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Pathology Section

Clinicoradiological, Histopathological and Immunohistochemical Features of Solid Pseudopapillary Neoplasms of Pancreas: A Cross-sectional Study

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ABSTRACT

Introduction: Solid Pseudopapillary Neoplasm (SPN) of the pancreas is a low-grade malignant tumour generally associated with good prognosis. This neoplasm usually shows characteristic morphologic features, but sometimes the differential diagnosis with other pancreatic neoplasms including well-differentiated Neuroendocrine Tumours (NET) and acinar cell carcinomas can be challenging, especially in cytology and biopsy specimens. In these cases, immunohistochemistry (IHC) is critical for accurate diagnosis. Given the diagnostic overlap with other pancreatic tumours and the limited clinicopathological and immunohistochemical data from the Indian population, a comprehensive evaluation of SPN is essential to facilitate accurate diagnosis and appropriate patient management.

Aim: To analyse the clinicopathological, radiological and immunohistochemical features of SPN of pancreas.

Materials and Methods: The present cross-sectional study included all cases diagnosed and reported as SPN from 1 August 2014 to 31 July 2024. Data retrieval and analysis were performed from October 2022 to June 2025 in the Department of Pathology, Regional cancer centre (RCC), Thiruvananthapuram, Kerala, India were included. Demographic details, clinical presentation, radiological findings, gross features, histomorphology, and immunohistochemical profiles were retrieved and analysed after the study was approved by the Institutional Ethics Committee. Haematoxylin and Eosin (H&E)- stained sections were reviewed in detail to assess histomorphological features. The IHC for cytokeratin, β-catenin, CD10, vimentin, Progesterone Receptor (PR), synaptophysin, and chromogranin was evaluated. Descriptive statistical analysis was performed, and data were expressed as frequencies, percentages, mean, and range.

Results: A total of 24 cases were identified, with 21 (87.5%) females and a female-to-male ratio of 7:1; the mean age was 30 years (range: 9-58 years). Abdominal pain was the most common presenting symptom in 18 (75%) cases, and the pancreatic body-tail was the most frequent tumour location in 14 (58.33%) cases. Tumour size ranged from 2.5 to 17 cm (mean: 7.5 cm), with tumours confined to the pancreas in 22 (91.66%) cases and metastasis in 2 (8.33%) cases. Histologically, all cases (100%) showed solid and pseudopapillary patterns. IHC revealed diffuse expression of CD10 in 95.24% (20/21), PR in 94.73% (18/19), vimentin in 100% (10/10), nuclear β-catenin in 92.85% (13/14), synaptophysin in 86.66% (13/15), and paranuclear dot-like CD99 in 100% (6/6) of cases tested. Follow-up information retrieved from records was available for 20 (83.33%; 20/24) patients, of whom 17 (85%; 17/20) were alive at last recorded contact.

Conclusion: The SPN predominantly affects young females and typically arises in the pancreatic body-tail. Despite its low-grade behaviour, a minority of cases may exhibit aggressive features, including local invasion and metastasis. A combination of histomorphology and a characteristic IHC profile is essential for accurate diagnosis and distinction from histologic mimics.

Keywords: β-Catenin, Differential diagnosis, Epithelial tumours, Histopathology, Immunophenotyping, Pancreatic neoplasms

INTRODUCTION

The SPN of the pancreas are described in the 5th edition of the World Health Organisation (WHO) Classification of digestive system tumours as low-grade malignant tumours. These tumours consist of poorly cohesive epithelial cells that form both solid and pseudopapillary structures and do not exhibit a specific line of pancreatic epithelial differentiation [1]. The tumour was previously referred to by various names including Frantz's neoplasm, Hamoudi's neoplasm, papillary cystic neoplasm, solid and papillary epithelial neoplasm, and solid and cystic papillary epithelial neoplasm. It was officially classified by the WHO as a solid pseudopapillary tumour in 1996 and later reclassified as a SPN in 2010 which has been retained without change in the latest 5th edition of WHO classification [2].

The SPN shows a marked predilection for young females, with incidence rates reported to be two to 14 times higher than in males, suggesting a potential link between its development and specific hormones or hormone receptors [3-5]. In adults, SPNs account for 1% to 2% of exocrine pancreatic lesions and 5% of cystic pancreatic lesions. In children, they represent about 6% to 17% of all pancreatic tumours [6]. The increased detection of SPNs in recent years is largely due to advancements in imaging and diagnostic technologies. An overwhelming majority of SPNs carry mutations in CTNNB1, which is the gene encoding ß-catenin, thus resulting in its nuclear accumulation [7,8]. Despite the typically favourable prognosis, the histological characteristics of SPN do not reliably predict its biological behaviour. The overall 5-year survival rate is about 97% [9]. The exact origin of the tumour remains unclear, possibly arising from a primordial cell with divergent differentiation. SPN continues to be a puzzling neoplasm, underscoring the need for further research [10]. The present study aims to describe the clinical, radiological, histomorphological, and immunohistochemical features of SPNs of the pancreas diagnosed at a tertiary cancer center and to identify key pathological features that facilitate accurate diagnosis.

