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Basics of Contrast-Enhanced Spectral Mammography

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Basics of Contrast-Enhanced Spectral Mammography

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Introduction

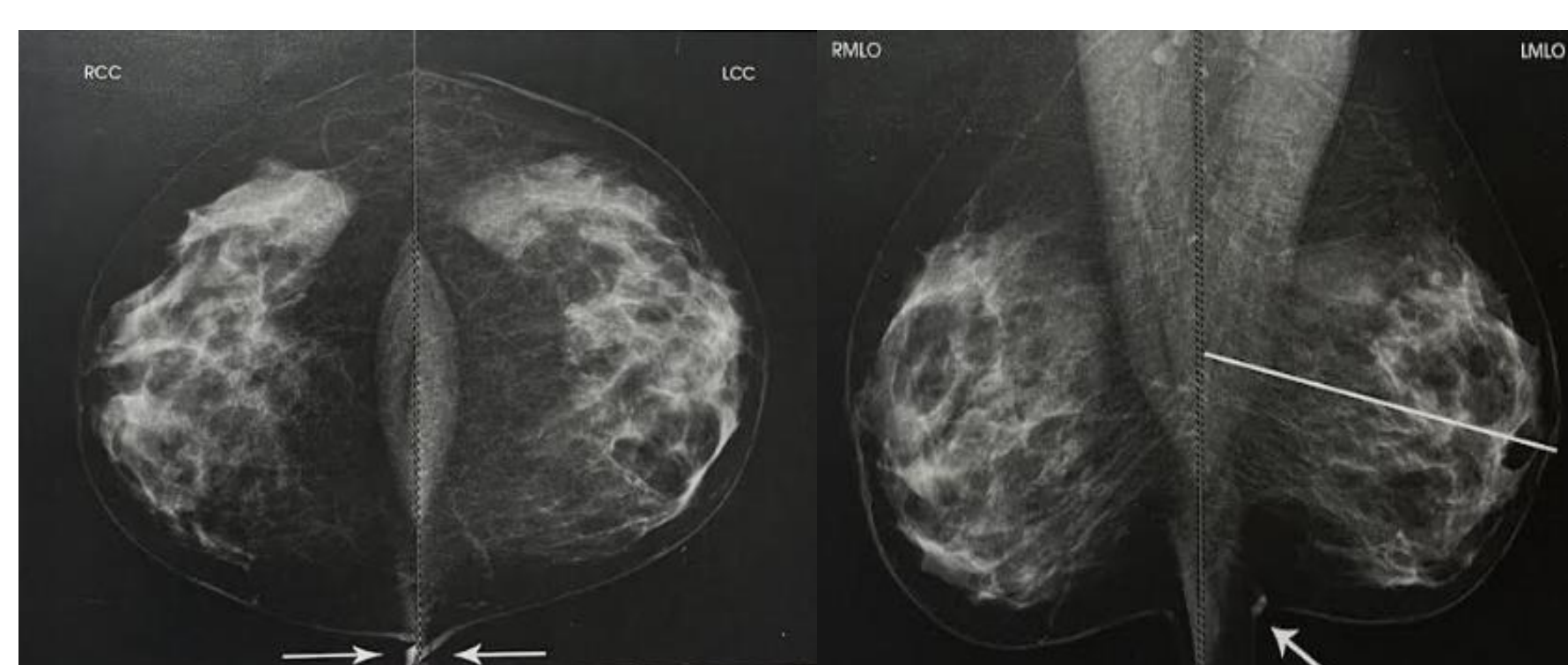
Mammography is the gold standard for early breast cancer detection by offering detailed visualization of internal breast structures. However, traditional two-dimensional imaging can be limited in dense breast tissue, where overlapping structures may obscure abnormalities. Contrast-Enhanced Spectral Mammography (CESM) combines the anatomical detail of conventional mammography with functional imaging using iodinated contrast, allowing radiologists to detect tumor vascularity and improve diagnostic accuracy.

