AN ANATOMICAL AND RADIOLOGICAL INVESTIGATION ON THE PANCREATIC DUCT SYSTEM IN MAN.

by

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A thesis submitted to the Faculty of Graduate Studies and Research, in partial fulfilment of the requirements for the Degree of Master of Science.

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April, 1963.

ACKNOWLEDGEMENTS

The advantages of special facilities and the privilege of associating with such stimulating colleagues as in the Anatomy Department of the McGill University, are not fully recognised until one is thirteen thousand miles away. It was with this added feeling of appreciation that these acknowledgements were written.

I would like to thank the Chairman of the Anatomy Department, Professor C.P. Leblond, for giving me this opportunity to work in his Department. Also for the kind advice which he has given in the course of study in Montreal. For the direction and supervision of this thesis, I would like to heartily thank, Professor Jan Langman. I am sure that this work would not have been completed without Dr. Langman's cooperation and guidance.

For the assistance in collecting the literature on the History of the Pancreatic Duct, I would like to acknowledge Dr. M. Banfill and the Librarian from the Osler Library at McGill University. Furthermore, the help received from Dr. B. Kopriwa with the German translations of these works was invaluable, and to her I would like to express my deepest thanks. For the tedious task of having to repeatedly type numerous copies of the thesis in its early stages, I would like to thank Miss I. Bullen, of the Royal Perth Hospital, and Miss B. Jones of the Anatomy Department of McGill for typing the final copy. I would also like to express my appreciation to a number of my colleagues at McGill for their kind advice on this work; in particular, Ursula Herwig, Tony Graham and Mr. Policard, and their help in illustrating the thesis.

This study could not have been undertaken without the coopera-

tion of Dr. W. Mathews from the Department of Pathology Montreal General Hospital, who provided the material for these investigations, and Dr. Pierce of the Royal Victoria Hospital for his radiological assistance. To these men and their staff, I would like to offer a sincere acknowledgement for their cooperation

The financial assistance for this work was made available by the Rotary International by means of the Rotary Foundation Fellowship 1959/60., for Western Australia.

To the Rotarians, and in particular, Rotarians in the Fremantle Rotary Club, I am extremely thankful, and I shall always be indebted to these men for this opportunity to study overseas.

In conclusion, I would like to express my gratitude for the forebearance, patience and tolerance of my wife Gwen, who has assisted and encouraged me during the arduous preparation of this material.

TABLE OF CONTENTS

INTRODUCTION

PREFACE

The main purpose of this investigation was to determine whether a difference between the pancreatic duct system in male and female may explain the higher incidence of pancreatitis in the female and, on the contrary, the higher frequency of pancreatic tumours in the male. Paxten and Payne ('48); Morse and Achs ('49) and Edlund ('50) have statistically shown that pancreatitis is seen two to three times more often in the female than in the male, while carcinoma of the pancreas is twice as common in males as in females, (Willis, '48; Anderson, '51). Furthermore, this study will provide a precise account of the basic anatomy of the pancreatic duct pattern.

The pancreatic duct system of twenty foetuses, twenty infants and one hundred and forty four adults, was therefore examined by eosin injection, radiological and dissection techniques. Special attention was given to the presence of the accessory pancreatic duct (Santorini), patency of the minor papilla, and the relation of the common bile duct to the duct of Wirsung. The data collected were correlated with age and sex of the subjects from whom the specimens were obtained.

HISTORY

The original description of the pancreatic duct has been accredited to Wirsung, who outlined the duct system of the human pancreas in 1642. Though he was honoured for this discovery by having his name connected to it (ductus Wirsungianus), he had to pay for it with his life. Shortly after publication of his findings, Wirsung was assassinated, apparently as a result of a quarrel with

Hoffman as to priority in discovery of the duct. It is reported that Hoffman (1641), working on the rooster, was the first to find the main pancreatic duct. However, after having mentioned this to Wirsung, the latter immediately dissected a human pancreas and published the findings as his own.

Following the description of the pancreatic duct by Wirsung, Regner de Graaf (1671) observed that the pancreas had two or even three large collecting ducts. He concluded however, that a pancreas with more than one duct was abnormal. Further work by Bidloo (1685), showed that the ductus pancreaticus Wirsungianus and the ductus choledochus entered into the duodenum through a large common papilla.

A century later, Giovanni Domenico Santorini (1775), Professor of Anatomy and Medicine at Venice, described the pancreatic duct system in detail. He reported the presence of an additional pancreatic duct, draining the head of the pancreas and connecting the ductus pancreaticus Wirsungianus with the minor papilla. This second duct is now known as the Duct of Santorini, or the accessory pancreatic duct.

To verify Santorini's findings, Claude Bernard (1856) injected metallic mercury through the main pancreatic duct, and, indeed, was able to demonstrate the regular occurrence of the accessory duct. Further impetus to research on the pancreas was given by Langerhans (1867), who described clumps of epithelium-like cells, rich in protoplasm and located in the interalveolar tissue of the pancreas. Since Langerhans did not know the function of these cells, he considered them to be nerve endings.

The possible existence of a sphincter around the duodenal entrance of the bile duct was first suggested by Glisson as early as 1654. This structure, however, was not clearly demonstrated until Oddi (1887), identified it in histological sections of the major papilla as a smooth muscle surrounding the bile duct at its entry into the duodenum. Later, in 1898, Hendrickson gave a detailed description of this sphincter and, in addition, reported the presence of muscular fibres surrounding the extra hepatic ducts in man.

