Listen to the associated podcast episode: Breast Imaging: Breast MRI Overview, available at theradiologyreview.com or on your favorite podcast directory.

Indications for breast MRI:

- Extent of disease evaluation/Cancer staging
    - Allows extent of disease of a known cancer and allows screening of the contralateral breast
    - May be particularly helpful for invasive lobular carcinoma (often difficult to see on mammogram, tends to have diffuse or multicentric involvement, and may be bilateral in up to 15% of cases)
    - Women with extremely dense breast tissue with known cancer may particularly benefit from MRI for extent of disease due to potential masking of tumor extent
    - Also provides assessment of chest wall invasion, skin invasion, nipple-areolar complex involvement, axillary adenopathy, internal mammary adenopathy, supraclavicular adenopathy, sternal and possible rib involvement
        - Axillary lymph node levels
            - Level I: Lateral to pec minor
            - Level II: Under pec minor
            - Level III: Medial to pec minor
        - Rotter's node is interpectoral node between pec major and minor
- Neoadjuvant chemotherapy response assessment: Assess for both shrinkage of tumor (anatomic response) and resolution of enhancement (physiologic response—reduced blood flow)
- High risk screening
    - Recommended for women with >20% risk of developing breast cancer
        - Includes women with high-risk family history and/or known mutations including untested first-degree female relatives with
            - BRCA1/BRCA2
            - Li-Fraumeni syndrome
            - Cowden Syndrome
            - Banayan-Riley-Ruvalcaba syndrome
        - Chest radiation (often for lymphoma treatment) between ages 10-30
        - ACR recommends breast MRI for women with prior breast cancer who have dense breast tissue or who developed premenopausal cancer
    - Known axillary nodal metastasis with unknown primary
    - Silicone implant evaluation
        - May be performed without contrast, need silicone selective sequences
    - Problem solving:
        - For example, a highly suspicious palpable finding with negative mammogram and targeted ultrasound
        - Pathologic nipple discharge (unilateral, spontaneous, clear or bloody) and negative mammogram (including subareolar magnification views) and targeted ultrasound

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    - Conditions that currently don't qualify as high enough risk for MRI (this may change but not for the ABR in 2020)
        - Dense breast tissue, prior atypia alone (ADH, LCIS), history of post-menopausal breast cancer with non-dense breast tissue

When to perform breast MRI?

- There are different ranges (for example days 8-14 or days 7-12) but I remember to choose that range that includes day 10.
- This is during the follicular phase when background parenchymal enhancement is thought to be lower due to less hormonal stimulation of breast tissue. This may not actually be the case based on some recent reviews but is historical wisdom and often tested.

For the ABR core exam remember that breast MRI is highly sensitive but less specific in comparison to mammography.

For cancer evaluation, breast MRI requires obtaining dynamic subtracted contrast-enhanced sequences. Subtraction allows you to remove fibroglandular tissue from the image and you are essentially left with a map of contrast enhancement including MIP images that are really useful. Also get a non-fat stat T1 and a fat sat T2 or STIR image.

Breast MRI lexicon:

Background parenchymal enhancement:

- All start with "M": minimal, mild, moderate, marked
- Does not necessarily correlate with breast density

Focus:

- Punctate enhancement measuring <5 mm
- Is unique compared to background enhancement
    - The outlier is what you are looking for
- Lots of foci that appear similar in both breasts = background enhancement
- For core exam: focus of enhancement with washout kinetics needs further evaluation
- Can end up being benign fibrocystic change, lymph node, fibroadenoma, papilloma, DCIS, IDC

*For board purposes a T2 bright focus or mass is likely to be benign. For real life if you use this rule strictly you will miss cancer. I think this concept is over-tested because it is not as clinically useful as you would think.

Masses:

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- Space-occupying enhancing lesion with outward/convex contour
- Shape
    - Round, oval, irregular
    - Margin: Circumscribed, irregular, spiculated
- Internal enhancement
    - Benign is more often uniform/homogeneous
    - Heterogeneous internal enhancement more likely to be malignant
    - Rim enhancement
        - Thin rim enhancement and T2 bright: inflammatory cyst
        - Thick or nodular rim enhancement with T2 bright internal components may be tumor with necrosis or papillary neoplasm
    - Dark internal septations
        - Feature associated with fibroadenomas
        - If they show this to you on the board exam assume it is a fibroadenoma
            - Fibroadenoma that is T2 bright is myxoid fibroadenoma
                - Younger women
            - Fibroadenoma that is T2 hypointense is sclerotic fibroadenoma
                - Post-menopausal, may have susceptibility artifact from popcorn calcifications
    - T2 bright masses
        - Can include cysts, lymph nodes, fibroadenomas, fat necrosis, mucinous carcinoma, IDC, IDC with necrosis
        - *For board purposes a T2 bright focus or mass is likely to be benign. For real life if you use this rule strictly you will miss cancer. I think this concept is over-tested because it is not as clinically useful as you would think.
        - Lymph nodes are T2 bright and most common have type 3 (rapid initial with washout) kinetics
            - Look for fatty hilum and typical location near vessels to confirm

Non-mass enhancement

- Not a focus or a mass
- Distribution:
    - Focal is <1 quadrant
    - Linear (usually means enhancement in a single duct)
    - Segmental (triangular with apex towards nipple—means within multiple ducts)
    - Regional (>1 quadrant)
    - Multiple regions
    - Diffuse
- Internal enhancement
    - Homogeneous
    - Heterogeneous

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    - Clumped
        - Clumped enhancement often described as “cobblestone” pattern
        - Looks like multiple enhancing foci clumped together, often in a linear pattern
        - This is internal ductal enhancement, as in DCIS
    - Clustered ring enhancement
        - Multiple peripheral ring-like contiguous areas of enhancement
        - These are the walls of ducts enhancing giving a contiguous ring-like appearance, as in DCIS
- Non-mass enhancement can result from
    - DCIS, IDC, fibrocystic changes, stromal fibrosis, sclerosing adenosis, papilloma, etc.

MRI Kinetics

- Thought is that cancers will enhance more rapidly and demonstrate washout faster than normal breast tissue or benign lesions due to angioneogenesis
- Part of why we get multiple (usually 3) post-contrast runs on breast MRI so you can assess both initial and delayed enhancement patterns
- Considers both INITIAL and DELAYED enhancement
    - Type 1
        - Progressive
        - Slow initial enhancement that gradually increases on delayed images
        - Typically, a benign pattern
    - Type 2 enhancement
        - Plateau
        - Initial rapid uptake followed by a plateau on delayed images (no washout)
        - Potentially concerning for malignancy
    - Type 3 enhancement
        - Washout pattern
        - Rapid initial enhancement followed by washout (drop in enhancement) on delayed images
        - This is the most concerning pattern
        - Strongly suggestive of malignancy
- In terms of malignancy risk Type 3 > Type 2 > Type 1
- Caveat: The boards and a lot of radiology literature make MRI kinetics seem really useful which from my experience it is not
- On boards: Type 3 = malignant and Type 1 = benign.
- In real life: Cancers and benign entities have A LOT of overlap