Original Article

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Anatomy Section

Anatomical Variations of Pancreas Divisum in Magnetic Resonance Cholangiopancreatography: A Cross-sectional Study

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ABSTRACT

Introduction: Pancreas divisum is the most common congenital anomaly of the pancreas. It occurs due to failure of fusion of the dorsal and ventral pancreatic buds in the 7th week of intrauterine life, and leads to the formation of a large dorsal pancreatic duct and a small ventral pancreatic duct. Different types of pancreas divisum had been reported in the literature due to varying patterns of fusion of the dorsal and ventral pancreatic ducts.

Aim: The present study had been performed to find out the anatomical variations of pancreas divisum, pancreatic ducts and associated congenital anomalies.

Materials and Methods: The present cross-sectional retrospective study was carried out in the Department of Radiology, Gauhati Medical College and Hospital, Guwahati, Assam from January 2022 to March 2023. The Magnetic Resonance Cholangiopancreatography (MRCP) plates of 159 patients were collected and studied for variations of pancreas divisum, pancreatic ducts and associated congenital anomalies.

Results: In the present study, 34 (29.8%) cases had Type-1 (classical), 5 (4.4%) cases had Type-2 and 75 (65.9%) cases had Type-3 pancreas divisum. Also, 105 (66.03%) cases had Type-1 pancreatic duct and 34 (21.4%) cases had Type-4 pancreatic duct. Four (21%) cases had associated Komi Type-2A, a choledochal cyst.

Conclusion: In the present study, Type-3 pancreas divisum was most common. Also, most cases had Type-1 Major Pancreatic Duct (MPD). Choledochal cysts were found to be mostly associated with pancreas divisum.

Keywords: Anomaly, Congenital, Pancreatic duct

INTRODUCTION

Pancreas divisum is one of the common congenital anomalies of the pancreas and is found in approximately 10% of the population [1,2]. It is a condition where the dorsal and ventral pancreatic ducts fail to fuse. As a result, the secretions of the major parts of the pancreas have to pass through the accessory pancreatic duct, and only the uncinate process drains through the MPD. It may be associated with pancreatic diseases and pancreatic anomalies [3,4].

Though the diagnosis of pancreas divisum depends on the type of investigation used, MRCP provides easier evaluation due to its noninvasiveness [5]. Most of the studies had been conducted on pancreatic ducts and their variations with very few studies being done on pancreas divisum and associated congenital anomalies [6,7].

The purpose of the present study was to determine the frequency of pancreas divisum, variations of the pancreatic ducts and the frequency of associated congenital anomalies by MRCP which will help in the diagnostic evaluation of such cases, as well as, in the management of pancreatico-biliary surgeries.

MATERIALS AND METHODS

The present cross-sectional retrospective study was carried out in the Department of Radiology, Gauhati Medical College and Hospital, Guwahati, Assam from January 2022 to March 2023. The MRCP plates of 159 patients from 2017 to 2019 were collected and studied for variations of pancreas divisum and associated congenital anomalies, after obtaining ethical clearance from the Institutional Ethical Committee (IEC letter number: MC/190/2007/Pt-11/13; dated, 24.08.2018).

Inclusion and Exclusion criteria: The patients aged between 18 and 70 years, of both sexes referred with provisional diagnosis of cholecystitis and choledocholithiasis were included in the study. Post cholecystectomy cases, cases with ductal pathology and overlapping of structures were excluded from the study.

Sample size: The number of patients who underwent the MRCP during the study period was included. Total 159 numbers of patients were imaged by MRCP to identify the variations.

Radiological imaging method:

The patients were imaged on Siemens 1.5-T Magnetron Avanto scanner using routine MRI protocol that included T2-weighted coronal, axial; T1 fat suppressed axial; T2 HASTE Coronal thick and thin; and T2 space coronal 3D imaging [8].

Parameters assessed:

After collection, the MRCP readings were analysed by experienced radiologists. Two radiologists independently reported the findings. The parameters assessed in the study were:

1. **Type of pancreas divisum:** It can be classified into three main types:
   a) Type-1: It is the complete failure of fusion of major and accessory pancreatic ducts (70%). It can be further divided into two sub-types. In the first sub-type (classical pancreas divisum), the MPD drains into the accessory pancreatic duct (the dorsal pancreatic duct does not fuse with the ventral pancreatic duct). In the second sub-type (atypical or inverted pancreas divisum), the MPD does not drain into the accessory pancreatic duct (dorsal pancreatic duct drains in the ventral pancreatic duct with complete failure of fusion}.
   b) Type-2: It is the absence of the MPD of Wirsung (20-25%).

