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Original Article

Diagnostic value of "t sign" on MRCP-MIP imaging in the evaluation of pancreas divisum

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Abstract

Aim: To determine the "t sign" diagnostic criteria on MRCP-MIP imaging in patients with pancreas divisum (PD).

Material and Methods: Between May 2013 and August 2019 a total of 1289 patients who underwent both ERCP and MRCP, were enrolled to the study. To select the patients with PD diagnosis on both MRCP and ERCP were planned. Patients were compared with control group. MRCP assessment included presence and type of PD, relationship of common bile duct on axial and coronal MIP-MRCP images.

Test characteristics were introduced for demonstrating diagnostic value of "t sign" on MRCP in patients with PD in the study group compared with those in the control group. Analysis was performed using the Breeze/STAT statistical calculation with computation of the 95% confidence intervals (CIs).

Results: Twenty-eight patients with diagnosis of PD according to the MRCP reports were selected for the study. Of the 28 cases, five patients without PD biliary morphology excluded from the study group due to ERCP results and one patient with the diagnosis of "probable PD" by the ERCP report was also excluded. Twenty-two patients had typical PD (95.45 %) and incomplete PD was demonstrated in one case (4.55%) . Sensitivity, specificity, positive predictive value, negative predictive value and accuracy value of MRCP-MIP imaging for demonstrating PD with using "t sign" criteria were 100%, 99%, 100%, 99% and 99% respectively. (95% CI)..

Conclusion: We concluded that, dorsal main pancreatic duct (MPD) and common bile duct cross relation was identified in all complete PD patients as a "t sign" diagnostic criteria on coronal MIP-MRCP images.

Keywords: Pancreas; magnetic resonance cholangiopancreatography; pancreatitis; pancreatic duct.

INTRODUCTION

Pancreas divisum (PD), the most common congenital ductal variation of the pancreas, is the fusion defect of dorsal pancreas and ventral pancreas during fetal development (1). Under normal conditions, dorsal pancreas joins the ventral pancreas at the neck of pancreas and forms the main pancreatic duct called ' Wirsung '. Thus, most of the pancreas parencyhma is drained thorough major papilla by ventral duct where Wirsung joins the common bile duct. This connection looks like a "beak shape" with an acute angle on coronal magnetic resonance imaging (MRI). But in PD, most of the pancreas parencyhma is drained by dorsal duct called Santorini thorough minor papilla. By the way, the minority (about 10%) of drainage is through the ventral duct of Wirsung into the uncinate process through the major papilla (2). Ductal anomalies of the pancreas are incidentally detected on MRI. PD usually do not reveal clinical complaints. It has been reported that PD is associated with chronic unexplaned abdominal pain and recurrent pancreatitis (3). Today, endoscopic retrograde cholangiopancreatography (ERCP) is admitted gold standard invasive procedure to make a definitive diagnosis of PD (4,5). However, diagnostic ERCP may cause serious complications. A noninvasive method, magnetic resonance cholangiopancreatography (MRCP), it has been reported that it has a high specifity and sesitivity for demonstrating panceatic ducts without secretin infusion or contrast injection and has high accuracy in diagnosing biliary diseases becomes an alternative modality. (4-7). MRCP picturizes the pancreatic duct without injection of contrast material and reported that for demonstrating pancreatic ducts without secretin infusion it has a high spesificity and sensitivity. Nowadays considering radiation, MRCP may be preferred more frequently than ERCP. Today, MRCP has become a primary

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modality due to recent imaging techniques and narrowing time of MRI sequences for demonstrating congenital pancreaticobiliary malformation. Maximum Intensity Projection (MIP) imaging is a recently developed CT and MRI imaging technique that made of reconstructed a couple of images as a slab image. MIP image is a volumetric image that using the highest intensity value voxels for volumetric data from every angle onto 2D image. It reveals the volumetric and multiplanar evaluation of interested area. By the way, MRCP-MIP imaging is very helpful for evaluating the choledochal and pancreatic duct relations and pathways (8). Interestingly, cross-relationship between common bile duct and main pancreatic duct was seen in most of PD cases during evaluation process of coronal MRCP – MIP images. The aim of this study was to evaluate the relationship between common bile duct and pancreatic duct in PD cases by MRCP-MIP imaging for demonstrating specific diagnostic sign.