At the beginning of the century, the pancreas was considered to consist of two parts: an exocrine or externally secreting alveolar tissue, forming the bulk of the gland and producing approximately one litre of pancreatic juice per day, and an endocrine portion consisting of the islets of Langerhans. Although the islets, which Lane ('07) showed to consist of two types of cells, A & B, were known to be important for carbohydrate metabolism, their precise function was not known.

EMBRYOLOGY.

Phisalix (1888) and Zimmerman (1889) were the first to examine the formation of the pancreas in rabbits, guinea pigs, pigs, cats, dogs and birds. By studying 10μ horizontal histological sections of embryos and fully formed organs, and reconstructing models, fifty to one hundred times the original size, using wax plates, they found that the adult pancreas in these animals is formed by the fusion of two ventral pancreatic primordia and a dorsal primordium. It was, therefore, suggested that the human pancreas was probably formed in a similar manner.

Later embryologists, examining the pancreas from human foetuses varying in size from 3 to 45 mm. C-R length, showed considerable variation in their descriptions of development of the ventral pancreatic tissue. In man, the investigators agree that the dorsal pancreas is formed at the 2.5 - 3mm. stage by a proliferation of endodermal cells on the dorsal aspect of the intestinal tract, slightly cephalic to the hepatic diverticulum. A little later (3.5 - 4mm stage), the ventral pancreatic tissue grows out of the caudal aspect of the common bile duct (see Fig. 1).

According to Hamburger (1892), and Thyng ('07), who described eighteen models based on the studies of human embryos varying in size from 7.5 mm. up to 24mm., the ventral pancreas is a small solid mass of cells with no suggestion of independent lateral parts. Helly ('01), examining an 11mm. human embryo, found double ventral outgrowths but the left anlage was small, rudimentary and showed degenerative changes. However, Felix (1892), Jankelowitz (1895), Ingalls ('07) and Siwe (1927), studying specimens prior to the 8mm. stage, have all shown that there are two ventral anlagen with separate lumen. Histologically, the two parts are at first widely separated but, as the sections progress caudally, the separation is narrower and, in still more distal sections, there is fusion with a common lumen for the two ventral outgrowths entering the bile duct.

Odgers (1930) described a bilobed ventral pancreas in the 5mm. stage, but in larger embryos (7.1 mm.and 11.4 mm. C-R length) he found the ventral outgrowth to be a single solid anlage containing two ducts, which fuse to enter the hepatic diverticulum as a single structure. He concludes that the two ventral anlagen fuse at the

7mm. stage. This explanation would account for the varying descriptions by the previous investigators.

During the 4 - 7mm. C-R length period, the dorsal anlage grows rapidly upwards into the dorsal mesentery, whilst the ventral pancreas remains small. At the 7mm. stage, the ventral anlage of the pancreas, and the common bile duct, start to rotate around the duodenum in a clockwise direction, probably because of differential growth in the various parts of the duodenum. By the 12mm. stage, when rotation is completed and the ventral pancreas is located posterior to the dorsal pancreas, fusion of the two anlagen commences. The larger, dorsal outgrowth, forms the body, tail and anterior surface of the head, whilst the ventral outgrowth accounts for the uncinate process, preduodenal tubercle and the dorsal aspect of the head in the adult organ. Anastomosis of the duct systems usually occurs as well as the interlocking of the glandular tissue. Delmas ('40) demonstrated that the main pancreatic duct or Wirsung's duct formed, at the 17 mm. stage, by the fusion of the distal and middle portion of the dorsal pancreatic duct with the duct of the ventral pancreas. The adult configuration of the pancreatic ducts was shown as early as the 22 mm. stage of development.

ANATOMY

MACROSCOPIC

In the adult, the pancreas is located retroperitoneally at the level of the second and third lumbar vertebrae, and runs transversely across the posterior abdominal wall, from the second part of the duodenum on the right to the hilum of the spleen on the left. Due to its typical form, the gland is divided in four different parts.

That part in which fusion of ventral and dorsal pancreas is found, and which is located within the loop of the duodenum, is referred to as the head (caput pancreatis). A particular part of the head, which forms a small projection from the left posterio-inferior aspect, is known as the uncinate process. The body of the gland forming the bulk of the organ is connected with the head by a narrow bridge of tissue called the neck. The final part of the gland, located close to the hilum of the spleen and becoming much narrower, is referred to as the tail (cauda pancreatis).

The vascular supply to the pancreas is generally constant (Woodburne and Olsen, '51). Two arterial arcades are formed by branches of superior and inferior pancreatic duodenal vessels, which respectively originate from the gastro-duodenal and superior mesenteric arteries. The splenic artery provides arteria pancreatica magna and caudal pancreatic arteries to the left part of the body and tail of the pancreas. It is apparent on dissection, according to Kleitsch ('55), that the portion of the gland formed by the dorsal pancreatic outgrowth receives its blood supply from the coeliac axis, by way of the splenic and hepatogastroduodenal systems. The ventral component, on the other hand, receives its blood supply from the superior mesenteric artery, by way of the inferior pancreatico-duodenal artery. Significant collaterals develop between the two systems. The pancreas derives its innervation from the autonomic nervous system, by way of the coeliac plexus and the vagus nerves.

