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Research Article

Anatomical Variations of the Pancreatic Ductal System on MRCP: Clinical Implications and Correlation with Pancreatitis

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A B S T R A C T

Introduction: The pancreatic ductal system (PDS), comprising the main pancreatic duct (MPD) and the accessory pancreatic duct (APD), exhibits considerable anatomical variation. Certain ductal anomalies such as pancreas divisum and ansa pancreatica are known to be associated with recurrent or idiopathic pancreatitis. Magnetic resonance cholangiopancreatography (MRCP) offers a non-invasive means to evaluate these configurations. This study aimed to analyse the ductal patterns of the pancreas using MRCP and to assess their clinical significance.

Materials and Methods: This observational cross-sectional study was conducted on 12 adult patients who underwent MRCP for evaluation of pancreaticobiliary anatomy. Patients with previous pancreatic surgery, poor-quality images, or known malignancy were excluded. Ductal configurations were categorized as normal or variant types (e.g., pancreas divisum, ansa pancreatica, ductal duplication, absent APD). Clinical correlations were noted.

Results: The most common configuration was normal MPD-APD fusion (Type I), seen in 7 patients (58.3%). Pancreas divisum was observed in 2 patients (16.7%), one of whom had chronic abdominal pain. Ansa pancreatica was noted in 1 patient (8.3%) with a history of acute pancreatitis. Less common variants included absent APD and ductal duplication (each in 1 patient, 8.3%). Most other variants were asymptomatic.

Conclusion: Normal ductal anatomy was most common, but clinically significant variants such as pancreas divisum and ansa pancreatica were also identified. MRCP is an effective non-invasive tool for detecting ductal anomalies, and recognizing these variants is essential in evaluating patients with unexplained pancreatitis or before pancreatic interventions.

Keywords: Pancreatic Ductal System, Pancreas divisum, Magnetic Resonance Cholangiopancreatography (MRCP), Ductal Anomalies, Pancreatic Variants, Idiopathic Pancreatitis, Pancreaticobiliary Imaging

Introduction

The pancreas is a complex retroperitoneal organ endowed with dual endocrine and exocrine functions. Its exocrine component is responsible for the secretion of digestive enzymes, which are transported through an intricate network of ducts forming the pancreatic ductal system (PDS). This system primarily comprises the main pancreatic duct (MPD)—also referred to as the duct of Wirsung—and the accessory pancreatic duct (APD) or duct of Santorini. The MPD typically originates in the pancreatic tail and drains at the major duodenal papilla, while the APD arises in the pancreatic head and often communicates with the MPD at the pancreatic neck, terminating at the minor duodenal papilla approximately 2 cm proximal to the major papilla.[1,2]

Embryologically, the pancreatic ductal configuration is the result of a fusion between the dorsal and ventral pancreatic buds during the seventh week of gestation. Any deviation in this developmental process can give rise to numerous anatomical variants, such as pancreas divisum, ansa pancreatica, ductal duplication, or absence of communication between the two ducts.[3,4] These variants, while often asymptomatic, may have significant clinical implications—particularly in the context of recurrent acute or chronic pancreatitis, pancreaticobiliary malfunction, or during surgical procedures like pancreaticoduodenectomy.[5,6]

Historically, the anatomical configuration of the PDS was studied through cadaveric dissections and contrast-enhanced dictograph. With the evolution of imaging technology, endoscopic retrograde cholangiopancreatography (ERCP) emerged as the gold standard for ductal evaluation.[1] However, due to its invasive nature and risk of complications, it has largely been replaced in recent years by magnetic resonance cholangiopancreatography (MRCP)—a non-invasive imaging modality capable of delineating ductal anatomy and associated pancreatic parenchymal changes.[7] Furthermore, the advent of secretin-enhanced MRCP (s-MRCP) has enabled better visualization of ductal morphology and functional assessment by transiently stimulating ductal dilation.[7]