Screening Mammography

Mammography is a specialized imaging technique that uses low-dose x-rays to examine the breast for early signs of cancer or other abnormalities. It is considered the modality of choice for breast cancer screening because of its proven ability to detect disease earlier at a more treatable stage. (Rollins, et al., 2023)

How It Works:

- The breast is compressed between two imaging plates to spread the tissue evenly and reduce motion. The two required projections: Craniocaudal (CC) and Mediolateral Oblique (MLO).



On the left is bilateral CC images and on the right is bilateral MLO projections showing basic mammography images. (Rollins, et al., 2023, p. 401)

Indications for Screening:

- Annual exam for women ages 40 and older
- Women with a family history of breast cancer
- Those with known genetic mutation (Breast Cancer Gene 1 or Breast Cancer Gene)

Patient Preparation:

- Avoid deodorants, powders, and lotions which can mimic calcifications. (Rollins, et al., 2023)

Diagnostic Mammography

Performed when a specific breast concern or abnormality is identified on a screening mammogram or during a physical exam. This exam provides targeted imaging to further evaluate suspicious areas. (Rollins, et al., 2023)

Purpose:

- To investigate abnormalities such as lumps, calcifications, asymmetry, nipple discharge, or skin changes. (Rollins, et al., 2023)

Correlation:

- Ultrasound to help differentiate cystic vs. solid lesions and evaluate dense tissue. (Rollins, et al., 2023)

Contrast-Enhanced Spectral Mammography

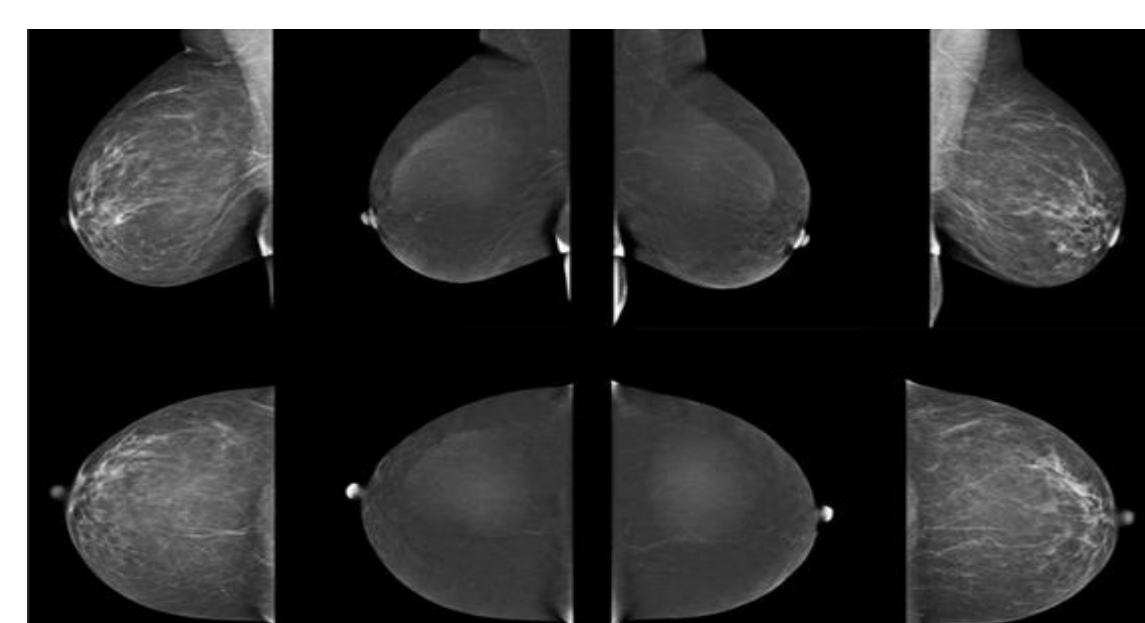
CESM or Contrast-Enhanced Digital Mammography (CEDM) is an advanced imaging technique that merges traditional mammography's anatomical detail with functional imaging through contrast enhancement. (Jochelson & Lobbes, 2021)

How It Works

After an intravenous injection of iodinated contrast, two sets of x-ray images are obtained:

- Low-energy (LE):** Images capture structural details similar to a standard mammogram.
- High-energy (HE):** Images highlight areas where iodine accumulates (reflecting blood flow).