DUCTS

The pancreatic ducts, responsible for transport of the exocrine secretion products of the acinar cells toward the duodenum, begin

in the form of minute channels - intercalary ducts - which join to form the intra-lobular ducts. These ducts in turn join, to form the so-called intra-lobular ducts which drain into the main pancreatic channel. This main pancreatic duct, or duct of Wirsung, begins in the tail of the pancreas and runs a tortuous course through the body. In the head it curves dorsally, caudally and to the right, and terminates by opening on to the major papilla, or into the common bile duct to form the ampulla of Vater. Frequently, there is an additional system which receives the ducts of the anterior and lower portion of the head. This duct is known as the accessory duct, or the duct of Santorini. This additional drainage runs upwards, in front of the main pancreatic duct, to which it is connected by a communicating duct, and may enter the duodenum by way of the minor papilla.

Though the anatomy of the main pancreatic duct is generally accepted, this is not the case with the duct of Santorini. Helly (1898), Opie ('30), Baldwin ('11), Reinhoff & Pickrell ('45) and Kleitsch ('55), using dissection and latex injection methods, showed the accessory duct to be present in all the specimens they examined. Other authors, however, as Millbourn ('50), Cordier and Arsac ('52) and Birnstingl ('59) applying radiographic methods, were able to demonstrate an accessory duct in only 51% to 75% of their cases.

Not only in regard to the existence of the accessory duct of Santorini, but also in regard to the patency of the minor papilla, exists some confusion. Lockhart, Hamilton and Fyfe ('59); Gardner, Gray and O'Rahilly ('60); Woodburne ('57) and Hafferl ('53) report that the accessory duct drains into the duodenum at the minor papilla.

Braus ('34), on the contrary, states that usually it drains into the main pancreatic duct, and only rarely into the duodenum. None of these authors, however, makes any reference to a sex difference. When Hjorth ('47), in addition to examining the existence of the duct and patency of minor papilla, examined the sex of the specimens, he discovered that in the male the accessory duct of Santorini opened into the duodenum in twenty two of the fifty examined specimens, but in the female only in seven of the fifty cases. Millbourn, however, repeating Hjorth's experiments, was unable to confirm these findings, thus adding to the general controversy.

PATHOLOGY

Since the present study was undertaken to examine whether a difference between the pancreatic duct system in male and female could explain the higher frequency of pancreatitis in the female, and the higher incidence of pancreatic cysts and tumours in the male, the general pathology and aetiology of these diseases is discussed in the following paragraphs.

a. Acute Haemorrhagic Pancreatitis is an acute, diffuse, inflammatory disease of the pancreas, accompanied by focal areas of fat necrosis, oedema and haemorrhage in and about the gland and abdominal cavity. The underlying mechanism of the necrosis is the destructive lytic effect of pancreatic enzymes, either activated in situ, or released into the interstitial tissue of the pancreas by rupture of cells or ducts. The exact manner in which these enzymes escape and produce the disease is, however, still subject of much discussion. Six theories are suggested in regard to the pathogenesis

of pancreatitis:

I. Bacterial or viral infections. According to Joske ('55), it is generally accepted that virus diseases, such as mumps, hepatitis, infectious mononucleosis and infections with Coxsackie virus, as well as pathogenic bacteria giving rise to typhoid fever and scarlet fever, may cause pancreatitis. No sex difference was reported in the cases of pancreatic necrosis associated with acute infections. As an alternative, Dragstedt, Raymond and Ellis ('34) stated that bacteria present in the normal pancreas in 75 - 100% of all cases, if not the primary cause of pancreatitis, might produce the severe toxaemia observed in pancreatic necrosis.

II. Specific pancreatic poisons. Recent studies by Farber and Popper ('50) and De Almeida and Grossman ('52) demonstrate that specific pancreatic poisons such as ethionine may produce pancreatitis. Administration of ethionine, an inhibitor of methionine, produces a protein deficiency leading to pancreatic cell damage. This would also explain the occurrence of pancreatitis in metabolic diseases and dietary deficiencies. Myers and Keeffer ('34) and Doubilet and Mulholland ('48) suspected that alcohol may also act as a pancreatic poison. Dreiling, Richmond and Fradkin ('52) showed, however, that intravenous ethyl alcohol did not have any effect on the serum amylase level in normal patients, or in those with chronic pancreatitis.

III. Vascular lesions. Saint ('54) and Frobstein, Joshi and Blumenthol ('57), suggest that vascular lesions may be considered as an important cause in pancreatitis. Porphyria, malignant hypertension, myocardial infarction, dissecting aortic aneurysm and atheromatous embolization, may all interfere with the blood supply, giving rise

to pancreatic infarcts, subsequently leading to disruption of the duct system.

IV. Increased pressure in duct system. Wangenstein, Lever and Manson ('31) advanced the theory of raised intraductular pressure, and showed that ligation of the pancreatic duct following a fatty meal produced a high incidence of pancreatitis in experimental animals. The work of Luim, Portsmouth and Maddock ('48) indeed supports this explanation, as these workers were able to produce pancreatitis, by ligating the pancreatic duct and stimulating pancreatic secretion by injection of secretin, acetylcholine, pilocarpine and stimulation of the vagus. The most severe reaction was produced by ligation of the main pancreatic duct when the gland was at its height of secretion, that is, approximately two hours after a large meal. Pfeffer, Stephenson and Hinton ('53) added to this theory, by demonstrating that secretin given after a subcutaneous injection of morphine (causing sphincter spasm), resulted in a high serum amylase level (200 units) in six out of twelve patients examined. Morphine, or secretin alone, however, had no effect on the serum amylase level. Previously, Doubilet ('47) had demonstrated that morphine not only caused a spasm of the sphincter of Oddi, but also of the musculature of the duodenal wall. This spasm was shown to prevent a reflux of radiopaque iodized oil from the common bile duct into the main pancreatic duct, therefore the serum amylase elevation could not be due to a flow of biliary products into the pancreas. Surgery of the stomach as reported by Millbourn ('49) or an alcoholic spree both giving rise to oedema, hyperaemia and sphincteric spasm would in humans have a

similar effect as experimental duct ligation. At present this concept is considered the most plausible.

