World Journal of Surgical Oncology

RESEARCH

Open Access

Solid pseudopapillary neoplasms of the pancreas (SPNs): diagnostic accuracy of CT and CT imaging features

Ming Zhao[1,2†], Jie Wang[2†], Jiejuan Lai[2], Fenghao Liu[2], Yujun Zhang[2], Li Cao[2], Li Liu[2], Kuansheng Ma[2], Jianwei Li[2*] and Qingsong Deng[2*]

Abstract

Purpose To summarize the abdominal computed tomography (CT) imaging and clinicopathological data of patients with SPNs of the pancreas and analyze the accuracy of preoperative CT diagnosis and features.

Materials and methods Between June 2006 and June 2023, CT images of 120 histopathologically proven SPNs in the pancreas were retrospectively reviewed. Fifteen features, including age, sex, and CT-determined features, were included in a multiple stepwise regression analysis. The correlations between features and SPNs, including odds ratios (ORs) and 95% confidence intervals (CIs), were evaluated.

Results Among the 120 patients, the diagnostic accuracy of CT was 43.3%. The baseline CT results of patients with a correct diagnosis and misdiagnosis revealed significant differences in sex ($P=0.043$), age ($P=0.004$), boundary ($P=0.037$) and encapsulation ($P=0.002$) between the two groups. The preoperative imaging diagnostic accuracy was significantly greater in females than in males (47.9% vs. 25.0%, $P=0.043$). The immunohistochemical indices did not significantly differ between the two groups. The results of univariate analysis revealed significant differences in sex ($P=0.048$), age ($P=0.014$), tumor length ($P=0.023$), tumor boundaries ($P=0.039$) and capsule type ($P=0.003$). The results of multivariate analysis revealed that encapsulation was closely related to the diagnostic accuracy of CT ($P=0.04$).

Conclusions The accuracy of CT in the diagnosis of SPNs is low, but a length–diameter ratio of the tumor approaching 1.0, encapsulation and clear boundaries are important CT-determined features. The capsule is an independent CT predictor in the diagnosis of SPNs.

Key results

- In this retrospective study of 120 participants with SPNs, the diagnostic accuracy of CT was 43.3% and, which was significantly greater in females than in males (47.9% vs. 25.0%, $P=0.043$).

†Ming Zhao and Jie Wang contributed equally to this work.

*Correspondence:
Jianwei Li
594457357@qq.com
Qingsong Deng
qingsongdeng@tmmu.edu.cn

Full list of author information is available at the end of the article

- Sex, age, tumor length, tumor boundaries and capsule type may indicate a diagnosis of SPNs, especially in the presence of a capsule.

Keywords Solid pseudopapillary neoplasms of the pancreas, CT imaging features, Diagnostic accuracy

Background

Solid pseudopapillary neoplasms (SPNs) of the pancreas are rare pancreatic tumors that account for approximately 1–2% of all pancreatic exocrine tumors. SPNs usually affect young women aged 20 to 30 years [1–3]. The growth of the neoplasm is slow, the degree of malignancy is low, and the prognosis is good after complete surgical resection. The 5-year survival rate of patients with SPNs is reported to exceed 95% [4–7]. The typical imaging findings of SPNs include intact capsular masses with solid and cystic components with varying degrees of bleeding and necrosis [8–11]. However, atypical SPNs can be similar to pancreatic ductal adenocarcinoma, islet cell tumors, mucinous cystadenomas, or intraductal papillary mucinous neoplasms on imaging, increasing the difficulty of diagnosis for radiologists and clinicians [2]. Moreover, the typical imaging manifestations of SPNs are relatively rare. Therefore, diagnosing SPNs by clinical imaging is often difficult.

Several aspects of the surgical method depend on the benign and malignant classification and degree of malignancy of pancreatic tumors, and the classification and degree of tumors are mainly related to the scope of surgical resection and the extent of surgical trauma. For patients with benign tumors diagnosed before surgery, surgical methods and reduced surgical trauma are usually selected to preserve function as much as possible. Previous studies have demonstrated that the preoperative CT diagnosis of some patients with SPNs confirmed by postoperative pathology is inaccurate and includes a preoperative misdiagnosis of pancreatic cancer, pancreatic neuroendocrine tumor, insulinoma, pancreatic serous cystadenoma, pancreatic mucinous cystadenoma or pancreatic intraductal papillary cystadenoma [8, 12–14]. Therefore, the imaging features of SPNs are particularly important for accurate diagnosis before surgery.