MATERIALS AND METHODS

The present study was a cross-sectional study conducted in the Department of Pathology, Regional Cancer Centre (RCC), Thiruvananthapuram, Kerala, India. The study analysis was carried out during the period from 1 October 2022 to 30 June 2025 and received approval from the Institutional Ethics Committee (HEC No. 37/25).

Inclusion criteria: All cases reported as SPN in the Department of Pathology of the Institute over a ten-year period from 1 August 2014 to 31 July 2024 were included.

Exclusion criteria: Cases with incomplete clinical data were excluded.

Study Procedure

The demographic data, clinical details, radiological features, and laboratory investigations were retrieved from the medical records. The gross features including location, size, colour, and consistency, infiltration into the adjacent areas as well as necrosis, haemorrhage, cystic change were noted. The H&E stained sections of all the cases were reviewed by two pathologists to assess the histomorphological features in detail. Any discrepancies in interpretation were resolved by joint review and consensus. The histomorphological features analysed include cellular arrangement, nuclear grooves, eosinophilic hyaline globules, vacuolated cytoplasm, foamy histiocytes, cholesterol clefts, calcification, giant cells, clear cell change, necrosis and nuclear atypia. IHC for cytokeratin, beta catenin, CD10, Vimentin, PR, synaptophysin and chromogranin were analysed.

STATISTICAL ANALYSIS

Descriptive statistical analysis was performed to summarise the clinicopathological characteristics. Categorical variables were expressed as frequencies and percentages. Continuous variables were presented as mean and range.

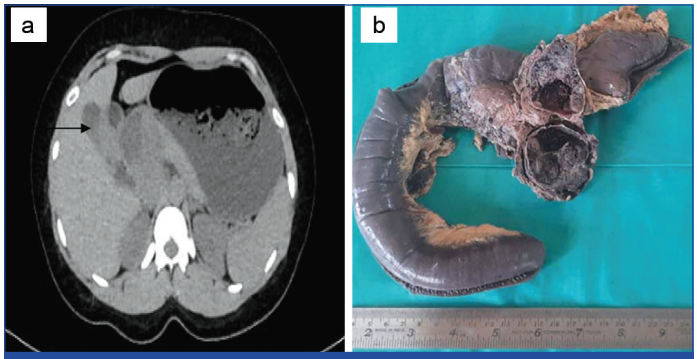
RESULTS

A total of 24 cases of SPN were reported at RCC, Thiruvananthapuram, during the 10-year study period. There was a striking female preponderance with 21 (87.5%) females and three males with female: male ratio 7:1. The age of the patients ranged from 9 to 58 years (mean age 30 years). Six patients were aged ≤18 years and were categorised as belonging to the paediatric age group. The duration of clinical symptoms ranged from seven days to two years. The most common clinical features were abdominal discomfort/pain seen in 18 cases (75%) followed by palpable abdominal mass seen in two cases (8.33%). In two patients (8.33%) it was incidentally detected. One patient (4.16%) presented with jaundice, vomiting and one (4.16%) with back pain. Three patients (12.5%) had prior history of malignancies which included carcinoma colon, papillary thyroid carcinoma and diffuse large B cell lymphoma of tonsil.

The patients underwent radiological investigations including Ultrasonography (USG), Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). The diagnosis was suggested on imaging in seven cases (29.16%) and not diagnostic in ten cases (41.66%). Rest of the cases were diagnosed as NET (N=3, 12.5%), pancreatoblastoma (N=3, 12.5%) and pancreatic mesenchymal tumour (N=1, 4.16%) in radiology. Radiology showed mainly solid and cystic lesion in 16 cases (66.66%) [Table/Fig-1a]. Predominant solid lesion was seen in six cases (25%) and predominant cystic lesion in two cases (8.33%).Calcification in radiology was noted in 11 cases (45.83%). Carbohydrate Antigen 19-9 (CA 19-9) was done in 14 patients and was found to be <37 U/mL in all the patients tested. Preoperative guided Fine-Needle Aspiration Cytology (FNAC)/biopsy was performed in 14 cases and a diagnosis suggestive of SPN was given in nine cases (N=9/14, 64.28%). Diagnosis was given as NET (N=2/14, 14.28%), pancreatoblastoma (N=2/14, 14.28%) and spindle cell neoplasm (N=1/14, 7.14%) in the remaining cases.

