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ABOUT COVER

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ORIGINAL ARTICLE

Retrospective Study

Comparison between solid pseudopapillary neoplasms of the pancreas and pancreatic ductal adenocarcinoma with cystic changes using computed tomography

Shuai Ren, Li-Chao Qian, Xiao-Jing Lv, Ying-Ying Cao, Marcus J Daniels, Zhong-Qiu Wang, Li-Na Song, Ying Tian

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Abstract

BACKGROUND

Solid pseudopapillary neoplasms of the pancreas (SPN) share similar imaging findings with pancreatic ductal adenocarcinoma with cystic changes (PDAC with cystic changes), which may result in unnecessary surgery.

AIM

To investigate the value of computed tomography (CT) in differentiation of SPN from PDAC with cystic changes.

METHODS

This study retrospectively analyzed the clinical and imaging findings of 32 patients diagnosed with SPN and 14 patients diagnosed with PDAC exhibiting cystic changes, confirmed through pathological diagnosis. Quantitative and qualitative analysis was performed, including assessment of age, sex, tumor size, shape, margin, density, enhancement pattern, CT values of tumors, CT contrast

enhancement ratios, "floating cloud sign," calcification, main pancreatic duct dilatation, pancreatic atrophy, and peripancreatic invasion or distal metastasis. Multivariate logistic regression analysis was used to identify relevant features to differentiate between SPN and PDAC with cystic changes, and receiver operating characteristic curves were obtained to evaluate the diagnostic performance of each variable and their combination.

RESULTS

When compared to PDAC with cystic changes, SPN had a lower age (32 years *vs* 64 years, $P < 0.05$) and a slightly larger size (5.41 cm *vs* 3.90 cm, $P < 0.05$). SPN had a higher frequency of "floating cloud sign" and peripancreatic invasion or distal metastasis than PDAC with cystic changes (both $P < 0.05$). No significant difference was found with respect to sex, tumor location, shape, margin, density, main pancreatic duct dilatation, calcification, pancreatic atrophy, enhancement pattern, CT values of tumors, or CT contrast enhancement ratios between the two groups (all $P > 0.05$). The area under the receiver operating characteristic curve of the combination was 0.833 (95% confidence interval: 0.708-0.957) with 78.6% sensitivity, 81.3% specificity, and 80.4% accuracy in differentiation of SPN from PDAC with cystic changes.

CONCLUSION

A larger tumor size, "floating cloud sign," and peripancreatic invasion or distal metastasis are useful CT imaging features that are more common in SPN and may help discriminate SPN from PDAC with cystic changes.

Key Words: Solid pseudopapillary neoplasm; Pancreas; Pancreatic ductal adenocarcinoma; Computed tomography; Differential diagnosis

Core Tip: Most solid pseudopapillary neoplasms of the pancreas (SPN) are indolent tumors that could yield a perfect prognosis with complete surgical resection. Approximately 8% of pancreatic ductal adenocarcinoma (PDAC) may have cystic characteristics, which share similar radiological imaging features with SPN and lead to misinterpretation. It would be of great clinical value to preoperatively differentiate SPN from PDAC with cystic changes. In this study, a larger tumor size, "floating cloud sign," and peripancreatic invasion or distal metastasis are useful computed tomography imaging features that are more common in SPN and may help discriminate SPN from PDAC with cystic changes.

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INTRODUCTION

The majority of pancreatic neoplasms have a solid growth pattern and are pancreatic ductal adenocarcinoma (PDAC). Cystic neoplasms are rare but have special pathology and biology. The most common cystic tumors are serous cystic neoplasms, mucinous cystic neoplasms, intraductal papillary mucinous neoplasms, and solid pseudopapillary neoplasms (SPNs). Rare cystic neoplasms include acinar cell cystadenomas, cystic neuroendocrine tumors, acinar cell cystadenocarcinomas, and PDAC with cystic changes[1].

SPNs of the pancreas are low-grade malignant tumors that exhibit local metastasis or invasion in only 20% of cases[2]. Most SPNs are relatively indolent tumors that yield a great prognosis with complete surgical resection[3]. SPNs account for 1%-2% of all pancreatic neoplasms and 10%-15% of cystic pancreatic neoplasms[4]. The detection rate of SPNs has increased due to the widespread use of medical examination technology. The varying radiological imaging features of SPNs has made it easy to be diagnosed radiologically to be PDAC, neuroendocrine tumors, or cystadenoma[1,4-6].