These are digitally recombined to create an "iodine-only" image (RI) that emphasizes areas of increased vascularity, associated with malignancy. (Jochelson & Lobbes, 2021)



Normal CESM study with standard 8 views showing LE and RI in a patient with no abnormal enhancement. (Yang, et al., 2023, p. 3)

Rational:

- Malignant tumors stimulate new blood vessel formation to sustain their growth. CESM exploits this by detecting the contrast uptake patterns, presenting as areas of rapid enhancement and washout typically indicate cancer. (Jochelson & Lobbes, 2021)

Advantages:

- Detects lesions obscured by dense tissue
- Provides functional information about lesion perfusion
- Faster and more accessible than Magnetic Resonance Imaging (MRI)
- Helps in treatment monitoring, preoperative planning, and staging (Jochelson & Lobbes, 2021)

Timing:

- Imaging begins about 2 minutes after injection to allow circulation throughout the body
- Imaging occurs within a specific time of about 2–10 minutes to capture peak vascular enhancement (Jochelson & Lobbes, 2021)

Contrast Type:

- Iodinated contrast agents
 - Iopamidol
 - Iomeprol
 - Ioversol (Kul, et al., 2024)
- Dose: Typically, 1.5 mL/kg.
- Injection: Intravenous, usually antecubital vein. (Kul, et al., 2024)



Vials of iodinated contrast agent. (GE Healthcare / Amersham, n.d.)

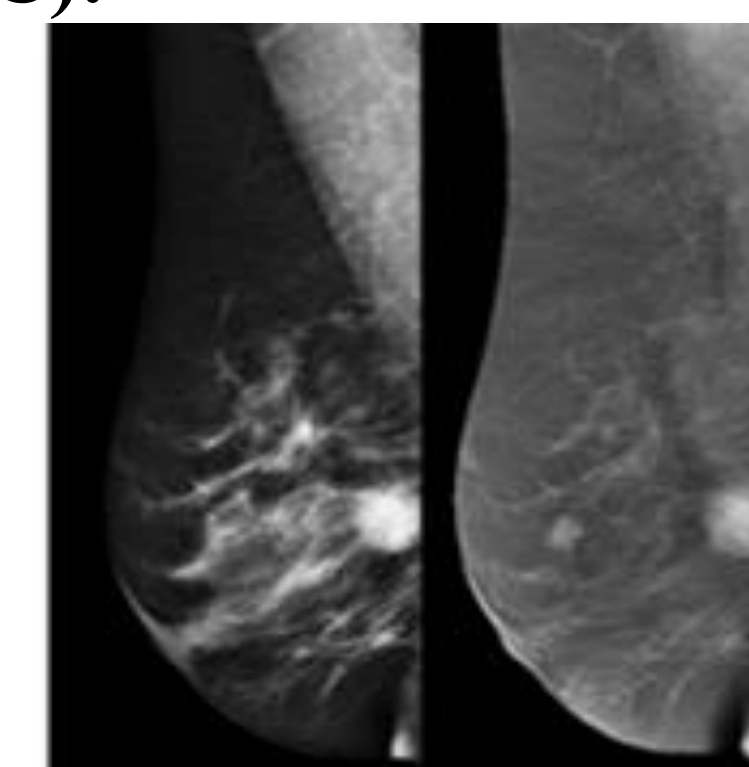
Potential Pathologies

CESM not only shows anatomic features but also vascular characteristics that correlate with tumor behavior. (Yang, et al., 2023)

Invasive Ductal Carcinoma (IDC):

Breast cancer that begins in the lining of a milk duct and spreads outside the duct to other tissues in the breast. (Rollins, et al., 2023)