The purpose of this study was to summarize the abdominal CT and clinicopathological data of patients with SPNs, analyze the accuracy of pre-CT diagnosis and CT imaging features, improve the accuracy of SPN diagnosis and provide a basis for clinical guidance.

Materials and methods

Study participants

We conducted a retrospective study at the Army Institute of Hepatobiliary Surgery, Southwest Hospital, Army Medical University, which was approved by the Institutional Review Board. Patients who underwent surgical resection from June 2006 to June 2023 for pathologically identified SPNs were included in our study. The following inclusion criteria were applied: (1) had pathologically diagnosed SPNs, (2) had complete electronic medical records and imaging records, and (3) had follow-up data. The exclusion criteria for patients were as follows: (1) unavailability of preoperative imaging data and (2) a previous pathological diagnosis of SPNSs but incomplete imaging data. The selection procedure for the study participants is presented in Fig. 1.

Surgery

The surgical decision was made after general discussion. If the lesion was diagnosed as a cystic or benign lesion of the pancreas by imaging, the surgical indications followed the International Consensus Guidelines. Surgical indications for patients who were diagnosed with invasive cancer were in accordance with the guidelines of the Chinese Society of Pancreatic Surgery. The choice of surgical method depended on the intraoperative pathological results, the location of the lesions and the experience of the surgeons.

The perioperative management was completed by experienced surgeons at the Army Institute of Hepatobiliary Surgery, Southwest Hospital, Army Medical University. Routine preoperative examinations included routine bloodwork, liver function, renal function, electrolytes, coagulation function, electrocardiogram, pulmonary function and cardiac ultrasound. After surgery, amylase analysis of the drainage fluid was performed to determine whether a postoperative pancreatic fistula (POPF) existed. Routine blood examinations and temperature monitoring were performed to determine whether infection existed and whether antibiotics were necessary. Abdominal CT was performed to determine whether bleeding or ascites occurred and to determine the cause of the infection.

Follow-up and endpoints

The main endpoint of this study was the diagnostic accuracy of CT for identifying SPNs. The secondary endpoints were the correlations between the diagnostic accuracy of CT and imaging features, the incidence of postoperative complications and the overall survival rate. The endpoint of follow-up was June 30, 2023. Follow-up data were obtained via telephone interviews and/or outpatient interviews. Postoperative recurrence was defined as a local or metastatic tumor confirmed by radiology or histology after the operation.

