Incidental Extra-Mammary Findings on Breast MRI: 

*Mediastinal Masses and Beyond*

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DISCLOSURES

• Aguanunu, Brown, Wahab, Vijapura, Mahoney: No relevant disclosure.

• Lee: Spouse is common stockholder of General Electric Co and Siemens.
Clinical Relevance

The use of breast MRI has dramatically increased over the past few decades. Radiologists should be aware of the spectrum of extra-mammary findings (EMFs) on breast MRI and be able to distinguish clinically significant from benign findings in order to guide follow-up recommendations.

Educational Goals:

- Discuss the prevalence of EMFs on breast MRI and clinical significance of these findings
- Review the mediastinal compartments, differential diagnosis for mediastinal masses and their MRI characteristics
- Identify other common reported sites of EMFs
- Formulate strategies to guide in the follow-up management of EMFs
**Key Teaching Points:**

- The most common sites of metastatic disease in patients with breast cancer are regional lymph nodes, lung, bone, and brain.

- A review of 10 studies, published in 2011 to 2017, examining 316 to 2361 patients found the most common location of an EMF was the liver (i.e. cyst or hemangioma). ¹⁻¹⁰

- Most EMFs were benign.

- Malignant EMFs tended to be in patients that had a personal history of breast cancer and/or history of other primary malignancy.

**MOST Common locations of EMFs**

- Liver
- Bone
- Lung
- Pleura

**LEAST Common**

- Mediastinum
- Other (kidney, gallbladder, vascular, etc.)
Overview of the Mediastinal Compartments

**Anterior**
- **Boundaries** – thoracic inlet, sternum, parietal mediastinal pleura, anterior aspect of the pericardium, diaphragm
- **Contents** – thyroid gland, thymus, fat, lymph nodes

**Middle**
- **Boundaries** – thoracic inlet, posterior boundaries of the anterior compartment, vertical line 1 cm posterior to the anterior margin of the thoracic vertebral bodies, diaphragm
- **Contents** – heart, major vessels (aorta, superior vena cava (SVC), intrapericardial pulmonary artery, thoracic duct), trachea, esophagus, lymph nodes

**Posterior**
- **Boundaries** – thoracic inlet, posterior boundaries of the middle compartment, vertical line at the lateral margin of the thoracic spine transverse processes, diaphragm
- **Contents** – paravertebral soft tissues, thoracic spine

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11 A specific note or annotation might be present in the original text, indicated by the superscript number 11.
Mediastinal Compartments & Differential Diagnosis

ANTERIOR
- Thymic Lesions
- Lymphoma
- Germ Cell Tumor
- Thyroid Lesions

MIDDLE
- Arch Anomalies
- Duplication Cysts
- Esophageal Lesions
- Lymph nodes

POSTERIOR
- Neurogenic Lesions
- Bone and Marrow Lesions

Key Teaching Points:
- Characterize lesions based on location/mediastinal compartment, tissue of origin, and MRI characteristics
- Most important MRI characteristics to assess for are the presence of fat, fluid, or soft tissue within the lesion, as well as the enhancement characteristics of the lesion

Anterior Mediastinum
Thyroid Multinodular Goiter

**Background Information**

- **Sporadic** (etiology generally unknown, no age predilection) vs. **Endemic** (environmental iodine deficiency, childhood onset)
- Female predilection
- Signs & symptoms: large lower neck mass, airway compression, hoarseness, and dysphagia
- Most are clinically euthyroid, but can become hyperthyroid or, rarely, hypothyroid
- Can gradually increase in size leading to development of multiple nodules, local compression symptoms, and cosmetic issues
- Malignancy occurs in 5-7% of all thyroid nodules

**Key Imaging Features**

- Well-circumscribed, diffuse enlargement of the thyroid gland with heterogenous, nodular appearance
- Calcifications, degenerative cysts and hemorrhage may be present
- Diffuse heterogenous enhancement
- Look for mass effect, including compression and/or deviation of the trachea
- Look for suspicious features, such as enlarged cervical lymph nodes or invasion of local structures
ACR White Paper Algorithm for Managing Incidental Thyroid Nodules