Approximately 8% of PDAC cases have cystic characteristics, which share similar radiological imaging features with cystic pancreatic tumors and lead to misinterpretation[6]. Most PDAC with cystic changes reported in the literature were poorly differentiated tumors showing pseudocystic changes[7]. A large proportion of PDAC patients with locally advanced disease are not eligible for curative surgical resection, resulting in an unfavorable prognosis and short survival time[8]. Awareness of these atypical or uncommon presentations may avoid a delayed diagnosis of PDAC. Unfortunately, it is difficult for radiologists to differentiate PDAC with cystic changes from its mimickers in routine clinical practice. As treatment strategies and patient prognosis are totally different for PDAC and SPNs, preoperative differentiation of PDAC with cystic changes from SPNs is key. The purpose of our study was to investigate the potential value of computed tomography (CT) imaging features in the differential diagnosis between PDAC with cystic changes and SPNs.

MATERIALS AND METHODS

Patients

Our institutional review board approved this retrospective study, and the need to obtain informed consent was waived. Between January 2016 and December 2019, a total of 164 patients with pathologically proven PDAC were found in our medical database. Inclusion criteria for PDAC were as follows: (1) Contrast-enhanced CT (CE-CT) images were available; (2) Diagnosis of PDAC was made pathologically following surgical resection or needle biopsy; and (3) Radiologically, tumors demonstrated cystic features including neoplastic cystic region within the tumor or as a non-neoplastic cyst surrounding the tumor. According to preassigned inclusion criteria, 150 patients were excluded from the study, *i.e.* 17 patients did not have available CE-CT, 6 patients had a history of local treatment prior to CT scan, and 127 patients had predominantly solid tumors. Finally, 14 PDAC patients with cystic changes were included in this study (Figure 1).

Similarly, 59 patients with pathologically proven SPNs were found in our medical database between January 2016 and December 2019. Inclusion criteria for SPN were as follows: (1) CE-CT images were available; and (2) Diagnosis of SPN was made pathologically following surgical resection or needle biopsy. According to these criteria, 27 patients were excluded from the study, *i.e.* 15 patients did not have available CE-CT, 7 patients had inadequacy of histopathological data, 2 patients had a history of local treatment prior to CT scans, and 3 patients did not have the tumor identified on preoperative CT. Finally, 32 SPNs patients were included in this study (Figure 1).

CT imaging

CE-CT images consisting of plain phase, arterial phase, portal venous phase, and delayed phase were acquired using the following scanners: Philips Brilliance 64 (Philips Healthcare, DA Best); Discovery HD750 (GE Healthcare); and Optima 670 (GE Healthcare). The following parameters were used during CT scanning: 3.0 mm slice thickness with a reconstruction interval of 1.25 mm; tube voltage of 120 kVp; automated tube current of 200-400 mA; and gantry rotation speed of 0.75 seconds. For CE-CT scans, patients received an amount of 100-120 mL of contrast media (Omnipaque 350 mgI/mL, GE Healthcare) at a rate of 3.0 mL/s followed by 40 mL saline solution. Triple-phase CE-CT was acquired with a delay time of 35 s, 60 s, and 120 s for the arterial, portal venous, and delayed phase after the start of contrast agent administration.

Qualitative imaging analysis

Two abdominal radiologists blinded to the histopathological information, evaluated the following CT imaging characteristics for a consensus opinion: Tumor location (head-neck *vs* body-tail); tumor size (the largest section on the axial position); tumor margin (well-defined *vs* ill-defined); tumor density (predominantly solid, cystic-solid, predominantly cystic); tumor shape (round, lobulated, or irregular); calcification; "floating cloud" sign; main pancreatic duct (MPD) dilatation; pancreatic atrophy; and peripancreatic invasion or distal metastasis. Smooth and visible margin indicated a well-defined margin and spiculation or infiltration on more than one-quarter of the mass perimeter indicated an ill-defined margin[9]. Tumor density was divided into predominantly solid (solid components > 90%), cystic-solid (solid components 10%-90%), and predominantly cystic (solid components < 10%)[10]. Calcification was observed and defined at the plain phase. "Floating cloud" sign was defined as enhanced solid components within the non-enhanced cystic components[10]. The MPD diameter ≥ 4 mm in the head of pancreas and ≥ 3 mm in the body and tail of the pancreas indicated MPD dilatation[11]. Pancreatic atrophy was regarded as atrophy of parenchyma distal to the focal lesion or disproportional atrophy if there was no pancreatic focal lesion[12].