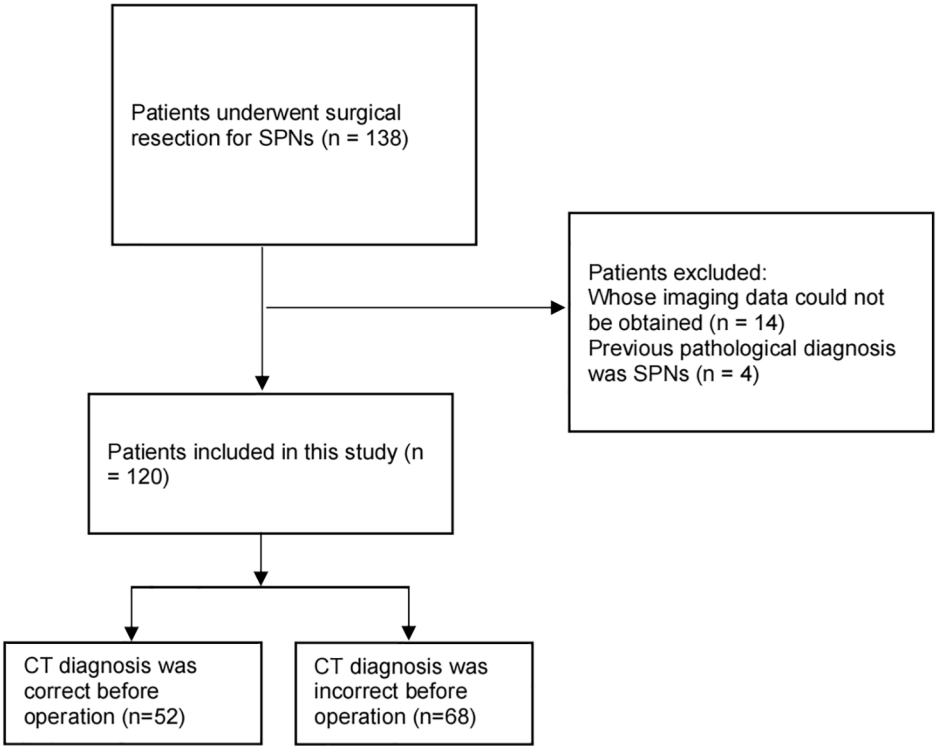

Fig. 1 Flowchart presenting the selection process of studies

Construction of the prediction model

The patients were assigned to two groups: the correct CT diagnosis group and the incorrect CT diagnosis group. Fifteen features, including age, sex, tumor size, location, ratio of long to short diameter, boundary, maximum sectional area, maximum sectional solid area, maximum sectional cystic area, cystic area proportion, calcification, capsule, main pancreatic duct dilatation, enhancement mode and exogenous growth, were applied in multiple stepwise regression analysis to test the correlation between CT features and SPNs. The correlation intensity was evaluated by odds ratios (ORs) and 95% confidence intervals (CIs). Using receiver operating characteristic (ROC) analysis, the prediction ability of the model was evaluated using the area under the ROC curve (AUC), and the best cutoff point was obtained when the Jordan index was maximized.

Statistical analyses

The data were processed using the software packages SPSS version 25.0 (IBM Corp., Armonk, NY, USA) and R (version 4.2.0). Continuous (quantitative) data were analyzed with the Shapiro normality test to determine the normality of the sample data. Continuous variables that were normally distributed are reported as the mean±standard deviation, those with a skewed distribution are reported as the median and quartile spacing, and classification data are reported as percentages. To compare continuous variables, the t test was used for normally distributed continuous variables, and the Mann–Whitney U test was used for nonnormally distributed continuous variables. To compare categorical variables, the chi-square test and Fisher's exact test were used. First, univariate logistic regression analysis was used to analyze the factors related to SPNs, and multivariate logistic regression analysis was subsequently used to analyze the factors for which $P<0.1$. $P<0.05$ was considered indicative of statistical significance.

Results

Baseline characteristics of participants

Among the 138 participants assessed for eligibility, 18 met the exclusion criteria: Imaging data could not be obtained for 14 participants, and 4 participants were diagnosed with SPNs by previous pathology (Fig. 1). Ultimately, 120 participants who underwent pancreatic surgery were included in this study. According to the final histological examination, all the tumors were confirmed to be SPNs. The cohort included 24 males (20%) and 96 females (80%). The average age was 32.5±12.7 years. Most of the cases were incidental (59.1%). Among patients with symptoms, abdominal pain was the most common symptom (32/49, 65.3%), followed by abdominal pain and distension (8/49, 16.3%), abdominal distension (6/49, 12.2%), and nausea and vomiting (3/49, 6.1%). Among the patients, pancreatoduodenectomy (PD) was

Table 1 Baseline characteristics of the patients with SPNs

Parameters	SPNs ($n=120$)
Female [n (%)]	96 (80)
Age (years), mean ± SD	32.5 ± 12.7
Symptoms, N%	
incidentally found	71 (59.1)
abdominal pain	32 (26.7)
abdominal distension	6 (5.0)
abdominal pain and distension	8 (6.7)
nausea and vomiting	3 (2.5)
Ca 19.9 > 37 U/ml, N%	3 (2.5)
Surgical methods, N%	
pancreatoduodenectomy	20(16.5)
distal pancreatectomy, with splenectomy	43 (35.5)
distal pancreatectomy, spleen preserving	33 (27.2)
central pancreatectomy	15 (12.3)
Enucleations	9(7.4)
Time of surgery (minutes), mean ± SD	276
Hospital stays (days), mean ± SD	20.7 ± 10.0

performed in 20 (16.5%), distal pancreatectomy (DP) with splenectomy in 43 (35.5%), DP and spleen preservation in 33 (27.2%), central pancreatectomy (CP) in 15 (12.3%), and enucleation in 9 (7.4%) patients. The average surgical time was 276 min, and the average hospital stay was 20.7 ± 10.0 days. The average follow-up time was 37 months. The baseline characteristics of the participants are shown in Table 1.

