Anatomic variants of the pancreatic duct and their clinical relevance: an MR-guided study in the general population

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Abstract
Objectives To investigate the frequency of pancreatic duct (PD) variants and their effect on pancreatic exocrine function in a population-based study using non-invasive secretin-stimulated magnetic resonance cholangiopancreatography (sMRCP).

Methods Nine hundred and ninety-five volunteers, 457 women and 538 men, aged 51.9±13.4 years, underwent navigator-triggered, T2-weighted, 3D turbo spin echo MRCP on a 1.5 T system after 1 unit/kg secretin administration. Two readers evaluated images for PD variants. Pancreatic exocrine function and morphological signs of chronic pancreatitis such as abnormalities of the main PD, side branch dilatation, and pancreatic cysts were evaluated and related to PD variants using a Kruskal-Wallis test and post hoc analysis.

Results Of all sMRCP, 93.2 % were of diagnostic quality. Interobserver reliability for detection of PD variants was found to be kappa 0.752 (95 %CI, 0.733 – 0.771). Normal PD variants were observed in 90.4 % (n=838/927). Variants of pancreas divisum was identified in 9.6 % (n=89/927). Abnormalities of the main PD, side branch dilatation, and pancreatic cysts were observed in 2.4 %, 16.6 %, and 27.7 %, respectively, and were not significantly different between pancreas divisum and non-divisum group (P=0.122; P=0.152; P=0.741). There was no association between PD variants and pancreatic exocrine function (P=0.367).

Conclusion PD variants including pancreas divisum are not associated with morphological signs of chronic pancreatitis or restriction of pancreatic exocrine function.

Key Points
- MRCP allows the evaluation of pancreatic duct variants and morphological change.
- Pancreatic duct variants are not associated with morphological signs of chronic pancreatitis.
- Pancreas divisum is not accompanied by restriction of pancreatic exocrine function.
- Pancreatic duct variants including pancreas divisum are limited in their clinical relevance.

Keywords Pancreas divisum · Pancreatic duct variants · Magnetic resonance imaging · Cholangiopancreatography · Chronic pancreatitis

Abbreviations
PD Pancreatic duct
sMRCP Secretin-stimulated magnetic resonance cholangiopancreatography
CP Chronic pancreatitis
MRCP Magnetic resonance cholangiopancreatography
ERCP Endoscopic retrograde cholangiopancreatography
MRI Magnetic resonance imaging
TSE Turbo spin echo
MIP Maximum-intensity projection

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APD  Accessory pancreatic duct
MPD  Main pancreatic duct
CBD  Common bile duct
TEV  Total excreted volume
PFO  Pancreatic flow output
BMI  Body mass index

Introduction

Chronic pancreatitis (CP) is a common gastrointestinal disease in the western world with a prevalence of 27.4 cases to every 100,000 people [1, 2]. The single most important risk factor is the consumption of alcohol, which causes 60 – 90 % of all cases [3]. CP patients experience a loss of health-related quality of life and higher mortality rates compared to the general population at the same age [4]. The socioeconomic burden of CP in terms of annual medical costs is considerable [1]. Therefore, it is important to define risk cohorts for the appearance of CP and to understand the pathophysiology including further underlying causes of CP.

Except pancreas divisum, pancreatic duct variants are not well studied. The frequencies of these variants remain to be determined in a non-diseased population to assess clinical relevance. Normal pancreatic duct variants and variants of pancreas divisum are frequently detected as incidental findings on clinical imaging. It is as yet unclear if pancreatic duct variants can promote the occurrence of CP. Indeed, variants of pancreas divisum are suspected to increase the susceptibility for recurrent episodes of acute pancreatitis, which can progress to chronic pancreatitis [5]. A prospective evaluation of the hypothesis that pancreas divisum has functional relevance and is involved in the genesis of CP especially in a population-based non-clinical cohort is still missing.

Magnetic resonance cholangiopancreatography (MRCP) is a well established, non-invasive diagnostic technique for visualizing the pancreatic and biliary duct system without the adverse effects of injecting a contrast agent. MRCP detects pancreas divisum with similar accuracy as the invasive technique of endoscopic retrograde cholangiopancreatography (ERCP) [6]. Secretin stimulation in magnetic resonance cholangiopancreatography (sMRCP) can improve the visualization of the pancreatic duct system and evaluation of pancreatic findings in CP patients [7–9]. In recent years, sMRCP has become a clinically accepted technique for identifying early changes in the main PD and for assessing pancreatic exocrine function in CP patients [10–13].