- Suspicious features include abnormal lymph nodes and/or invasion of local tissues by the thyroid nodule
- Abnormal lymph node features include calcifications, cystic components, and/or increased enhancement

Hoang, JK et al. JACR 2014
Mediastinal Teratoma

Background Information

- Commonly affects children and young adults
- Most common extra-gonadal germ cell tumor (mature and immature types)
- Should contain elements from ≥ 2 embryological layers: endoderm, mesoderm, and ectoderm
- Majority of patients are asymptomatic
- Mature teratomas are associated with Klinefelter syndrome

Key Imaging Features

- Look for presence of visible intra-lesion fat (T1 hyperintense)
- Fat-fluid level (specific)
- Presence of calcifications, which are better visualized on CT
- Prevascular location
- Well-circumscribed
- Variable enhancement pattern

1.1, 16
Thymic lesions

Background Information
- The thymus is variable in shape and size; involutes with age
- May acutely shrink at times of bodily stress (i.e. infection, radiation therapy, chemotherapy, surgery, hyperthyroidism, etc.) → During recovery, it grows back to original size or larger, this is known as thymic rebound hyperplasia
- ~ 10–25% of patients that undergo chemotherapy may develop rebound hyperplasia, which usually occurs within 2 years of initiation of chemotherapy.

Differential Diagnosis
- Non-neoplastic: anatomic variants, hyperplasia, cysts, ectopic tissue
- Neoplastic: Most common in adults (thymoma > primary mediastinal lymphoma arising from the thymus > germ cell neoplasm)

Key Imaging Features
- Imaging features that help distinguish thymic hyperplasia from malignancy
- Hyperplasia – diffuse enlargement, smooth contour, internal contents of fat and lymphoid tissue, normal vessels
- Malignancy – nodular contour, frequently contains necrotic or calcified foci → look for heterogeneous enhancement

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Lymphoma

Hematologic Malignancy of Lymphoid Origin

Hodgkin Lymphoma (40%)
Characterized by the presence of Reed-Sternberg cells

B symptoms: (fever, weight loss & night sweats)

Non-Hodgkin Lymphoma (60%)
Classified according to criteria based on architecture & morphology

Background Information

- **Hodgkin lymphoma** (HL) – more prevalent in developed countries, bimodal age distribution (20s & 50s), usually curable, more likely to have intrathoracic involvement at initial presentation (80%)
- **Non-Hodgkin lymphoma** (NHL) – more heterogenous with variable clinical presentation, curability, prognosis, and less likely to have intrathoracic involvement at initial presentation (45%)

Key Imaging Features

- A pathological lymph node measures $\geq$ 1cm in short axis
- **Adenopathy** – mediastinal, hilar, pericardial, visualized upper abdomen on MRI
- The spleen can be a site of lymphatic extension of disease $\rightarrow$ look for splenomegaly or multiple splenic lesions
- HL and NHL are practically indistinguishable based on nodal involvement on imaging. Biopsy is needed for typing.
ACR White Paper Algorithm for Managing Incidental Mediastinal Lymph Nodes

The following should be considered when reporting incidental mediastinal lymph nodes:

- ≥ 15mm short axis dimension
- Lymph node morphology
- Pulmonary findings
- Clinical history

Munden RF et al. *JACR* 2018
Middle Mediastinum
Deep Venous Thrombosis

**Key Imaging Features**

- **Direct signs** – filling defect in the venous lumen, abrupt vessel cutoff, or lack of flow
- **Indirect signs** – focal organ damage, global end-organ damage, and hemodynamic changes (collateral formation or unusual enhancement pattern)
- **Acute thrombus** (partial vs. complete occlusion) – homogenous, expanded lumen, and centrally located
- **Chronic thrombus** – heterogenous, decreased lumen diameter, and peripherally attached to the venous wall