CT features

The mean tumor size in the entire cohort was 45.0 ± 24.1 mm, and the mean length–to–diameter ratio was 1.3 ± 0.2. The tumors were located in the head of the pancreas in 35 patients, in the neck in 16 patients, in the body in 34 patients and in the tail in 35 patients. All patients underwent contrast-enhanced CT examination before the surgery. Fifty-two patients (43.3%) were correctly diagnosed with SPNs by CT, and 68 patients (56.7%) were diagnosed with other tumors. The cohort included 80 patients (66.7%) with regular boundaries, 92 patients (76.7%) with capsules, 35 patients (29.2%) with calcification and 1 patient (0.8%) with tumor bleeding. After enhancement with a contrast agent, 112 patients (93.3%) exhibited tumor enhancement, 4 (3.6%) had homogeneous enhancement, 56 (50.0%) had heterogeneous enhancement, 14 (12.5%) had peripheral enhancement, and 38 (33.3%) had slight enhancement. The main pancreatic duct dilatation was larger than 4 mm in 12 patients (9.9%), ductal dilatation occurred in 3 patients (2.4%), and tumor growth was observed in 72 patients (59.5%). The maximum sectional area of the tumor was 1952.11 ± 2245.66 mm^2, of which the maximum sectional solid area was 1290.07 ± 1319.46 mm^2, the maximum sectional cystic area was 647.22 ± 1317.33 mm^2, and the cystic area was 20.5% (Table 2).

Table 2 CT characteristics of the patients with SPNs

Parameters	SPNs ($n=120$)
Tumor size (mm), mean ± SD	45.0 ± 24.1
Length-diameter ratio, mean ± SD	1.3 ± 0.2
Location, N%	
head	35 (28.9)
neck	16 (13.2)
body	34 (28.0)
tail	35 (28.9)
Tumor border, N%	
smooth	80 (66.7)
irregular	40 (33.3)
Capsule, N%	92(76.7)
Calcification, N%	35 (29.2)
Bleeding, N%	1 (0.8)
Enhancement, N%	112 (93.3)
Enhancement pattern during pancreatic phase, N%	
Homogeneous	4 (3.6)
Heterogeneous	56 (50.0)
Peripheral	14 (12.5)
Slight	38 (33.9)
Main pancreatic duct dilatation (> 4 mm), N%	12 (9.9)
Ductal dilatation, N%	3 (2.4)
Exophytic growth, N%	72 (59.5)
Tumor maximum sectional area (mm^2), mean ± SD	1952.11 ± 2245.66
Tumor maximum sectional solid area (mm^2), mean ± SD	1290.07 ± 1319.46
Tumor maximum sectional cystic area (mm^2), mean ± SD	647.22 ± 1317.33
Cystic area proportion, N%	20.5
Imaging diagnoses, N%	
SPN	52 (43.3)
Malignant tumor	32 (26.7)
Neuroendocrine tumor	5 (4.2)
Other benign tumors	31 (25.8)
Local invasion and distant metastasis, N%	
Peripheral aggression	3 (2.5)
Nerve invasion	2 (1.7)
Liver metastasis	1 (0.8)
Splenic metastasis	1 (0.8)
Lymph node metastasis	1 (0.8)

The patients were assigned to a correct CT diagnosis group or an incorrect CT diagnosis group. Sex ($P=0.043$), age ($P=0.004$), boundaries ($P=0.037$) and capsules ($P=0.002$) significantly differed between the two groups (Table 3). The preoperative imaging diagnostic accuracy was significantly greater in females than in males (47.9% vs. 25.0%, $P=0.043$).

Variables such as age, sex, and tumor size were used as dependent variables for univariate analysis to explore the relationships between these variables and the diagnostic accuracy of CT. Variables with $P<0.1$ were included in

Table 3 The factors influencing the diagnostic accuracy of CT

Number of patients	Correct (*n* = 52)	Incorrect (*n* = 68)	*P* value
Female [n (%)]	46 (88.5)	50 (73.5)	0.043
Age, years, median (range)	28 (19–35)	36 (25–43)	0.004
Location, [n (%)]			0.081
head	15 (28.9)	20 (29.4)	
neck	9 (17.3)	7 (10.3)	
body	9 (17.3)	25 (36.8)	
tail	19 (36.5)	16 (23.5)	
Length-diameter ratio	1.17 (1.12–1.29)	1.21 (1.12–1.45)	0.133
Tumor size (cm)	4.28 (2.71–5.31)	3.72 (2.68–5.74)	0.634
Tumor border, [n (%)]			0.037
smooth	40 (76.9)	40 (58.8)	
irregular	12 (23.1)	28 (41.2)	
Tumor maximum sectional area (mm^2)	1355.66 (512.6-2334.1)	944.7 (534.32, 2288.98)	0.630
Tumor maximum sectional solid area (mm^2)	99.36 (0-390.39)	107.77 (0-944.76)	0.755
Tumor maximum sectional cystic area (mm^2),	998.02 (419.11-562.44)	728.66 (457.76-1512.49)	0.406
cystic area proportion	9 (0–28)	6 (0–45)	0.730
Capsule, [n (%)]	47 (90.38%)	45 (66.18%)	0.002
Calcification, [n (%)]	11 (21.15%)	24 (35.29%)	0.091
Main pancreatic duct dilatation (> 4 mm), [n (%)]	4 (7.7)	8 (11.8)	0.461
Exophytic growth, [n (%)]	36 (69.2)	36 (52.9)	0.071
Enhancement pattern during pancreatic phase [n (%)]			0.105
Non-enhancement	2 (3.9)	6 (8.8)	
Slight	2 (3.9)	2 (2.9)	
Heterogeneous	11 (21.2)	27 (39.7)	
Peripheral	31 (59.6)	25 (36.8)	
Homogeneous	6 (11.5)	8 (11.8)	