The frequency of pancreatic duct variants in a general population and their functional relevance are not well investigated. Therefore, the purpose of our study was to investigate the frequency of pancreatic duct variants and effect on pancreatic function in a population-based study using non-invasive sMRCP.

Material and methods

Study population

This prospective study is part of the population-based Study of Health in Pomerania (SHIP), a project conducted in Northeast Germany. The objectives of this interdisciplinary study are to estimate the prevalence of diseases including their risk factors [14, 15]. A special focus is on understanding the mechanisms underlying the development of CP. For this reason, sMRCP was included in a whole body MRI protocol, as an SHIP subproject, with the added value of thorough medical history and laboratory data. The local ethics committee approved this study, and written informed consent was obtained from all participating volunteers before secretin-stimulated MRCP.

Between July 2008 and September 2011, 995 volunteers, consisting of 538 men and 457 women, with a mean age of 51.9±13.4 years, who had serum pancreatic enzyme levels of lipase and amylase within the reference range participated in SHIP. Exclusion criteria for MRI and sMRCP were absolute and relative contraindications, e.g., non-MR-safe metal implants, pacemakers, tattoos, pregnancy, and a known allergic disposition for secretin.

MRI protocol

MR imaging was performed on a 1.5 Tesla MRI system (Magnetom Avanto, Siemens HealthCare, Erlangen, Germany). The complete whole body MR protocol was previously described [14].

Image acquisition of the upper abdominal organs was conducted without the use of a negative orally administered contrast agent. Navigator-triggered, strongly T2-weighted 3D turbo spin echo (TSE) MRCP including an automated maximum-intensity projection (MIP) reconstruction was performed in coronal orientation using the following imaging parameters: TR, ~900 ms (adapted to navigator-triggered data); TE, 742 ms; bandwidth, 260 Hz/pixel; matrix, 384×384×44; slice thickness, 1.5 mm. In each volunteer, MRCP was performed before and after secretin stimulation (Secrelux®, Sanochemia Pharmazeutika AG, Vienna, Austria) using the same orientation and parameters. A dose of 1 unit/kg secretin was slowly injected by hand over an interval of 60 s, followed by a slow flush of 20 ml of saline. The time between injection of secretin and acquisition of sMRCP was variable (mean 11.88±2.78 min). The time ranged from a minimum of 6 min to a maximum of 22 min.
Image analysis

Two readers (PT, RT), each with more than 3 years of experience in hepatobiliary imaging, reviewed the pancreatic duct variants using the Impax system (Agfa-Gevaert N.V., AGFA Healthcare, Mortse, Belgium). The readers were unaware of each other’s results. Afterwards, a consensus reading in the presence of an attending (JK) with more than 8 years of experience in hepatobiliary imaging was defined as the gold standard for pancreatic duct variants.

Pancreatic duct variants were divided into normal pancreatic variants (types A-C) (Fig. 1) and variants of pancreas divisum (types D-E) (Fig. 2) [16]. The pancreatic duct variants were defined as follows [17]:

**Type A:** is characterized by a well defined accessory pancreatic duct (APD) with the main pancreatic duct (MPD) draining into the duodenum via the major papilla

**Type B:** similar to Type A, but with a barely definable or completely absent APD

**Type C:** is defined as a separate APD with the MPD draining to the major papilla

**Type D:** MPD drains to minor papilla with connection to APD, which drains into the major papilla distally

**Type E:** MPD drains into the major papilla and the APD into the minor papilla. There is no connection between the two ducts.

Pancreatic exocrine function was subjectively assessed by two readers (PM, JK) according to duodenal filling using a 4-point scale: grade 0 – no duodenal filling, grade 1 – low duodenal filling, grade 2 – moderate duodenal filling, grade 3 – high duodenal filling [18, 19]. Thereafter, pancreatic exocrine function was quantified by measurement of pancreatic flow output (PFO). This analysis was done by one reader (blinded) in a highly standardized workflow which did not allow manually driven deviations. In a first step, the total excreted volume (TEV) was calculated as difference between the fluid volumes of secretin-stimulated MRCP

