

Neuroendocrine Tumors: A Review of CT and MRI Findings

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Neuroendocrine tumors, including pancreatic neuroendocrine tumors and carcinoid tumors, are rare neoplasms that arise from a common precursor, the APUD cell (amine precursor uptake and decarboxylation). All neuroendocrine tumors have the ability to produce and secrete peptides and hormones, although many do not. Functional tumors, those that secrete hormones, tend to present early with small tumors due to the resulting clinical syndrome related to the excess hormone secretion. Conversely, non-functioning tumors (those without hormone secretion) tend to present later and with larger tumor size. For this reason, functional tumors can be sometime be very difficult, if not impossible, to identify on imaging due to small size.

Pancreatic neuroendocrine tumors are derived from the islet cells of Langerhans and include insulinomas, gastrinomas, and VIPomas. Although most pancreatic neuroendocrine tumors secrete a variety of hormones, they are classified based upon the presenting clinical syndrome. Additionally, it can be difficult to characterize a pancreatic neuroendocrine tumor as benign or malignant based upon histology, therefore careful evaluation for local invasive features and distant metastatic disease is important. It is also important to suggest the possibility of MEN 1 syndrome (Multiple Endocrine Neoplasia) in those patients who present before the 2nd decade or with multiple tumors.

CT is used widely for the localization of a primary pancreatic neuroendocrine tumor and to evaluate for metastatic disease. Most neuroendocrine tumors are isodense to the pancreas on precontrast (non-contrast) CT examinations. As most neuroendocrine tumors are hypervascular, they are best visualized as a hyperattenuating, enhancing mass after the administration of intravenous contrast. It is unclear, however, whether arterial phase imaging or portal venous phase imaging is best for identifying these tumors, especially when they are very small. Delayed imaging has also proven to be helpful in some cases. For this reason, many authors suggest multiphase imaging in order to increase sensitivity (Figure 1). Some authors also suggest using narrow window-level settings in order to increase the contrast between the tumor and background pancreas.

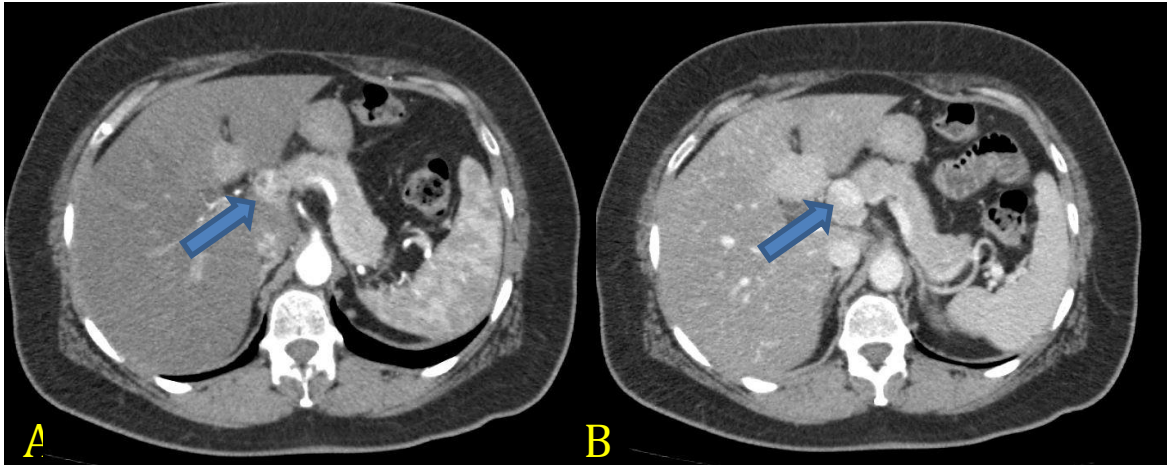


Figure 1: Axial CT images obtained in the arterial phase (A) and portal venous phase (B) demonstrate an enhancing mass within the pancreatic head consistent with pancreatic neuroendocrine tumor (blue arrows).

The use of MRI in the detection of pancreatic neuroendocrine tumors is rapidly increasing with sensitivity rivaling that of CT. These tumors classically demonstrate low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. Additionally, T1-weighted GRE (gradient recalled echo) sequences have shown to be of value in the identification of these tumors. Similar to CT, these tumors also demonstrate avid enhancement after the administration of gadolinium, reflecting their hypervascular nature. Larger lesions tend to demonstrate necrosis. Gadolinium based contrast may be especially useful in cases where non-contrast MRI techniques are negative or equivocal.