Quantitative imaging analysis

A third radiologist who did not perform qualitative image analysis and was blinded to the histopathological information measured tumor size, CT attenuation values of tumors, and adjacent pancreatic parenchyma. Oval regions of interest were placed within the mass and the downstream pancreatic parenchyma as large as possible at each imaging phase. Cystic or necrotic components, calcifications, pancreatic ducts, and vessels were avoided during region of interest delineation. CT attenuation values of tumors measured in the arterial, portal, and delayed phases were defined as ACE, PCE, and DCE. The tumor-to-pancreas enhancement ratio was calculated by dividing the Hounsfield Unit (HU) values of the tumor by those of adjacent pancreatic parenchyma. This measurement was performed in the arterial (AER), portal venous (PER), and delayed phases (DER)[9].

Statistical analysis

Statistical analyses were carried out with commercially available software (SPSS 20.0, Armonk, NY, United States, and R software 3.6.1, https://www.r-project.org). We compared the CT imaging features between SPN and PDAC with cystic changes. Interobserver agreement of the qualitative imaging features was assessed by calculating the κ coefficient. We defined κ values for level of agreement as following: Slight agreement, < 0.2; fair agreement, 0.21-0.40; moderate agreement, 0.41-0.60; substantial agreement, 0.61-0.80; excellent agreement, > 0.80. Qualitative variables were compared using χ^2 or Fisher's exact tests, and quantitative variables were compared using Mann-Whitney *U* test. Multivariate logistic regression analysis was used to analyze significant imaging features associated with SPNs, and receiver operating characteristic curves were obtained to evaluate the diagnostic performance of each variable and their combination. To analyze statistical difference and calculate the standard error of the areas under the curve (AUC), the *Z*-test and DeLong's method was used in the present study. A *P* value < 0.05 was considered statistically significant.

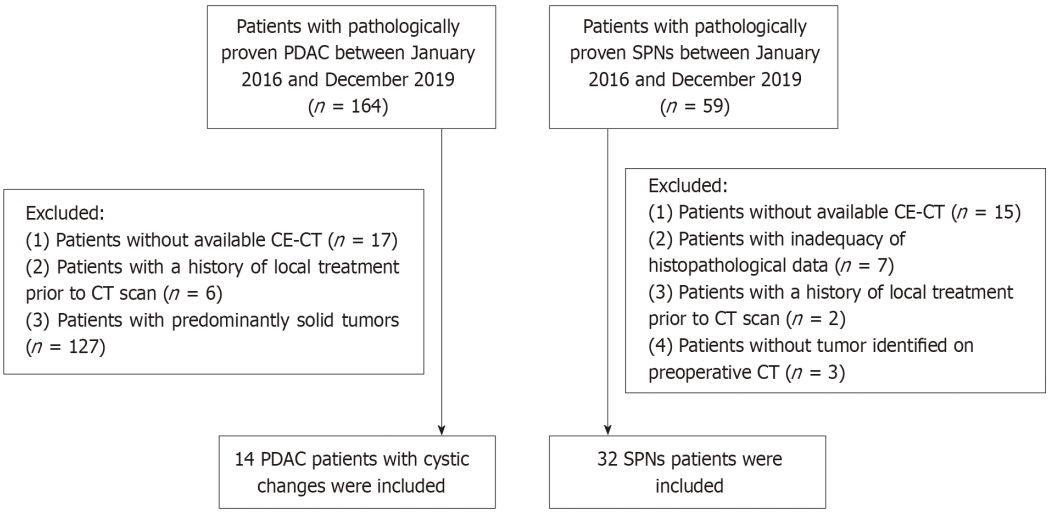

Figure 1 Flowchart of patients throughout the study. CE-CT: Contrast-enhanced computed tomography; CT: Computed tomography; PDAC: Pancreatic ductal adenocarcinoma; SPN: Solid pseudopapillary neoplasms.

RESULTS

Fourteen patients (7 males and 7 females) with pathologically confirmed PDAC and 32 patients (8 males and 24 females) with pathologically confirmed SPNs were included and analyzed in our study. Typically, SPNs occurred more frequently in younger patients than PDAC with cystic changes (age, mean ± SD, 32.00 ± 13.04 years *vs* 64.93 ± 11.72 years, $P < 0.001$). In the SPN group, 14 patients had tumors located at the head and neck of the pancreas and 18 at the body or the tail. In the PDAC with cystic changes group, 9 patients had tumors located at the head and neck of the pancreas and 5 at the body or the tail. No significant difference was found with respect to sex or tumor location (both $P > 0.05$). Qualitative CT characteristics between PDAC with cystic changes and SPNs are listed in Table 1.