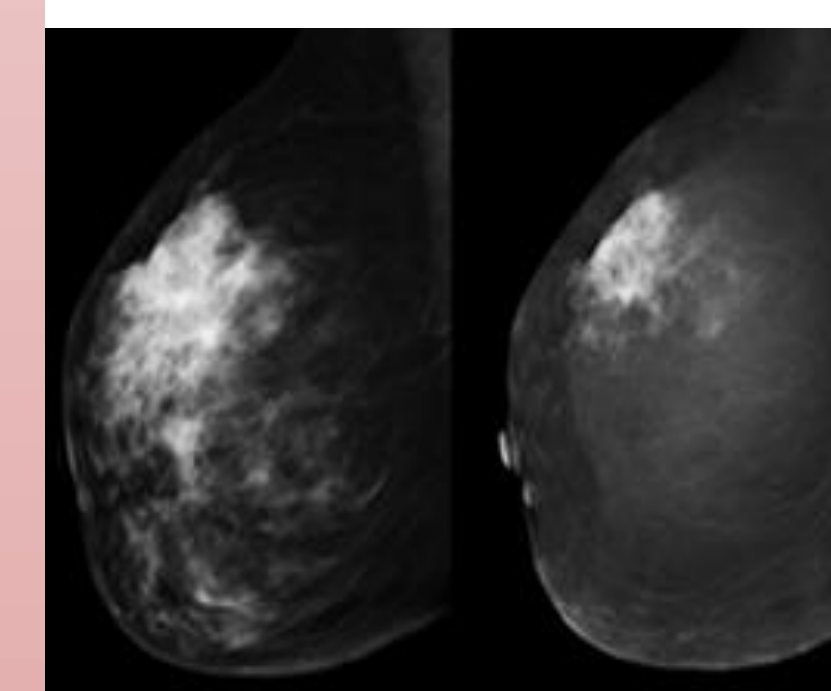
Presents: Strong enhancement with rapid uptake and washout. Often appears as a spiculated or irregular enhancing mass. (Yang, et al., 2023)



Mass in the inferior central breast. Biopsy findings on pathology was multicentric IDC. (Yang, et al., 2023, p. 3)

Invasive Lobular Carcinoma (ILC):

Invasive lobular carcinoma (ILC) is a type of breast cancer that begins in the milk producing glands (lobules) of the breast and can spread into the surrounding breast tissue. (Rollins, et al., 2023)



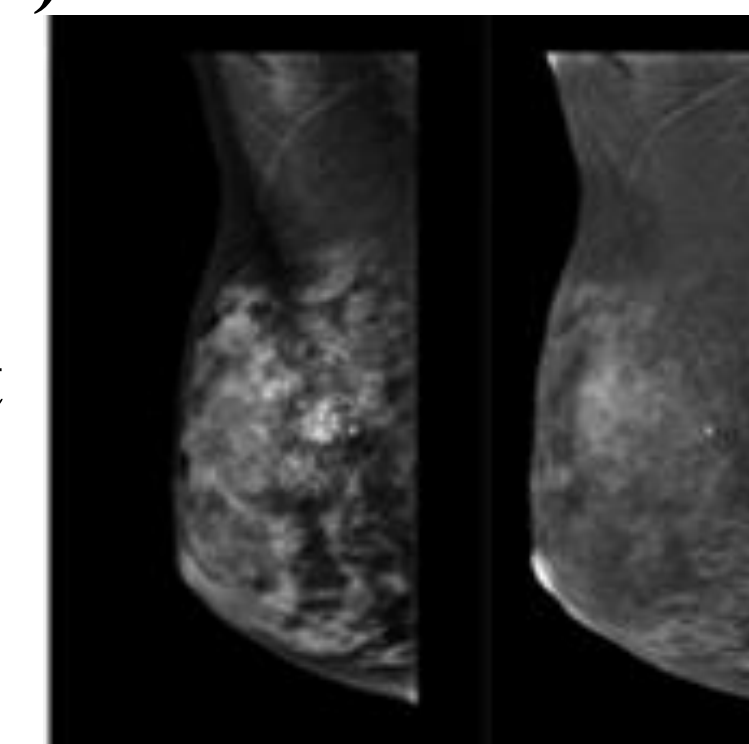
Large high density spiculated mass at 12:00. Final diagnosis: invasive lobular carcinoma. (Yang, et al., 2023, p. 3)

