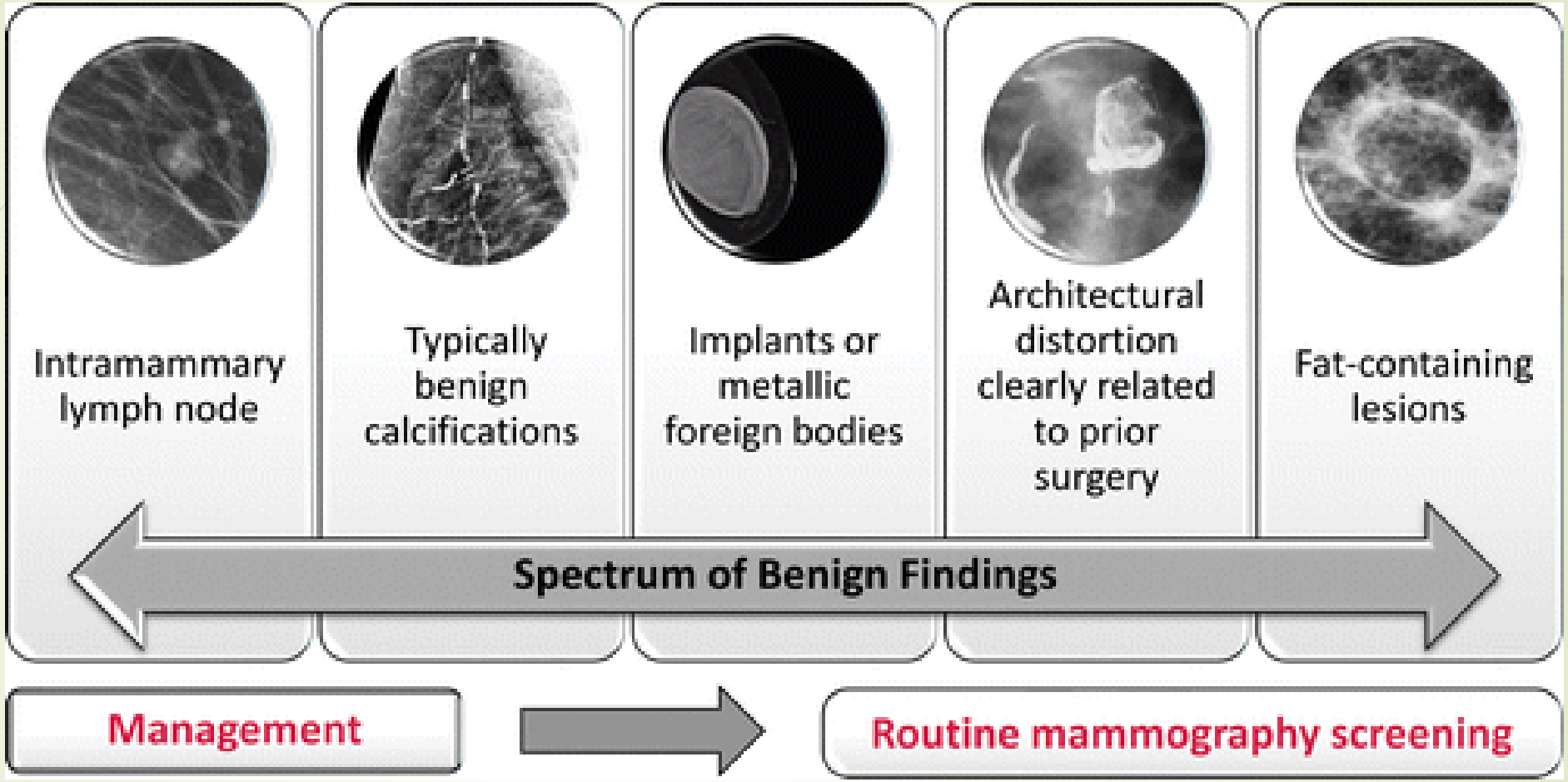
- BI-RADS provides standardized terminology to describe breast imaging findings.