SPNs showed a higher frequency of "floating cloud" sign (84.4% *vs* 42.9%, $P < 0.001$) and a lower frequency of peripancreatic invasion or distal metastasis (6.25% *vs* 42.90%, $P = 0.006$) compared with PDAC with cystic changes (Figure 2). However, a misdiagnosis of SPN might still occur in some atypical cases where the "floating cloud" sign is observed in PDAC with cystic changes (Figure 3). No significant difference was found in tumor shape, margin, density, calcification, pancreatic atrophy, MPD dilatation, or enhancement pattern (all $P > 0.05$). PDAC with cystic changes was more likely to appear with pancreatic duct dilatation compared with SPNs, although the difference did not reach statistical significance between groups ($P = 0.117$).

We assessed the interobserver agreement of the qualitative CT imaging features between the two radiologists. The following imaging features demonstrated excellent interobserver agreement: Tumor margin ($\kappa = 0.898$); calcification ($\kappa = 1.0$); "floating cloud" sign ($\kappa = 0.850$); pancreatic atrophy ($\kappa = 0.826$); MPD dilatation ($\kappa = 0.869$); and peripancreatic invasion or distal metastasis ($\kappa = 0.862$). Tumor density ($\kappa = 0.641$), tumor shape ($\kappa = 0.786$), and enhancement pattern ($\kappa = 0.657$) showed substantial interobserver agreement.

Quantitative CT characteristics between PDAC with cystic changes and SPNs are listed in Table 1. SPNs were more likely to have a larger size compared with PDAC with cystic changes (5.41 ± 2.89 cm *vs* 3.90 ± 1.24 cm, $P = 0.017$). No significant difference was found with respect to ACE (55.39 ± 7.57 HU *vs* 54.88 ± 10.85 HU, $P = 0.854$), PCE (66.79 ± 7.31 HU *vs* 67.99 ± 13.03 HU, $P = 0.691$), or DCE (73.34 ± 7.16 HU *vs* 72.70 ± 9.47 HU, $P = 0.799$). Similarly, there were no significant differences in AER (0.57 ± 0.10 *vs* 0.61 ± 0.11, $P = 0.224$), PER (0.67 ± 0.11 *vs* 0.66 ± 0.13, $P = 0.833$), or DER (0.81 ± 0.08 *vs* 0.79 ± 0.09, $P = 0.557$).

We subsequently evaluated the diagnostic performance of the CT characteristics and their combination (named as "model") in differentiating PDAC with cystic changes from SPNs (Table 2 and Figure 4). The AUCs ranged from 0.634 to 0.833. The sensitivity and specificity ranged from 42.9% to 78.6% and from 53.1% to 93.8%, respectively. The accuracies with "floating cloud" sign, peripancreatic invasion or distal metastasis, tumor size, and model ranged from 60.9% to 80.4%. The positive and negative predictive values ranged from 42.3% to 75.0% and 78.9% to 89.7%, respectively. Finally, we used the *Z* test to compare the AUCs among CT characteristics and their combination. A significant difference was found in AUCs between tumor and model ($P = 0.01$) and peripancreatic invasion or distal metastasis and model ($P = 0.01$). There was no statistically significant difference in AUCs between tumor size and "floating cloud" sign ($P = 0.50$), tumor size and peripancreatic invasion or distal metastasis ($P = 0.60$), "floating cloud" sign and peripancreatic invasion or distal metastasis ($P = 0.82$), or "floating cloud" sign and model ($P = 0.08$).

DISCUSSION

SPNs are uncommon tumors and predominantly seen in young female patients for as-yet-unknown reasons. Most SPN

Table 1 Comparisons of the clinical and imaging findings between solid pseudopapillary neoplasms of the pancreas and pancreatic ductal adenocarcinoma with cystic changes