For the tumours primarily located in the head and/or neck of the pancreas, pancreaticoduodenectomy (Whipple procedure) was performed in nine cases (37.5%). Ten tumours (41.66%) were located in the head and/or neck region; however, one patient (4.16%) underwent only peritoneal biopsy and pancreatic incision biopsy and declined definitive surgical management. Tumours located predominantly in the body or tail underwent distal pancreatectomy with or without splenectomy (N=14, 58.33%).

Tumour size ranged from 2.5-17cm in largest dimension with a mean size of 7.5 cm. The location of the tumour in the pancreas included body and tail (N=14, 58.33%), head (N=8, 33.33%). The tumour was located in the head and neck of the pancreas in two cases (8.33%). Grossly the tumours were predominantly nodular, well-circumscribed, and either partially or completely encapsulated [Table/Fig-1b]. On cut-section, they displayed solid, grey-white surfaces. The consistency ranged from firm to friable. Infiltration into the adjacent pancreas was noted in six cases (25%). In the majority of cases (N= 22, 91.6%), the tumour was confined to the pancreas, and all resection margins were negative, with clearance distances ranging from 0.3 to 0.6 cm. In two cases (8.33%) the margins were positive, with tumour extension beyond the pancreas.



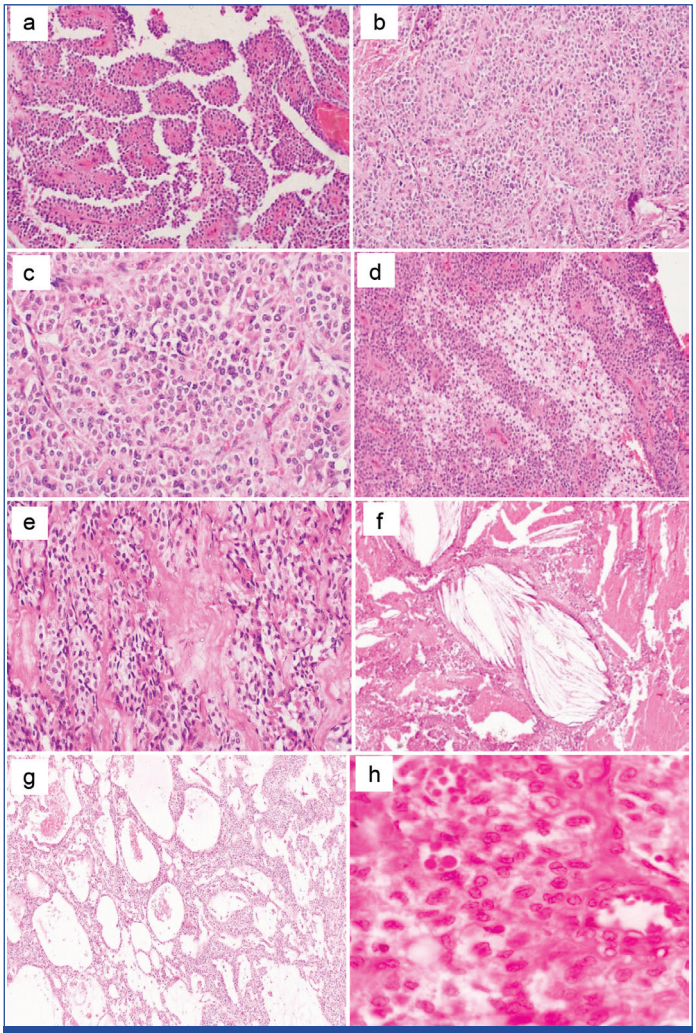
[Table/Fig-1]: a) Contrast-enhanced CT of the abdomen demonstrating a well-defined, encapsulated, lobulated solid-cystic lesion in the head of the pancreas (arrow); b) Gross specimen of a Solid Pseudopapillary Neoplasm (SPN) showing a well-circumscribed, encapsulated solid-cystic mass in the pancreatic head.

Histologically, all tumours (N=24, 100%) exhibited a combination of solid and pseudopapillary architectural patterns, with variable secondary features [Table/Fig-2]. The tumour cells were poorly cohesive uniform & arranged around delicate fibrovascular core. Nuclear grooves were seen all the cases (N=24,100%). Hyaline globules were identified in 18 cases (75%), while vacuolated cytoplasm was noted in 11 cases (45.83%). Necrosis was observed in seven cases (29.16%), and infiltration into the adjacent pancreatic tissue was seen in six cases (25%). Cholesterol clefts and foamy histiocytes were each present in five cases (20.83%). Clear-cell change, calcification, and multinucleated giant cells were documented in four cases each (16.66%) [Table/Fig-3]. Perineural invasion was identified in three cases (12.5%). Lymph node

Histological features	Number of cases (n=24)	Percentage
Combination of Pseudopapillary and solid pattern	24	100
Hyaline globules	18	75
Vacuolated cytoplasm	11	45.83
Necrosis	7	29.16
Cellular atypia	5	20.83
Cholesterol clefts	5	20.83
Foamy histiocytes	5	20.83
Giant cells	4	16.66
Calcification	4	16.66

Clear cells	4	16.66
Perineural invasion	3	12.5
Lymph node metastasis	2	8.33

[Table/Fig-2]: Histopathological characteristics.