V. Common channel theory. In 1901 Opie described eight cases of acute pancreatitis accompanied by cholelithiasis. Based on these observations and a detailed study of pancreatic anatomy, he postulated ('03) that a common channel between the common bile duct and Wirsung's duct, as shown in 89% of his specimens, would permit a free flow of bile into the pancreatic duct system. This would subsequently lead to activation of the pancreatic enzyme, resulting in destruction of pancreatic tissue. Though this theory is still the most popular and has survived severe criticism over the last sixty years, a number of valid objections may be raised against it. Hjorth ('47), Millbourn ('44) and Liedberg ('41) have shown that reflux of contrast medium into the pancreatic duct occurs in operative cholangiography in 40% to 47% of patients without any ill effect on the pancreas, indicating that reflux of bile into the pancreatic duct system may be a physiological process. Furthermore, Dragstedt, Raymond and Ellis ('34) have demonstrated pancreatitis in a number of cases in which the main duct entered the duodenum through the minor papilla, while Warren and Catell ('58) have shown pancreatitis in aberrant pancreatic tissue.

Another discrepancy in this theory is the anatomical relation between the pancreatic and common bile duct. While numerous studies have been carried out on this aspect, the results are not consistent and some even contradict each other. Opie ('03), Baldwin ('11), Cameron and Noble ('24), Nuboer ('31), Hjorth ('47) and Millbourn ('50) state that reflux would be possible in the majority of cases

(76% to 86%), while others such as Job ('26), Judd ('31) and Stirling ('54) found a common channel of sufficient length to permit reflux in only 3% to 5% of their specimens. Howard and Jones ('47), who blocked the major papilla with a gall stone, reported that reflux of biliary products into the pancreatic duct system occurred only in 54% of their cases, and was dependent on the length of the common channel. It was suggested by Kienhoff and Rickrell ('45), that reflux could only occur in those cases in which the length of the common channel was greater than 2mm. Although the length of the common channel is known to vary from 1mm. to 14mm., comparative data on a series of female and male specimens to determine whether a morphological difference between the sexes occurs in this regard, have not been reported.

VI. Open accessory duct. Another anatomical factor suggested as an explanation for the higher incidence of pancreatitis in the female has been advanced by Hjorth ('47). This author found a significant difference between males and females in regard to the patency of the accessory duct, and suggested that an occlusion of the main pancreatic duct at the level of the major papilla in the majority of female cases would prevent the outflow of pancreatic secretory products. This stagnation would subsequently lead to inflammatory processes in the pancreas. Under similar conditions in the male, however, the accessory duct would act as a shunt between the main pancreatic duct and the duodenum, thus permitting drainage of the gland by way of the minor papilla.

(b) Tumours of the Pancreas.

Willis ('48) and Clifton ('56) report that the frequency of

carcinoma of the pancreas is twice as high in males as in females, while the ratio of neoplasms in the head to the body and tail of the gland is approximately 7 : 2.

Since the majority of pancreatic tumours originate from cylindrical duct cells, and a relatively greater number of such cells are present in the head than the body of the pancreas, Willis ('48) suggests that this may be the reason for the higher incidence of neoplasms in the head of the gland. Another possible reason for location of the carcinoma is the high incidence of duct metaplasia and cysts formed in the head of the gland.

(c) Cysts. A variety of pathological cystic structures differing in size, from minute cysts detectable only on histological section to large swellings up to 40 centimeters in diameter, may be found in the pancreas.

Pancreatic cysts may be classified in the following order:

(I) PSEUDOCYSTS

The aetiology of this type of cyst, usually found in solitary state and being large, is considered to be of post-inflammatory origin. Trauma to the pancreas, however, may also cause this type of cyst.

(II) RETENTION CYSTS

This lesion develops as a dilation of the ducts behind an obstruction. While Anderson ('51) reports that these cysts are most frequently found in the body and tail, Birnstingl ('59) demonstrated radiographically that these pancreatic cysts and sacculated dilations of the secondary and tertiary ducts are more common in the head of the gland.

In fibrocystic disease of the pancreas in infants, cysts are

formed in a similar manner to retention cysts. The ducts are obstructed throughout the pancreas by its abnormal secretion. According to Robbins ('57), this condition may occur with equal frequency in male or female.

(III) CYSTADENOMAS

These lesions are multilobular solitary cysts and are considered to originate as cystic neoplasms from the pancreatic ducts. The incidence of this type of cyst, however, is low.

(IV) CONGENITAL CYSTS

This type of cyst is usually found in multiple form and is closely associated with congenital cysts which occur in the liver and kidney.

Four of these cysts, demonstrated by Birnstingl ('59), showed squamous metaplasia of their epithelial lining, but whether this condition is precancerous is still doubtful. Willis ('48) reports that squamous metaplasia is rare in pancreatic carcinoma. Birnstingl ('59), examining the sex of the specimens with pancreatic cysts and finding a higher incidence of pancreatic carcinoma in males than females, does not mention whether these cysts were associated with a particular duct pattern.