Table 4 Independent prediction factors for SPNs diagnosis by CT

Variable	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex	2.76 [1.01,7.55]	0.048	1.15 [0.29,4.56]	0.844
Age	1.04 [1.01,1.07]	0.014	1.04 [1,1.08]	0.085
Tumor size	0.97 [0.84,1.13]	0.724		
Length-diameter ratio	8.46 [1.35,53.07]	0.023	3.78 [0.39,36.97]	0.253
Tumor border	2.33 [1.04,5.22]	0.039	1.82 [0.61,5.39]	0.282
Capsule	0.21 [0.07,0.59]	0.003	0.13 [0.03,0.71]	0.018
Calcification	2.03 [0.89,4.67]	0.094	1.64 [0.54,4.95]	0.379
Exophytic growth	0.5 [0.23,1.07]	0.073	0.82 [0.19,3.61]	0.794
Main pancreatic duct dilatation (> 4 mm),	1.6 [0.45,5.63]	0.464		

the multivariate analysis. The results revealed significant differences in sex ($P=0.048$), age ($P=0.014$), tumor length and short diameter ($P=0.023$), boundary ($P=0.039$) and capsule ($P=0.003$) according to univariate analysis, suggesting that the above features have some specificity for the diagnosis of SPNs by CT. According to our multivariate analysis, the capsule ($P=0.04$) was closely related to the diagnostic accuracy of CT (Table 4), suggesting that the capsule was an independent CT predictor for the diagnosis of SPNs. The summary area under the ROC curve was 0.715 (95% CI 0.623–0.807), and the cutoff was 0.426 (Fig. 2).

Pathological and immunohistochemical features

Most SPNs are well circumscribed. The mean tumor size was 5.0 cm. Perineural invasion was detected in 2 (1.7%) patients, and peripheral tissue invasion was detected in 3 (2.5%) patients. Liver metastasis was detected in 1 (0.8%) patient. Splenic metastasis was detected in 1 (0.8%) patient, and lymph node metastasis was detected in 1 (0.8%) patient (Table 2).

Immunohistochemical studies were performed in most patients. The results were typically positive for vimentin (Vim, 100/102, 98%), CD10 (107/111, 96.4%), CD56 (108/111, 97.3%), CD99 (75/80, 93.8%), β-catenin (115/115, 100%), progesterone receptor (PR, 61/65,