Variables	SPN, *n* = 32	PDAC with cystic changes, *n* = 14	*P* value
Sex			
Male	8 (25)	7 (50)	0.170
Female	24 (75)	7 (50)	
Age in yr	32.00 ± 13.04	64.93 ± 11.72	< 0.001
Location			
Head & neck	14 (43.75)	9 (64.3)	0.337
Body & tail	18 (56.25)	5 (35.7)	
Shape			
Round	12 (37.5)	1 (7.1)	0.072
Lobulated or irregular	20 (62.5)	13 (92.9)	
Margin			
Well-defined	21 (65.6)	5 (35.7)	0.060
Ill-defined	11 (34.4)	9 (64.3)	
Density			
Predominantly solid	2 (6.25)	0 (0)	0.384
Cystic-solid	28 (87.50)	14 (100)	
Predominantly cystic	2 (6.25)	0 (0)	
Calcification			
Yes	11 (34.4)	1 (7.1)	0.073
No	21 (65.6)	13 (92.9)	
"Floating cloud" sign			
Yes	27 (84.4)	6 (42.9)	< 0.001
No	5 (15.6)	8 (57.1)	
Pancreatic atrophy			
Yes	6 (18.75)	5 (35.7)	0.269
No	26 (81.25)	9 (64.3)	
MPD dilatation			
Yes	12 (37.5)	9 (64.3)	0.117
No	20 (62.5)	5 (35.7)	
Peripancreatic invasion or distal metastasis			0.006
Yes	2 (6.25)	6 (42.9)	
No	30 (93.75)	8 (57.1)	
Enhancement pattern			0.504
Homogeneous	1 (3.1)	0 (0)	
Heterogeneous	31 (96.9)	14 (100)	
Size in cm	5.41 ± 2.89	3.90 ± 1.24	0.017
CT attenuation values in HU			
Plain phase	37.37 ± 4.82	36.82 ± 4.80	0.729
Arterial phase	55.39 ± 7.57	54.88 ± 10.85	0.854
Portal venous phase	66.79 ± 7.31	67.99 ± 13.03	0.691

Delayed phase	73.34 ± 7.16	72.70 ± 9.47	0.799
Tumor-to-pancreas enhancement ratio			
Arterial phase	0.57 ± 0.10	0.61 ± 0.11	0.224
Portal venous phase	0.67 ± 0.11	0.66 ± 0.13	0.833
Delayed phase	0.81 ± 0.08	0.79 ± 0.09	0.557

Data are *n* (%). CT: Computed tomography; HU: Hounsfield unit; MPD: Main pancreatic duct; PDAC: Pancreatic ductal adenocarcinoma; SPN: Solid pseudopapillary neoplasms.

Table 2 Diagnostic performance of computed tomography characteristics and their combination (named as "model") in differentiating pancreatic ductal adenocarcinoma with cystic changes from solid pseudopapillary neoplasms

Variables	AUC	Sensitivity, %	Specificity, %	Accuracy, %	PPV, %	NPV, %
Tumor size	0.634	79	53	61	42	85
"Floating cloud" sign	0.708	57	84	76	62	82
Peripancreatic invasion or distal metastasis	0.683	43	94	78	75	79
Model	0.833	79	81	80	65	90

AUC: Area under curve; NPV: Negative predictive value; PPV: Positive predictive value.