Mammography Lexicon

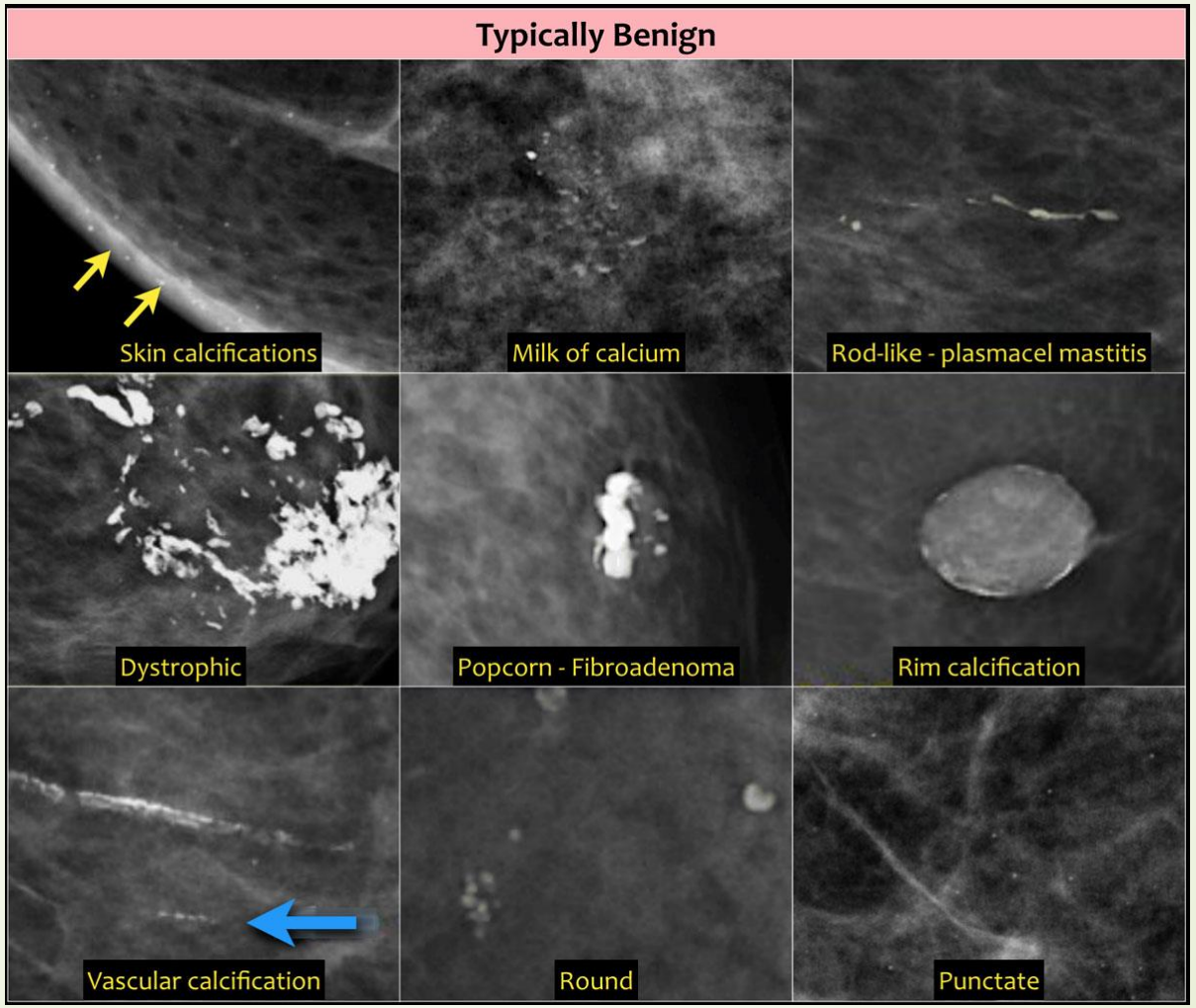
Breast composition	A. entirely fatty B. scattered areas of fibroglandular density C. heterogeneously dense, which may obscure masses D. extremely dense, which lowers sensitivity		
Mass	**shape**	oval - round - irregular	
	margin	circumscribed - obscured - microlobulated - indistinct - spiculated	
	density	fat - low - equal - high	
Asymmetry	asymmetry - global - focal - developing		
Architectural distortion	distorted parenchyma with no visible mass		
Calcifications	**morpho-logy**	typically benign	
		suspi-cious	1. amorphous 2. coarse heterogeneous 3. fine pleiomorphic 4. fine linear or fine linear branching