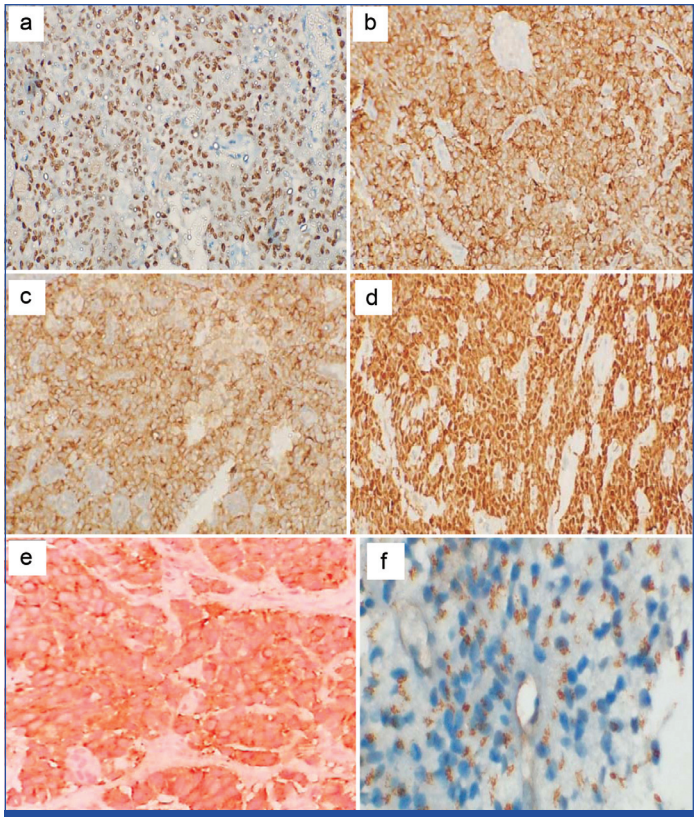
[Table/Fig-3]: Histopathological features of Solid Pseudopapillary Neoplasm (SPN) (H&E): a) Prominent pseudopapillary structures (H&E X200); b) Solid sheets of tumour cells (H&E X200); c) Tumour cells with eosinophilic cytoplasm arranged around delicate fibrovascular cores (H&E X400); d) Collections of foamy histiocytes (H&E X200); e) Clear cells and hyalinisation (H&E X400); f) Cholesterol clefts (H&E X100); g) Cystic change (H&E X100); h) Eosinophilic globules of varying sizes and nuclear grooves (H&E oil immersionX1000).

granuloma was noted in one case (4.16%). Lymphovascular emboli was not identified in any of the cases in the present study.

Mild cellular atypia was observed in five cases (20.83%), of which one case showed infiltration into adjacent pancreatic tissue and was associated with metastatic disease. Lymph node metastasis was identified in two cases (8.33%), of which one showed distant metastases to the liver and lungs with peritoneal deposits, while the other exhibited a tumour deposit in the hepatogastric ligament. Microscopically, high-grade transformation was not observed in any of the cases in the study.

Immunophenotypically tumours showed positivity for Vimentin (N=10/10, 100%), CD10 (N=20/21,95.23%), PR (N=18/19, 94.73%) and β-catenin (N=13/14, 92.85%). Cytokeratin AE1/AE3 showed cytoplasmic expression in 82.35% (N=14/17). Synaptophysin was performed in 15 cases and was positive in 13 (86.66%). Chromogranin showed weak staining in one case (5.26%) out of the 19 cases. CD99 (MIC2) showed paranuclear dot like positivity in all six cases (100%) in which it was performed [Table/Fig-4].

There were two patients with aggressive SPN biological behaviour. One case showed disseminated disease with metastasis in liver, mesenteric and retroperitoneal lymph nodes, lung and peritoneal



[Table/Fig-4]: Immunohistochemical profile of Solid Pseudopapillary Neoplasm (SPN): a) Neoplastic cells showing nuclear PR expression (IHC, X400); b) Cytoplasmic expression of cytokeratin AE1/AE3 in neoplastic cells (IHC, X400); c) CD10 positivity in neoplastic cells (IHC, X400); d) Aberrant nuclear β-catenin expression in neoplastic cells (IHC, X400); e) Synaptophysin positivity in neoplastic cells (IHC oil immersion X1000); f) Paranuclear dot-like CD99 (MIC2) expression in neoplastic cells (IHCoil immersion X1000).

deposit. The other patient had tumour deposit in hepatogastric ligament and mesenteric nodal metastasis.