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Fig. 1 Normal pancreatic duct variants: The anatomical variants of the main pancreatic duct system include different variations of the drainage of the APD (accessory pancreatic duct) into the minor papilla. In all variants (A-C) the MPD (main pancreatic duct) drains to the major papilla. The most frequent pancreatic duct variant is type B with 63.0 %, followed by type A with 22.5 %, and the rare type C with 4.9 %. “CBD, common bile duct; MPD, main pancreatic duct; APD, accessory pancreatic duct; 1, minor papilla; 2, major papilla”
and MRCP before injection. Therefore, fluid volumes were assessed using commercially available software (Voxar 3D, version 4.2, Toshiba Medical Visualization Systems).

\[ \text{TEV} = \text{fluid volume in sMRCP} - \text{fluid volume in MRCP} \]

Secondly, PFO was calculated from the TEV divided by the time between secretin injection and the start of sMRCP [11]. The PFO calculation was also described in more detail [20].

\[ \text{PFO} = \frac{\text{TEV}}{\text{time between secretin injection and sMRCP}} \]

Two readers (PM, JK) evaluated images for the presence of pancreatic cysts as a sign of chronic pancreatitis. For data analysis, observer 1 was defined as standard of reference. Further, an experienced reader (blinded) with more than 8 years of expertise in hepatobiliary imaging analyzed the occurrence of side branch dilatation and pancreatic abnormalities of the main pancreatic duct. Pancreatic cysts were defined as circular structures (>2 mm) with or without a connection to the pancreatic duct system. In contrast, side branch dilatations were tubular structures in connection to the main pancreatic duct or accessory pancreatic duct. Pancreatic abnormalities were defined as focal dilatation or duct stenosis of the main pancreatic duct, as well as intraductal concrements.

Statistics

Data are given as means and standard deviations or numbers and percentages as indicated.

Statistical analysis included interobserver reliability analysis using Cohen’s kappa statistic including weighted-kappa analysis for categorical data [21]. Mann-Whitney U test was performed to evaluate differences between normal duct variants (A/B/C) and variants of pancreas divisum (D/E) and terms of pancreatic exocrine function and morphological signs of CP (e.g., pancreatic cysts, side branch dilatation, and abnormalities of the main pancreatic duct).

Additionally, Kruskal-Wallis was used to analyze the association between the pancreatic duct variants (A-E) and age or BMI as well as gender. Further, differences in the functional status of the pancreas and morphological features of CP between groups (A-E) were evaluated using a Kruskal-Wallis test. If the Kruskal-Wallis test revealed a significant difference, a post hoc analysis was performed using a Mann-Whitney U test.

Statistical significance was assumed at a \( P \)-value of <0.05. Data documentation and statistical analyses were performed using Excel (v.2007, Microsoft Corporation, Redmond, WA, USA) and SPSS v.14 (SPSS Inc, Chicago, IL, USA).

Results

The majority of MR examinations (93.2%; \( n=927/995 \) MRCPs) was of diagnostic quality and allowed evaluation of pancreatic duct variants and assessment of morphological and functional CP signs. Sixty-eight subjects were excluded from evaluation because of non-diagnostic image quality (\( n=61 \)) or faulty slice positioning (\( n=7 \)). A valid study population of 927 subjects (489 men and 438 women) with a mean age of 52.3±13.3 years were included in MRCP analysis.
Interobserver reliability for detection of pancreatic duct variants was found to be kappa 0.752 (95 %CI, 0.733 – 0.771). The calculated kappa of pancreatic cysts was 0.738 (95 %CI, 0.713 – 0.753) between both observers. Pancreatic exocrine function was graded on the basis of duodenal filling, whereas the weighted-kappa value was found to be 0.813 (95 %CI, 0.812 – 0.850) between observers.

The frequency of normal pancreatic duct variants (Fig. 1: A, B, and C) was 90.4 % (n=838/927), consisting of 22.5 % (209 subjects) type A, 63.0 % (584 subjects) type B, and 4.9 % (45 subjects) type C. Variants of pancreas divisum (Fig. 1: D and E) were diagnosed in 9.6 % of cases (n=89/927), with 2.4 % (22 subjects) classified as type D, and 7.2 % (67 subjects) classified as type E.

Table 1 summarizes the results of the pancreatic duct variants, mean PFO, and the frequency of morphological signs of CP. Additionally, the results were categorized by gender and age groups to review age-related functional and morphological MRCP characteristics (Table 2).