	distribu-tion	diffuse - regional - grouped - linear - segmental	
Associated features	skin retraction - nipple retraction - skin thickening - trabecular thickening - axillary adenopathy - architectural distortion - calcifications		

Ultrasound Lexicon

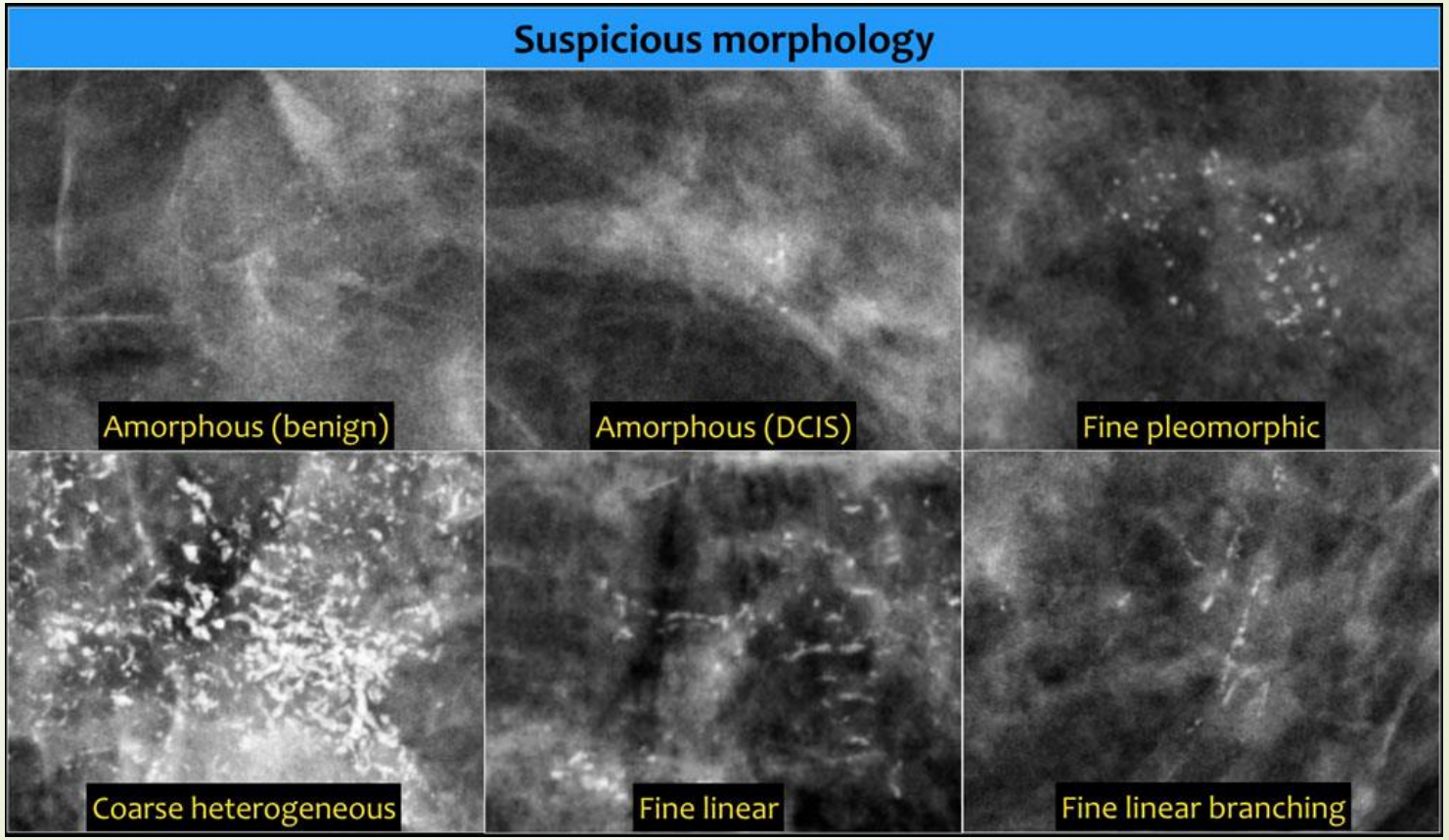
Breast composition	a. homogeneous - fat b. homogeneous - fibroglandular c. heterogeneous	
Mass	**shape**	oval - round - irregular
	margin	Circumscribed **or** Not-circumscribed: indistinct, angular, microlobulated, spiculated
	orienta-tion	parallel - not parallel