MATERIAL and METHODS

The research design was approved by the ethics commitee of our university. This retrospective study was approved by the institutional review board of the university. Informed consent was obtained from all individual participants included in the study. Between May 2013 and August 2019, a total of 1289 patients consequently underwent successful MRCP and ERCP in our institution for a variety of clinical indications enrolled to this study. ERCP reports of these patients were reviewed for confirming the exact diagnosis. Forty consequent patients with totally normal MRCP imaging and ERCP reports from these patients also collected for control group evaluation. Two over ten-year experienced radiologists retrospectively reviewed all MRCP studies in consensus. Coronal MIP images were re-evaluated and discussed in consensus about relationship of common bile duct and pancreatic duct morphology.

Imaging techniques

All the MR studies were obtained on a 1.5 Tesla MRI system (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany - 2011) using a phased array body coil without injection of Secretin or a negative orally administered contrast agent. Navigator-triggered, half Fourier acquisition single-shot turbo spin-echo (HASTE) ultrafast T2-weighted sequence MRCP with an automated maximum-intensity projection (MIP) reconstruction was implemented in coronal orientation using the following parameters; TR: 2500 ms, TE: 700 ms, bandwidth: 372 Hz/pixel, matrix: 354x384x320, slice thickness: 1 mm and averages: 1.7 determined. For optimal visualization of bile and pancreatic ducts, thin-slap MRCP images that ranged from 15-28 images per patient were obtained at coronal and axial planes.

Imaging analysis

Two radiologists more than 10 years of experience in abdominal radiology retrospectively reviewed all the images in this study using -interactive picture archiving and communicating system- (PACS) workstations. Coronal and axial MIP images were used for the diagnosis of the pancreatic duct variations. Pancreatic ductal variations were defined as follows (9):

Type A: This is a normal variant which is characterized by a well seen main pancreatic duct (MPD-Santorini) drains via the major papilla and accessory pancreatic duct (APD-Wirsung) drains via the minor papilla separately.

Type B: Basically, this type is similar to type A, but with a barely detectable or completely absent from APD connection to minor papilla.

Type C: Another rare variation is formed a filamentous thin ductal branch that connects the ventral and dorsal ducts which is known as incomplete PD.

These three types are known as the normal pancreatic duct variants except real PD variation. Real PD variations of pancreas described as follows:

Type D: Entire ductal system as being MPD opens to minor papilla with or without a little connection with APD which known as incomplete PD.

Type E: Which known as typical PD, occurs as a complete failure of fusion of the ducts of Santorini and Wirsung; a large MPD drains via the minor papilla while a small APD opens to major papilla directly. This is the most commonly seen variation of PD and known as complete PD (Figure 1).

During the re-evaluation, the following items were taken into account:

First; Pancreatic duct changes including MPD morphology, APD presence or absence, side branch ectasia and connections, ductal dilatation and strictures were evaluated.

Second; classification of PD, complete (Type E) or incomplete (Type D) PD was concluded.

Third, Morphologic anatomy and the relation of pancreatic ducts and common bile duct for detecting the cross-relation between them were demonstrated on MIP images.

The classification and distributions of findings were compared between the study and control group. After detailed analysis of the above-mentioned findings, coronal anatomic configurations of pancreaticobiliary ducts in PD was established.

Statistical analysis

Statistical analysis was performed using ERCP as the gold reference for PD. Test characteristics were introduced for demonstrating the diagnostic value of “t sign” on MRCP in patients with PD in the study group compared with those in the control group. “ t sign” is defined as the image that the dorsal pancreatic duct crossing over the choledoch at the pancreatic head on coronal MRCP-MIP image. We compared the results of the MRCP-MIP images of PD patients with ERCP for sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy. The analysis was performed using the Breeze/STAT statistical calculation with computation of the 95% confidence intervals (CIs).

