FULL PAPER

Multidetector CT imaging features of solid pseudopapillary tumours of the pancreas in male patients: distinctive imaging features with female patients

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Objective: To describe multidetector CT imaging features of solid pseudopapillary tumours (SPTs) in male patients and to compare these imaging features with those found in female patients.

Methods: The institutional review board approved this retrospective study. We included the CT images of 72 patients (M:F = 12:60; mean age, 35.0 years) diagnosed with SPT by histology. CT images were reviewed on the following: location of the tumour, maximal diameter, shape, margin and the fraction of the tumour composition. Statistical differences in CT imaging features were analysed.

Results: Male patients with SPTs were significantly older than female patients (42.4 years *vs* 33.4 years, $p = 0.0408$) and the mean size of the SPTs in male patients was larger (6.3 cm *vs* 4.6 cm, $p = 0.0413$) than that of SPTs in female patients. Lobulated shape of the

SPTs was most frequent in male patients, whereas oval shape was most frequent in female patients ($p = 0.0133$). SPTs in male patients tended to have a solid component ($p = 0.0434$). Progressive enhancement in the solid portion of the tumour was seen in 9 (81.8%) of 11 SPTs in male patients and in 30 (79.0%) of 38 SPTs in female patients on multiphasic CT.

Conclusion: The imaging features of SPTs in male patients usually appeared as a somewhat large-sized solid mass with a lobulated margin and progressive enhancement. These imaging features may help to differentiate SPTs from other pancreatic tumours for their proper management.

Advances in knowledge: SPTs in male patients appear as somewhat large-sized solid masses with lobulated margins, and this form occurs more frequently in older male patients than in female patients.

Solid pseudopapillary tumour (SPT) of the pancreas is a rare low-grade malignant neoplasm accounting for only 1–2% of all pancreatic tumours.[1–3] Synonyms for this neoplasm include solid and cystic tumours, solid and papillary epithelial neoplasms, solid cystic papillary tumour, papillary cystic neoplasm, papillary cystic epithelial neoplasm, papillary cystic tumour or Frantz's tumour.[3,4]

SPT is known to occur preferentially in young females and has a favourable prognosis. The characteristic imaging features of SPTs include encapsulation, solid and cystic components and peripheral calcification.[1,3,4] Although the imaging characteristics of SPTs have been well described in recent years,[3,5] it remains uncertain if the features of SPT occurring in males differ from those in females.

Machado et al[6] and Takahashi et al[7] described distinctive clinicopathological characteristics of SPTs occurring in males. The purpose of this study was to describe multidetector CT

(MDCT) imaging features of SPTs in male patients and to compare these features with those of female patients.

METHODS AND MATERIALS

Patient selection

The institutional review boards approved this retrospective study, and the requirement for informed consent was waived. By performing a computerized search of medical records, we identified 84 patients with a histopathological diagnosis of SPT of the pancreas who underwent surgical treatment between January 2000 and December 2011 at 2 institutions. Because the CT data for 5 patients were not available and 7 patients had not had MDCT performed, we included the data for 72 patients (M:F = 12:60; mean age, 35.0 years; age range, 13–81 years) in our retrospective study.

All patients with SPT underwent a complete pancreatic tumour resection by distal pancreatectomy ($n = 40$), the Whipple

operation ($n = 6$), pylorus-preserving pancreaticoduodenectomy ($n = 7$), central pancreatectomy ($n = 3$), partial pancreatectomy ($n = 2$) or excision ($n = 14$).

Image acquisition

MDCT was performed by using one of the following CT scanners: SOMATOM® Sensation 16 (Siemens Healthcare, Forchheim, Germany) ($n = 31$); SOMATOM® Sensation 64 (Siemens Healthcare) ($n = 19$); Brillance 16 (Philips Healthcare, Cleveland, OH) ($n = 11$); Brillance 64 (Philips Healthcare) ($n = 5$); LightSpeed Plus®, VCT (GE Healthcare, Milwaukee, WI) ($n = 3$); or Aquillion™ 64 (Toshiba Medical Systems, Tokyo, Japan) ($n = 3$).