Despite these technological advancements, there remains a paucity of population-based data detailing the spectrum and prevalence of PDS variants beyond pancreas divisum. Studies focusing on these ductal patterns, particularly in the South Asian population, are limited.[2,3] Literature often emphasizes pancreas divisum due to its known association with pancreatitis; however, the clinical impact of other less well-known variants like ansa pancreatica, ductal loop formations, or duplication anomalies is under-reported.[6,8] For example, a study by Adibelli et al. involving over 1600 MRCP examinations emphasized the need to consider pancreas divisum as a potential risk factor for pancreaticobiliary malignancies.[9]

In light of these gaps, this study aims to systematically assess the ductal pattern of the pancreas using cross-sectional imaging, particularly MRCP, to identify and classify anatomical variants of the PDS. The study further seeks to evaluate the frequency, morphological types, and potential clinical significance of these variations. By correlating imaging findings with clinical symptoms or disease presentations, the study endeavors to enhance radiological diagnostic accuracy and assist in therapeutic planning. It also aims to contribute valuable regional data that may support the development of standardized classification and management guidelines for pancreatic ductal anomalies.

Materials and Methods

Study Design and Setting

This conducted in the Department of Radiodiagnosis at a tertiary care teaching hospital.

Study Population

The study included patients referred for magnetic resonance cholangiopancreatography (MRCP) to evaluate pancreaticobiliary anatomy. A total of 12 adult patients who underwent MRCP for various clinical indications such as abdominal pain, suspected pancreatitis, or biliary obstruction were enrolled after fulfilling the eligibility criteria.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients undergoing MRCP for evaluation of pancreatic ductal anatomy.
- Patients with diagnostic-quality MRCP images.
- Patients providing informed written consent.

Exclusion Criteria

- History of pancreatic or biliary surgery.
- Known pancreatic neoplasms distorting normal ductal anatomy.
- Inadequate or poor-quality MRCP images.
- Congenital anomalies unrelated to the pancreatic ductal system.

Imaging Protocol

All MRCP examinations were performed using a 1.5 Tesla MRI scanner. The protocol included heavily T2-weighted sequences in axial, coronal, and oblique planes using a phased-array abdominal coil. Imaging parameters were optimized for high-resolution visualization of the pancreatic ductal system. Secretin-enhanced MRCP was not performed in this study.

Image Analysis

MRCP images were independently reviewed by two experienced radiologists (each with >5 years of experience in abdominal imaging). The following ductal parameters were assessed:

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- Course and morphology of the main pancreatic duct (MPD).
- Presence, course, and termination of the accessory pancreatic duct (APD).
- Variants such as pancreas divisum, ansa pancreatica, absent APD, ductal duplication, and ductal loop formations.

Any disagreement between reviewers was resolved by consensus. The ductal configurations were classified based on standard anatomical criteria and previously described classification systems.[1,2]

Data Collection

Demographic details (age, sex), clinical indications for MRCP, and associated imaging findings (e.g., chronic pancreatitis, ductal dilatation, pancreatic cysts) were recorded for all patients in a structured data sheet.

Statistical Analysis

All data were compiled in Microsoft Excel and analyzed using SPSS version.[25] Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Due to the small sample size, only descriptive statistics were applied without inferential statistical testing. Data were summarized to report the prevalence and distribution of various pancreatic ductal patterns in the study cohort.

Results

A total of 12 adult patients who underwent MRCP for evaluation of pancreatic ductal anatomy were included in the study. The age of the patients ranged from 21 to 68 years, with a mean age of 44.3 ± 13.6 years. Table 1 The majority of the participants were male, comprising 7 patients (58.3%), while 5 were female (41.7%). Table 2

Ductal Configuration Patterns

On analysis of the pancreatic ductal system, the most frequently observed anatomical configuration was the normal fusion pattern of the main pancreatic duct (MPD) and accessory pancreatic duct (APD), also referred to as Type I configuration. This was seen in 7 out of 12 patients, accounting for 58.3% of the study population. Among these, the accessory duct was successfully visualized in 5 patients (71.4%), and it was found to be draining into the minor duodenal papilla. Table 3

Pancreas divisum, characterized by non-fusion of the dorsal and ventral pancreatic ducts with dominant drainage through the dorsal duct into the minor papilla, was observed in 2 patients (16.7%). Additionally, ansa pancreatica—a rare anatomical variant presenting as an S-shaped communication between the MPD and APD—was identified in 1 patient (8.3%). Other less common variants included absent accessory pancreatic duct in 1 patient (8.3%) and ductal duplication (bifid MPD) in another patient (8.3%).