	echo pattern	anechoic - hyperechoic - complex cystic/solid hypoechoic - isoechoic - heterogeneous
	posterior features	no features - enhancement - shadowing - combined pattern
Calcifications	in mass - outside mass - intraductal	
Associated features	architectural distortion - duct changes - skin thickening - skin retraction - edema - vascularity (absent, internal, rim) - elasticity	
Special cases *(cases with a unique diagnosis)*	simple cyst - clustered microcysts - complicated cyst - mass in or on skin - foreign body (including implants) - intramammary lymph node - AVM - Mondor disease - postsurgical fluid collection - fat necrosis	

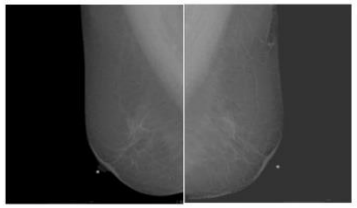
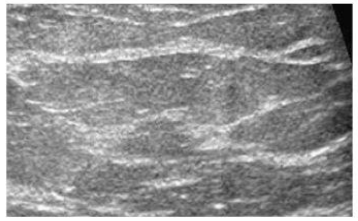
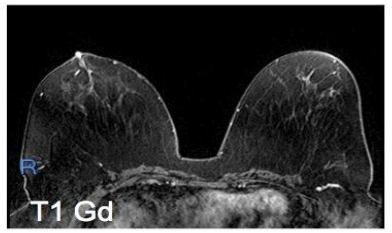
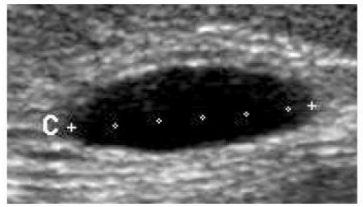
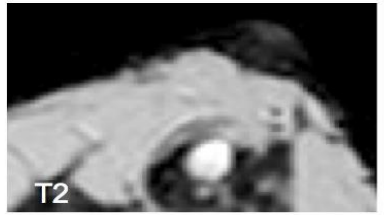
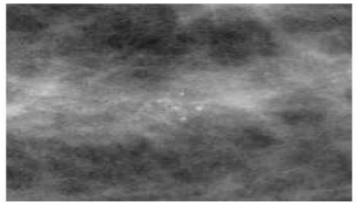
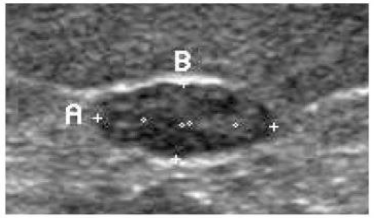
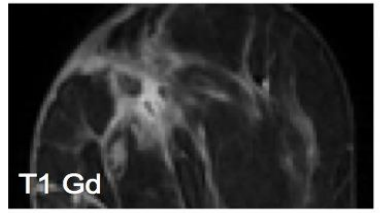
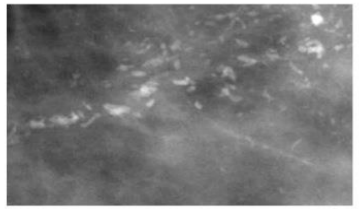
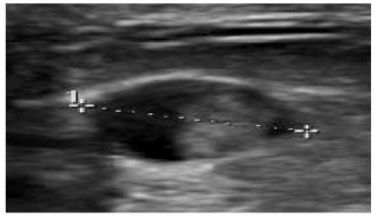
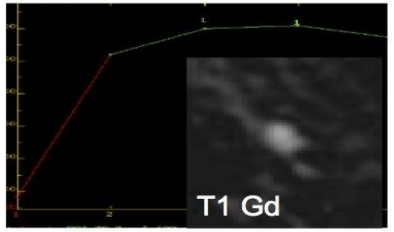
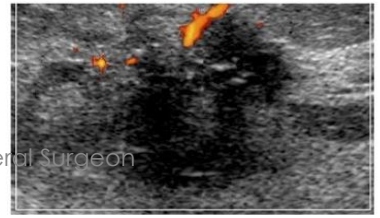
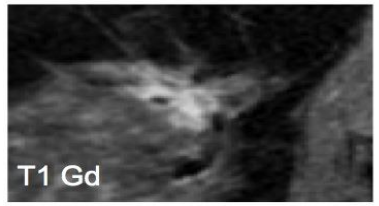

Intramammary lymph node
Typically benign calcifications
Implants or metallic foreign bodies
Architectural distortion clearly related to prior surgery