Pre-contrast CT scans were obtained before contrast media injection. A total of 120–150 ml of a non-ionic contrast material (iohexol, Omnipaque™ 300; Nycomed Inc., Princeton, NJ, or iopromide, Ultravist® 300; Schering, Berlin, Germany) was injected into an antecubital vein through an 18-gauge plastic intravenous catheter. Pancreatic phases were obtained with a scan delay of 18 s after the abdominal aorta reached 100 HU with a power injector at a rate of 2–3 ml s^{-1}. A 60- to 70-s scanning delay after the contrast material injection was used for the portal venous phase. Pancreatic-phase CT scans were obtained at a section thickness of 2.5–3.0 mm, a tube current–time product of 150–200 mAs and a peak voltage of 120 kVp. For portal venous-phase scanning, images were acquired with sections 3–5 mm thick.

Imaging analysis

Two board-certified abdominal radiologists (JHL and MJP with 16 and 7 years' experience, respectively) collectively and retrospectively reviewed the CT images by consensus on a picture archiving and communication system workstation monitor. Both observers were blinded to the clinical information (sex and age) but knew that the patients had been diagnosed with SPT.

Each tumour was analysed according to the following categories: tumour location (head, neck, body or tail), maximal transverse diameter of the tumour, shape (round, oval or lobulated), margin (well defined or ill defined) and thickness of the capsule [thin (<2 mm) or thick (>2 mm)]. Calcification was assessed for shape and distribution (no calcification, peripheral–linear or central–stippled). The solid-to-cystic component ratio was evaluated and classified into one of the following four types: completely solid, >50% solid, <50% solid and completely cystic.

Contrast enhancement patterns (no enhancement, homogeneous or heterogeneous and progressive enhancement in multiphasic images) of the tumour were also determined.

Statistical analysis

Statistical differences in CT imaging features of SPT in male and female patients were analysed using the Student's t-test or the χ^2 test.

Patient age and tumour size in the two groups were compared with each other using the Student's t-test. The location, shape, margin, thickness of capsule, morphology of calcifications, proportion of solid-to-cystic composition of the tumours and enhancement pattern were compared using the χ^2 test or Fisher's exact test.

Proportions of solid-to-cystic composition of the tumours were correlated with tumour size using Spearman's coefficient of rank correlation.

Significant differences were defined as those with $p < 0.05$. All statistical analyses were performed using commercially available software packages (MedCalc® v. 8.2.1.0; MedCalc, Mariakerke, Belgium).

RESULTS

Table 1 summarises the different CT imaging features observed in male and female patients with SPT. No significant differences were found between male and female patients with SPT with respect to location, margin, thickness of capsule, morphology of calcification and enhancement pattern.

Male patients (mean age, 42.4 years) with SPTs were significantly older than female patients (mean age, 33.4 years) with SPTs ($p = 0.0408$). The mean size of SPTs in male patients was 6.3 ± 3.3 cm [standard deviation (SD)] and that of SPTs in female patients 4.6 ± 2.5 cm (SD). There was a significant difference in the mean size of SPTs between the male and female patients ($p = 0.0413$).

The shape of SPTs in male patients appeared lobulated, oval and round in 8 (67%), 3 (25%) and 1 (8%) cases, respectively. But, SPTs in female patients appeared oval, round and lobulated in 24 (40%), 19 (32%) and 17 (28%) cases, respectively ($p = 0.0133$). The proportion of solid-to-cystic composition of the tumours was also different ($p = 0.0434$). SPTs in male patients appeared completely solid in 5 (42%) patients, >50% solid in 6 (50%) patients and <50% solid in 1 (8%) patient. SPTs in female patients appeared completely solid in 17 (28%) patients, >50% solid in 17 (28%) patients, <50% solid in 15 (25%) patients and completely cystic in 11 (19%) patients. SPTs in male patients tended to have a solid component (Figures 1 and 2), but SPTs in female patients showed solid or cystic composition of the tumour (Figure 3).

