A New Embryological Theory of the Pancreatic Duct System

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Accessory pancreatic duct  ·  Endoscopic retrograde pancreatography  ·  Main pancreatic duct  ·  Pancreas divisum  ·  Pancreaticobiliary maljunction

Abstract
Background/Aims: To clarify the anatomy of the pancreatic duct system and to investigate its embryology. Methods: We reviewed pancreatograms of 256 patients with a normal pancreatic head and 36 cases of complete pancreas divisum. Results: Accessory pancreatograms were divided into two patterns. The long-type accessory pancreatic duct (APD) forms a straight line and joins the main pancreatic duct (MPD) at the neck portion of the pancreas. The short-type APD joins the MPD near its first inferior branch. The short-type APD is less likely to have a long inferior branch arising from the APD. The length of the APD from the orifice to the first long inferior branch was similar in the short- and long-type APD. The first long inferior branch from the long-type APD passes through the MPD near the origin of the inferior branch from the MPD. Immunohistochemically, in the short-type APD, the MPD between the junction of the short-type APD and the neck portion originated from the ventral pancreas. Conclusion: The long-type APD represents a continuation of the main duct of the dorsal pancreatic bud. The short-type APD is very likely formed by the proximal main duct of the dorsal pancreatic bud and its long inferior branch, with the main duct of the dorsal pancreatic bud at the point of connection with the main duct of the ventral pancreatic bud being obliterated and replaced by this additional communication.

Introduction
Embryological development of the human pancreas is complex, resulting in various congenital pancreaticobiliary malformations. The human pancreas develops embryologically from the dorsal and ventral pancreatic buds. Fusion of the pancreatic buds is accompanied by anastomosis of the ducts. It has been suggested that the distal portion of the dorsal pancreatic duct and the ventral pancreatic duct usually merge into the main pancreatic duct (MPD), and the proximal portion of the dorsal pancreatic duct becomes the accessory pancreatic duct (APD, Santorini’s duct), which opens into the minor duodenal papilla [1–5].

Embryology of the Pancreatic Duct System
In the 3- to 4-mm-long embryo, the pancreas arises from two diverticula, or buds, in the region of the primitive foregut that later becomes the duodenum. The larg-
Er dorsal bud develops dorsal and slightly proximal to the hepatic diverticulum, and contains a large dorsal duct opening into the pars descendens of the duodenum. A smaller ventral bud (the right and left lobes) arises from the base of the hepatic diverticulum. Each of the two lobes of the ventral bud contains a small duct, which opens at the ductus hepaticus communis. The left ventral bud and its duct usually undergo complete regression. As the duodenum rapidly grows and rotates, the right ventral bud together with the developing common bile duct rotates clockwise behind the duodenum and comes to lie adjacent to, below and somewhat posterior to the dorsal bud. Finally, the right ventral bud fuses with the dorsal bud to form the pancreas in the 7-week-old embryo. The dorsal bud gives rise to the anterior part of the head of the pancreas in addition to the body and tail, while the ventral pancreas develops into the posterior part of the head of the gland (fig. 1). Fusion of the pancreatic buds is accompanied by anastomosis of the ducts. The common bile duct and ventral duct of the pancreas open into the major duodenal papilla. The ventral duct communicates with the main duct of the dorsal bud, with the point of union lying between the isthmus and the head of the pancreas. The proximal part of the main dorsal duct partially regresses to form the APD (Santorini’s duct), which opens into the minor duodenal papilla [1–5].

**Materials and Methods**

We have prospectively studied the anatomy of the pancreatic duct system using endoscopic retrograde pancreatography [6–9]. To achieve optimal visualization, several pancreatograms of the head of the pancreas were taken with the patient in the prone or slightly oblique position. Pancreatograms of 256 cases of normal pancreatic heads with satisfactory imaging of the entire APD and 36 cases of complete pancreas divisum were examined, focusing on long inferior branches arising from the APD and MPD.

The number of long inferior branches arising from the APD that exceeded 20 mm in length and passed through the MPD to the caudal portion was determined. The length of the inferior branches, and the length of the APD from the orifice at the minor duodenal papilla to the origin of the first and second inferior branch, and the length of the MPD from the orifice at the major duodenal papilla to the origin of a long inferior branch were measured using a manual goniometer.
Pancreatograms of the head were taken in 8 pancreases obtained from routine autopsies of cases of pancreatic diseases. Each tissue section crossed the MPD, the APD, and the common bile duct in the same plane, and serial sections were immunostained with anti-pancreatic polypeptide (PP) antibody.