The statistical analysis revealed no association between any of the pancreatic duct variants (A-E) with BMI (P_{BMI}=0.917) or gender (P_{gender}=0.577). Nevertheless, we found a significant association between age and the pancreatic duct variants (A-E) (P_{age}=0.005). A post hoc analysis revealed a significantly lower age of subjects with type B duct variant (51.1±13.6 years) compared to type A (54.9±12.7 years) (P=0.001), and also marginally lower age of subjects with type B variant compared to type E variant (54.3±12.4 years) (P=0.050).

Grading of pancreatic exocrine function according to duodenal filling revealed no statistical differences between the pancreatic duct variants (A-C) and variants of pancreas divisum (D-E) (P=0.210). A subgroup analysis of all five variants (A-E) revealed no significant differences in the duodenal filling (P=0.187). A quantitative assessment of pancreatic exocrine function in sMRCP demonstrated an average PFO of 9.5±4.1 ml/min for normal pancreatic duct variants (A-C) and 9.5±3.5 ml/min in variants of pancreas divisum (D-E), which was not statistically different (P_{PFO}=0.547). Additionally, a comparison of all pancreatic duct variants (A-E) revealed no statistical differences (P_{PFO}=0.369).

The frequency of pancreatic cysts (>2 mm) as a potential CP sign was 27.7 % (257/927 subjects). There was no statistically significant difference between normal duct variants (A-C) and variants of pancreas divisum (D-E) (P_{cysts}=0.741). In contrast, the Kruskal-Wallis test over all variants (A-E) revealed no significant difference in the frequency of pancreatic cysts (P_{cysts}=0.45), while a post hoc analysis demonstrated significant differences in the number of cysts for group A (33 %) versus group B (25 %) (P=0.019) and group B versus group C (40 %) (P=0.023) (Table 2).

Dilatation of pancreatic side branches as a CP feature was observed in 16.6 % of volunteers (n=154/927 subjects). Other pancreatic abnormalities such as focal dilatation, duct stenosis, and intraductal calculi were present in only 2.4 % (n=22/927) of all cases. No significant differences were found between normal pancreatic duct variants (A-C) and pancreas divisum (D-E) (P_{side_branch}=0.152; P_{abnormalities}=0.122) or between each pancreatic duct variant (A-E) (P_{side_branch}=0.103; P_{abnormalities}=0.427) (Table 2).

**Discussion**

We used sMRCP to determine the frequency of anatomical variants of the main pancreatic duct and the prevalence of pancreas divisum in volunteers participating in a large, population-based study. Further, the clinical relevance of these pancreatic duct variants including pancreas divisum was investigated by relating these variants to pancreatic exocrine function and signs of CP as assessed by sMRCP. Our study results demonstrate that neither normal pancreatic duct variants nor pancreas divisum variants were significantly associated with pancreatic exocrine function.

### Table 1 Pancreatic duct type frequencies with corresponding functional characteristics and the occurrence rate of morphological findings

<table>
<thead>
<tr>
<th>Pancreatic duct variants</th>
<th>Frequency of PD type</th>
<th>MRCP cohort</th>
<th>MRCP function</th>
<th>MRCP morphology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean age in years</td>
<td>Gender (men %: women %)</td>
<td>Mean BMI (kg/m²)</td>
</tr>
<tr>
<td>Pancreatic duct variants</td>
<td>A</td>
<td>22.5 %</td>
<td>54.9±12.7</td>
<td>56:44</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>63.0 %</td>
<td>51.1±13.6</td>
<td>53:47</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>4.9 %</td>
<td>54.0±13.1</td>
<td>51:49</td>
</tr>
<tr>
<td>Pancreas divisum</td>
<td>D</td>
<td>2.4 %</td>
<td>53.3±10.9</td>
<td>45:55</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>7.2 %</td>
<td>54.3±12.4</td>
<td>45:55</td>
</tr>
</tbody>
</table>

The table lists the frequencies of normal pancreatic duct (PD) variants (A-C) and pancreas divisum variants (D, E) in the MRCP cohort. The study population was defined by age, gender, body mass index (BMI). Further analyses revealed functional MRCP characteristics (pancreatic exocrine function by visual grading of duodenal filling on a 4-point scale and by pancreatic flow output [PFO] based on sMRCP) as well as the occurrence rates of morphological findings (e.g. pancreatic cysts, side branch dilatation, and main PD abnormalities) for each PD variant.
variants of pancreas divisum are of clinical relevance with regard to reduced pancreatic exocrine function or signs of CP.