No significant differences in contrast enhancement patterns were observed in SPTs between male and female patients ($p = 0.2526$).

After exclusion of 23 patients (13 patients without multiphasic CT and 10 patients with completely cystic SPT of the pancreas), the enhancement pattern of multiphasic CT was performed, resulting in 9 (81.8%) of 11 male SPTs and 30 (79.0%) of 38 female SPTs being designated as having a progressive enhancement in the solid portion of the tumour.

A positive correlation was observed between the size and the proportions of solid-to-cystic composition of tumours in female SPT patients, associating large tumour size with high cystic composition. The Spearman correlation coefficient (SCC) was 0.516 ($p = 0.0001$). No correlation was found between the size

Table 1. CT imaging features of males and females with solid pseudopapillary tumour (SPT) of the pancreas

| CT imaging findings	Male SPT ($n = 12$)	Female SPT ($n = 60$)	*p*-value
Age (mean)	42.4	33.4	0.0408
Size (mean, cm)	6.3	4.6	0.0413
<3	2 (17)	21 (35)	
3.1–5.0	4 (33)	14 (23)	
5.1–10.0	4 (33)	23 (39)	
≧10.0	2 (17)	2 (3)	
Location			
Head	5 (42)	16 (27)	
Neck	0	5 (8)	
Body	2 (16)	13 (22)	
Tail	5 (42)	26 (43)	0.5618
Shape			
Round	1 (8)	19 (32)	
Oval	3 (25)	24 (40)	
Lobulated	8 (67)	17 (28)	0.0133
Margin			
Well defined	10 (83)	49 (82)	
Ill defined	2 (17)	11 (18)	0.7841
Capsule			
Thin	7 (58)	34 (57)	
Thick	5 (42)	26 (43)	0.8314
Solid–cystic ratio			
Completely solid	5 (42)	17 (28)	
>50% solid	6 (50)	17 (28)	
<50% solid	1 (8)	15 (25)	
Completely cystic	0	11 (19)	0.0434
Calcification			
No calcification	8 (66)	30 (50)	
Peripheral or septal	2 (17)	14 (23)	
Central	2 (17)	16 (27)	0.3137
Enhancement pattern			
No enhancement	1 (8)	10 (17)	
Heterogeneous	8 (67)	42 (70)	
Homogeneous	3 (25)	8 (13)	0.2526

Data in parentheses are percentages.

and the proportions of solid-to-cystic composition of tumours in male SPT patients ($p = 0.0734$). The SCC was 0.540.