Fat-containing lesions
Spectrum of Benign Findings
Management
Routine mammography screening

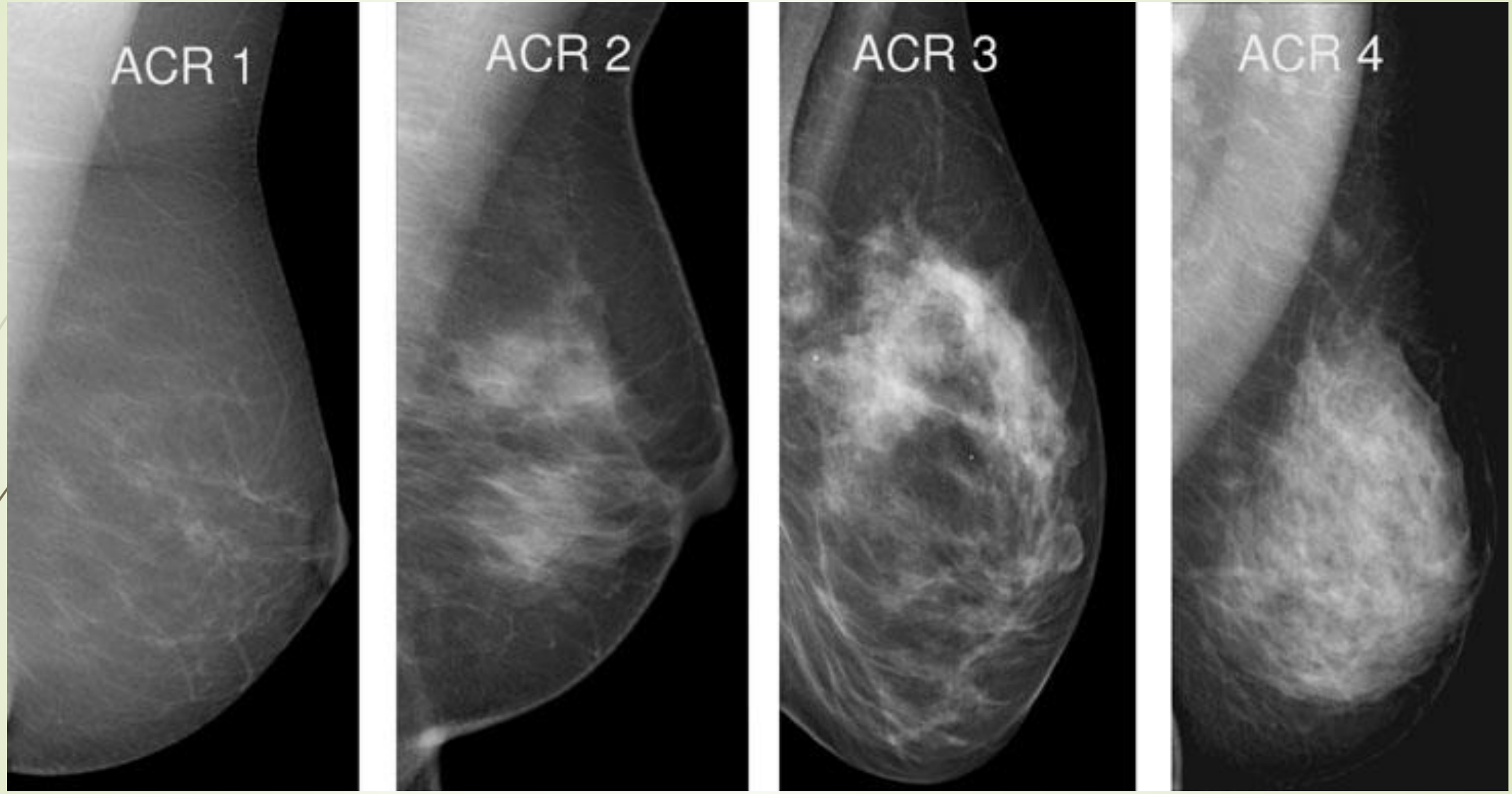
Breast Mammogram: Benign Features



Breast Mammogram: Suspicious Features



BI-RADS Category	A. Mammography	B.Ultrasound	C. MRI	
1				Almost entirely fatty. No abnormality
2				A. Involuting, calcified fibroadenoma B,C. Simple Cyst
3				A. Cluster of punctate calcifications B. Solid mass, most likely fibroadenoma C. Seroma postbiopsy, probable inflamattory changes
4				A. Pleomorphic calcifications B. Complex cyst C. Lobulated solid mass, kinetic curve: type II
