Imaging of Neuroendocrine Tumors

Indications, Interpretations, Limits, and Pitfalls

Run Yu, MD, PhD[a,*], Ashley Wachsman, MD[b]

KEYWORDS

• Neuroendocrine tumor • Anatomic imaging • Functional imaging • CT • MRI
• Octreotide scan • Gallium-68 somatostatin analog PET

KEY POINTS

- Imaging plays critical and indispensable roles in the diagnosis, prognosis, and management of neuroendocrine tumors (NETs).
- Each imaging modality has its strengths and limits, and may give false-negative or false-positive results.
- NETs share common imaging features, but each type of NET exhibits unique imaging features.
- Computed tomography and MRI are used routinely to assess tumor burden; functional imaging with octreotide scan or Gallium-68 somatostatin analog PET is used selectively to confirm diagnosis and guide therapy.
- Open, frank, and inquisitive discussions among radiologists and clinicians are required to give a consistent, well-explained interpretation of the latest imaging findings to patients.

GENERAL PRINCIPLES ON IMAGING OF NEUROENDOCRINE TUMORS

Neuroendocrine Tumors

Neuroendocrine tumors (NETs) are a group of unique tumors and are defined in various ways.[1–3] Based on cellular origin, NETs are tumors derived from neuroendocrine cells, which share common features such as secreting peptide hormones, harboring dense core vesicles, and lack of neural structures. Based on histology, NETs are tumors composed of cells with stippled ("salt-and-pepper") chromatin and arranged in trabecular growth pattern; NETs are also positive for specific markers such as chromogranin A. Based on clinical behavior, NETs are usually indolent, but

Disclosure Statement: The authors have nothing to disclose.
[a] Division of Endocrinology, Diabetes & Metabolism, UCLA David Geffen School of Medicine, 200 Medical Plaza Driveway #530, Los Angeles, CA 90095, USA; [b] Department of Imaging, Cedars-Sinai Medical Center, 8700 Beverly Boulevard #M335, Los Angeles, CA 90048, USA
* Corresponding author.
E-mail address: runyu@mednet.ucla.edu

Endocrinol Metab Clin N Am ■ (2017) ■–■
http://dx.doi.org/10.1016/j.ecl.2017.04.008 **endo.theclinics.com**

have malignant potential and may secrete hormones that cause certain syndromes (eg, carcinoid syndrome). NETs can arise in virtually every organ but are most commonly found in the gastrointestinal (GI) tract, pancreas, and lungs. The clinical behavior, treatment, and prognosis of NETs largely depend on the organ of origin, hormonal secretion, tumor grade, and tumor stage, on most of which imaging provides invaluable information.

Roles of Imaging in Neuroendocrine Tumor Diagnosis, Prognosis, and Management

The roles of imaging in the diagnosis, prognosis, and management of NETs are critical and indispensable (**Box 1**). Imaging is important for NET diagnosis. In patients with hormonal hypersecretion syndromes such as carcinoid syndrome, positive biochemical test results per se are not sufficient to establish NET diagnosis because false-positive test results are common owing to interferences from other diseases, medications, and laboratory and cleric errors.[4–6] Imaging is required to locate the potential tumor and assess overall tumor burden. If extensive imaging studies cannot find the suspected tumor, the NET diagnosis is seriously challenged and alternative diagnoses need to be entertained. When a tumor is identified incidentally by imaging for other purposes, the imaging characteristics of the tumor often give helpful clues to the potential NET diagnosis.[7,8] Sometimes the imaging features are so unique that they can make an NET diagnosis. For example, focal hepatic steatosis around an enhancing mass is pathognomonic for malignant insulinoma liver metastasis.[9]

Once an NET is diagnosed, imaging further characterizes the NET to guide prognosis and management. Because the organ of origin often is informative of prognosis and treatment, identifying the organ of NET origin by imaging is routine in clinical practice.[8,10] Because NET staging is anatomically based, imaging is the most important and easiest means of establishing stage.[11] Although imaging itself cannot tell if an NET is functional or not, large tumor burden identified by imaging in a patient without specific symptoms strongly suggests that the tumor is nonfunctional; a small tumor burden in a similar patient cannot exclude a functional NET. Even for tumor grade, which is defined by proliferative markers in tumor specimen,[12] imaging still helps to confirm or dispute the tumor grade by documenting tumor growth speed. Functional imaging can also suggest tumor grade (see section on F-18 fluorodeoxyglucose [FDG] PET).

NET treatment is composed of surgical resection, liver-directed therapy, systemic therapy, and complication prevention and control.[1,3] Specific treatment and order of treatment need to be individualized, largely based on imaging findings in most patients. Patients with NETs limited to the primary organ or 1 liver lobe are often treated with surgical resection, those with a large liver tumor burden are treated

Box 1
Roles of imaging in NET diagnosis, prognosis, and management

- Finding an NET by imaging is required for NET diagnosis in most patients.
- Imaging is the predominant means of NET staging and contributes to prognosticating.
- NET imaging characteristics help guide therapeutic options.
- Imaging is the most reliable way to monitor treatment response and disease progression.

Abbreviation: NET, neuroendocrine tumor.