RESULTS

Twenty-eight patients were selected as study group from 1289 patients with the diagnosis of PD according to the MRCP reports. Since ERCP is accepted as gold standard for diagnosis of PD, ERCP reports of these patients were also reviewed and cross-checked with MRCP comments.

Of the 28 cases, five patients with normal pancreatic duct system according to ERCP reports excluded from the study group. In the group with false-positive MRCPs, the patients had chronic pancreatitis as well. For this group, the close location of the papillas in two patients and a stone in the pancreatic duct at the neck of the pancreas in the other two patients may have lead to misdiagnosis of PD on MRCP images. The last one patient with the diagnosis of "probable PD" by the ERCP report due to insufficient cannulation of minor papilla was also excluded after a review of the ERCP record. Therefore, there were 22 patients with exact diagnosis of PD confirmed by ERCP reports. Fourteen patients were male and eight patients were female. The mean age was 44.5 years (range, 20-82 years).

Reasons for referral of patients to MRCP-ERCP in the patient group were: idiopathic acute pancreatitis (N=12), chronic pancreatitis (N=5), nonspecific abdominal pain (N=3), and suspected sphincter of Oddi dysfunction (N=2).

However, forty consequent patients with complaint of nonspecific abdominal pain were selected in control group for comparing biliary system on MRCP. Control group patients had totally normal MRCP imaging.

Among the 22 patients with complete PD diagnosed on MRCP and ERCP, both the ventral and dorsal pancreatic ducts were confirmed in all patients with ERCP. During ERCP, dorsal and ventral pancreatography through the majör and minor papilla was achieved and relatively large-scaled dorsal duct and short ventral duct demonstrated in PD group.

The frequency of pancreatic duct variants in PD, twenty-one patients had typical type E (95.45 %). Type E; showing a large MPD drains via the minor papilla while a small APD opens to major papilla directly. Type D; incomplete PD was demonstrated in one case (4.55%) with MPD opens to minor papilla without a connection with APD.

On MRCP imaging, a finding of a large dorsal pancreatic duct crossing the common bile duct and terminated onto the duodenum wall without communicating with the ventral pancreatic duct demonstrated in all complete PD patient group. Interestingly, crossing the common bile duct to dorsal pancreatic duct relation was created a shape of "t sign" in all PD patients when evaluating the coronal MIP images (Figure 2-3). This sign is regarded as a new diagnostic sign for PD on MRCP evaluation.

In summary, the sensitivity, specificity, PPV, NPV and accuracy value of MRCP-MIP imaging for demonstrating PD with using "t sign" criteria were 100%, 99%, 100%, 99% and 99% respectively (Table 1). Significant differences detected between control group - normal pancreaticobiliary system and PD study group (95% CI).

Table 1. Biostatistical data of MRCP for diagnosis of Pancreas Divisum

		ERCP		
	Pancreas Divisum (PD)	Present	Absent	Subtotal
MRCP	Present	22	6	28
	Absent	0	1261	0
	Total	22	1267	1289
		Sensitivity:100%	Specificity:99%	Accuracy:99%

