Imaging and pathological findings of solid pseudopapillary tumor of the pancreas: a report of 53 cases

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Purpose

Solid pseudopapillary tumor (SPT) of the pancreas is a rare low malignant pancreatic neoplasm, accounting for approximately 1%~2% of exocrine pancreatic tumors. The characteristic findings have reported of SPTs include encapsulation, hemorrhage, calcification, mixed solid and cystic components et al.

We collected pathologically proved SPTs, analyzed CT, MRI findings and pathological features. Apart from review of common image signs, we analyzed the image and pathology correlation, as well as details on tumor composition, size et al and found statistically differences in certain characteristics between different groups.

The study aims to increase the knowledge to this rare entity through relatively large sampled and comprehensive investigation.
Methods and Materials

Patient selection

1. We reviewed a series of 53 cases in our hospital between Jan 2005 and Feb 2012.
2. Patients with histopathologic confirmed SPTs who had undergone material-enhanced CT or MRI prior to surgery were included. These included 5 male and 48 female (mean age: 33 years; age range, 13-68 years). 21 of 48 female were younger than 30 years old.
3. The pathologic results were conducted under the 2000th edition World Health Organization (WHO) Classification of Tumors which defined SPTs with specific vessels and nerves invasion, invasion to adjacent pancreatic parenchyma or organs, lymph nodes involvement and metastasis as solid pseudopapillary carcinoma (SPC) of the pancreas.

CT technique

- 44 patients were performed CT by using the following CT scanners: Toshiba Aquillion 64-MDCT scanner (n=30), Light Speed 64-channel CT scanner (n=14). They underwent upper-abdomen routine scan after drinking 800~1000ml warm water. A bolus of nonionic contrast agent (Ultravist 300ml I/L) was used as the contrast material for dynamic contrast-enhanced CT images, administered as an IV infusion, injected at a rate of 3~3.5 mL/s and at a dose of 1.5ml/kg body weight.
- Dynamic CT images were obtained 25s, 45s and 65s respectively after completion of the intravenous injection, corresponding to arterial phase, pancreatic phase and portal phase. Images with 5mm-thick sections were acquired and reconstruction was performed with the thickness of 1.25mm and reconstruction interval of 0.8 mm for both scanners.

MRI technique

- 21 patients were performed MRI after fasting for 6-8 hours. All images were performed using a 3.0 T superconduction MR scanner and phased array body coils for MRI multi-sequence scan, including T1-FSE (Fast spin echo) sequence #TR# 300ms #TE# 3.9ms #, T2-FSE sequence #TR# 6667ms #TE# 117ms #, T2-FSE sequence with fat suppression #TR# 6667ms # TE# 103ms #. Images of axial plane were collected and the scan range is from the superior border of liver to the inferior border of the kidney.
- 18 dynamic contrast-enhanced MR images were acquired in the axial plane using a T1-weighted in-phase two-dimensional gradient-echo MR sequence (TR, 2.8ms; TE, 1.3 ms; slice thickness, 3.8mm with 0 mm interslice.
gap; breathholding, 17-22s). A bolus of gadolinium-diethylenetriamine pentaacetic acid (Gd-DTPA) was administered to all patients as the intravenous contrast material; the Gd-DTPA dose was 0.1 mmol per kilogram of body weight at an intravenously injection rate of 2.0 ml/s. Arterial phase MR images were obtained 15s after completion of the intravenous infusion. The operation was repeated for 3 times with a 5s internal and it was achieved with portal phase and delay phase for 50s and 110s after Gd-DTPA administration successively.

**Imaging analysis**

All CT and MRI images were analyzed by two certified radiologist. The images were read simultaneously by both readers and a consensus was reached.

1. Review: location, morphology, size, capsule, margin, calcification, hemorrhage, constitution, attenuation/intensity, enhancing model, dilation of pancreatic and biliary ducts, invasion to adjacent organs, lymphadenopathy et al.
2. Classification:
   • solid-to-cystic component ratio: purely solid, mixed with more than 50% of tumor with solid component, mixed with less than 50% of tumor with solid component and purely cystic.
   • the enhancement pattern during pancreatic phase: homogeneous, heterogeneous, peripheral enhancement and minimal enhancement.
   • tumor size (maximal diameter): Small group was 3 cm or less in diameter, middle group was between 3 and 6 cm (include 6) and large SPTs were greater than 6 cm.
   • age groups (30 years old or younger and over 30 years old),
   • gender groups (male and female)
   • benign SPTs and SPCs.

**Statistics**

- Quantitative variables: were shown as means±standard deviations.
- Classified variables: were shown as counts and percentages.
- Mann-Whitney test: to compare age and diameters between different groups.
- The Fisher exact test or chi-square test: to evaluate differences of categorical variables among groups.