5				A,B,C. Spiculated mass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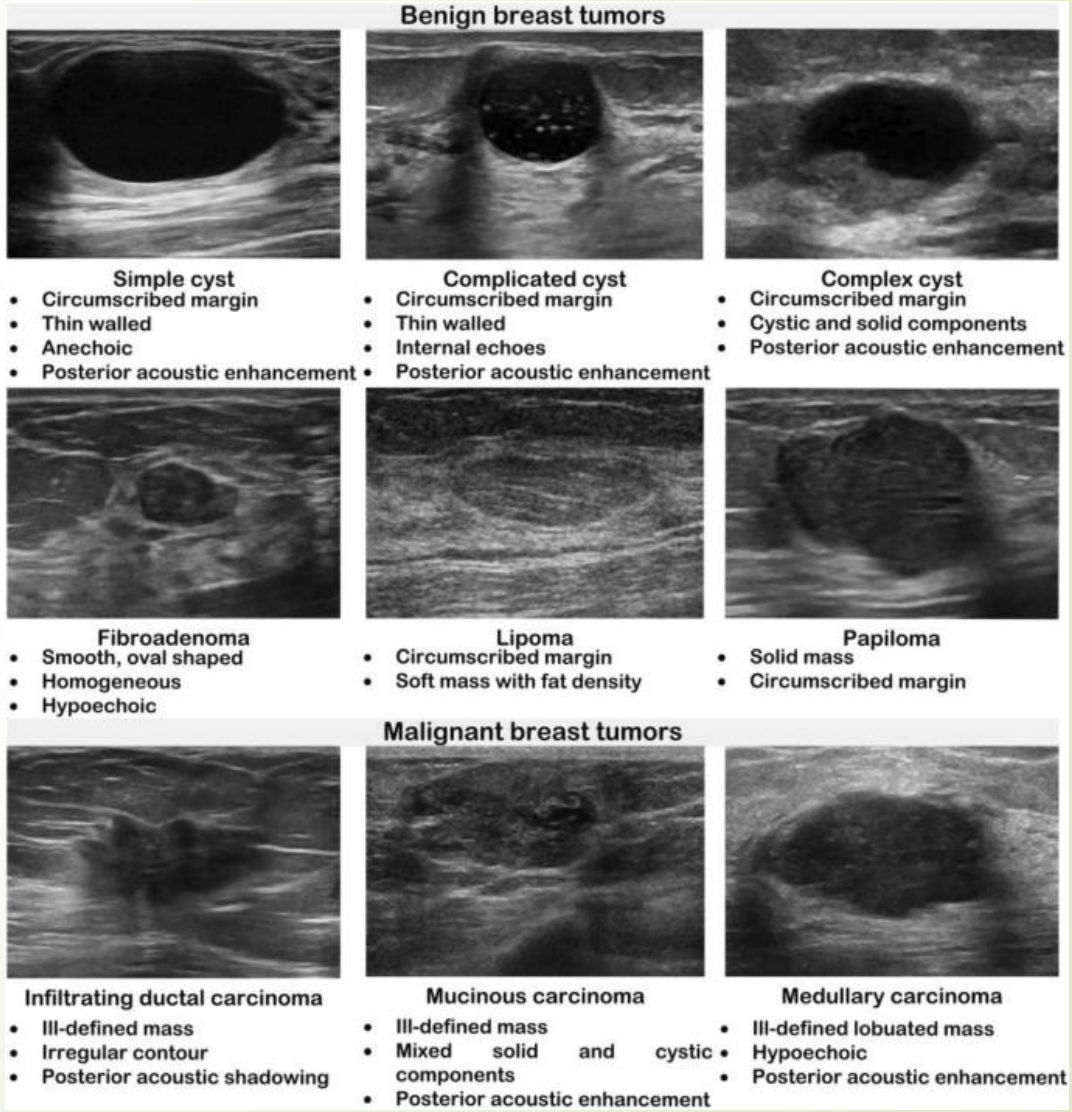
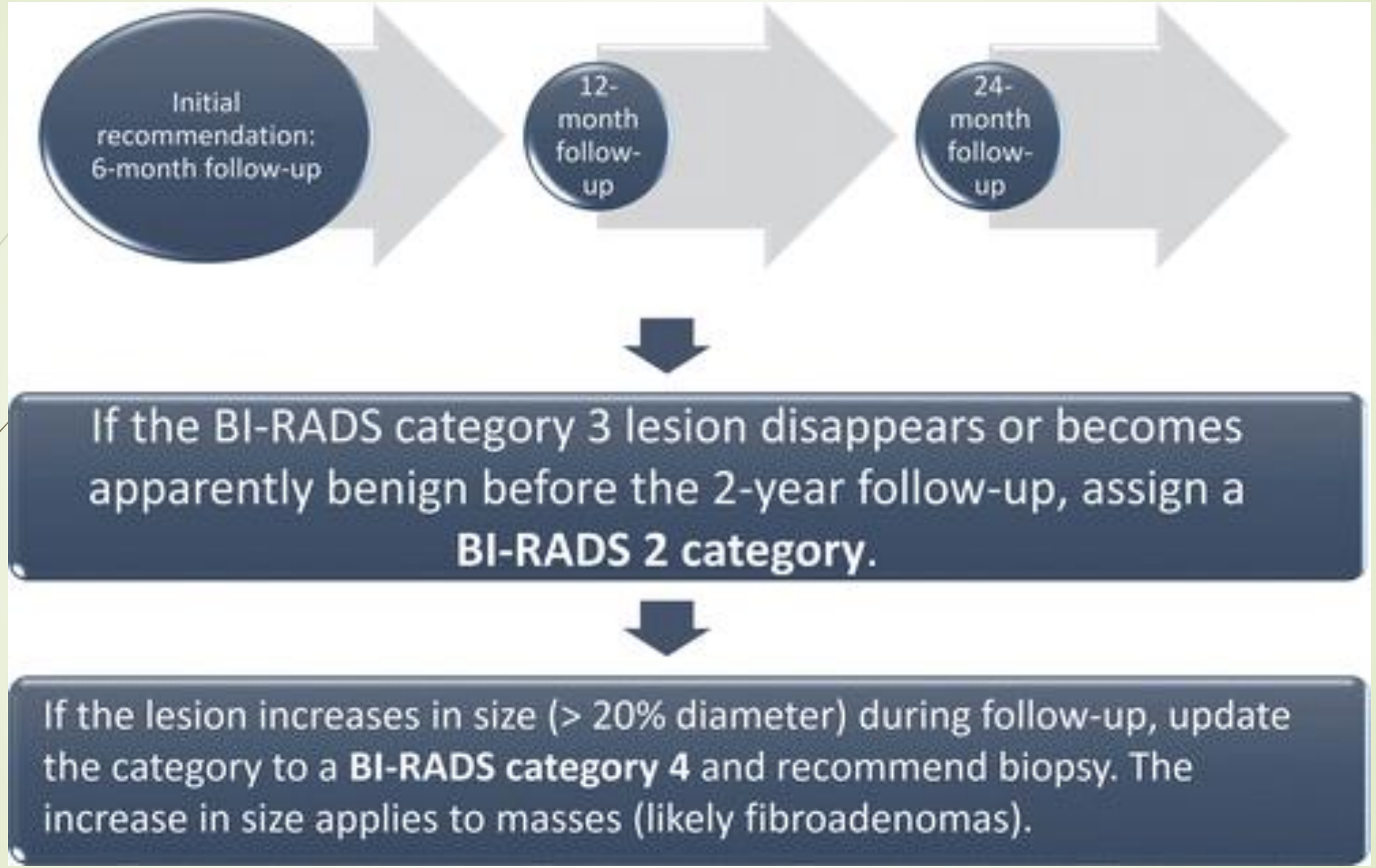
Breast Ultrasound: Benign vs. Malignant



Final Assessment Categories			
Category		Management	Likelihood of cancer
0	Need additional imaging or prior examinations	Recall for additional imaging and/or await prior examinations	n/a
1	Negative	Routine screening	Essentially 0%
2	Benign	Routine screening	Essentially 0%
3	Probably Benign	Short interval-follow-up (6 month) or continued	>0 % but ≤ 2%
4	Suspicious	Tissue diagnosis	4a. low suspicion for malignancy (>2% to ≤ 10%) 4b. moderate suspicion for malignancy (>10% to ≤ 50%) 4c. high suspicion for malignancy (>50% to <95%)
5	Highly suggestive of malignancy	Tissue diagnosis	≥95%
6	Known biopsy-proven	Surgical excision when clinical appropriate	n/a


Initial recommendation: 6-month follow-up
12-month follow-up
24-month follow-up
If the BI-RADS category 3 lesion disappears or becomes apparently benign before the 2-year follow-up, assign a BI-RADS 2 category.
If the lesion increases in size (> 20% diameter) during follow-up, update the category to a BI-RADS category 4 and recommend biopsy. The increase in size applies to masses (likely fibroadenomas).

The End