The first case of metastasis was that of a 43-year-old female, a known case of carcinoma colon who was diagnosed in 2000 and treated with three cycles of chemotherapy following which she presented with a large heterogeneous mass (11×10×9 cm) arising from the pancreatic tail with associated liver (6×6×6 cm), mesenteric, retroperitoneal lymph nodes, lung, and peritoneal metastases on contrast-enhanced CT. Serum tumour markers (CA19-9, CEA, AFP) were within normal limits. Biopsies from both the pancreatic tail mass and peritoneal deposits confirmed the diagnosis of SPN. Mild cellular atypia and necrosis was noted with sparse mitosis. No lymphovascular emboli or perineural invasion was noted. IHC showed positivity for Cytokeratin, CD10, cyclin D1, β-catenin, PR, synaptophysin, and CD99(MIC2) (dot-like positivity). The patient declined surgical management and was managed palliatively, with a follow-up of one year.

The second metastatic case involved a 49-year-old woman with intermittent abdominal pain for 13 years. Imaging revealed a solid retroperitoneal mass (4.4×3.6×3.4 cm) involving the pancreatic body with hepatogastric ligament deposits and mesenteric nodal metastasis. Tumour markers (CEA, CA19-9, AFP) were within normal range. The case was referred from an outside centre with a provisional diagnosis of a NET. On review, the histomorphology and subsequent IHC (positivity for cytokeratin, β-catenin, CD10, PR, and synaptophysin, with negativity for chromogranin) confirmed the diagnosis of a SPN. Increased mitosis of 6-8/10 high power field (hpf) was noted. Ki67 index was 6-10%. No cellular atypia, necrosis or high-grade transformation was seen. The patient succumbed to disease three years after initial diagnosis.

Follow-up data retrieved from medical records were available for 20 of the 24 patients. Of these, seventeen patients were alive including one patient with hepatic metastasis. Three patients had died, one due to metastatic disease, while the remaining two survived for two

and nine years after diagnosis, respectively, with the cause of death unknown.

DISCUSSION

Solid Pseudopapillary Neoplasms (SPN) of the pancreas are rare pancreatic tumours first described by Dr. Virginia Kneeland Frantz in 1959 [11]. The exact pathological origin of SPN remains elusive, but its molecular profile may shed light on its malignant potential. In contrast to other common pancreatic neoplasms of epithelial origin, SPN displays distinctive pathogenic characteristics, indicating a unique histogenesis and biological identity [12].

In the present study, a striking female preponderance was observed, with 21 females and three males (F:M=7:1), aligning closely with previously reported ratios of approximately 10:1 [6,13,14].

The age of patients ranged from nine to 58 years, with a mean of 30 years, and six patients belonging to the paediatric age group. This demographic distribution is consistent with existing literature, which describes SPNs as occurring predominantly in young women, with a median age between 20 and 30 years [15,16].

Although earlier studies have suggested that SPNs in males tend to occur at an older age and exhibit more aggressive biological behaviour, our findings did not support this observation [17]. Among the three male patients in the current study, one belonged to the paediatric age group, and the remaining two adult males did not demonstrate any evidence of aggressive clinical or pathological features. Hence, no significant difference in age of onset or tumour aggressiveness was identified between male and female patients in our study. Overall, these results reinforce the well-established demographic pattern of SPNs, characterised by a strong female predominance and occurrence in younger age groups. The female predisposition has been postulated to result from the proximity of primordial pancreatic cells to the ovarian ridge during embryogenesis [18].

The duration of clinical symptoms ranged from seven days to two years. SPN typically presents with nonspecific symptoms, most commonly abdominal pain and abdominal distension or increased abdominal girth, while laboratory investigations, including tumour markers, are often within normal limits [19]. The clinical profile in this series was consistent with these findings, with abdominal discomfort being the predominant symptom, observed in 18 cases (75%). The case presenting with jaundice and vomiting corresponded to a tumour located in the head of the pancreas, indicating the relationship between tumour site and clinical manifestations.

In the present study, average tumour size was 7.5 cm. The tumours were distributed throughout the pancreas, with body and tail in 14 cases (58.3%) being the most common site. SPNs can arise in any region of the pancreas but are more frequently located in the body and tail in adults whereas in children, the head of the pancreas is more commonly affected [20,21]. However, the current series demonstrated that the body and tail of the pancreas were the most common locations even among paediatric patients (5 cases), with only one child showing a tumour in the head of the pancreas.