Pancreas divisum is a common finding with a reported frequency of 3–13% in autopsy and ERCP studies [22–24]. In clinical imaging studies using MRCP, pancreas divisum was detected in approximately 9% of cases, typically as incidental findings [6]. Our study revealed a pancreas divisum in 9.6% of volunteers of a general population study, which is consistent with recent data [22]. The frequencies of normal pancreatic duct variants excluding pancreas divisum were unclear so far. In our study, type B, which is defined as a normal type, was found to be the most frequent variant. At this time, it is unclear if these normal pancreatic duct variants are genetically determined similar to the pancreas divisum or phenotypes acquired in the course of life.

In this study, 35.2% of all volunteers showed at least one sign of CP, e.g., pancreatic abnormalities (2.4%) or side branch dilatation (16.6%) as well as pancreatic cysts (27.7%). A situation which either reflects minimal change chronic pancreatitis [25, 26] or is of no clinical relevance but underlines the importance of studying a healthy population to establish the frequency of accidental findings. It is an accepted fact that morphological changes in chronic pancreatitis are out of proportion to the severity of clinical symptoms, but, in late onset chronic pancreatitis, for example, 50% of patients with pancreatic calcifications and loss of exocrine and endocrine function have never experienced episodes of abdominal pain [27, 28]. We cannot exclude that our cohort might harbour such cases of chronic pancreatitis.

To overcome the limitations to evaluate solely morphological changes, we assessed pancreatic exocrine function by measurement of pancreatic exocrine function using quantitative calculation of pancreatic flow output and semiquantitative assessment of duodenal filling over time after secretin stimulation (Matos criteria) as recommended in the literature [11, 13, 18]. Of interest, we did not detect a correlation between morphological signs of chronic pancreatitis and pancreatic exocrine function, underscoring the problem of classification systems, such as the Cambridge classification [26], which solely rely on morphology. With respect to our cohort, we have to phrase this argument with caution, as only long-term follow up will prove whether the probands now presenting with morphological signs suggestive for chronic pancreatitis will develop clinically overt chronic pancreatitis or whether the morphological findings just reflect the pancreas of an aging population.

Even if the clinical relevance of pancreas divisum is controversially discussed [29], recent studies suggest that most subjects with pancreas divisum are asymptomatic [8, 30]. On the other hand, ERCP studies demonstrated an increased frequency of pancreas divisum in patients with signs of a pancreatitis [16, 31, 32]. However, these ERCP studies are of limited value as they included only symptomatic patients.

### Table 2: Study cohort categorization in age groups with pancreatic exocrine function from sMRCP and the occurrence rate of morphological findings

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Subjects</th>
<th>MRCP function</th>
<th>MRCP morphology</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean PFO (ml/min)</td>
<td>Cysts</td>
<td>Side branches</td>
</tr>
<tr>
<td>All (men)</td>
<td>489</td>
<td>8.9±3.9</td>
<td>27.8%</td>
</tr>
<tr>
<td>20-29</td>
<td>27</td>
<td>10.8±4.1*</td>
<td>0.0%*</td>
</tr>
<tr>
<td>30-39</td>
<td>74</td>
<td>10.0±4.0*</td>
<td>15.6%*</td>
</tr>
<tr>
<td>40-49</td>
<td>105</td>
<td>9.1±4.0*</td>
<td>18.1%*</td>
</tr>
<tr>
<td>50-59</td>
<td>118</td>
<td>9.1±4.2*</td>
<td>30.5%*</td>
</tr>
<tr>
<td>60-69</td>
<td>120</td>
<td>7.8±3.0*</td>
<td>40.0%*</td>
</tr>
<tr>
<td>70-79</td>
<td>42</td>
<td>7.3±4.0*</td>
<td>47.6%*</td>
</tr>
<tr>
<td>80-89</td>
<td>3</td>
<td>7.3±1.8*</td>
<td>100.0%*</td>
</tr>
<tr>
<td>All (women)</td>
<td>438</td>
<td>10.2±3.9</td>
<td>27.6%</td>
</tr>
<tr>
<td>20-29</td>
<td>20</td>
<td>10.2±3.7*</td>
<td>0.0%*</td>
</tr>
<tr>
<td>30-39</td>
<td>70</td>
<td>11.3±4.4*</td>
<td>10.0%*</td>
</tr>
<tr>
<td>40-49</td>
<td>120</td>
<td>10.9±3.9*</td>
<td>19.2%*</td>
</tr>
<tr>
<td>50-59</td>
<td>109</td>
<td>10.1±3.7*</td>
<td>30.3%*</td>
</tr>
<tr>
<td>60-69</td>
<td>88</td>
<td>9.1±3.8*</td>
<td>48.9%*</td>
</tr>
<tr>
<td>70-79</td>
<td>29</td>
<td>8.5±3.4*</td>
<td>44.8%*</td>
</tr>
<tr>
<td>80-89</td>
<td>2</td>
<td>6.7±3.7*</td>
<td>100.0%*</td>
</tr>
</tbody>
</table>