Purpose of the Present Investigation

The present investigation was undertaken to clarify the confusion existing on the pancreatic duct system in regard to its development, precise morphological description and possible relation to pancreatic diseases such as pancreatitis and neoplasm, which show such a remarkable sex preference for the female and male respectively. To achieve this goal the following points were carefully investigated:

1. The precise anatomy of the pancreatic duct system, to determine whether a difference exists in the presence and patency of the accessory duct and minor papilla between male and female.
2. The precise relationship between the common bile duct and the main pancreatic duct, and the correlation of the length of the common channel with the sex of the specimen and the patency of the accessory duct.
3. A precise comparison between the pancreatic duct system found by means of dissection and by way of radiological examination.

MATERIALS AND METHODS

The pancreatic duct system of one hundred and forty four adult human specimens, twenty infants and twenty foetuses was carefully examined. The adult specimens, consisting of pancreas, duodenum and common bile duct, were obtained from autopsy cases varying in age from twenty nine to ninety five years. The pancreases of twenty infants, ranging in age from birth to four and a half years, were likewise obtained from autopsy cases. While the adult specimens were examined without fixation, the infant specimens were fixed in 5% formalin, while the twenty foetal cases, varying in C-R length from 130 to 300 mm., were fixed in 85% alcohol. Whenever a gland showed gross macroscopic changes caused by pathological processes, the specimen was discarded. Sex and age of the specimens were unknown until the end of the investigation.

The following methods were used for examination of the pancreatic system:

Injection Method.

In one hundred adult specimens and twenty infants, the main

pancreatic duct was first located in the body of the gland, and dissected towards the tail end of the pancreas. Subsequently, a needle varying in size from 16 - 27 gauge was inserted in the end of the duct and an eosin solution injected with a 10 cc. syringe in the direction of the head of the gland. The appearance of the dye in the duodenum was studied by observing the major and minor papilla under the dissecting microscope, and was considered to be an indication of the patency of the ducts. When the minor papilla did not show the outflow of eosin, the minor papilla and terminal portion of the accessory duct were excised after the gland was dissected, fixed in Bouin's solution, cut into 10μ sections, stained with haematoxylin-eosin, and finally examined microscopically to verify our previous findings.

Radiological Method.

The technique for injecting the pancreatic duct system with micropaque was originally described by Birnstingl ('59). By passing a blunt probe down the common bile duct, the major papilla was located and grasped with a toothed forceps. Subsequently, a small incision was made on the inferior aspect of the papilla, and the mucosa dissected back approximately one centimeter. Wirsung's duct could then be isolated with little difficulty and a cannula inserted and tied in position. With a 10cc. syringe, a microcrystalline suspension of barium sulphate (micropaque) was subsequently injected into the pancreatic duct. The duct in the body of the gland could be seen distending as the fluid coursed towards the tail. Usually two, or two and a half, cc. of solution were required to fill the entire duct system. In some specimens, however, only 0.5 cc. of

micropaque could be introduced into the duct system, while no distension of the duct in the body of the gland was noticed. When this occurred, it was assumed that anastomosis between the duct of the dorsal and ventral pancreatic buds had failed to occur. When this was found to be the case on the radiograph, micropaque was injected through the duct in the tail of the pancreas and a second exposure made.

The best results were obtained by using an ordinary medical type 508 XTRA-fast film, and exposure of 46 K.V. (at three quarters of a second), 100 Milli-amps and a small focus.

Dissection.

After application of the eosin injection method, the main pancreatic duct was located in the body of the gland and dissected in the direction of the major papilla. Special attention was thereby given to the relation between the pancreatic duct and the common bile duct. Subsequently, the large branches and the accessory duct of Santorini were carefully followed in order to confirm the observations obtained by the injection method. Precise drawings were made of each case. The adult cases were dissected under the magnifying glass (2x) while the duct system of the infants and foetuses was dissected under the binocular microscope (6x). The dissections were finally completed by opening the ducts, and measuring the diameter of the accessory duct at various places along its course, and the length of the common channel between the common bile duct and Wirsung's duct.

TERMINOLOGY

As the nomenclature of the pancreatic ducts is based on findings in the adults and does not refer to its development, the presently used terminology was found to be insufficient in a number of cases. Therefore, the following terminology was used:-

(I) DORSAL PANCREATIC DUCT, indicating the duct of the dorsal pancreatic bud in the embryo, entering the duodenum at the minor papilla.

(II) VENTRAL PANCREATIC DUCT, indicating the duct of the ventral pancreatic bud in the embryo, entering the duodenum at the major papilla.

These terms were also applied for those adult specimens in which the ducts had failed to fuse and which had retained their embryonic pattern.

(III) COMBINED PANCREATIC DUCT (main pancreatic duct - duct of Wirsung - ductus pancreaticus), indicating the duct formed by fusion of the distal, and middle portion, of the dorsal pancreatic duct and the ventral pancreatic duct. This duct enters the duodenum at the major papilla.

(IV) ACCESSORY PANCREATIC DUCT (accessory duct of Santorini), indicating the proximal part of the dorsal pancreatic duct, which forms a shunt between the combined pancreatic duct and the duodenum. It enters the intestinal tract at the minor papilla.

(V) SUPERIOR AND INFERIOR BRANCH of the dorsal and ventral pancreatic ducts, indicating the branches of dorsal and ventral pancreatic ducts coursing in superior or inferior directions.

RESULTS

Since the pancreatic duct system in the adult specimens showed considerable variation it was classified in the following four groups:-

GROUP I

EMBRYONIC TYPE (13 cases).

This group is characterised by the failure of the ventral and dorsal pancreatic ducts to fuse (fig. 2).