**Background Information**

- Venous thrombosis has multiple etiologies with *7x increased* incidence and progression in patients with cancer.
- Pathogenesis → hypercoagulability, venous stasis, and vessel wall damage.
- Classified → acute, subacute, and chronic.
- **Clinical presentation**: affected extremity pain, swelling, tenderness. If associated with pulmonary embolism, there may be shortness of breath, pleuritic chest pain, tachycardia, ± hypoxia.²¹
### ACR Appropriateness Criteria for Suspected Upper-Extremity Deep Vein Thrombosis: Initial Imaging

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Appropriateness Category</th>
<th>Relative Radiation Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>US duplex Doppler upper extremity</td>
<td>Usually Appropriate</td>
<td>O</td>
</tr>
<tr>
<td>CTV upper extremity with IV contrast</td>
<td>May Be Appropriate</td>
<td>🌟🌟🌟🌟🌟</td>
</tr>
<tr>
<td>MRV upper extremity without and with IV contrast</td>
<td>May Be Appropriate</td>
<td>O</td>
</tr>
<tr>
<td>MRV upper extremity without IV contrast</td>
<td>May Be Appropriate</td>
<td>O</td>
</tr>
<tr>
<td>Catheter venography upper extremity</td>
<td>Usually Not Appropriate</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Nuclear medicine venography upper extremity</td>
<td>Usually Not Appropriate</td>
<td>🌟🌟🌟</td>
</tr>
<tr>
<td>Radiography chest</td>
<td>Usually Not Appropriate</td>
<td>🌟</td>
</tr>
</tbody>
</table>

- Upper extremity DVT accounts for ~ 10% of all diagnosed DVTs
- Secondary > primary causes of DVT:
  - indwelling venous devices such as catheters, pacemakers, defibrillators

Desjardins et al. *JACR* 2020
Esophageal Leiomyoma

Background Information

- Most common **benign** esophageal neoplasm
- Originate from **mature smooth muscle cells**
- **Male** predilection
- Mostly **asymptomatic**, but may cause dysphagia and pain depending on size.

Key Imaging Features

- Smoothly marginated, homogenous **intramural mass**
- Usually in the **mid to lower esophagus**
- Form right angles or slightly obtuse angles with the adjacent esophageal wall
- **Homogenous** enhancement without necrosis \(^{23}\)
**Hiatal Hernia**

### Background Information
- Prevalence increases with age
- 2 types: **sliding** and **para-esophageal**; **sliding is more common**
- Associated with GERD
- When large, there is ↑ risk of volvulus, strangulation, ischemia, and perforation

### Key Imaging Features
- **Widening** of the esophageal hiatus
- **Herniated stomach** into the lower thoracic cavity
- **Herniated contents laying adjacent to the distal esophagus**

Coronal image of sliding hiatal hernia on localizer.
Posterior Mediastinum
Posterior Mediastinum: Cervical Spinal Cord Syrinx

Background Information

Primary (young adults) vs. Secondary (any age group)
Unknown etiology but postulated to be due to abnormal drive of cerebral spinal fluid (CSF) into the cord vs. cord damage secondary to primary disease process (i.e. trauma, infectious/inflammatory, etc.)

Associated with:
Chiari malformation, hydrocephalus, blood products/trauma debris

Key Imaging Features

- Expanded spinal cord with dilated, beaded or sacculated appearance
- CSF-filled cavity in the spinal cord
- Fluid signal within the central cord → T1 hypointense, T2 hyperintense, non-enhancing

Sagittal localizer image
Vertebral Hemangioma

**Background Information**

- Common **benign** lesion within the vertebrae
- Most appear after the 4th or 5th decade of life
- **Female** predilection
- Complication rate < 1% (compression fracture, cord compression)
- Most frequently affect the **thoracic > lumbar > cervical vertebrae**

**Key Imaging Features**

- **Typical hemangioma** – T1 & T2 hyperintense (fat content)
- **Bone metastases** – T1 hypointense, T2 hypo-/hyperintense
- **Atypical hemangioma** – T1 iso- to hypointense, T2 hyperintense
- **Variable enhancement**
- **Look for aggressive features** – extension beyond the vertebral body, destruction of the cortex, and invasion of epidural and/or paravertebral spaces