Presents: Areas of enhancement correspond to increased tumor angiogenesis. (Yang, et al., 2023)

Ductal Carcinoma in Situ (DCIS):

A very early form of breast cancer, where cancer cells are confined inside a milk duct in the breast. Often called stage 0 breast cancer. (Rollins, et al., 2023)

Presents: Microcalcifications may or may not show enhancement with moderate DCIS with active blood supply can appear as clustered enhancement. (Yang, et al., 2023)

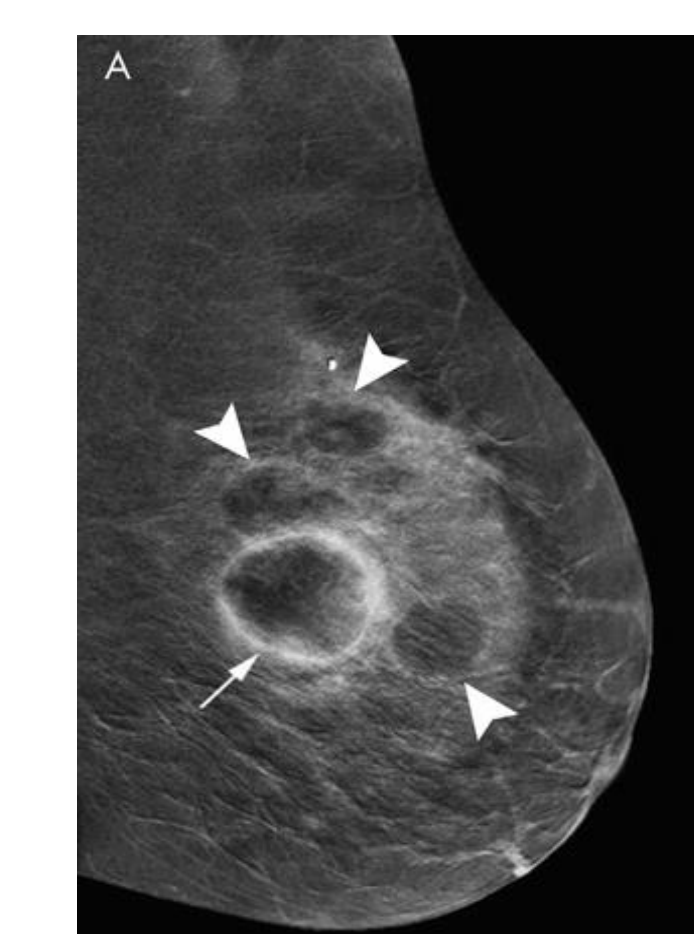


Microcalcifications throughout UOQ on LE images. Pathology findings supply can appear as clustered DCIS. (Yang, et al., 2023, p. 3)

Benign Findings:

Cysts: A small sac-like pocket of tissue that contains fluid, or air (Rollins, et al., 2023)

Presents: Non-enhancing spot
Fibroadenomas: A benign breast tumor; a mixture of glandular and fibrous tissues and usually feels like a smooth lump. (Rollins, et al., 2023)



CESM MLO image of left breast with cysts in central area shown by arrows. (Jochelson & Lobbes, 2021, p. 42)