When eosin was injected into the tail end of the duct, it became visible in the duodenum at the minor papilla, but not at the major papilla. Subsequent injection of micropaque at the major papilla, revealed that the duct entering the duodenum at this papilla - under normal conditions forming part of the duct of Wirsung - had failed to fuse with the duct coursing from the tail towards the minor papilla.

As this duct pattern is similar to that found in the early embryo, it has been called "embryonic type". Figure 3 shows a datiograph of the ventral pancreatic duct with its two branches, a ramus superior coursing upwards in the direction of the tuber omentale and terminating in a network of small branches, and a ramus inferior running downwards and in its terminal part curving in the direction of the second part of the duodenum. This pattern was found consistently in the seven cases of the group examined radiologically. Figure 4 represents the duct system after additional injection of micropaque in the tail end of the gland. It shows clearly that the superior branch of the ventral pancreatic duct by-passes the dorsal pancreatic duct and suggests that under

normal conditions fusion between the two duct systems is established by the superior branch of the ventral pancreatic duct. In regard to the drainage of the lower part of the head, it can been seen in Figure 4 that this part is drained by two inferior branches. The anterior surface is drained by the inferior branch of the dorsal pancreatic duct, while the inferior branch of the ventral duct supplies the posterior surface. While the inferior branch of the ventral pancreatic duct can be clearly seen in Figure 3, the inferior branch of the dorsal system is represented in Figure 5.

The results obtained by injection and radiological techniques were substantiated by dissection of the specimens. All thirteen specimens showed clearly the presence of the superior and inferior branch of the ventral pancreas and a constant inferior branch of the dorsal pancreatic duct. The stem of the ventral duct had an average length of 2.7 cm. before dividing, and the inferior branch of the dorsal duct was found on the average to arise 2.0 cm. from the minor papilla.

GROUP II.

PATENT ACCESSORY DUCT (57 cases).

In this group, the accessory duct and the combined pancreatic duct are both present and patent (fig.6). The two ducts apparently have joined to form a functioning anastomosis.

Eosin injected into the tail end of the duct entered the duodenum at the major as well as the minor papilla. Similarly, when in twenty cases of this group micropaque was injected through the major papilla, it was found to enter the intestine by way of the minor papilla, thus indicating the presence of the combined pancreatic duct (Wirsung) and

the patency of the accessory pancreatic duct. Careful dissection of the specimens confirmed this observation for all cases. When during dissection the distance between the two papillae was measured, it was found to vary from 3.5 to 0.7 cm. The average distance between the two papillae was 2.2 cm.

In addition to the above described pattern it was noticed that in two cases an extra duct was present forming a loop in the lower part of the head of the pancreas, connecting the dorsal and ventral pancreatic ducts. This additional connecting loop was formed by fusion of the inferior branches of the ventral and dorsal pancreatic ducts. As this loop has not been described previously, it was called the "ansa pancreatica" (Fig.7).

GROUP III.

ACCESSORY PANCREATIC DUCT REPLACED BY "ANSA PANCREATICA" (24 cases)

The main characteristic of this particular group is obliteration of the accessory pancreatic duct at its place of connection with the combined pancreatic duct, and its replacement by the ansa pancreatica. As can be seen from Figure 7, this loop is formed by the most proximal part of the accessory duct, the inferior branch of the original dorsal pancreatic duct, and the inferior branch of the ventral pancreatic duct. This particular duct pattern was most readily seen by dissection, but it was also visible on the radiograph (Fig.8).

Though the ansa pancreatica morphologically seemed to replace the direct communication between the combined pancreatic duct and the duodenum, functionally it was not able to do so. When eosin was injected into the tail end of the duct, it appeared at the minor papilla in seven of the twenty four cases. In the remaining cases,

the minor papilla was clearly visible, but the entrance of the duct was obliterated, thus preventing outflow of pancreatic products into the duodenum.

GROUP IV.

ACCESSORY PANCREATIC DUCT PARTLY OR COMPLETELY OBLITERATED (50 cases)

When eosin was injected into the tail end of the duct, it became visible in the duodenum at the major papilla, but not at the minor papilla. Likewise when micropaque was injected through the major papilla it did not enter the duodenum at the minor papilla. Indeed, careful dissection of the duct system confirmed that some degree of obliteration of the accessory duct was present in all cases. In forty five of the fifty cases this obliteration was found to be restricted to the entrance of the duct into the duodenum (fig.9). When the diameter of the remaining part of the accessory duct was measured at various places along its course an average diameter of 1.4 mm was found at the entrance in the combined pancreatic duct, while in the direction of the duodenum it became narrow, finally obliterating in the intestinal wall. Only in one case was a complete obliteration of the accessory pancreatic duct observed. In the remaining four cases, the accessory duct had lost its contact with the combined pancreatic duct (fig.10).

Comparison of dissection and radiological methods

The dissection method showed the presence of the accessory duct, either complete or partially in one hundred and thirty specimens, while thirteen of the remaining cases were found to be of the embryonic type. Hence, the accessory duct or part of it was present in all except one specimen. The radiographic method, however, revealed

the presence of the accessory duct of Santorini in only forty six of the fifty cases studied by this method. Dissection of the four specimens in which the accessory duct could not be detected on the radiograph, showed that these glands belonged in Group III and Group IV. Furthermore, the dissection method showed the inferior branch of the dorsal pancreatic duct to be present in eighty six percent of the cases examined, while the inferior branch of the ventral pancreatic duct was found in all specimens dissected. By radiographic means, however, these two branches could be identified with certainty in eighty to ninety percent of the cases.