Histologically, SPN is composed of poorly cohesive, monomorphic cells forming solid and pseudopapillary structures with delicate fibrovascular cores, along with cystic spaces and areas of necrosis. These characteristic features, described by Kiani AZ et al., and others, were consistently observed in the present study as well [15,22]. All tumours (N=24, 100%) demonstrated combination of solid and pseudopapillary architectural patterns with variable secondary features. Nuclear grooves were observed in all cases (100%). Hyaline globules were seen in 18 cases (75%) and clear cell change in four cases (16.6%). Secondary degenerative changes included vacuolated cytoplasm, cholesterol clefts, foamy histiocytes, calcification, and multinucleated giant cells, underscoring the diverse morphologic spectrum of this neoplasm. Radiologically detected calcification was more frequent than histopathological identification in the present study. This discrepancy can be attributed to sampling limitations in large, heterogeneous tumours, as radiologic calcifications, particularly fine or peripheral dystrophic calcifications may not be represented in routine histological sections.

Infiltration into the adjacent pancreas was seen in six cases. Mild cellular atypia was present in five cases (20.83%).Of these only one case showed distant metastasis. The second metastatic case was not among those demonstrating mild cellular atypia. It is important to note that the presence of neoplastic cells with bizarre nuclei, a common histopathological finding in SPN, does not adversely influence prognosis and should not be misinterpreted as high-grade transformation [23]. Lymphovascular emboli were not identified in any of the cases in the present study. However, lymph node metastasis was observed in two cases and distant metastasis in one case. Lymphovascular emboli represent a microscopic histological finding that depends on sampling. Metastatic disease can occur even when lymphovascular invasion is not demonstrable in examined sections. Perineural invasion was observed in three cases (12.5%).

These findings are in concordance with prior studies describing the heterogeneous morphology yet typically low-grade cytological features of SPN [10,23]. There are no specific immunohistochemical biomarkers for SPNs at present, and β-catenin, vimentin, CD10, PR and synaptophysin are usually combined to improve the diagnosis rate and are key in confirming the diagnosis of SPN [24]. The immunohistochemical profile observed in our study is highly characteristic of SPNs and reinforces their distinct molecular signature. The nuclear positivity for β-catenin (13/14; 92.85%) underscores the central role of aberrant Wnt/β-catenin pathway activation in SPN tumourigenesis, with percentages comparable to those reported in the studies by Kiani AZ et al., [7,22]. Similarly, the diffuse expression of vimentin (10/10; 100%) and CD10 (20/21; 95.24%) in the present study aligns closely with the frequencies described in the reference literature by Din NU et al., and Fu C et al., further supporting the characteristic mixed epithelial-mesenchymal immunophenotype of SPN [10,25,26]. The high PR positivity rate (N=18/19, 94.73%) is consistent with previous literature and highlights the hormone responsive nature of SPNs, particularly in young female patients [3-5]. Synaptophysin positivity was observed in 86.66% cases (N=13/15). Chromogranin showed weak staining in one case (5.26%) and was negative in the remaining cases, helping to distinguish SPNs from pancreatic NETs, which typically show strong chromogranin expression [12]. A recent study reported that the CD99 protein yields unique paranuclear spots in SPNs and can be used as a diagnostic biomarker [27]. Paranuclear dot like CD99 (MIC2) positivity was observed in all the six cases tested (100%) in our study. Overall, the combined IHC panel including β-catenin, vimentin, CD10, PR, and synaptophysin provides a reliable, supportive profile for confirming SPN, particularly in morphologically challenging or limited biopsy sample.

The SPN of the pancreas generally behaves in a benign manner, with complete surgical resection being curative in more than 85% of cases. However, recurrence and metastasis may occur in fewer than 15% of patients, most commonly involving the liver and peritoneum [15,28]. It may occur synchronously or metachronously, and despite metastatic spread, patients often exhibit relatively prolonged survival compared with other pancreatic malignancies, reflecting the tumour's indolent biological nature [29]. Reported risk factors for recurrence and metastasis include large tumour size (>8 cm)and lymph node involvement [24]. The prognostic value of Ki-67 in SPN remains uncertain, with conflicting evidence in the literature. While some studies suggest that a Ki-67 index

greater than 5% may be associated with tumour recurrence. Others report that elevated Ki-67, when combined with adverse histological features such as extensive necrosis, nuclear atypia, and a high mitotic rate, correlates with aggressive behaviour [30,31].Other poor prognostic factors include male gender, vascular invasion, perineural invasion and invasion into adjacent structures [32].

In the present study, metastatic disease was observed in two cases (8.3%). One patient had a large tumour (>8 cm) with mild cellular atypia and necrosis, while the other demonstrated a Ki-67 index >5% with increased mitotic activity. Both cases showed lymph node involvement; however, given the limited number of aggressive cases, these observations should be interpreted with caution. No vascular invasion, perineural invasion, or invasion into adjacent structures was identified in either case.