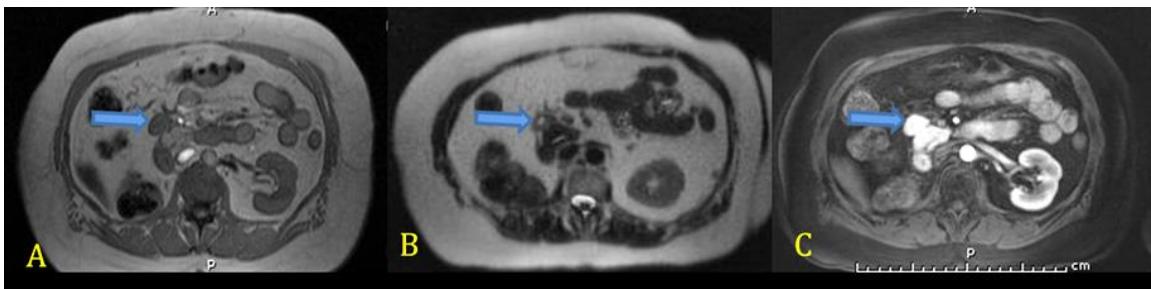


Figure 2: Multiple axial MRI images demonstrate a small exophytic mass that is inseparable from the pancreatic head. This mass demonstrates low signal intensity on T1-weighted sequences (A), increased signal intensity on T2-weighted sequences (B), and avid enhancement after the administration of gadolinium (C). This was a biopsy proven pancreatic neuroendocrine tumor.

CT and MRI both also play critical role in suggesting malignant behavior and in the identification of metastatic disease. Characteristics suggesting malignancy include large primary tumor, central necrosis, locally aggressive features such as vascular invasion, and calcification. Metastatic lesions appear similarly to the primary neoplasm, therefore typically presenting as hypervascular lesions with or

without central necrosis (Figure 3-5). The most common location for metastases is the liver.

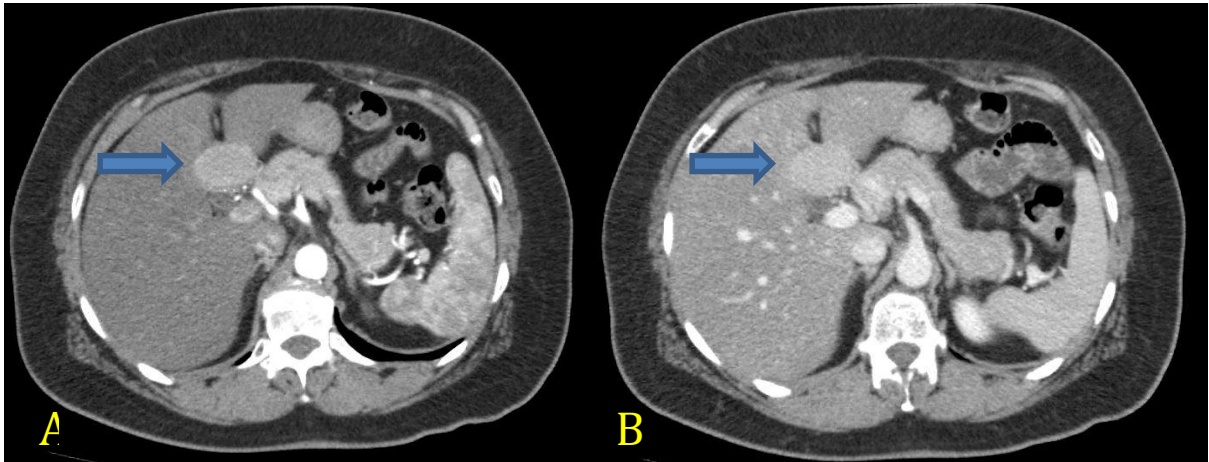


Figure 3: Multiple axial CT images from the same patient as in Figure 1, with imaging performed in the arterial phase (A) and portal venous phase (B), demonstrates an avidly enhancing mass within the liver adjacent to the falciform ligament consistent with hepatic metastasis.