DISCUSSION

SPT of the pancreas is a rare low-grade malignant neoplasm that usually occurs in young females in the second to fourth decade of life.[1,2] SPT of the pancreas was first described by Frantz in 1959, and the tumour has had a convoluted nomenclature and imprecise characterization since it was first described.[1,8–10] In 1996, the World Health Organization renamed this tumour as SPT.[1,7,11] This tumour is composed of poorly cohesive monomorphic epithelial cells forming solid and pseudopapillary structures, which frequently undergo haemorrhagic–cystic degeneration.[11,12] The preferential occurrence of SPTs among
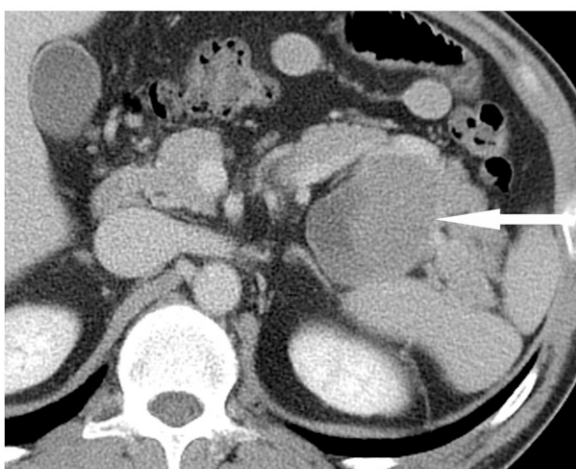
Figure 1. A solid pseudopapillary tumour of the pancreas in a 36-year-old male. (a) Axial pre-contrast CT scan shows a homogeneous hypoattenuating lesion without calcification in the tail of the pancreas. (b) CT scan obtained during the pancreatic phase shows a mainly solid poorly enhancing mass. (c) CT scan obtained during the portal venous phase shows a heterogeneous enhancing mass. Gradual enhancement of the solid portion (arrow) of the mass is seen.
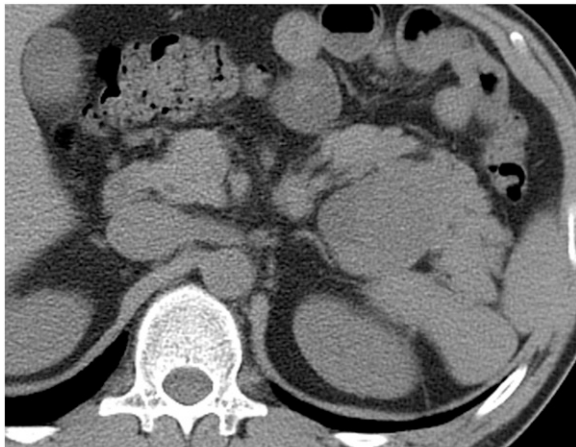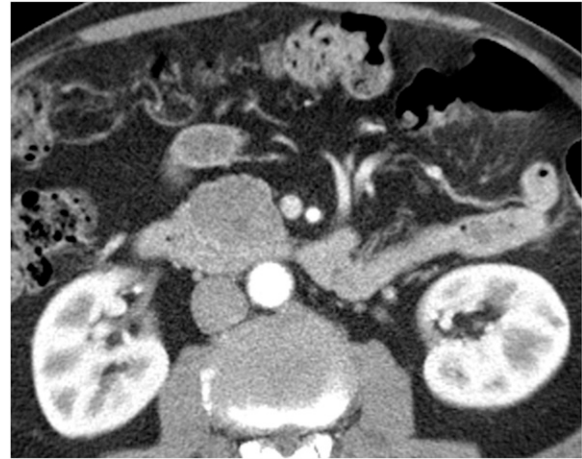

(a)

(b)

(c)

Figure 2. Solid pseudopapillary tumour of the pancreas in a 63-year-old male. (a) Axial CT scan obtained during the pancreatic phase shows a completely solid poorly enhancing mass at the pancreas head. (b) Coronal multiplanar reconstruction image of the portal venous phase shows a lobulated shape mass (arrows) with heterogeneous enhancement.

(a)

(b)

females at the beginning of the reproductive period may suggest that it is a sex hormone-dependent neoplasm. But, it is not clear whether sex hormones influence growth of the SPT or its pathogenesis.[6]

In our study, the mean age of the 12 male patients with SPTs was greater than that of the 60 female patients (42.4 years *vs* 33.4 years). In a previous study of SPTs by Machado et al,[6] in which there were seven male patients, the mean age was higher among male patients (37 years *vs* 25 years). Matsuda et al[13] reported a case of SPT of the pancreas in a 76-year-old male and Tanino et al[14] reported a case of a 58-year-old male with SPT. However, Takahashi et al[7] reported that the mean age of the seven male patients with SPT in their group was 45.0 years and that of the seven female patients in the group was 45.5 years. Owing to the rare occurrence of SPT in male patients, the number of cases was limited and there might be selection bias, but this study has the largest number of male patients with SPTs.

Figure 3. Solid pseudopapillary tumour of the pancreas in a 17-year-old female. (a) Axial pre-contrast CT scan shows a well-defined mass in the pancreas body. (b) CT scan obtained during the portal venous phase mainly shows a cystic mass with a small solid portion (arrow) at the pancreas body. Mild contrast enhancement of the solid portion of the mass is seen as well.