The overall prognosis of SPN remains favourable, with a 5-year survival rate exceeding 95% [9]. Given its unpredictable biological behavior and potential for late metastasis, sometimes appearing even 10-15 years postoperatively, long-term follow-up remains essential [33-35].

Limitation(s)

The present study was limited by its small sample size, which was expected, given the relative rarity of SPN of the pancreas, and by its retrospective design. In addition, immunohistochemical analysis could not be performed uniformly in all cases due to limited tissue availability.

CONCLUSION(S)

The SPN of the pancreas predominantly affects young females and commonly involves the body and tail of the pancreas. The present study identifies key pathological features that aid in accurate diagnosis, including characteristic histomorphological patterns such as solid and pseudopapillary architecture with uniform neoplastic cells showing nuclear grooves, along with a distinctive immunohistochemical profile marked by nuclear β-catenin, diffuse CD10, and PR expression. Recognition of these defining pathological features is essential for reliable distinction of SPN from its histologic mimics, particularly pancreatic NETs and acinar cell carcinoma. Although SPN is a low-grade malignant neoplasm with an overall favourable prognosis, a small subset of cases may demonstrate aggressive behaviour, including local invasion or metastasis, warranting careful evaluation and long-term follow-up.

REFERENCES

[1] Klöppel G, Basturk O, Klimstra DS, Akın Ö, Notohara K. Solid pseudopapillary neoplasm of the pancreas. In: Gill AJ, Klimstra DS, Lam AK, Washington MK, editors. WHO Classification of Tumours: Digestive System Tumours. 5th ed. Lyon: International Agency for Research on Cancer; 2019. p. 340-342.

[2] Bosman FT, Carneiro F, Hruban RH, Theise ND, editors. WHO classification of tumours of the digestive system. 4th ed. Lyon: International Agency for Research on Cancer; 2010.

[3] Wu L, Zou T, Shi D, Cheng H, Shahbaz M, Umar M, et al. Age in combination with gender is a valuable parameter in differential diagnosis of solid pseudopapillary tumors and pancreatic neuroendocrine neoplasm. BMC Endocr Disord. 2022;22(1):255.

[4] Wu J, Mao Y, Jiang Y, Song Y, Yu P, Sun S, et al. Sex differences in solid pseudopapillary neoplasm of the pancreas: A population-based study. Cancer Med. 2020;9(16):6030-41.

[5] Cienfuegos JA, Lozano MD, Rotellar F, Martí P, Pedano N, Arredondo J, et al. Solid pseudopapillary tumor of the pancreas (SPPT): Still an unsolved enigma. Rev Esp Enferm Dig. 2010;102(12):722-28.

[6] La Rosa S, Bongiovanni M. Pancreatic solid pseudopapillary neoplasm: Key pathologic and genetic features. Arch Pathol Lab Med. 2020;144(7):829-37.

[7] Omiyale AO. Solid pseudopapillary neoplasm of the pancreas. World J Hepatol. 2021;13(8):896-903.

[8] Ebrahim NAA, Othman MO, Salama RA, Abdelfatah D, Tahoun NS. Diagnostic insights into solid pseudopapillary neoplasms of the pancreas: A decade of experience with pediatric representation. Diagn Pathol. 2025;20(1):57.

[9] Cruz MAA, Moutinho-Ribeiro P, Costa-Moreira P, Macedo G. Solid pseudopapillary neoplasm of the pancreas: Unfolding an intriguing condition. GE Port J Gastroenterol. 2021;29(3):151-62.

[10] Zalatnai A, Kis-Orha V. Solid-pseudopapillary neoplasms of the pancreas: A clinicopathological review. Pathol Oncol Res. 2020;26(2):641-49.

[11] Frantz VK. Tumors of the pancreas. Washington: Armed Forces Institute of Pathology; 1959. pp. 32-33.

[12] Lu X, Chen H, Zhang T. Solid pseudopapillary neoplasm of the pancreas: Current understanding on its malignant potential and management. Discov Oncol. 2024;15:77.

[13] Chen X, Zhou GW, Zhou HJ, Peng CH, Li HW. Diagnosis and treatment of solid-pseudopapillary tumors of the pancreas. Hepatobiliary Pancreat Dis Int. 2005;4(3):456-59.

[14] Darius T, Brouwers J, Van Dijck H, Bernard P. Solid and cystic papillary neoplasm of the pancreas: A rare tumour in young women. Acta Chir Belg. 2006;106(6):726-29.

[15] Papavramidis T, Papavramidis S. Solid pseudopapillary tumors of the pancreas: Review of 718 patients reported in English literature. J Am Coll Surg. 2005;200(6):965-72.