Clinical Correlation

Among the two patients diagnosed with pancreas divisum, one patient presented with clinical symptoms of recurrent abdominal pain suggestive of chronic pancreatitis. The single case of ansa pancreatica was found in a patient with a prior history of acute pancreatitis. The remaining patients, including those with normal fusion, absent accessory duct, and bifid MPD, did not report any significant symptoms related to the pancreaticobiliary system during the study period. Table 4

These findings suggest that while most ductal variants may remain asymptomatic, certain anomalies like pancreas divisum and ansa pancreatica may have clinical relevance, particularly in cases of recurrent or unexplained pancreatitis.

Table 1.Age Interval Distribution

Age Interval (Years)	Number of Patients	Percentage (%)
20–39	4	33.3%
40–59	6	50.0%
60 and above	2	16.7%
Total	12	100.00%
Mean ± SD	44.3 ± 13.6 years	-

Table 2.Sex Distribution of Patiaents

n = 12

Sex	Number of Patients	Percentage (%)
Male	7	58.3%
Female	5	41.7%

Table 3.Distribution of Pancreatic Ductal Variants

Ductal Variant	Number of Patients (n = 12)	Percentage (%)
Normal fusion (Type I)	7	58.3%
Pancreas divisum	2	16.7%
Ansa pancreatica	1	8.3%
Absent accessory duct	1	8.3%
Ductal duplication (bifid MPD)	1	8.3%

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Table 4.Clinical Correlation with Ductal Variants

Ductal Variant	No. of Patients	Percentage (%)	Associated Clinical Feature
Pancreas divisum	2	16.7%	Recurrent abdominal pain / chronic pancreatitis
Ansa pancreatica	1	8.3%	Previous acute pancreatitis
Normal fusion (Type I)	7	58.3%	No significant symptoms
Absent accessory duct	1	8.3%	No significant symptoms
Ductal duplication (bifid MPD)	1	8.3%	No significant symptoms

Discussion

In our study, the age of the 12 patients ranged from 21 to 68 years, with a mean age of 44.3 ± 13.6 years. The majority (50%) were in the 40–59-year group, followed by 33.3% in 20–39 years, and 16.7% were aged 60 years or older.

This age distribution is in line with the study by Bülow et al. (2014),[10] who analysed MRCP images of 1,000 adults and reported the mean age of patients with pancreatic ductal variants to be 47.2 ± 15.3 years Similarly, De Filippo et al. (2008)[11] observed a peak prevalence of ductal anomalies in patients aged 30–60 years, accounting for over 65% of their cohort. These findings suggest that pancreatic ductal variants are more frequently detected in middle-aged individuals, likely due to the higher rate of symptomatic presentations and referrals in this age group.

In our study, there was a slight male predominance: 7 patients (58.3%) were male and 5 (41.7%) were female. This male predominance has also been observed in previous studies. Türkvatan et al. (2013)[12] reported a male-to-female ratio of 1.4:1 in their MRCP-based analysis of congenital pancreatic anomalies. Bülow et al. (2014)[10] similarly found that 55% of individuals with ductal variants were male. This may reflect gender differences in disease exposure (e.g., alcohol-related pancreatitis) or healthcare-seeking behaviour.

In our study, the normal fusion pattern (Type I) was most common, observed in 7 of 12 patients (58.3%). This is comparable to the finding by Jagielski et al. (2018),[6] who reported normal fusion in 55.6% of 90 patients undergoing MRCP. Bang et al. (2006)[13] observed a higher rate of 84.4% normal configuration in a Korean population undergoing ERCP, though this may reflect differences in imaging modality and patient selection.