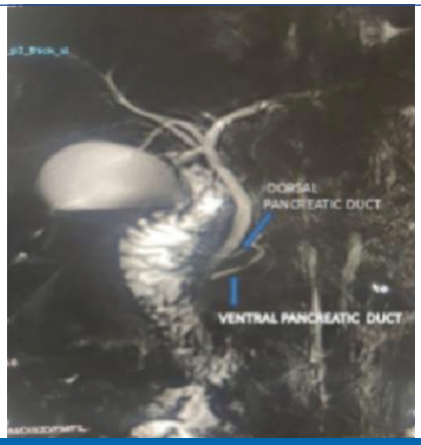
c) Type-3 (incomplete pancreas divisum): It is the presence of a small connection between the dorsal and ventral pancreatic ducts (5-6%) [9].

2. **Type of the pancreatic duct:** There are five types of pancreatic ducts. These are:
   a) Type-1: Bifid configuration with dominant duct of Wirsung.
   b) Type-2: Bifid configuration with dominant duct of Santorini without divisum.
   c) Type-3: Absent or rudimentary duct of Santorini (without communication with the duct of Wirsung).
   d) Type-4: Pancreas divisum (Type-1: classical pancreas divisum).
   e) Type-5: Ansa pancreatica (loop type course of the pancreatic duct) [6].

   Types 1, 2 and 3 are regarded as normal anatomy [Table/Fig-1] [10].

3. **Anomalies associated with pancreas divisum.**

Various anomalies associated with pancreas divisum were noted.



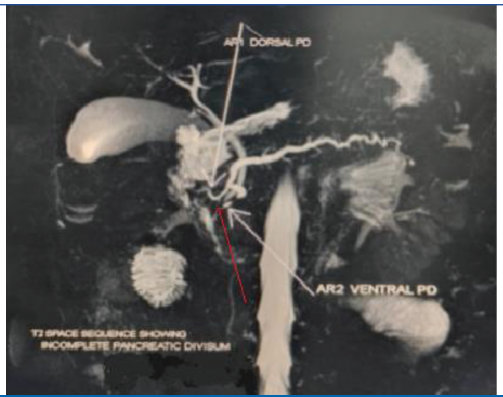
[Table/Fig-1]: Normal pancreatic duct anatomy.
MRCP showing dorsal and ventral pancreatic ducts (blue arrow) which are fused

STATISTICAL ANALYSIS

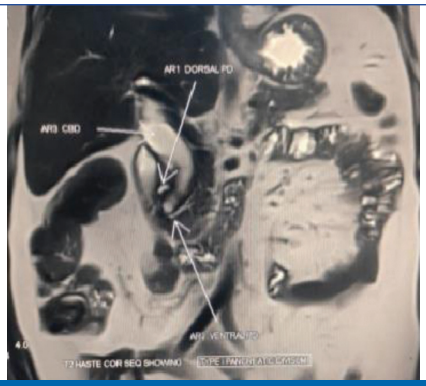
Tabulation and analysis of the data was done in Microsoft Excel sheets. Data was presented as frequency and percentage.

RESULTS

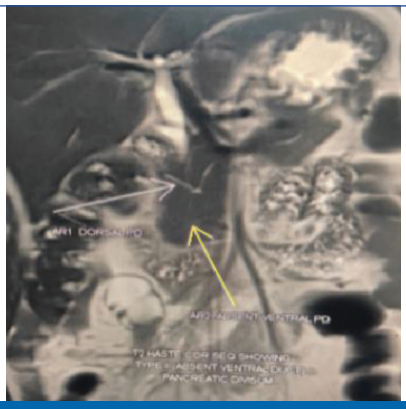
In the present study, out of 159 patients in which pancreatic duct had been observed, 114 (71.7%) patients had pancreas divisum. Out of 114 patients with pancreas divisum, 75 (65.9%) cases had Type-3 (incomplete) pancreas divisum [Table/Fig-2], followed by Type-1 (complete) pancreas divisum which was present in 34 (29.8%) cases [Table/Fig-3] and Type-2 pancreas divisum which was present in 5 (4.4%) cases [Table/Fig-4]. In 1 (0.9%) case of Type-3 (incomplete) pancreas divisum, bifid MPD was present. [Table/Fig-5].



[Table/Fig-2]: Type III (incomplete) pancreas divisum. MRCP showing dorsal and ventral pancreatic ducts (white arrow) and connection between these two ducts (red arrow).



[Table/Fig-3]: Type I (complete) pancreas divisum. MRCP showing dorsal and ventral pancreatic ducts (white arrows) which are not fused.



[Table/Fig-4]: Type II pancreas divisum. MRCP showing dorsal pancreatic ducts (white arrow) and absent ventral pancreatic duct (Yellow arrow).