[16] Reddy S, Wolfgang CL. Solid pseudopapillary neoplasm of the pancreas. Adv Surg. 2009;43:269-82.

[17] 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(1):29-34.

[18] Kosmahl M, Seada LS, Jänig U, Harms D, Klöppel G. Solid–pseudopapillary tumor of the pancreas: Its origin revisited. Virchows Arch. 2000;436(5):473-80.

[19] AlQattan AS, Alshaqaq HM, Al Abdrabalnabi AA, Alnamlah M, Alanazi AA, Alqahtani MS. Huge solid pseudopapillary tumor of the pancreas 'Frantz tumor': A case report. J Gastrointest Oncol. 2020;11(5):1098-104.

[20] Lee SE, Jang JY, Hwang DW, Park KW, Kim SW. Clinical features and outcomes of solid pseudopapillary neoplasm: Differences between adults and children. Arch Surg. 2008;143(12):1218-21.

[21] Michalova K, Michal M, Sedivcova M, Kazakov DV, Bacchi C, Antic T et al. Solid pseudopapillary neoplasm (SPN) of the testis: Comprehensive mutational analysis of 6 testicular and 8 pancreatic SPNs. Ann Diagn Pathol. 2018;35:42-47.

[22] Kiani AZ, Khan HM, Ali Z, Sheikh HS, Khan AS, Atiq M. A Single Institution Experience with Solid Pseudopapillary Neoplasm of the Pancreas: Clinicopathological Correlation and Review of the Literature. Asian Pac J Cancer Care. 2023;8(1):49-57.

[23] Chen J, Zong L, Wang P, Liu Y, Zhang H, Chang X, et al. Solid pseudopapillary neoplasms of the pancreas: Clinicopathologic analysis and a predictive model. Mod Pathol. 2023;36(6):100141.

[24] Chen H, Huang Y, Yang N, Yan W, Yang R, Zhang S, et al. Solid-pseudopapillary neoplasm of the pancreas: A 63-case analysis of clinicopathologic and immunohistochemical features and risk factors of malignancy. Cancer Manag Res. 2021;13:3335-43.

[25] Din NU, Rahim S, Abdul-Ghafar J, Ahmed A, Ahmad Z. Clinicopathological and immunohistochemical study of 29 cases of solid-pseudopapillary neoplasms of the pancreas in patients under 20 years of age along with detailed review of literature. Diagn Pathol. 2020;15(1):139.

[26] Fu C, Li X, Wang Y, Wang C, Jin H, Liu K, et al. Solid pseudopapillary neoplasm of the pancreas: A retrospective study of 195 cases. Front Oncol. 2024;14:1349282.

[27] Ardengh JC, Lopes CV, Venco FE, Machado MA. Diagnosis of pancreatic solid pseudopapillary neoplasms using cell-blocks and immunohistochemical evaluation of endoscopic ultrasound-guided fine needle aspiration biopsy specimens. Cytopathology. 2021;32(1):50-56.

[28] Jagannathan AM, Rymbai ML, Anand A, Paul A, Das B, Kodiatte TA, et al. Curative resection for metastatic solid pseudopapillary neoplasm of pancreas-a case series. Indian J Surg Oncol. 2024;15(Suppl 2):232-37.

[29] Li X, Ren J, Ke J, Jiang P, Guo L, Zhang L, et al. Solid pseudopapillary neoplasm of the pancreas with hepatic metastases: Problems and strategies. Front Oncol. 2024;14:1410888.

[30] Yang F, Wu W, Wang X, Zhang Q, Bao Y, Zhou Z, et al. Grading solid pseudopapillary tumors of the pancreas: The Fudan prognostic index. Ann Surg Oncol. 2021;28(1):550-59.

[31] 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 SurgPathol. 2005;29(4):512-19.

[32] Del Chiaro M, Verbeke C, Salvia R, Klöppel G, Werner J, McKay C, et al; European Study Group on Cystic Tumours of the Pancreas. European experts consensus statement on cystic tumours of the pancreas. Dig Liver Dis. 2013;45(9):703-11.

[33] Ng KH, Tan PH, Thng CH, Ooi LL. Solid pseudopapillary tumour of the pancreas. ANZ J Surg. 2003;73(6):410-15.

[34] Gomez P, Yorke R, Ayala AG, Ro JY. Solid-pseudopapillary neoplasm of pancreas with long delayed liver metastasis. Ann Diagn Pathol. 2012;16(5):380-84.

[35] Wang WB, Zhang TP, Sun MQ, Peng Z, Chen G, Zhao YP. Solid pseudopapillary tumor of the pancreas with liver metastasis: Clinical features and management. Eur J Surg Oncol. 2014;40(11):1572-77.

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