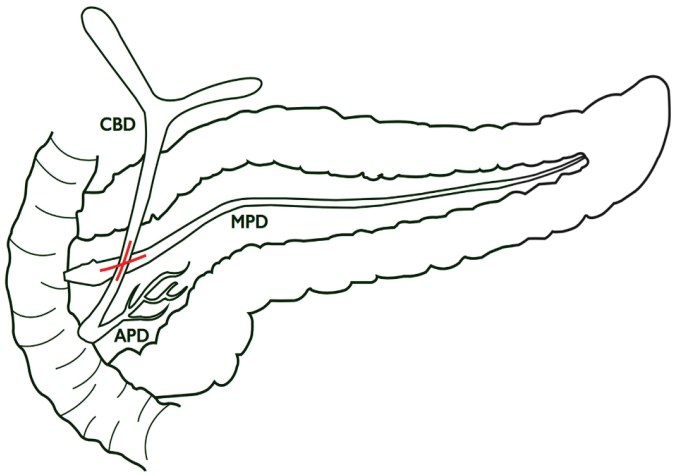

Figure 1. Schematic diagram shows typical pancreas divisum without any connection between main pancreatic duct (MPD) and accessory pancreatic duct (APD). Red sign depicts cross relation between common bile duct and MPD that resemble "t sign"

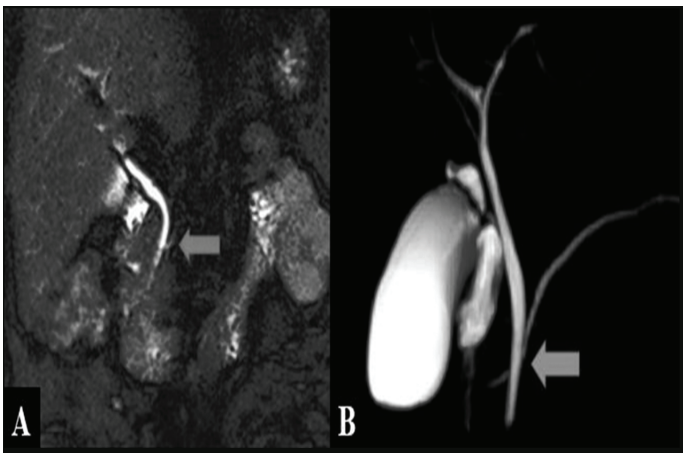

Figure 2. Magnetic resonance cholangiopancreatography and coronal MIP imaging of typical pancreas divisum in a 45-year-old-woman with several episodes of abdominal pain. A: Coronal oblique thin-section (3 mm) half fourier acquisition single shot turbo spin echo (HASTE) ultrafast T2-weighted sequence cholangiogram shows mild dilatation of common bile duct with crossing the main pancreatic duct that partially seen (arrow). B: Coronal MIP imaging is clearly depicts crossing relationship of common bile duct and main pancreatic duct (arrow).

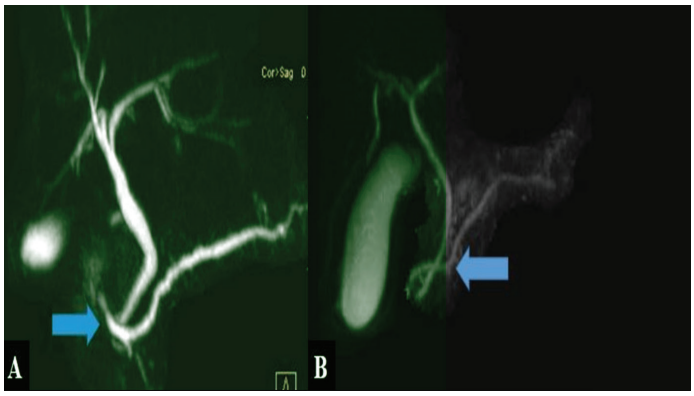

Figure 3. Magnetic resonance cholangiopancreatography coronal MIP imaging in 55 year-old man (A) and 35 year-old woman (B). Two different cross relation with creating "t sign" on strongly T2-weighted 3D turbo spin echo MIP reconstruction in coronal orientation images (A-B)

DISCUSSION

PD is the most common congenital ductal variation of the pancreas with clinical importance in a significant number of patients. The reported frequency of PD is 3-13 % in autopsy and ERCP studies (10) . In MRCP studies, the reported frequency of PD is approximately 9%, typically as incidental cases (1). The patient with typical complete PD, is defined as complete failure of fusion of the ducts of Santorini (MPD) and Wirsung (APD) (Type E). The mismatch between papilla size and the amount of its drained parenchyma may cause pressure in pancreatic duct, which may result in subsequent pancreatitis (11).