S. No.	Type of pancreas divisum	Frequency (n=114)	Percentage (%)
1.	Type-1 PD (classical type of complete PD)	34	29.8
2.	Type-1 PD (atypical/inverted type of complete PD)	0	0
3.	Type-2 PD	5	4.4
4.	Type-3 PD (incomplete PD)	74	64.9
5.	Type-3 PD (incomplete PD with bifid MPD)	1	0.9

[Table/Fig-5]: Variations of pancreas divisum.
n=Total number of patients with pancreas divisum; PD: Pancreas divisum; MPD: Major pancreatic duct

In the present study, out of 159 patients, 105 (66.03%) patients had bifid MPD with dominant duct of Wirsung (Type-1 MPD), followed by classical complete pancreas divisum (Type-4 MPD) which was present in 34 (21.4%) cases and ansa pancreatica (Type-5 MPD) which was present in 11 (6.9%) cases [Table/Fig-6]. In 3 (1.9%) cases, meandering (twisting) MPD was present.

S. No.	Type of the pancreatic duct	Frequency (n=159)	Percentage (%)
1.	Bifid MPD with dominant duct of Wirsung (Type-1 MPD)	105	66.03
2.	Bifid MPD with dominant duct of Santorini (Type-2 MPD)	5	3.1
3.	Faint accessory pancreatic duct (Type-3 MPD)	1	0.6
4.	Pancreas divisum (classical) (Type-4 MPD)	34	21.4
5.	Ansa pancreatica (Type-5 MPD)	11	6.9
6.	Meandering Main Pancreatic Duct (MPD)	3	1.9

[Table/Fig-6]: Types of the pancreatic duct.
n: Total number of patients; MPD: Major pancreatic duct; PD: Pancreas divisum

In the present study, out of 114 patients with pancreas divisum, in 19 (16.7%) patients, pancreas divisum was associated with other anomalies. The most common anomaly associated with pancreas divisum was Komi Type-2A, a choledochal cyst which was present in four patients (21.05%), followed by phrygian cap gall bladder which was present in three patients (15.8%) [Table/Fig-7].

S. No.	Associated anomalies	Frequency (n=19)	Percentage (%)
1.	Komi Type-2A (Todani IB) choledochal cyst	4	21.05
2.	Komi Type-2B (Todani IVA) choledochal cyst	1	5.3
3.	Bifid MPD with Wirsungocele	1	5.3
4.	Bifid MPDs with Santorinicele	2	10.5
5.	CBD and MPD opening separately in major duodenal papilla	1	5.3
6.	Annular pancreas	2	10.5
7.	Partial dorsal pancreatic agenesis	1	5.3
8.	Phrygian cap gall bladder	3	15.8
9.	Horseshoe kidney	1	5.3
10.	Ectopic malrotated left kidney in the pelvic cavity with its pelvis directed superiorly	1	5.3
11.	Bilateral bifid renal pelvis	1	5.3
12.	Tortuous abdominal aorta	1	5.3

[Table/Fig-7]: Anomalies associated with pancreas divisum.
n: Total number of patients with associated anomaly; CBD: Common bile duct; MPD: Major pancreatic duct

DISCUSSION

In the present study, 71.7% cases of pancreas divisum were reported among 159 patients. Type-3 pancreas divisum was found to be most common in the present study. In most of the studies, Type-1 and Type-2 pancreas divisum were most common [6]. Adibelli ZH et al., reported 4.6% cases of pancreas divisum among 1158 patients and Sharath Kumar V et al., reported the incidence of pancreas divisum as 42.9% out of 14 cases [6,7]. Comparison of type of pancreas divisum with previous studies has been done in [Table/Fig-8] [6,11-14].

Authors, year, method and place of study	Sample size	Type-1 PD (%)	Type-2 PD (%)	Type-3 PD (%)
Bang S et al., [11] (2006) (ERCP) (Korea)	582	2.1	--	1.2
Adibelli ZH et al., [6] (2016) (MRCP) (Turkey)	1158	44.4	37	18.6
Abdelkareem H et al., [12] (2019) (MRCP) (Palestine)	401	30.8	38.4	15.4
Aljiffry M et al., [13] (2020) (MRCP) (Saudi Arabia)	370	0.6	--	--
Johansson K et al., [14] (2022) (MRCP, control group) (Finland)	214	5.7	--	--
Present study (MRCP) (2023) (India)	159	29.8	4.4	65.9

[Table/Fig-8]: Comparison with previous studies (pancreas divisum) [6,11-14].
PD: Pancreas divisum

In the present study, 66.03% cases of Type-1, 3.1% cases of Type-2, 0.6% cases of Type-3, 21.4% cases of Type-4, 6.9% cases of Type-5 and 1.9% cases of meandering pancreatic ducts were present. Most of the studies had Type-3 as most common type of pancreatic duct, followed by Type-1 [6,15]. Adibelli ZH et al., reported 45% cases of Type-1 and 45.6% cases of Type-3 pancreatic ducts [6]. Sharath Kumar V et al., reported 42.9% cases of Type-4 pancreatic ducts [7]. Comparison of type of the pancreatic duct with previous studies has been done in [Table/Fig-9] [6,7,12-15]. Meandering (twisting) MPD may be present in 3% of patients with healthy pancreas [14]. In the present study, 1.9% cases of meandering MPD were present.