Though comparison of the two methods applied showed the dissection technique to be superior to the radiographic technique in regard to a precise description of the duct pattern, the latter method revealed some features overlooked during the dissection.

In eight of the twenty two cases in which the accessory duct was found obliterated (Table I) the injection of micropaque, showed the presence of multiple cysts at the duodenal termination of the accessory duct (Fig.11). When the sex of these eight cases was determined, six of them were found to be of male origin (see Table I A). Likewise eighteen cases showed cystic formations which appeared along the path of the small ducts and at the acinar termination (Fig. 12). The terminal duct dilations were usually solitary and had a smooth, regular configuration, whereas disrupted acinar with extravasations of micropaque, due to excessive pressure on injection or tissue lysis, had variegated, irregular outlines. In one case a hard concretion one centimetre in diameter was found in the accessory duct at the minor papilla.

Difficulty was encountered in dissection of the tertiary pancreatic ducts and no definite idea could be obtained of the minute ductular detail. Radiographs, however, demonstrated that tertiary ducts differ in appearance from gland to gland. Some of the radiographs showed a paucity of collecting ducts (fig.13), while in other specimens the ducts were well defined down to their smallest ramifications.

Eighteen (36%) of the specimens examined radiologically demonstrated a narrowing of the combined pancreatic duct in the neck of the gland. This isthmus was located in the region of the junction of the accessory and combined pancreatic duct (fig.13). The dissecting method revealed this constriction only in fourteen of the cases. No evidence of pathological lesions was found in this area.

One gland showed on X-ray, and later at dissection, considerable dilatation of the combined pancreatic duct and the inferior branch of the ventral pancreatic duct in the head. The combined duct in the body was not grossly distended and the accessory duct appeared slightly larger than normal. In this specimen, the minor papilla was freely patent (fig.14).

Pancreatic duct pattern and sex.

After the pancreatic duct system in all specimens was dissected and classified, the sex of the cases was determined. It was found that seventy seven were of male and sixty seven of female origin. When subsequently the sex distribution for each particular group was studied (see table II) it appeared that only in Group II (patent accessory duct) the number of female specimens was higher than that of the male cases. The probability value for this group was between

.05 and .02, thus making the difference in patency of the accessory duct between male and female statistically significant. This, however, does not automatically imply that the safety valve mechanism in the form of a patent accessory duct and open minor papilla, is more frequently present in the female than in the male. An open minor papilla was also found in a number of cases of Group III (ansa pancreatica), in which this ductular loop may function as a safety valve when the accessory duct is partly obliterated. In addition, it is thought justifiable also to include the specimens of Group I (Embryonic type), as in these cases occlusion of the major papilla will not affect the drainage of the tail and body of the gland. It was thus found that the minor papilla can act as a safety valve in fifty eight percent of the female and forty nine percent of the male cases. This difference, however, with a probability value between .90 and .80 is not statistically significant.

PATENCY OF ACCESSORY DUCT IN RELATION TO AGE AND SEX.

To examine whether the accessory duct in the female closes earlier in life than in the male, thus possibly providing an anatomical basis for the higher frequency of pancreatitis in the female, the age of the patients from which the specimens were obtained was recorded. Table III shows the age of the cases correlated with sex and patency of the accessory duct. It shows that open accessory ducts can be found at any age, and the results do not indicate that the accessory duct in the female obliterates earlier than in the male.

Table IV represents the patency of the accessory duct in twenty foetuses and twenty infants, varying in age from birth to

four and a half years. It shows that obliteration of the accessory duct and minor papilla rarely occurs during foetal life. After birth, however, the number of cases with an obliterated accessory duct appears to gradually increase. One of the infants showing an obliterated duct was three months old, while the other two cases were three and four years old.

RELATION OF COMMON BILE DUCT TO PANCREATIC DUCT.

To study the relation between the common bile duct and the duct of Wirsung, the examined specimens were classified into three types (Fig.15).

I) The common bile duct and pancreatic duct each have a separate outlet into the duodenum.

II) The two ducts have a common channel of 2 mm or less.

III) The length of the common channel is 3 mm. or more.

Table V shows the sex of the specimens and the relation between the common bile duct and Wirsung's duct. It indicates that no significant difference exists between male and female specimens in regard to possible reflux of biliary products into the pancreatic ducts.

In the study of the relationship of the ducts in the region of the ampulla of Vater, only ninety five of the one hundred and forty four cases were considered, for in forty nine of the fifty specimens injected with micropaque, the needle was inserted through a sphincterotomy, disrupting the normal arrangement of the main pancreatic duct and common bile duct. When the chance of reflux and the patency of the accessory duct were considered, a further nine cases were excluded, as these belonged to the "embryonic" type, in which the duct arrangement is such that reflux of biliary products into the body and tail of the gland is impossible. Furthermore, no accessory duct is present in this type.

Table VI shows the sex of the specimens, the possibility of reflux and the patency of the accessory duct. Reflux of biliary products was considered to be possible when the length of the common

TABLE I.

PATENCY OF ACCESSORY DUCT IN ADULTS

NUMBER OF CASES	PATENT	OBLITERATED
50	28 56%	22 44%

TABLE I A.