**Results**

Pancreatographic Analysis

APD pancreatograms were divided into two types: the long type (171 cases) and the short type (85 cases) according to the length of the MPD from the orifice to the junction with the APD (fig. 2) [2, 3, 7]. The long-type APD forms a straight line and joins the MPD at the neck portion of the pancreas. The short-type APD joins the MPD near the inferior branch and runs a descending course (long arrow: a long inferior branch from the APD; short arrow: short inferior branches).

Pancreatogram (a) and schematic illustration (b) of the long-type APD which joined the MPD in the neck portion and ran straight from the upper dorsal pancreatic duct (long arrow: the first long inferior branch from the APD). Pancreatogram (c) and schematic illustration (d) of the short-type APD which joined the MPD near the inferior branch and ran a descending course (long arrow: a long inferior branch from the APD; short arrow: short inferior branches).

A long inferior branch arising from the MPD was observed in 118 (69%) of 171 cases with the long-type APD, and the length of the MPD from the orifice to the long inferior branch was 17.4 ± 2.8 mm. A long inferior branch arising from the MPD was observed in 55 (65%) of 85 cases with the short-type APD, and the length of the MPD from the orifice to the long inferior branch was 17.8 ± 4.5 mm.)

The first long inferior branch from the long-type APD passed through the MPD near the origin of the inferior
branch from the MPD, and the short-type APD joined the MPD near its inferior branch.

**Immunohistochemical Studies of Autopsied Pancreases**

In 5 pancreases with the long-type APD, the APD and the MPD above the junction with the APD were always located in the dorsal pancreas with PP-poor islets, while the MPD from the orifice to the junction with the APD was located in the ventral pancreas with PP-rich islets. On the other hand, in 3 pancreases with the short-type APD, the portion of the MPD located in the ventral pancreas was not confined to the area located from the orifice to the junction with the APD, but the neck portion was still located in the ventral pancreas as indicated by the surrounding PP-rich islets.

**Discussion**

In this study, the anatomy of the pancreatic duct system of the head of the pancreas was clarified by focusing on long inferior branches arising from the APD and MPD to add new data to confirm the embryological theory.

The shape of the long-type APD was quite similar to that of the dorsal pancreatic duct of pancreas divisum. The long-type APD appears to represent an embryonic dorsal pancreatic duct, which is a persistent main duct of the dorsal pancreatic bud.

The short-type APD was less likely to possess a long inferior branch arising from the APD than the long-type APD. Although 18% of 171 cases had 2 long inferior branches arising from the long-type APD, the number of long inferior branches arising from the short-type APD was only one. Furthermore, the length of the short-type APD from the orifice to the long inferior branch was similar to the length of the long-type APD from the orifice to the first long inferior branch. On the other hand, the frequency of occurrence of a long inferior branch from the MPD and the length of the MPD from the orifice to the long inferior branch did not differ between the long- and short-type APD. The first long inferior branch from the long-type APD passed through the MPD near the origin of the inferior branch from the MPD, and the short-type APD joined the MPD near its inferior branch. These observations suggest that the short-type APD is formed by the most proximal part of the main duct of the dorsal pancreatic bud and its long inferior branch; the main duct of the dorsal pancreatic bud at the point of connection with the main duct of the ventral pancreatic bud is obliterated and replaced by this additional communication (fig. 3). The branch connecting with the duct of the ventral pancreatic bud is the first inferior branch arising from the duct of the dorsal pancreatic bud in most cases with the short-type APD, but it is the second inferior branch in cases with the short-type APD possessing a long inferior branch.

Immunohistochemical studies of autopsied pancreases implies that the MPD between the junction of the short-type APD and the neck portion originated from the ventral pancreatic duct, and the duct of the dorsal pancreatic bud connected the duct of the ventral pancreatic bud at two points.

In conclusion, there are two types of APD. The long-type APD was quite similar to the shape of the dorsal pancreatic duct of pancreas divisum, and seems to represent a continuation of the main duct of the dorsal pancreatic bud. The short-type APD was less likely to have a long inferior branch, and seems to be formed by the most proximal part of the main duct of the dorsal pancreatic bud and its long inferior branch.
References