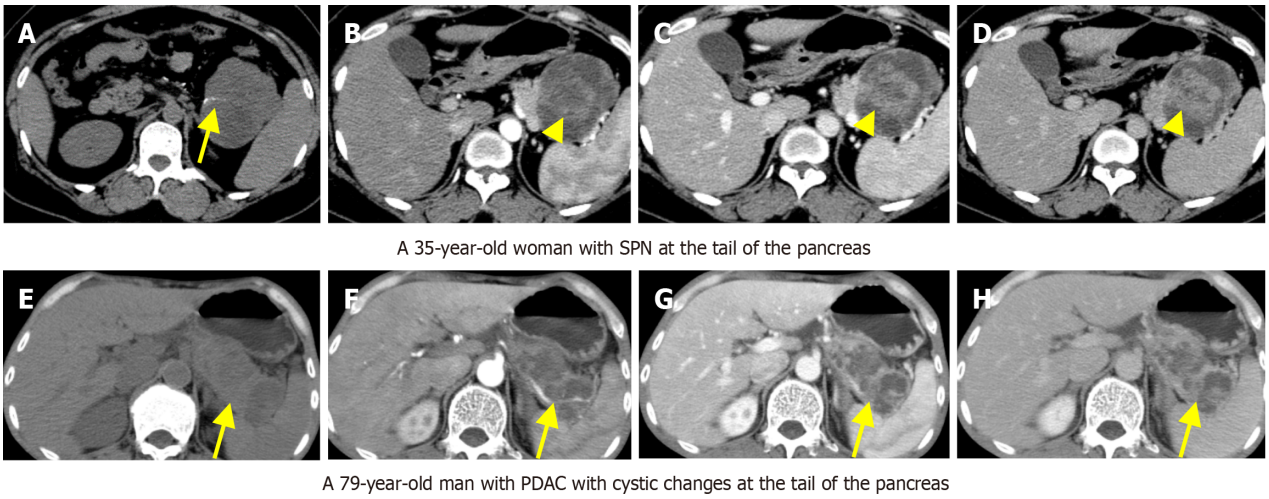

Figure 2 Computed tomography images of two cases with solid pseudopapillary neoplasms of the pancreas and pancreatic ductal adenocarcinoma with cystic changes. A: Plain phase computed tomography images showed a hypodensity tumor with a well-defined margin, and calcifications (arrow) were observed within the tumor; B-D: The tumor showed a heterogeneous enhancement pattern in the arterial, portal venous, and delayed phases. Notably, the solid components within the tumor showed enhanced patchy-like structures, which were defined as "floating cloud sign" (arrowhead); E: Plain phase computed tomography images showed a hypodensity tumor with an ill-defined margin (arrow); F: The tumor showed a heterogeneous enhancement pattern with blood vessels wrapped by the tumor in the arterial phase; G and H: The solid components within the tumor showed a slight persistent enhancement pattern. SPN: Solid pseudopapillary neoplasms of the pancreas; PDAC: Pancreatic ductal adenocarcinoma.

patients are asymptomatic at diagnosis with abdominal pain as the most common symptom[13]. SPNs are likely to be large at presentation with a mean size of 9 cm (range: 2.5-17.0 cm) and a well-defined margin, which can be found throughout the pancreas. Large SPNs can be differentiated from PDAC due to the fact that they contain solid and cystic components correlated with hemorrhage, necrosis, and cystic degeneration[14,15]. When SPNs lack hemorrhagic components or necrosis, they may appear nonspecific and mimic PDAC[14].

Additionally, although most PDAC show classic imaging characteristics, some PDAC patients can present with atypical features including calcifications, cystic changes, and multifocal masses. Atypical PDAC cases may also appear solid with cystic components, and it represents PDAC arising from a branch duct or main duct intraductal papillary mucinous neoplasms, making it difficult to differentiate from SPNs[16]. More than 80% of SPNs are localized tumors that are benign or have low-grade malignancy and can be cured with the aid of somewhat minimal surgical resection[17].