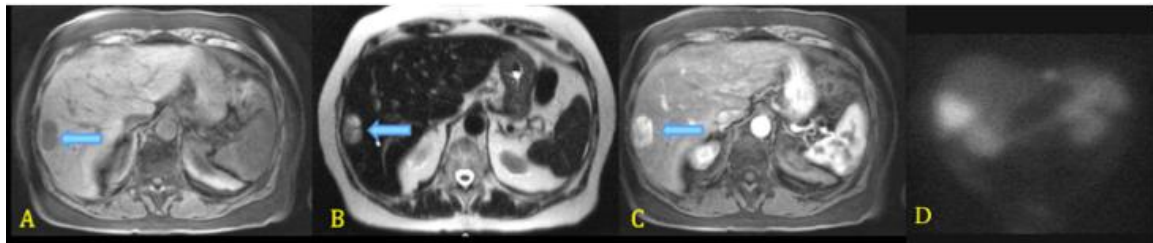


Figure 4: Multiple axial MRI images in a patient with metastatic pancreatic neuroendocrine tumor demonstrates a hepatic lesion with low signal intensity on T1-weighted sequences (A), increased signal intensity on T2-weighted sequences (B), and avid enhancement after the administration of gadolinium (C) consistent with metastasis. This confirms the findings on a ^{111}In -Octreoscan examination (D), which demonstrates focal uptake within the peripheral right hepatic lobe.



Figure 5: Single axial CT with contrast demonstrates multiple hepatic masses with central necrosis in a patient with known metastatic insulinoma.

Carcinoid tumors arise most commonly within the GI tract or the respiratory tract and are more common compared to pancreatic neuroendocrine tumors. These tumors are typically classified based on location of the primary lesion. Classically, carcinoid tumors produce and secrete serotonin, although more recent evidence demonstrates that these tumors produce a wide range of peptides and hormones, not just serotonin. Nevertheless, carcinoid syndrome develops in the presence of a serotonin secreting tumor with hepatic metastatic disease.

CT is also widely used in identifying primary carcinoid tumors. As with other neuroendocrine tumors, carcinoid tumors are also hypervascular and therefore avidly enhance following the administration of intravenous contrast. Central bronchial carcinoid typically presents as a smooth, enhancing mass within the bronchial lumen (often with an extraluminal component) with associated airway obstruction, collapse, or recurrent infection (Figure 6). Peripheral bronchial carcinoid has the appearance of a solitary pulmonary nodule. It is important to not mistake this hypervascular mass as a vessel or aneurysm, especially when precontrast images are not obtained. Although only typically used in problem solving scenarios, MRI will show a T2-hyperintense nodule that enhances avidly after gadolinium administration.

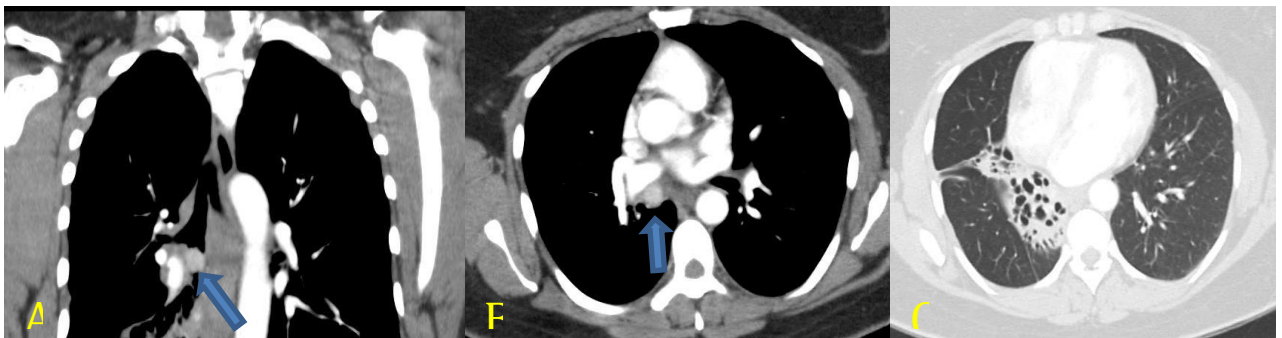


Figure 6: Coronal (A) and Axial (B) CT images of the chest in soft tissue windows demonstrate an avidly enhancing mass within the right lower lobe bronchus which was a biopsy proven carcinoid. Axial CT image (C) more inferiorly in lung windows illustrates post-obstructive bronchiectasis and collapse.