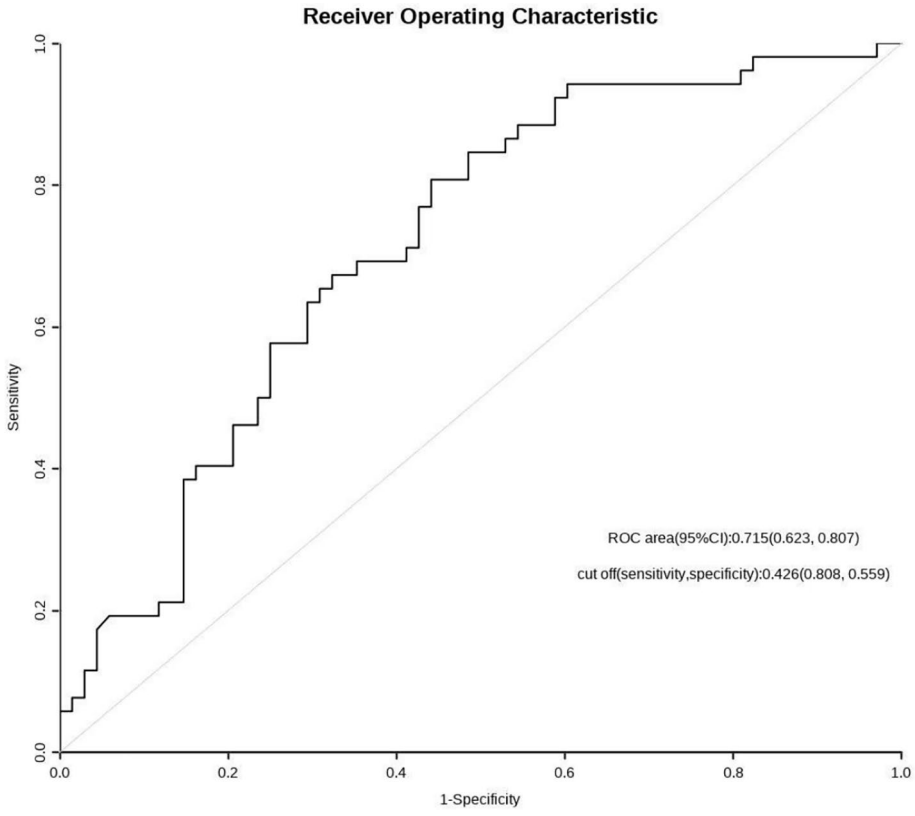

Fig. 2 ROC curve of the CT prediction models in SPNs patients cohorts

93.8%) and synaptophysin (Syn, 92/118, 78.0%). In addition, 13/17 (76.4%) patients were NSE positive, and 53/53 (100%) were a-AT positive. In contrast, the results were typically negative for chromatin granule protein A (CgA, 107/113, 94.7%), CK7 (54/56, 96.4%), alpha-inhibin (10/10, 100%), insulin (10/10, 100%), CK19 (10/10, 100%), CK20 (8/8, 100%) and carcinoembryonic antigen (CEA) (15/15100%). Ki-67 was detected in 115 patients, including 72 (62.6%) with an index < 3% (Grade I), 41 (35.7%) with an index 3–10% (Grade II), and 2 (1.7%) with an index > 10% (Grade III). Ki-67 was detected in 2 patients with splenic and lymph node metastases (Supplemental Table 1).

The patients were subsequently assigned to two groups according to whether they correctly or incorrectly diagnosed by CT, and the differences in the main positive and negative indices of immunohistochemistry between the two groups were compared. The results revealed that the immunohistochemical indices did not significantly differ between the two groups (Supplemental Table 2).

Complications and follow-up

Postoperative complications occurred in 64 patients, including 13 patients with fever (10.8%), 24 patients with pancreatic leakage (20.0%), 18 patients with ascites (15.0%), 1 patient with incisional infection (0.83%), 2 patients with pulmonary infection (1.7%) and 6 patients with abdominal bleeding (5.0%). The incidence of complications was 53.3%. The median follow-up time for all patients was 37 (1–151) months (Supplemental Table 3). Abdominal ultrasound and CT were performed every 1–2 years. One patient experienced tumor recurrence, refused further surgery, and ultimately died from tumor progression. The total survival time was 47 months. One patient died of multiple organ failure, and the total survival time was 6 months. The 1-, 3- and 5-year survival rates for all patients were 99.2%, 99.2% and 98.3%, respectively.

Discussion

Our study revealed that SPNs occurred mainly in young patients (32.5 ± 12.7 years), mainly in women (96 patients, 80%), and mostly in the body and tail of the pancreas (69 patients, 57.5%), which is consistent with the results of previous studies [7–9]. The accuracy of enhanced CT in diagnosing SPNs was 43.3%; the patient's sex, age, tumor length, boundary and capsule were correlated with diagnostic accuracy, and the presence of a capsule was an independent CT predictor in the diagnosis of SPNs. The area under the ROC curve was 0.715 (95% CI = 0.623–0.807), and the cutoff value was 0.426. Most patients with

SPNs have a good prognosis, and the 5-year survival rate is approximately 98.3%.

CT is one of the main examination methods for the diagnosis of SPNs. At present, large-sample reports on the accuracy of CT in the diagnosis of SPNs are lacking. In most centers, the number of patients with the disease is relatively low [15]. Anil et al. summarized the CT imaging features and the correlation between imaging and pathology in 10 patients with SPNs in a retrospective study [16]. The study revealed that 50% of the patients had a capsule, which could be identified by CT. 80% of the lesions consisted of cystic and solid components. In addition, intratumoral hemorrhage is one of the imaging features of SPNs. In this study, the diagnostic accuracy of CT for identifying SPNs was 43.3%. Moreover, this study revealed that the percentage of patients with capsules on CT images was 76.7%. However, none of the patients presented with intratumoral hemorrhage on CT imaging. According to the univariate and multivariate analyses of features and diagnostic accuracy, correlations existed between patient sex, age, tumor length and short diameter, boundary and capsule and diagnostic accuracy; moreover, the presence of a capsule was an independent predictor for the diagnosis of SPNs, suggesting that the presence of a capsule on CT images has important value for the diagnosis of SPNs.