(a)

(b)

The mean size of SPTs in male patients was larger than that in female patients in our study (6.3 *vs* 4.6 cm). However, Takahashi et al[7] reported that the mean size of the SPT in male patients was 3.8 cm and that of the female group was 5.1 cm. Machado et al[6] reported that the mean tumour size in male patients with SPT was 6.7 cm and that in the female group was 7.3 cm. With the widespread use of cross-sectional imaging and improvements in CT and MRI technology for the detection of pancreatic abnormalities, tumour size tended to be smaller in patients treated in more recent years.[6,15] This trend may have affected the measured size of the pancreatic tumours in our study. Although there were no consistent results with respect to size of the SPT and age of the male patients, the sample size was the highest in our study, and additional studies with increased

numbers of patients would be important to further evaluate these findings.

The proportion of the solid component was statistically different between the SPT in male patients and that in female patients, in the present study. The proportions of solid-to-cystic composition of the tumours were correlated with tumour size only in female patients but not in male patients. Takahashi et al[7] reported that most SPTs in females exhibited encapsulation by thick fibrous tissue and massive degenerative changes, whereas most SPTs in males showed solid components without prominent degenerative changes, although the SPTs were of a similar size to those found in females. These findings suggest that SPTs in males tend to be a solid mass with slower progression of degenerative changes during their growth than that in females.[7] There is no reliable explanation for this phenomenon. With histological and immunohistochemical analyses, the proliferating tumour cells in male and female SPTs were basically similar.[7] However, small SPTs with no cystic change might be confused with neuroendocrine tumours or pancreatic adenocarcinomas. SPTs are known to exhibit slow and progressive contrast enhancement, whereas most of the neuroendocrine tumours exhibit early homogeneous and prolonged enhancement up to the delayed phase.[5,16] In our study, SPTs in male and female patients also showed progressive enhancement in the solid portion of the tumour (81.8% *vs* 79.0%). Several imaging features of SPTs differed from those of pancreatic adenocarcinoma. One was the absence of secondary changes in the pancreas, such as dilatation of the upstream pancreatic duct or pancreatic parenchymal atrophy. Another different feature was the absence of lymph node metastasis, and no metastasis to abdominal solid organs such as the liver.[3,5] Also SPTs did not show infiltrative change to the surrounding pancreatic parenchymal or fat tissue.[3]

There are limitations to our study. First, because of the rare occurrence of SPTs and only surgically confirmed SPT cases were enrolled in our study, there may have been selection bias. However, our study included a relatively large number of SPTs detected with contrast-enhanced MDCT. Second, because the cases were retrospectively collected, we used different types of MDCT scanners. However, the reconstruction section thickness was similar (2.5–3.0 mm). We believe that 2.5–3.0 mm is an acceptable reconstruction section thickness for a pancreatic CT scan. Third, only surgically confirmed SPT cases were enrolled in our study; the ability to differentiate SPTs from other pancreatic tumours was not evaluated.

In conclusion, the imaging features of SPTs in male patients were different from those of SPTs in female patients: SPTs in male patients appeared as a somewhat large-sized solid mass with a lobulated margin. We should take into consideration the possibility of SPTs in the differential diagnosis of solid pancreatic tumour with progressive enhancement in male patients prior to pathological evaluation.

REFERENCES

1. Choi JY, Kim MJ, Kim JH, Kim SH, Lim JS, Oh YT, et al. Solid pseudopapillary tumor of the pancreas: typical and atypical manifestations. *AJR Am J Roentgenol* 2006; **187**: W178–86. doi: 10.2214/AJR.05.0569

2. Martin RC, Klimstra DS, Brennan MF, Conlon KC. Solid-pseudopapillary tumor of the pancreas: a surgical enigma? *Ann Surg Oncol* 2002; **9**: 35–40.