Pancreas divisum was detected in 2 patients (16.7%) in our study. One of these patients had recurrent abdominal pain with imaging features suggestive of chronic pancreatitis. This prevalence is higher than that reported in most imaging-based population studies. Bülow et al. (2014)[10] found pancreas divisum in 4.5% of 1,000 adults, and Türkvatan et al. (2013)[12] reported it in 6.2% of 843 cases. The higher prevalence in our study may reflect the small sample size or inclusion bias toward symptomatic individuals.

Ansa pancreatica was seen in 1 patient (8.3%) in our study. Although a rare finding, Dugic et al. (2020)[8] and Kamisawa et al. (2010)[14] reported that ansa pancreatica may predispose to acute or recurrent pancreatitis due to aberrant drainage via the minor papilla. Türkvatan et al. (2013)[12] noted ansa pancreatica in 1.5% of their population, while Bang et al. (2006)[13] found it in 2.5%. Our case had a prior episode of acute pancreatitis, supporting its clinical relevance.

Absent accessory duct and ductal duplication (bifid MPD) were identified in 1 patient each (8.3%). These anomalies are less commonly described. Shahriah et al. (2014),[15] in a cadaveric study, found an absent accessory duct in 6% of specimens,[18] while De Filippo et al. (2008)[11] reported it in 7.8% of MRCP scans. Ductal duplication is rarely quantified but was documented in 2.4% of subjects by Arora et al. (2011).[2] In our study, these variants were asymptomatic.

Clinical correlation in our study showed that pancreas divisum and ansa pancreatica had relevant symptom associations. One of the two patients with pancreas divisum presented with chronic abdominal pain and features of chronic pancreatitis. This is consistent with Kamisawa et al. (2010),[14] who noted that divisum was significantly more common in patients with idiopathic recurrent pancreatitis, accounting for up to 30% of such cases.

The single patient with ansa pancreatica had a prior history of acute pancreatitis, reinforcing its association with disrupted drainage patterns and pancreatitis risk. Bang et al. (2006)[13] found that 4 out of 11 patients with ansa pancreatica had recurrent pancreatitis.

In contrast, the remaining patients with normal fusion, absent accessory duct, and ductal duplication were asymptomatic during the study period. This mirrors the observations of De Filippo et al. (2008),[11] who reported that such ductal variants are often incidental findings with no clinical consequences in more than 80% of cases.

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Conclusion

This study demonstrated that the normal fusion pattern of the pancreatic ductal system was the most common anatomical configuration, observed in 58.3% of patients. Notably, ductal variants such as pancreas divisum (16.7%) and ansa pancreatica (8.3%) were also identified, with both showing clinical associations with chronic and acute pancreatitis, respectively. Other anomalies, including absent accessory duct and ductal duplication, were less frequent (8.3% each) and appeared to be incidental findings without clinical significance.

Our findings align with previously published studies and highlight the importance of recognizing anatomical variations of the pancreatic duct, especially in patients with unexplained abdominal symptoms. Magnetic resonance cholangiopancreatography (MRCP) proved to be an effective, non-invasive modality for identifying and classifying these ductal variants.

Although the sample size was limited, the study underscores the potential clinical relevance of ductal anomalies and supports the routine use of MRCP in evaluating pancreaticobiliary anatomy, particularly in patients with idiopathic pancreatitis or before interventional procedures. Further large-scale studies are warranted to validate these findings and to explore the functional impact of less common ductal configurations.

Limitations of the Study

This study had several limitations. The small sample size (n=12) limits the generalizability of the findings and may not accurately represent the prevalence of ductal variants in the broader population. Being a single-centre study, selection bias is possible. Secretin-enhanced MRCP was not used, which could have improved visualization of subtle ductal anomalies. Additionally, the study lacked functional correlation, long-term clinical follow-up, and surgical or pathological confirmation, restricting the assessment of the true clinical impact of the identified variants.

Conflict of Interest: None

Source of fnding: None

Author's Contribution: All authors are equally contributed

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