The presence of SPNs markedly differs by age and sex; specifically, SPNs are common in young women aged 20 to 30 years. Wei et al. conducted a retrospective study of the sex distribution of patients with SPNs [17]. The results revealed that the clinical and imaging features of male SPN patients were not completely consistent with those of female patients. The preoperative imaging diagnostic accuracy was significantly greater in females than in males (70.5% vs. 54%, $P=0.02$). SPNs in male patients tended to be misdiagnosed as other malignant tumors (37.7% vs. 10.7%, $P<0.0001$), with more solid components observed in images (66.8% vs. 24.7%, $P<0.0001$) [17]. In our study, the preoperative imaging diagnostic accuracy was significantly greater in females than in males (47.9% vs. 25.0%, $P=0.043$). These findings are consistent with the results of the present study, which indicated a significant difference in the preoperative imaging findings of patients with SPNs.

The CT findings of SPNs are closely related to pathological features. The proportion and composition of cystic and solid SPNs may affect the diagnosis by CT. Several previous studies have suggested that larger tumors are more likely to have cystic degeneration [18, 19]. Baek et al. reported that small SPNs (diameter < 3 cm) were mainly solid [19]. In this study, the maximum cross-sectional solid area of the tumor was significantly larger than the cystic area, and the average proportion of the cystic area was 20.5%. These findings suggest that the SPNs of patients are mainly solid and that the average size of the tumors in this study was 45.0 ± 24.1 mm, which contradicts the results of previous studies.

This study revealed that the accuracy of preoperative diagnosis in patients with SPNs was related to the tumor length-to-short diameter ratio and the capsule and boundary lengths. In patients with a correct CT diagnosis, the tumor length-to-short diameter ratio was closer to 1.0. The boundary was clearer, and more patients presented with capsules. Moreover, the capsule was an independent predictive factor to be considered when diagnosing SPNs, suggesting that the CT features in SPNs patients mainly describe the lesions as regular, round or oval with capsules.

Pathology and immunohistochemistry are the gold standards for the diagnosis of SPNs. In this study, the main positive markers included Vim, CD10, CD56, CD99, β-catenin, PR and Syn. The major negative markers included CgA, CK7, α-inhibin, insulin, CK19, CK20 and carcinoembryonic antigen. These findings are consistent with previous research results [20]. In addition, the Ki-67 index is related to the degree of malignancy and metastasis of the tumor. A Ki-67 index greater than 30% suggested that patients with SPNs could have distant metastasis.

This study has several limitations. First, this work was a single-center retrospective study, the sample size was small, and the results may be biased. Second, this study failed to include patients with suspected SPNs by CT whose diseases were pathologically confirmed to be other tumors, which excluded the analysis and comparison of the CT characteristics of false-positive patients. Third, in this study, we failed to further evaluate the changes in lesions during different CT scanning periods to determine additional imaging features.

In conclusion, the accuracy of CT in the diagnosis of SPNs is low, and SPNs are associated with certain characteristics on CT, including a tumor length-to-short diameter ratio approaching 1.0, capsule length and clear boundaries, among which the envelope is an independent CT predictor for the diagnosis of SPNs.

Abbreviations

CT	Computed tomography
SPNs	Solid pseudopapillary neoplasms of the pancreas

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12957-024-03503-5.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Acknowledgements
The authors thank all their colleagues for their help during this study.

Author contributions
M.Z and QS.D designed the study and were major contributors to the manuscript. M.Z and J. W mainly collected the data and wrote the manuscript. The two authors contributed equally. JW.L, JJ.L, FH.L, YJ.Z, L. C, and L. L analyzed the data. KS. M obtained funding, and QS.D critically revised the article.

Funding
Dr Qingsong Deng received fund No. 4246ZP112 from Chongqing Talent Plan. The funding body had no role in the design of the study and collection, analysis and interpretation of data, or in writing the manuscript.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Competing interests
The authors declare no competing interests.

Ethics approval
The study was conducted according to the Declaration of Helsinki, and it was granted approval by the Ethics Committee of the Southwest Hospital (Chongqing, China).

Patient consent for publication
Not applicable.