3. Baek JH, Lee JM, Kim SH, Kim SJ, Lee JY, Han JK, et al. Small (<or=3 cm) solid pseudopapillary tumors of the pancreas at multiphasic multidetector CT. *Radiology* 2010; **257**: 97–106. doi: 10.1148/radiol.10092089

4. Cantisani V, Mortele KJ, Levy A, Glickman JN, Ricci P, Passariello R, et al. MR imaging features of solid pseudopapillary tumor of the pancreas in adult and pediatric patients. *AJR Am J Roentgenol* 2003; **181**: 395–401. doi: 10.2214/ajr.181.2.1810395

5. Yu MH, Lee JY, Kim MA, Kim SH, Lee JM, Han JK, et al. MR imaging features of small solid pseudopapillary tumors: retrospective differentiation from other small solid pancreatic tumors. *AJR Am J Roentgenol* 2010; **195**: 1324–32. doi: 10.2214/AJR.10.4452

6. Machado MC, Machado MA, Bacchella T, Jukemura J, Almeida JL, Cunha JE. Solid pseudopapillary neoplasm of the pancreas: distinct patterns of onset, diagnosis, and prognosis for male versus female patients. *Surgery* 2008; **143**: 29–34. doi: 10.1016/j.surg.2007.07.030

7. Takahashi Y, Hiraoka N, Onozato K, Shibata T, Kosuge T, Nimura Y, et al. Solid-pseudopapillary neoplasms of the pancreas in men and women: do they differ? *Virchows Arch* 2006; **448**: 561–9. doi: 10.1007/s00428-006-0174-9

8. Mima K, Hirota M, Abe S, Iwatsuki M, Imamura H, Tsuruzoe S, et al. Small solid pseudopapillary tumor of the pancreas in a 32-year-old man: report of a case. *Surg Today* 2010; **40**: 772–6. doi: 10.1007/s00595-009-4139-x

9. Lee JH, Yu JS, Kim H, Kim JK, Kim TH, Kim KW, et al. Solid pseudopapillary carcinoma of the pancreas: differentiation from benign solid pseudopapillary tumour using CT and MRI. *Clin Radiol* 2008; **63**: 1006–14. doi: 10.1016/j.crad.2008.04.007

10. Mancini GJ, Dudrick PS, Grindstaff AD, Bell JL. Solid-pseudopapillary tumor of the pancreas: two cases in male patients. *Am Surg* 2004; **70**: 29–31.

11. Klöppel G, Hruban RH, Klimstra DS, Maitra A, Morohoshi T, Notohara K, et al. Solid-pseudopapillary neoplasm. In: Bosman FT, Carneiro F, Hruban RH, Theise ND, eds. *World Health Organization classification of tumours of the digestive system*. 4th edn. Lyons, France: IARC Press; 2010. pp. 327–30.

12. Tang LH, Aydin H, Brennan MF, Klimstra DS. Clinically aggressive solid pseudopapillary tumors of the pancreas: a report of two cases with components of undifferentiated carcinoma and a comparative clinicopathologic analysis of 34 conventional cases. *Am J Surg Pathol* 2005; **29**: 512–19.

13. Matsuda I, Hao H, Zozumi M, Koishi K, Matsumoto T, Kaibe N, et al. Solid-pseudopapillary neoplasm of the pancreas with massive central calcification in an old man. *Pathol Res Pract* 2010; **206**: 372–5. doi: 10.1016/j.prp.2009.07.014

14. Tanino M, Kohsaka S, Kimura T, Tabu K, Nishihara H, Sawa H, et al. A case of clear cell variant of solid-pseudopapillary tumor of the pancreas in an adult male patient. *Ann Diagn Pathol* 2012; **16**: 134–40. doi: 10.1016/j.anndiagpath.2010.11.011

15. Yao X, Ji Y, Zeng M, Rao S, Yang B. Solid pseudopapillary tumor of the pancreas: cross-sectional imaging and pathologic correlation. *Pancreas* 2010; **39**: 486–91. doi: 10.1097/MPA.0b013e3181bd6839

16. Buetow PC, Parrino TV, Buck JL, Pantongrag-Brown L, Ros PR, Dachman AH, et al. Islet cell tumors of the pancreas: pathologic-imaging correlation among size, necrosis and cysts, calcification, malignant behavior, and functional status. *AJR Am J Roentgenol* 1995; **165**: 1175–9. doi: 10.2214/ajr.165.5.7572498