The study population was categorized by gender and age groups to review functional and morphological MRCP characteristics. Pancreatic flow output (ml/min) (PFO) is presented as mean with standard deviation (±SD). Morphological features (e.g., cysts, side branch dilatation, and other abnormalities) were described as frequency of study cohort. According to the age groups, Kruskal-Wallis test revealed significant differences in frequency of pancreatic cysts and side branch dilatations in men and women. Abnormalities of the main PD were only significantly different in women *p<0.001; **p<0.187
In contrast, our study results revealed no association between pancreas divisum or subtypes of pancreas divisum and pancreatic exocrine function. Additionally, we also found no correlation between pancreatic duct variants and pancreatic exocrine function.

Furthermore, our study results showed no correlation between the frequency of pancreas divisum and duct alterations reflecting CP. We, therefore, conclude that the occurrence of pancreas divisum is not associated with a higher frequency of chronic pancreatitis. However, we found a significant association between pancreatic duct variants and the normal pancreatic duct variants excluding pancreas divisum. The frequency of cysts was significantly lower in pancreatic duct variant type B (normal type) compared to types A and C. Similar differences were found in relation to age between type B compared to type A and C. We assume that the occurrence of pancreatic cysts increases with age. In a comparison of the age between types A-C, we found a significant difference. In our study, subjects with type B were significantly older compared to type A/C ($P=0.001$). This might suggest that the different amounts of pancreatic cysts between anatomical variations of types A to C are symptoms of aging.

Although our study results demonstrate that normal pancreatic duct variants and variants of pancreas divisum are not associated with signs of CP or a restriction of pancreatic exocrine function, we cannot rule out that additional genetic factors such as mutations in the SPINK-1 gene or CFTR gene might infer susceptibility for chronic pancreatitis [33–38].

This study has limitations. The results were obtained in the setting of a population-based study, which included a cohort of subjects mostly without severe pancreatic diseases. However, it was the purpose of this project to assess the frequency of normal pancreatic duct variants and variants of pancreas divisum in the general population and to correlate duct variants and pancreas divisum with subclinical findings of CP. A second limitation of the study is the use of MRCP as standard of reference for the selection of subclinical subjects with CP as sequelae of acute recurrent pancreatitis. In the clinical setting, it is common to use the Cambridge classification, which defines five groups of CP (Cambridge 0 to 4). This classification was established on endoscopic retrograde pancreatography findings and adapted to other radiological imaging techniques such as contrast enhanced computed tomography and MRI. In our population-based study of volunteers, we could only use the non-invasive MRCP technique for assessment of CP. Therefore, it was impossible to detect reliably all criteria of the Cambridge classification, such as calcifications, mild pancreatic enlargement, and heterogeneous parenchymal structure. Being aware of these limitations and our study design, we focused on the appearance and frequency of the remaining items according to the Cambridge classification: pancreatic cysts, side branch dilatation, and other abnormalities (focal dilatation, duct stenosis, and intraductal concrement), but abstained from classifying the subjects according to the Cambridge classification.

In conclusion, the frequency of pancreas divisum in our analysis of volunteers participating in a population-based study is 9.6 % and comparable with recent data [22]. This fact underlines the feasibility of non-invasive sMRCP to evaluate pancreas divisum. Variants of pancreas divisum and normal pancreatic duct variants are not associated with subclinical findings of chronic pancreatitis including restrictions of pancreatic exocrine function.

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Approval from the institutional animal care committee was not required because animals were not part of the study. Some study subjects or cohorts have been previously reported in: the population-based Study of Health in Pomerania (SHIP), which is a project conducted in Northeast Germany. The objectives of this interdisciplinary study are to estimate the occurrence of diseases findings and further associations.

References