P<.05 was considered to be significantly different. The Statistical analysis was performed by using SPSS for Windows, version 17.0, 2008.
Results

Overview

1. Location: 23 in head, 15 in tail, 14 in body and tail with an obscure boundary, and 1 in neck.
2. Morphology and diameter: 90.9% (46 of 53) were round or ellipse and 9.1% (7 of 53) appeared to be nodular or lobular.
3. The average maximum diameter of tumors is 5.8 cm (range, 1-13) ± 2.9 (standard deviation).
4. Internal components: 83% (44 of 53) tumors were cystic-solid masses constituted with varied solid portion and 75.5% (40 of 53) had more than 50% solid portion. 15.1% (8 of 53) were purely solid and 1.9% (1 of 53) was purely cystic.
5. Capsule: 77.4% (41 of 53) SPTs were well defined with a capsule and 22.6% (12 of 53) were absent of capsule.
6. Calcification and hemorrhage: Calcification was noted in 28.3% (15 of 53) SPTs. Hemorrhage was found in 24.5% (13 of 53) cases with an average maximum diameter of 6.7 cm (range 3-12).

Comparison between different size groups

53 SPTs were divided into three groups according to size. Clinical features and imaging findings are shown in Table 1.

- The mean age of patients with small SPTs was significantly different from that of the patients in large group (P < 0.05; Mann-Whitney test).
- The frequency of complete solid tumors was higher among the small group (65%, 5 of 9) (P = 0.001).
- There was a significant difference in capsule presentation within the three groups (P < 0.05).
- Significant difference of hemorrhage observed on imaging existed between middle SPTs and large SPTs (P < 0.05).
- The enhancement pattern during pancreatic phase of three groups was significantly different (P < 0.05 or P < 0.001).

Comparison between different age and gender groups

Comparison of image features between different age and gender groups were showed in Table 2.

- The mean size of the younger patients was larger than that of the older group (P = 0.004 in diameter; Mann-Whitney test).
- There was no significant difference between the female and male patients in imaging features listed in Table 2.
Comparison between benign and malignant groups

Comparison between benign SPTs and SPCs were showed in Table 3 (Omitted).

- Significant difference was found only in metastasis between the two groups.

Computed tomography

- Computed tomography scans showed a cystic-solid, solid or cystic mass with heterogeneous attenuation in 44 patients. The arterial phase showed a slight or moderate intensity of solid portion. Enhancement was slightly increased in the pancreatic phase. Progressive delayed reinforcement was noted in the portal venous phase. (Fig 1).
- In the pancreatic phase, heterogeneous or homogeneous enhancement was noted in 40 cases and peripheral enhancement was noted in one case. Minimal enhancement was observed in 3 small SPTs during the pancreatic phase, after which they gradually enhanced during the portal venous phase and are isoattenuating to the surrounding pancreatic tissue (Fig 2). Calcification, dilation of pancreatic duct and infiltration to adjacent pancreatic parenchyma could be observed in small SPT.

MRI

- Hemorrhage was observed in 9 cases, showing distinctive high signal in T1WI and high, low or mixed signal in T2WI without enhancement and stratified hemorrhage was noted (Fig 3).
- The dynamic enhancement pattern on T1-weighted images was classified as follows: persistent homogeneous enhancement (0 of 18), early heterogeneous and progressive enhancement (14 of 18) (Fig 3, 4), early heterogeneous and no progressive enhancement (2 of 18). Peripheral enhancement (1 of 18) or minimal enhancement (1 of 18) was observed in small SPT.

Pathologic findings

- 45 cases were benign SPTs and 8 were SPCs, with an average maximum diameter of 4.8 cm (range 1-6.4).
- 7 SPCs had more than 50% solid portion and 2 had lymph node metastasis.
- SPTs with specific vessels and nerves invasion, invasion to adjacent pancreatic parenchyma or organs, lymph nodes involvement and metastasis were defined as SPCs (Fig 4).
Table 1: Clinical features and imaging findings of 53 SPTs in three groups. Note. Unless otherwise noted, data are numbers of SPTs, with percentage in parentheses. Statistical analyses were performed by using Fisher exact test, chi-square test, or analysis of variance. *P value for difference between the three groups †P value for difference between middle group and large group ‡P value for difference between small group and large group.

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Table 2: Comparison between different age groups and gender groups