Annular pancreas was reported to be more commonly associated with pancreas divisum [7]. In the present study, Komi Type-2A (Todani IB) choldochal cyst, followed by phrygian cap gall bladder and annular pancreas were more commonly associated with pancreas divisum [Table/Fig-10]. No study of association of choledochal cyst with pancreas divisum was found in the literature. There occurs a regional difference in the incidence of choledochal cyst with 2/3rd of the cases of Asia occurring in Japan. This condition is also reported to be more common in Asian population than the Western population [16]. Type-1 and IV choledochal cysts are more common in females [17]. Based on Todani's classification (1977), Type-1 choledochal cysts are more common (50%-80%), followed by Type-5 (also known as Caroli's disease) (20%), Type-4 (15%-35%), Type-2 (2%) and Type-3 (also known as choledochocele) (1.4%-4.5%) [18,19].

In most of the cases, the patients with pancreas divisum remain asymptomatic with the abnormality found incidentally on imaging. Pancreas divisum may cause acute relapsing pancreatitis, chronic pancreatitis and chronic abdominal pain syndrome. It may be associated with different types of pancreatic tumours [3,4].

Pancreas divisum is more frequently encountered in surgical practice. The anatomy of the pancreatic duct is variable as a result of the primordial bud development. Varying development results in suppression of either the main duct (10%) or the accessory duct (30%) [20]. Literature review suggests that as the MPD is short in individuals with pancreas divisum, the bulk of the secretions have to pass through the minor papilla causing relative stenosis which predisposes to chronic pancreatitis [3]. Thus, further studies need to be done to identify pancreas divisum as a cause of pancreatitis. In patients with pancreas divisum and pancreatitis, attempts to widen the orifice of the dorsal duct at the lesser papilla are unlikely to be of benefit [21]. Because of the duct anomalies and major pathomorphological changes in the pancreatic head, Duodenum Preserving Pancreatic Head Resection (DPPHR) is a casual treatment option [22].

Authors, year, method and place of study	Sample size	Type-1 MPD (%)	Type-2 MPD (%)	Type-3 MPD (%)	Type-4 MPD (classical/ Type-1 PD) (%)	Type-5 MPD (%)	Meandering MPD (%)
Adibelli ZH et al., [6] (2016) (MRCP) (Turkey)	1312	45	3.6	45.6	4.6	1.2	--
Prasad M et al., [15] (2019) (MRCP) (India)	103	25.2	3.9	55.3	7.8	0	--
Abdelkareem H et al., [12] (2019) (MRCP) (Palestine)	401	--	--	--	30.8	15.4	--
Aljiffry M et al., [13] (2020) (MRCP) (Saudi Arabia)	370	--	--	--	0.6	--	--
Sharath Kumar V et al., [7] (2022) (MRCP) (India)	14	--	--	--	42.9	--	--
Johansson K et al., [14] (2022, control group) (MRCP) (Finland)	214	--	--	--	5.7	9.4	3
Present study (2023) (MRCP) (India)	159	66.03	3.1	0.6	21.4	6.9	1.9

[Table/Fig-9]: Comparison with previous studies (type of the pancreatic duct) [6,7,12-15].
MPD: Major pancreatic duct; PD: Pancreas divisum

Authors, year, method and place of study	Sample size	Annular pancreas (%)	Partial dorsal pancreatic agenesis (%)
Sharath Kumar V et al., [7] (2022) (MRCP) (India)	14	14.3	14.2
Present study (2023) (MRCP) (India)	159	10.5	5.3

[Table/Fig-10]: Comparison with previous studies (associated anomalies) [7].

Variations of pancreatic duct and pancreas divisum help the general surgeons to perform pancreatic surgeries and pancreatic anastomoses. It also helps the gastroenterologists to perform Endoscopic Retrograde Cholangiopancreatography (ERCP) in the diagnosis and treatment of pancreatic diseases to avoid injury to the pancreas [23]. ERCP is the ideal procedure to diagnose pancreas divisum but due to its invasiveness MRCP is being performed [20].

Limitation(s)

In the present study, the authors had not used secretin stimulated MRCP, where secretin injection is given during MRCP to clearly visualise the pancreatic ducts [24]. Also, the retrospective nature of the study was another limitation.

CONCLUSION(S)

In the present study, Type-3 pancreas divisum and Type-1 MPD was found to be most common. Komi Type-2 A choledochal cyst and phrygian cap gall bladder were most commonly associated with pancreas divisum. More studies need to be done in future to find out congenital anomalies associated with pancreas divisum.

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