Computed Tomography (CT) imaging characteristics of pancreatic neuroendocrine tumors.

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Aims and objectives

Pancreatic neuroendocrine tumors (pNETs) are rare tumors, representing about 1-2% of all pancreatic neoplasms. An increase of pNET as an incidental finding on imaging has been reported (1). PNETs are divided into functioning or non-functioning tumors, indicating presence or absence of hormone production.

A limited number of studies have described imaging characteristics of pNETs. Functioning pNETs have been described as small hypervascular tumors. Non functioning pNETs are often described larger at presentation and can be capsulated with heterogeneous enhancement. Also necrotic or cystic changes and calcifications may occur. Malignant lesions may show invasive growth and metastases (1,2). The aim of this study is to describe the characteristics of pNETs on postcontrast CT.

Methods and materials

Patients

CT scans were reviewed of 46 consecutive patients who had a resected and pathologically proven pNET. Patients were referred to our tertiary referring center from January 2007 until January 2013. Imaging studies were either performed at the referring hospital or in our center.

Image Analysis

CT characteristics were scored by an abdominal radiologist with more than 10 years experience. The following CT features were evaluated; largest diameter and location of the tumor (head, uncinate, neck, body or tail of the pancreas).

Density of the pNET was measured in HU and compared to pancreatic parenchyma in all available phases. This was used as an aid to score the tumor as hyper-, iso- or hypodense relative to pancreatic parenchyma.

Presence of cystic and necrotic components was scored on basis of a nonenhancing low density area in different scan phases (comparison of pre- and postcontrast CT scans or early enhanced CT scans (arterial, pancreatic parenchymal phase) and enhanced CT scans in portovenous phase). A cystic component was scored when a thin walled collection was seen. Necrotic components were scored when a solid lesion with a central irregular shaped collection was seen.
Furthermore presence of calcifications was scored.

Pancreatic duct dilatation (PD) was described. Cut off value for the PD was 3 mm.

**Data Analysis**

IBM SPSS statistics, version 20.0 was used for statistical analysis. Chi-squared test or unpaired t-test were used, based on the type of outcome data. A $p$ value less than 0.05 was considered significant.

**Results**

**Pathologic and clinical findings.**

All lesions were resected and pathologically proven pNETs. Only 4 of 46 patients had a functioning pNET, all were insulinomas. No significant differences in size, cystic components, necrosis and/or enhancement pattern were found between the functioning and non functioning pNETs.

**Imaging findings**

All patients underwent a post contrast CT scan. Scan quality for all was found sufficient to include in this study. 12 patients had a non enhanced CT scan, 19 patients had a post contrast CT scan in arterial phase, 19 patients had a post contrast CT scan in pancreatic parenchymal phase and 43 patients had a post contrast CT scan in portovenous phase.

All lesions were solitary lesions diagnosed as pNETs, the median diameter was 26 mm (14 - 46mm).

In arterial phase 79% ($N=15/19$) of tumors were hyperdense relative to pancreatic parenchyma and 10.5% were either isodense or hypodense (both $N=2/19$). In pancreatic parenchymal phase 78% ($N=14/18$) were hyperdense, 17% isodense ($N=3/18$) and 5% hypodense ($N=1/18$). In portovenous phase 70% ($N=30/43$) were hyperdense, 21% isodense ($N=9/43$) and 9% hypodense ($N=4/43$). 33 patients had both an early enhanced CT scan (arterial or pancreatic parenchymal phase) and an enhanced CT scan in portovenous phase. In 72% ($N=24/33$) of these the density remained high in both early (arterial and/or pancreatic parenchymal) phase and portovenous phase ($P < 0.05$).
Calcifications were seen in 30% (N=14), cystic degeneration in 13% (N=6), necrosis in 28% (N=13). Occurrence of necrosis was not different between tumor size < 20 mm and ≥20 mm (N=4/19 vs. N=9/27).

A dilated pancreatic duct was seen in 12 patients (28%); all tumors were ≥20mm (P < 0.05), median diameter was 38 mm and most of these tumors were located distally in the pancreas (67%, 8/12).

Images for this section:

Fig. 1: Non enhanced CT with pNET in pancreatic tail with calcification
**Fig. 2:** Post contrast CT scan in arterial phase with hypodense pNET in the head/uncinate of the pancreas and punctiform central calcifications

**Fig. 3:** Two examples of cystic pNETs with central location in the pancreas on post contrast CT scan in pancreatic parenchymal scan phase
Fig. 4: Enhancing and necrotic pNET in uncinate on post contrast CT in arterial scan phase
**Fig. 5:** Large enhancing mass in head/uncinate with accompanying dilated PD anteriorly. Post contrast CT scan in pancreatic parenchymal scan phase.

**Fig. 6:** Very small hypervascular pNET in the body of the pancreas marked by red arrow on the left image. Right image shows extensive proximal dilatation of the PD. Both are post contrast CT scans in portovenous scan phase.
Conclusion

In this study a low prevalence of functional pNETs was found (4/46, 9%). Other authors describe a prevalence of up to 50% (3). Possible explanation is a selection bias.

Most pNETs in this study (72%) showed enhancement both in early and portovenous phase, indicating that the diagnosis can usually be made on routine abdominal CT.

A previous study related enhancement of pNETs to tumor vascularity in light microscopy (4). Hypervascularity of pNETs is well established, especially in functioning pNETs (1). This study shows that hypervascularity also frequently occurs in non functioning pNETs.

30% of pNETs in this series showed calcification. The role of calcification in pNETs remains to be elucidated. Studies have shown calcification to be associated with well differentiated tumors, whereas other studies describe it as a sign of malignancy (1,4,5).

Cystic degeneration was shown in 13% of pNETs. This finding is consistent with a recent study that showed cystic degeneration in 17% of pNETs (6).

Necrosis was found in 28% of pNETs in this series. Necrosis has been described as a general feature in non functioning pNETs. No clear mentioning of the prevalence is done (1).

28% of pNETS presented with a dilated PD. The presence of a dilated PD in pNETs is often described as a rare feature in comparison to this finding in adenocarcinoma of the pancreas(3). However since almost one third of patients in this series presented with a dilated PD we consider this finding noteworthy.

There are some general limitations to this study. It is a retrospective study that makes use of different scan protocols. Comparing results of multiphase imaging to tumor grade was not possible since pathology reporting according to latest WHO guidelines was not available for this population (7).

Personal information
References