<table>
<thead>
<tr>
<th>Features</th>
<th>Age ≤30 (n=23)</th>
<th>&gt;30 (n=30)</th>
<th>P value</th>
<th>Gender Female (n=48)</th>
<th>Male (n=5)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Size cm</td>
<td>7.1 ± 3.2</td>
<td>4.8 ± 2.3</td>
<td>.004</td>
<td>5.8 ± 2.9</td>
<td>5.1 ± 2.3</td>
<td>.6</td>
</tr>
<tr>
<td>Capsule present (%)</td>
<td>19 (83)</td>
<td>22 (73)</td>
<td>.323</td>
<td>38 (79)</td>
<td>3 (60)</td>
<td>.315</td>
</tr>
<tr>
<td>Hemorrhage (%)</td>
<td>7 (30)</td>
<td>6 (20)</td>
<td>.289</td>
<td>13 (27)</td>
<td>0</td>
<td>.229</td>
</tr>
<tr>
<td>Calcification (%)</td>
<td>8 (35)</td>
<td>7 (23)</td>
<td>.270</td>
<td>15 (31)</td>
<td>0</td>
<td>.175</td>
</tr>
<tr>
<td>Sharp margin (%)</td>
<td>20 (87)</td>
<td>22 (73)</td>
<td>.193</td>
<td>38 (79)</td>
<td>4 (80)</td>
<td></td>
</tr>
<tr>
<td>Internal components</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely solid</td>
<td>3 (13)</td>
<td>5 (17)</td>
<td>.514</td>
<td>6 (12)</td>
<td>2 (40)</td>
<td>.159</td>
</tr>
<tr>
<td>More than 50% solid</td>
<td>13 (57)</td>
<td>19 (63)</td>
<td>.412</td>
<td>30 (63)</td>
<td>2 (40)</td>
<td>.304</td>
</tr>
<tr>
<td>Less than 50% solid</td>
<td>7 (30)</td>
<td>5 (17)</td>
<td>.196</td>
<td>11 (23)</td>
<td>1 (20)</td>
<td>.685</td>
</tr>
<tr>
<td>Completely cystic</td>
<td>0</td>
<td>1 (3)</td>
<td>.566</td>
<td>1 (2)</td>
<td>C</td>
<td>.906</td>
</tr>
</tbody>
</table>

Note. Unless otherwise noted, data are numbers of SPTs, with percentage in parentheses. Statistical analyses were performed by using Mann-Whitney test, Fisher exact test, chi-square test, or analysis of variance.

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Fig. 1: Axial CT scans in 44-year-old woman with 5.7cm SPT in pancreas body and tail. (a) Precontrast scan shows homogeneous hypoattenuating lesion in body and tail of pancreas. (b-d)Scan obtained during arterial, pancreatic and hepatic venous phase shows well-defined cystic-solid lesion with gradual increasing enhancement. The degree of enhancement of lesion in each phase is lower than surrounding pancreatic parenchyma.
Fig. 2: Axial CT scans in 53-year-old man with 2.5-cm SPT in pancreas tail. (a) Precontrast scan shows homogeneous hypoattenuating lesion without calcification in tail of pancreas. (b-c) Scan obtained during arterial and pancreatic phase shows well-defined, poorly enhancing solid lesion. (d) Scan obtained during hepatic venous phase shows gradual enhancement in the lesion and near isoattenuation of tumor compared with surrounding pancreatic parenchyma. There is no dilation of pancreatic duct.

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Fig. 3: MRI scans in 18-year-old woman with 9-cm SPT in pancreas head. (a) Axial fat suppressed T2 weighted image shows well-defined heterogeneous mass with stratified hemorrhage. (b-c) Axial T1-weighted MR image obtained in arterial and pancreatic phase shows gradual heterogeneous enhancement of the lesion. (d) Sagittal T1-weighted image obtained in portal venous phase shows compression of portal vein.

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**Fig. 4:** MRI scans in 15-year-old woman with 7cm SPT in pancreas tail. (a) Axial fat saturation T2 weighted image shows mixed high signal intensity. (b-c) Axial T1-weighted MR image obtained in arterial and portal venous phase shows gradual heterogeneous enhancement of the lesion. (d) A gross specimen consisted mainly of solid components with old blood clots. The tumor surrounded spleen vessels and adhered to the spleen.

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Fig. 5: (a) On a high-power photography (HE stain, ×200), the tumor cells are uniform and form solid and pseudo-papillary structures. Foam cells are seen in mesenchyme. (b) On a low-power photography (HE stain, ×100), cystic degeneration and hemorrhage in the tumor is seen. (c-d) On a low-power photography (HE stain, ×100), invasion to pancreatic parenchyma of the tumor cells is seen. On a high-power photography (HE stain, ×200), perineural invasion to pancreatic of the tumor cells is seen. The tumor is considered to solid pseudopapillary carcinoma because of the histological presence of vascular, adjacent pancreatic parenchyma and neural invasion.

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Conclusion

In conclusion, in our study, small SPTs usually appeared as purely solid lesions with few capsules and sometimes can cause pancreatic infiltration and pancreatic duct dilation. Small SPTs usually show gradual enhancement which is not higher than the pancreatic parenchyma and peripheral enhancement is also observed sometimes. Most middle and large SPTs are solid-cystic masses with clear margin, capsule, and progressive delayed enhancement. Large SPTs incline to have more sharp margins and hemorrhage. No significant difference was found in the imaging features listed in our study between SPTs and SPCs, which supported the revision in the 2010th WHO classification.
References


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Fig. 6

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