Latest studies demonstrate that most PD patients are asymptomatic (12,13). Although in ERCP studies which usually include specially symptomatic patients, it is emphasized that the incidence of PD increases.

ERCP is still considered to be a gold standard method for demonstrating biliary system but it has several disadvantages such as invasiveness, radiation, use of iodinated contrast media and ERCP induced pancreatitis (7,14).

MRCP, a well established, non-invasive imaging method, which can figure out the biliary and pancreatic duct anatomy in detail without radiation, is becoming the first choice in examining pancreaticobiliary diseases(15). Therefore, MRCP can be the first choice for diagnosis whereas ERCP can be served for those who need interventional procedures for therapeutic purpose.

The diagnostic accuracy of complete PD on MRCP was declared 73 % nearly (4). On MRCP, the diagnostic findings of typical (Type E) PD included a dominant dorsal pancreatic duct crossing the common bile duct (Choledoch) and draining into the duodenum without merging with the ventral pancreatic duct (3). The reason why some cases could not be detected on MRCP is that, an unusual anatomic configuration of common bile duct and pancreatic ducts. In addition, a short ventral pancreatic duct in PD could not be detected and lead to misdiagnosis on MRCP. In literature, the ventral pancreatic duct was detected relatively long and thick (2.8 cm length on average) in PD patients on MRCP imaging (16). By the way, the short duct was difficult to detect on MRCP also concluded in this research.

With the recent development of three-dimensional (3D) MRCP imaging, the 3D data can be achieved by using thin slices and having the patient repetitively hold the breath for a short time during image collection. After processing with a maximum intensity projection algorithm, images can be viewed from different projections. Diagnostic emphasis and priority of coronal 3D MIP-MRCP in the evaluation of pancreaticobiliary morphology has been declared in a recent study (8).

On MRCP, we also declared that, evaluation of 3D MIP coronal imaging was very helpful for diagnosis of PD with specific morphology. Thus, the pathway of a dominant dorsal MPD crossing the lower common bile duct, creates a "t sing" on coronal MIP images. We demonstrated "t sign" on coronal MIP images in all patients with a complete PD diagnosis. In literature, nobody concluded this or similar sign-on MRCP images as a helpful sign for diagnosis of PD until today. This "t sign" criteria may be helpful for quick and highly sensitive diagnosis of PD by evaluation of coronal MIP images of MRCP. By the way, other non-invasive modalities such as multidetector thin-cut computed tomography with curvilinear reconstruction of the pancreas and endoscopic ultrasound have to be considered as alternative options for the detection of PD (6). However, considering a potential improvement for evaluating pancreatic duct morphology, secretin stimulating endoscopic ultrasonography could be a further technique compared to MRCP in future studies.

This research had several limitations. Firstly, MRCP may include the potentially poor definition of the pancreatic duct branch and peripheral biliary tree in some cases, that cause poor spatial resolution compared with ERCP. Secondly, dynamic MRCP with secretin stimulation has been shown to be an effective technique for the diagnosis of PD (17). We could not use this new technique due to retrospective evaluation of MRCP cases. Thirdly, due to retrospective evaluation; we could not evaluate the volume rendering (VR) reformatted images and compare them with MIP images of patients. VR-MRCP is a new up and coming MRCP technique and some authors concluded that, VR reformation more accurately defines the biliary anatomy than MIP imaging (18).

CONCLUSION

PD is a common congenital ductal abnormality of the pancreas and may be responsible for abdominal pain and idiopathic pancreatitis. Early diagnosis of PD is crucial and new MRCP techniques like as MIP-MRCP imaging is very helpful for correct diagnosis of PD. A new diagnostic marker, "t sign" is easy demonstrable finding on coronal MIP-MRCP images. Diagnostic accuracy will improve with the use of "t sing" on MRCP imaging in patients with PD.

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