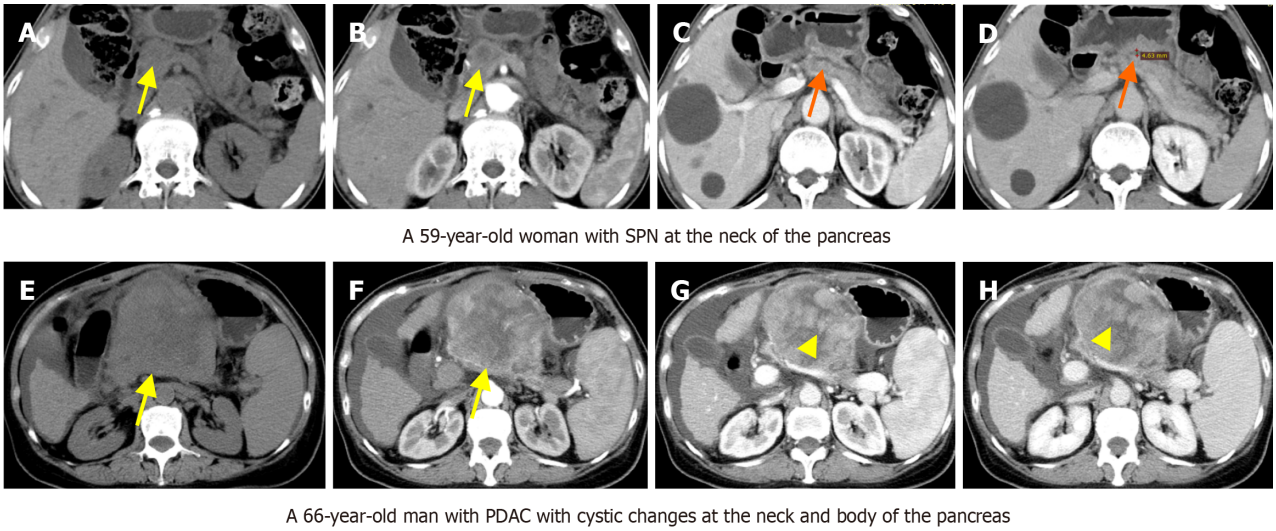

Figure 3 Computed tomography images of two cases with solid pseudopapillary neoplasms of the pancreas and pancreatic ductal adenocarcinoma with cystic changes. A: Plain phase computed tomography images showed a hypodensity tumor with an ill-defined margin; B: The tumor showed a heterogeneous enhancement pattern in the arterial phase; C and D: Portal venous and delayed phases showed slight upstream pancreatic duct dilatation; E: Plain phase computed tomography images showed a hypodensity tumor with a well-defined margin (arrow); F-H: The tumor showed a heterogeneous enhancement pattern in the arterial, portal venous, and delayed phases with blood vessels wrapped by the tumor. The solid components within the tumor showed enhanced patchy-like structures with a slight persistent enhancement pattern, which were defined as "floating cloud sign" (arrowhead) (G and H). SPN: Solid pseudopapillary neoplasms of the pancreas; PDAC: Pancreatic ductal adenocarcinoma.

However, less than 20% of PDAC patients are suitable for surgery and have an unfavorable prognosis. Therefore, it is of utmost importance to preoperatively differentiate SPNs from PDAC with a non-invasive method.

In our study, SPNs occurred more frequently in younger patients than PDAC with cystic changes (32.00 ± 13.04 years *vs* 64.93 ± 11.72 years, $P < 0.001$), which is consistent with the study by Shi *et al*[18]. Ma *et al*[19] concluded that SPNs often occurred in 20-40-year-old female patients with tumors located at the body or tail of the pancreas[19]. In our study, although no significant difference was found with respect to sex, 75% of SPN patients were female. SPNs are predominantly located at the body and tail of the pancreas compared with PDAC with cystic changes (56.25% *vs* 35.7%), although the difference did not reach statistical significance ($P = 0.337$). PDAC with cystic changes has a high frequency of a lobulated or irregular tumor margin compared with SPNs (92.9% *vs* 62.5%), although the difference did not reach statistical significance ($P = 0.072$).

"Floating cloud" sign is a specific characteristic for SPNs, which is defined as enhanced solid components within the non-enhanced cystic components[10]. In our study, SPNs showed a higher frequency of "floating cloud" sign compared with PDAC with cystic changes (84.4% *vs* 42.9%, $P < 0.001$). However, a misdiagnosis of SPNs might still occur in some atypical cases where the "floating cloud" sign is observed in PDAC with cystic changes. In our study, 42.9% of PDAC cases showed the "floating cloud" sign, which may be attributed to the fact that the included PDAC with cystic changes radiologically demonstrated cystic features including neoplastic cystic region within the tumor or as a non-neoplastic cyst surrounding the tumor.

SPN is a rare low-grade malignant neoplasm with a low frequency of aggressive behaviors such as local invasion or metastasis[20]. In our study, a significant difference was found in peripancreatic invasion or distal metastasis between the two groups ($P = 0.006$). Previous reports showed that size < 42.1 mm was one of the most common imaging features of aggressive SPNs[3]. In the present study, SPNs were more likely to have a larger size compared with PDAC with cystic changes (5.41 ± 2.89 cm *vs* 3.90 ± 1.24 cm, $P = 0.017$), and only 6.25% of SPNs showed peripancreatic invasion or distal metastasis, which is consistent with a previous study[3]. We speculated that aggressive SPNs may be more likely to cause symptoms and be detected at a smaller size.

A previous study showed that typical SPNs usually have a well-defined margin, and PDAC usually has an ill-defined margin[10,21]. In our study, 65.6% of SPNs had a well-defined margin, and 64.3% of PDAC with cystic changes had an ill-defined margin, which is consistent with a previous study. Calcification was more common in SPNs than in PDAC with cystic changes in the present study (34.4% *vs* 7.1%), although the difference did not reach statistical significance ($P = 0.073$).

We subsequently evaluated tumor contrast enhancement and enhancement ratios between PDAC with cystic changes and SPNs. No significant difference was found with respect to ACE, PCE, or DCE. Similarly, there was no significant difference in AER, PER, or DER. Baek *et al*[17] showed SPNs usually demonstrated a weak enhancement in the pancreatic phase and a gradually increasing enhancement pattern[17]. In our study, SPNs showed a weak enhancement in the arterial phase and a gradually increasing enhancement pattern in the portal venous and delayed phases, which was consistent with Baek *et al*[17].