Summary statement
The accuracy of CT in the diagnosis of SPNs remains low, but some features, such as the length–diameter ratio and capsule, may help in the diagnosis of SPNs.

Author details
[1]Department of Gastroenterology, The Third People's Hospital of Chengdu, The Affiliated Hospital of Southwest Jiaotong University, Chengdu, China
[2]Army Institute of Hepatobiliary Surgery, Southwest Hospital, Army Medical University, Third Military Medical University, Chongqing 400038, China

Received: 11 April 2024 / Accepted: 13 August 2024
Published online: 27 August 2024

References

1. Coleman KMDM, Bigler SA. Solid-pseudopapillary tumor of the pancreas. Radiographics. 2003;23:1644–8.
2. Papavramidis T, Papavramidis S. Solid pseudopapillary tumors of the pancreas: review of 718 patients reported in English literature. J Am Coll Surg. 2005;200:965–72.
3. Machado MC, Machado MA, Bacchella T, et al. Solid pseudopapillary neoplasm of the pancreas: distinct patterns of onset, diagnosis, and prognosis for male versus female patients. Surgery. 2008;143:29–34.
4. Adams ALSG, Jhala NC. Solid pseudopapillary tumor of the pancreas: a review of salient clinical and pathologic features. Adv Anat Pathol. 2008;15:39–45.
5. Sperti C, Berselli M, Pasquali C, et al. Aggressive behaviour of solid-pseudopapillary tumor of the pancreas in adults: a case report and review of the literature. World J Gastroenterol. 2008;14:960–5.
6. Huffman BM, Westin G, Alsidawi S, et al. Survival and prognostic factors in patients with solid Pseudopapillary neoplasms of the pancreas. Pancreas. 2018;47:1003–7.
7. Liu Q, Dai M, Guo J, et al. Long-term survival, quality of life, and molecular features of the patients with solid Pseudopapillary Neoplasm of the pancreas: a retrospective study of 454 cases. Ann Surg. 2023;278:1009–17.
8. Buetow PCBJ, Pantongrag-Brown L, Beck KG, Ros PR, Adair CF. Solid and papillary epithelial neoplasm of the pancreas: imaging-pathologic correlation on 56 cases. Radiology. 1996;199:707–11.
9. Dong PRLD, Degregario F, Fell SC, Au A, Kadell BM. Solid and papillary neoplasm ofthe pancreas: radiological-pathological studyof five cases and review of the literature. ClinRadiol. 1996;51:702–5.
10. Reddy S, Wolfgang CL. Solid pseudopapillary neoplasms of the pancreas. Adv Surg. 2009;43:269–82.
11. Law JK, Ahmed A, Singh VK, et al. A systematic review of solid-pseudopapillary neoplasms: are these rare lesions? Pancreas. 2014;43:331–7.
12. Choi BIKK, Han MC, Kim YI, Kim CW. Solid and papillary epithelial neoplasms of the pancreas: CT fi ndings. Radiology. 1988;166:413–6.
13. Martin RCKD, Brennan MF, ,Conlon KC. Solid-pseudopapillary tumor of the pancreas: a surgical enigma? Ann Surg Oncol. 2002;9:35–40.
14. Choi JY, Kim MJ, Kim JH, et al. Solid pseudopapillary tumor of the pancreas: typical and atypical manifestations. AJR Am J Roentgenol. 2006;187:W178–186.
15. Fu XB, Hao ZQ, He JY, et al. Pathology comparative study on the characteristic CT signs in solid pseudopapillary neoplasm of the pancreas. Exp Ther Med. 2017;13:3523–8.
16. Anil G, Zhang J, Al Hamar NE, et al. Solid pseudopapillary neoplasm of the pancreas: CT imaging features and radiologic-pathologic correlation. Diagn Interv Radiol. 2017;23:94–9.
17. Wei G, Luo Q, Fang J, et al. The sex features of patients with solid Pseudopapillary neoplasms of the pancreas: a retrospective study. Front Oncol. 2022;12:844182.
18. Adsay NV. Cystic neoplasia of the pancreas: pathology and biology. J Gastrointest Surg. 2008;12:401–4.
19. Baek JHLJ, Kim SH, et al. Small (< or = 3 cm) solid pseudopapillary tumors of the pancreasat multiphasic multidetector CT. Radiology. 2010;257:97–106.
20. Liu M, Liu J, Hu Q, et al. Management of solid pseudopapillary neoplasms of pancreas: a single center experience of 243 consecutive patients. Pancreatology. 2019;19:681–5.

Publisher's Note