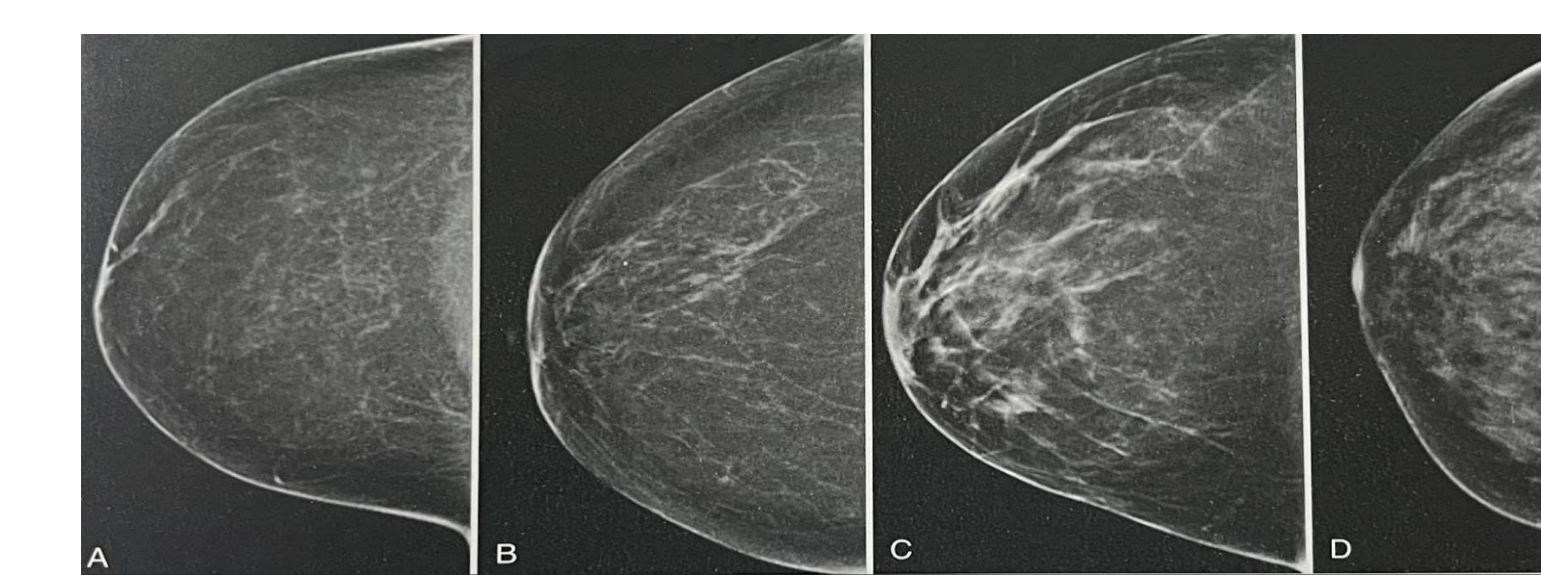
Presents: May show mild, homogeneous enhancement. (Yang, et al., 2023)

Indications of CESM

- Dense breast tissue masking abnormalities

There are four categories:

- A- Almost entirely fatty
- B- Scattered fibroglandular tissue
- C- Heterogeneously dense
- D- Extremely dense (Rollins, et al., 2023)



Classifications of tissue density used by Radiologists. (Rollins, et al., 2023, p. 371)

- Asymmetric densities or unclear mammogram results
- Confirm benign vs malignant features
- MRI contraindicated or inaccessible
- Ongoing surveillance in previously treated cancer patients
- Indeterminate findings on mammogram or ultrasound
- Preoperative staging of known cancer (Weaver, 2024)

Contraindications of CESM

- Pregnancy:** To avoid ionizing radiation and contrast exposure to fetus
- Severe Allergy**
- Renal impairment:** Risk of contrast-induced nephropathy
- Metformin:** Temporarily hold in renal impairment cases to prevent lactic acidosis
- Breastfeeding:** Generally safe, but some centers recommend discarding milk for 24 hours (Kul, et al., 2024)

Conclusion

Mammography has dramatically reduced breast cancer mortality by enabling early detection. However, dense tissue and subtle lesions can limit its effectiveness.

Contrast-Enhanced Spectral Mammography bridges this gap by adding functional contrast imaging, making hidden or indeterminate lesions visible. Early detection = better outcomes: Most ductal carcinoma in situ and early invasive cancers (Stage 0–1) are highly curable. Contrast-Enhanced Spectral Mammography complements, not replaces, biopsy: It guides decisions and improves confidence in imaging findings. Future outlook: Contrast-Enhanced Spectral Mammography will continue to expand due to its accessibility, cost-effectiveness, and accuracy comparable to MRI.