Learning objectives:
1. Review the ACR white paper’s recommendations for managing incidental thyroid nodules (ITN) detected on imaging.
2. Review the approach to preoperative assessment of a malignant thyroid mass on CT/MRI.
3. Discuss the imaging options for assessment of recurrent thyroid cancer.

Approach to incidental thyroid nodules on imaging
Thyroid cancer is the fastest increasing cancer in the USA. An exponential increase in incidence of thyroid cancer has been partly attributed to an increased work-up of incidentally detected thyroid nodules on imaging, especially ultrasound and CT. Excessive workup of incidental thyroid nodules and overdiagnosis of subclinical cancers is a costly healthcare problem. Although radiologists fear missing malignancies, the prognosis for most small localized small papillary cancers is excellent, even without treatment. The ACR white paper on incidental thyroid findings was published to guide the evaluation of incidental thyroid nodules detected on ultrasound, CT and MRI, and nuclear medicine studies (1). The criteria for workup with dedicated ultrasound is based on suspicious findings, nodule size, and comorbidities.

Preoperative assessment of the malignant thyroid mass with CT and MRI
• The majority of patients do not have preoperative imaging with CT or MRI because ultrasound adequately evaluates the primary tumor and nodal disease. The only reason to image with CT and MRI is concern for local invasion that may change operative approach or preclude curative intent surgery. In these patients it is valuable for the radiologist to appreciate components of the AJCC/UICC TNM staging system (Table 1) (2).
• It is important to recognize the difference in the pattern of metastases for different tumor histologies. Papillary and medullary thyroid carcinoma commonly metastasize to regional lymph nodes. The follicular subtype, on the other hand, rarely involves lymph nodes, but more commonly metastasizes to lung and bone. Anaplastic carcinoma is very locally aggressive, but can also metastasize to lymph nodes and the lung.
• The radiologist should evaluate invasion in viscera, neurovascular structures, and musculature.
  o Esophageal invasion: circumferential mass of >180°, obliteration of wall and lumen, focal T2 signal in the wall (3, 4).
  o Tracheal invasion: circumferential mass >180°, intraluminal mass/deformity, soft-tissue signal in cartilage (4, 5).
• Invasion of the RLN: effaced fatty tissue in the tracheoesophageal groove, >25% of circumference of the mass abuts the posterior thyroid capsule, signs of vocal cord paresis (4, 6).
• Vascular encasement: circumferential mass of >180°, arterial compression/deformation or loss of fat/fascia between tumor and artery (4, 7).
• Prevertebral musculature invasion: excluded if preserved retropharyngeal fat

• Morphological findings of thyroid cancer nodal metastases include cystic components, calcification, intense enhancement, or proteinaceous or hemorrhagic content appearing as hyperdensity on CT and T1 hyperintensity on MRI (8).
• In the past there were concerns about iodinated contrast agents delaying subsequent whole body scans or radioactive iodine, but this has now been shown to be unfounded. Recent studies show water soluble iodinated contrast agents are generally cleared within four weeks in most patients so post-thyroidectomy patients requiring radioiodine therapy can be scanned with radioactive iodine within one month of the contrasted CT (9, 10).

**Role of imaging in assessing recurrent thyroid cancer**
• Tumor recurrence with distant metastases reduces 10-year survival to 50%, but patients with locoregional recurrence interestingly may have no change in survival (11). Some patients may have small nodal metastases that remain undetected on imaging and untreated for their lifetime.
• Ultrasound of the neck is the first imaging investigation for suspected tumor recurrence and includes evaluation of the thyroid bed and cervical nodes. If the ultrasound is negative, radioiodine whole-body scintigraphy (WBS) is performed for differentiated thyroid carcinoma (DTC). WBS may also be performed as a first line investigation in high-risk DTC patients, such as those who initially had macroscopic invasion, gross residual disease or distant metastases.
• FDG-PET is performed if the ultrasound and WBS are negative. It is frequently positive when radioiodine uptake is negative, and vice versa. This is because radioiodine negative tumor represents dedifferentiated disease. FDG-avid disease is typically not responsive to radioactive iodine (RAI) and tends to have a worse prognosis (12-14).
• For medullary thyroid carcinoma (MTC), PET uptake can be helpful if positive, but even large metastases can be FDG-negative.

**Conclusion**
Excessive workup of incidental thyroid nodules and overdiagnosis of subclinical cancers is a costly healthcare problem. The ACR has recommendations for guiding the evaluation of incidental thyroid nodules detected on imaging. Ultrasound is ideal for characterizing thyroid nodules and guiding biopsy, but CT or MRI may be required preoperatively in cases of invasive thyroid cancer. PET-CT is the next
imaging option for suspected recurrent disease if the ultrasound and WBS are negative.

REFERENCES
14. Schreinemakers JM, Vriens MR, Munoz-Perez N, et al. Fluorodeoxyglucose-positron emission tomography scan-positive recurrent papillary thyroid cancer and

Table 1. American Joint Committee on Cancer (AJCC) TNM staging for differentiated thyroid carcinoma (DTC) and medullary thyroid carcinoma (MTC).

<table>
<thead>
<tr>
<th>Primary Tumor (T) Stage</th>
<th>Size in greatest dimension</th>
<th>Presence of Invasion</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1a</td>
<td>≤ 1 cm</td>
<td>Limited to thyroid</td>
</tr>
<tr>
<td>T1b</td>
<td>&gt; 1 cm but ≤ 2 cm</td>
<td>Limited to thyroid</td>
</tr>
<tr>
<td>T2</td>
<td>&gt; 2 cm but ≤ 4 cm</td>
<td>Limited to thyroid</td>
</tr>
<tr>
<td>T3</td>
<td>&gt; 4 cm or any size if minimal invasion</td>
<td>Limited to thyroid or minimal extrathyroid extension (e.g., extension to sternothyroid muscle or perithyroid soft tissues).</td>
</tr>
<tr>
<td>T4a</td>
<td>Any size</td>
<td>Beyond the thyroid capsule to invade subcutaneous soft tissues, larynx, trachea, esophagus, or recurrent laryngeal nerve.</td>
</tr>
<tr>
<td>T4b</td>
<td>Any size</td>
<td>Prevertebral fascia or encases carotid artery or mediastinal vessels.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regional Lymph Nodes (N) Stage</th>
<th>Nodal Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>N0</td>
<td>No regional metastasis</td>
</tr>
<tr>
<td>N1a</td>
<td>Central nodes</td>
</tr>
<tr>
<td>N1b</td>
<td>Level VI (pretracheal, paratracheal, and prelaryngeal/Delphian lymph nodes).</td>
</tr>
<tr>
<td>N1b</td>
<td>Lateral, retropharyngeal or mediastinal nodes</td>
</tr>
<tr>
<td></td>
<td>Metastases to unilateral, bilateral, or contralateral cervical (Levels I, II, III, IV, or V) or retropharyngeal or superior mediastinal lymph nodes (Level VII).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distant Metastases (M) Stage</th>
<th>Nodal Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0</td>
<td>No distant metastasis.</td>
</tr>
<tr>
<td>M1</td>
<td>Distant metastasis.</td>
</tr>
</tbody>
</table>

- DTC patients < 45 years of age can only be staged as Stage I or II, with Stage II having metastatic disease (M1).
- For DTC patients ≥ 45 years and for MTC of any age, M1 determines Stage IVC.
- All anaplastic carcinomas are T4a, confined to thyroid, or T4b, invasion beyond the capsule. Therefore, all are Stage IV.