In contrast to bronchial carcinoids, the primary carcinoid tumor within the GI tract may not be identified on imaging, usually due to small size and inability to differentiate from the adjacent bowel wall. If identified, they may present as a hypervascular mass or as bowel wall thickening with avid enhancement. In these cases, MRI, especially T1-weighted post contrast sequences, may be more sensitive compared to CT. Nevertheless, CT and MRI typically identify evidence of metastatic disease. Liver metastases are most common and can be predominantly hypervascular or predominantly necrotic (Figure 7). Mesenteric desmoplastic fibrosis and mesenteric masses are also common and indicate metastatic disease. These present as a large mesenteric mass and/or central mesenteric fibrotic changes with a “stellate” or “spoke-wheel” appearance, both readily identifiable on CT and MRI (Figure 8). Lymph node, pulmonary and osseous metastases are also possible.

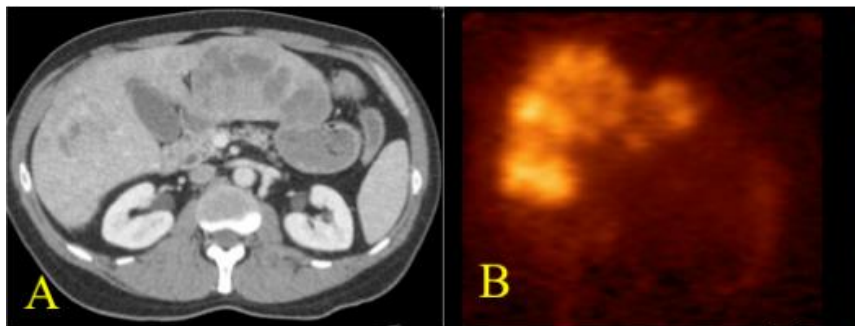


Figure 7: Single axial CT with contrast (A) demonstrates multiple, large ill-defined hepatic masses with large central necrosis confirming the findings of multiple octreotide avid hepatic masses on this coronal SPECT image from an 111-In-Octreoscan examination (B) in a patient with known metastatic carcinoid.

The identification of the primary neuroendocrine tumor is important in the treatment of both pancreatic neuroendocrine neoplasms and carcinoid tumors. However, many of the primary lesions are very small and identification can be difficult. It is impossible to know which modality will be best for any specific patient, and therefore, it may be necessary to obtain multiple examinations on the same patient. CT and MRI are powerful examinations, especially when used in conjunction with metabolic and radio-peptide imaging.

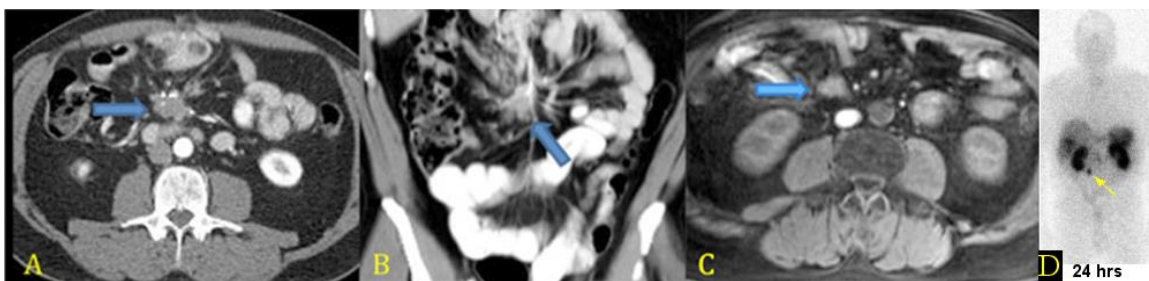


Figure 8: Axial (A) and Coronal (B) CT images demonstrate a mesenteric mass with associated desmoplastic reaction and fibrotic changes with calcifications

consistent with metastatic carcinoid. Similar findings are identified on an axial T1-weighted fat saturated image (C) in the same patient. The CT and MRI confirm and localize the finding of a somatostatin receptor avid mass (arrow) in the mid abdomen as seen on an anterior 111-In-Octreoscan examination (D).

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