![T1 hyperintense](image1.png)
![Subtle T2 hyperintensity from localizer image](image2.png)

27-28
Strategies To Guide Follow-up Management of Incidental Mediastinal Masses on MRI
Basic Algorithm for Managing Incidental Mediastinal Masses

- Localize to a compartment
- Identify suspicious features

Munden RF et al. JACR 2018
ACR Appropriateness Criteria for Indeterminant Mediastinal Masses on MRI: Next imaging study or surveillance

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Appropriateness Category</th>
<th>Relative Radiation Level</th>
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</thead>
<tbody>
<tr>
<td>Image-guided transthoracic needle biopsy</td>
<td>Usually Appropriate</td>
<td>Varies</td>
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<tr>
<td>MRI chest without and with IV contrast</td>
<td>Usually Appropriate</td>
<td>0</td>
</tr>
<tr>
<td>MRI chest without IV contrast</td>
<td>May Be Appropriate</td>
<td>0</td>
</tr>
<tr>
<td>CT chest with IV contrast</td>
<td>May Be Appropriate</td>
<td>🌟🌟</td>
</tr>
<tr>
<td>CT chest without IV contrast</td>
<td>May Be Appropriate</td>
<td>🌟🌟</td>
</tr>
<tr>
<td>FDG-PET/CT skull base to mid-thigh</td>
<td>May Be Appropriate</td>
<td>🌟🌟🌟🌟</td>
</tr>
<tr>
<td>US chest</td>
<td>Usually Not Appropriate</td>
<td>0</td>
</tr>
<tr>
<td>Radiography chest</td>
<td>Usually Not Appropriate</td>
<td>🌟</td>
</tr>
<tr>
<td>CT chest without and with IV contrast</td>
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Beyond the Mediastinum
Focal Liver Lesions: **Hemangioma**

**Benign**
- Cyst
- Hemangioma
- Focal nodular hyperplasia (FNH)
- Adenoma

**Malignant**
- Metastasis (most common)
- Hepatocellular carcinoma (HCC)
- Cholangiocarcinoma

**Key Imaging features**
- T2 hyperintense
- T1 hypointense
- Post contrast – nodular or flame-shaped, discontinuous, peripheral enhancement with late, progressive, centripetal filling and persistent delayed enhancement
Pleural Effusions

Types

- Transudative
- Exudative

Contents

- Low cell & protein count
- Protein rich

Etiology

- Congestive heart failure, cirrhosis, nephrotic syndrome, hypoalbuminemia
- Malignant neoplasm
- Infection

Key Imaging Features

- Fluid layering within the pleural space
- Mass effect on local structures
- Loculations
- Pleural thickness +/- enhancement

Large pleural effusion with compression of the underlying lung on localizer
**Rib Fractures**

- **Traumatic** – well-defined fracture line extending through the trabecular bone, heterogeneous T1 signal with patchy normal intervening fatty marrow, trace adjacent muscle edema
- **Pathologic** – absent or infiltrated fracture line, well-defined T1 hypointense signal abnormality, homogeneously low T1 without intervening marrow, substantial adjacent muscle edema

![Traumatic rib fracture on T1 post contrast](image)
Soft Tissue Infections: Abscess

Etiologies
• Direct Inoculation, local spread from broken skin
• Hematogenous spread

Predisposing factors
• Old age
• Immunosuppression, IV drug use
• HIV infection
• Diabetes
• Peripheral vascular disease
• Malnutrition

Classified by involved anatomic structures
• Skin & subcutaneous tissue (cellulitis & abscess)
• Fascia (necrotizing fasciitis)
• Muscle (infectious myositis & pyomyositis)
• Bursae (infectious bursitis)
• Tendons and tendon sheaths (suppurative tenosynovitis)

Key Imaging Features
• Anatomic location
• Low signal intensity fluid collection with rim enhancement
• Edema of surrounding tissues

Axillary subcutaneous abscess on T1 post-contrast
Intramuscular abscess: pectoralis major on T1 post-contrast
REFERENCES


REFERENCES (continued)


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