Finally, we evaluated the diagnostic performance of the CT characteristics and their combination in differentiating PDAC with cystic changes from SPNs. The AUCs ranged from 0.634 to 0.833. The sensitivity and specificity ranged from

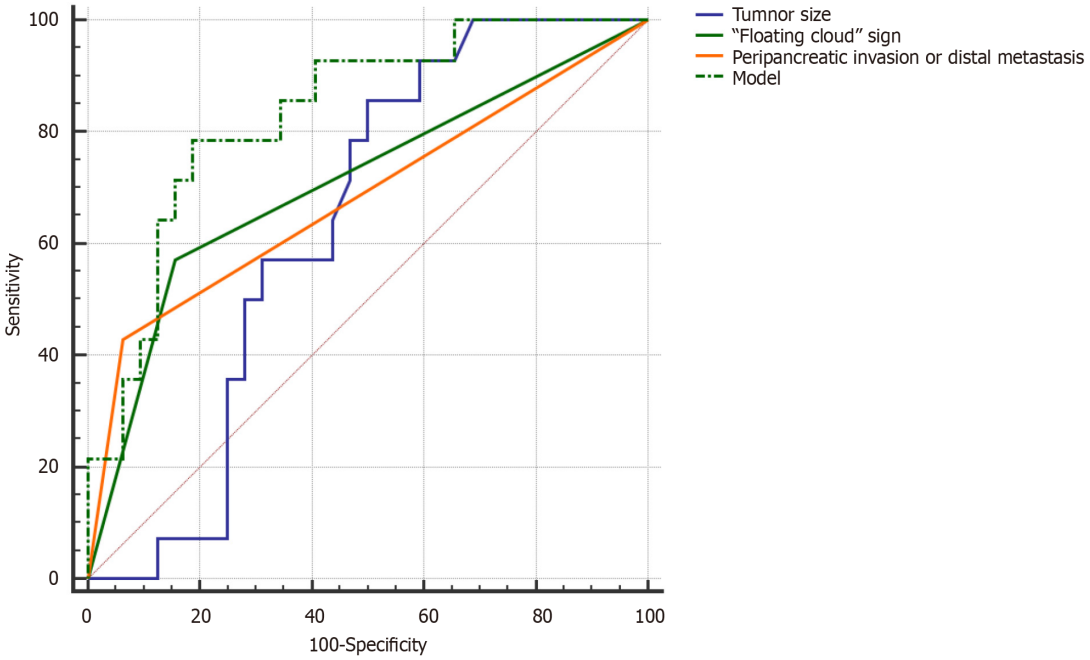

Figure 4 Diagnostic performance of the computed tomography characteristics and their combination (named as "model") in differentiating pancreatic ductal adenocarcinoma with cystic changes from solid pseudopapillary neoplasms of the pancreas.

42.9% to 78.6% and from 53.1% to 93.8%, respectively. The accuracy, positive predictive value, and negative predictive value ranged from 60.9% to 80.4%, 42.3% to 75.0% and 78.9% to 89.7%, respectively. Z test was used to compare the AUCs among CT characteristics and their combination. A significant difference was found in AUCs between tumor and model and peripancreatic invasion or distal metastasis and model. No statistically significant difference was found in AUCs between tumor size and "floating cloud" sign, tumor size and peripancreatic invasion or distal metastasis, "floating cloud" sign and peripancreatic invasion or distal metastasis, or "floating cloud" sign and model.

There were some limitations in our study. First, it was limited by its retrospective nature and by our limited control of the patient selection. Second, the low incidence of PDAC with cystic changes and SPNs resulted in a small number of enrolled patients. We will recruit more patients with SPNs and PDAC with cystic changes for further validation and reliability testing of our conclusions. Third, different types of CT scanners were used in this study, which may lead to inconsistent image quality[21]. Although different CT systems were used, the scanning parameters were consistent, and the duration of the enhancement scan was the same.

CONCLUSION

Our data indicated that CE-CT is a feasible tool for discrimination of PDAC with cystic changes from SPN. A younger age, larger tumor size, "floating cloud sign," and absence of peripancreatic invasion or distal metastasis were useful CT imaging features indicative of SPN. A larger-cohort study to validate the potential value of a non-invasive CT-based approach to differentiate PDAC with cystic changes from SPN are in order.

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FOOTNOTES

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