METHOD OF OBLITERATION OF MINOR PAPILLA

SEX	GRADUAL ATROPHY	CYSTIC.
Male	8	6
Female	7	2

TABLE II

C L A S S I F I C A T I O N

GROUP I	TOTAL	MALE	FEMALE
EMBRYONIC TYPE	13.	8.	5.
	9.0%	10.4%	7.46%
		P. Value .95 - .90	
GROUP II			
PATENT ACCESSORY DUCT	57.	25.	32.
	39.6%	32.4%	47.75%
		P. Value .05 - .02	
GROUP III		5 patent	2 patent
		6.49%	2.9%
ANSA PANCREATICA	24.	16.	8.
	16.66%	20.8%	11.9%
		11 not patent	6 not patent
		14.7%	9.0%
		P. Value .95 - .90	
GROUP IV			
OBLITERATED	50	28	22
ACCESSORY DUCT	34.7%	36.4%	32.8%
		P. Value .98 - .95	

TOTAL NUMBER OF PATENT MALES.....38.
49.29%

TOTAL NUMBER OF PATENT FEMALES.....39
58.11%

P. Value - .90 - .80

TABLE III

AGE, SEX AND PATENCY OF THE ACCESSORY DUCT

	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-95	TOTAL
MALE OPEN	-	1	4	5	12	13	3	-	38
MALE CLOSED	-	2	4	6	8	18	-	1	39
FEMALE OPEN	-	-	2	12	8	12	5	-	39
FEMALE CLOSED	1	-	1	3	8	9	6	-	28
	1	3	11	26	36	52	14	1	144

TABLE IV

FOETUSES AND INFANTS

PATENCY OF THE ACCESSORY DUCT

	NUMBER OF CASES	PATENT	OBLITERATED
FOETUSES	20	19 95%	1 5%
INFANTS	20	17 85%	3 15%

TABLE V.

RELATION OF COMMON BILE DUCT TO THE PANCREATIC DUCT

SEPARATE OPENINGS		COMMON CHANNEL 1 - 2 mm		COMMON CHANNEL 3 - 11 mm	
MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
11	11	13	13	26	21
22%	24.4%	26%	28.8%	52%	46.6%

TABLE VI.

COMMON CHANNEL AND PATENCY OF ACCESSORY DUCT

PATENCY	NO REFLUX POSSIBLE		REFLUX POSSIBLE	
	MALES	FEMALES	MALES	FEMALES
	20	19	26	21
	43.5%	47.5%	56.5%	52.5%
ACCESSORY DUCT.				
PATENT	6	11	12	12
	13%	27.5%	26%	30%
CLOSED	14	8	14	9
	30%	20%	30%	22.5%

channel was more than 2 mm. It shows that of the twenty six (56.5%) male and twenty one (47 percent) female cases in which reflux was possible, twelve (26%) male and twelve (30%) female specimens are accompanied by an open accessory duct able to act as a safety valve, while fourteen males (30%) and nine females (22.5%) have a closed accessory duct present.

Hence, no statistically significant difference exists between male and female cases which have a patent accessory duct and reflux possibility.

DISCUSSION

TERMINOLOGY.

Though Millbourn ('50) admits that the existing terminology offers some difficulty in describing the various duct patterns, he suggests retaining the conventional terms - duct of Wirsung and duct of Santorini - as a change in nomenclature would lead to confusion. Consequently, when describing a specimen of the embryonic type, he applies the term "small system of Wirsung" and " large system of Santorini" for the ventral and dorsal duct system respectively. Hollingshead ('56) refers to Wirsung's duct as the "chief pancreatic duct" and, when describing a case of the embryonic type, uses the term "large accessory duct" for the duct of the dorsal pancreas. Letulle and Nattan-Larrier (1898), reporting a similar case, state that the main pancreatic duct of Wirsung terminates at the minor papilla, whereas the accessory duct of Santorini enters the duodenum at the major papilla. Therefore, the terminology used by the

above mentioned authors in describing the embryonic duct arrangement is confusing and incorrect, and should be replaced by "dorsal and ventral pancreatic ducts", as used for the ducts in the embryo (Thyng, '07 and Naatanen, '42). Similarly, as the term "main pancreatic duct" has been applied as a synonym for the duct of Wirsung as well as to indicate the dorsal pancreatic duct in the embryo, it is suggested that this term be replaced by "combined pancreatic duct". This term clearly indicates that it is formed by a combination of the dorsal and ventral pancreatic duct and will prevent confusion with the dorsal pancreatic duct.

With regard to the secondary ducts, Cordier and Arsac ('52) refer to the branch draining the uncinate process and the head of the pancreas below the duct of Wirsung as "the inferior duct of the head of the pancreas". Figures 2 and 4 however, show clearly the presence of two such branches: a) the inferior branch of the dorsal pancreatic duct draining the anterior aspect of the head; b) the inferior branch of the ventral pancreatic duct draining the posterior surface of the head and the uncinate process.

While the inferior branch of the dorsal pancreatic duct was found in eighty six percent of the cases examined by dissection, the inferior branch of the ventral pancreatic duct was found consistently. Whenever the two inferior branches fused, thus establishing a new contact between the dorsal and ventral duct system, the term "ansa pancreatica" was applied.

Opie ('03) first described the inferior branch of the dorsal pancreatic bud, and this branch is shown in most anatomical text books. Rienhoff and Pickrell ('45), however, were unable to show

the presence of this duct in their series and critisised the former authors for showing the inferior branch of the dorsal pancreatic duct in their illustrations. From this study it is evident that a large secondary duct, the inferior branch of the dorsal duct (figs.) is present in the majority of adult human specimens and is readily demonstrated by dissection and radiography.

CLASSIFICATION

As the main purpose of this investigation was to study whether or not the duct entering the duodenum at the minor papilla can act as a safety valve in case of occlusion of the major papilla, special attention was given to the minor papilla and the accessory duct. The classification of the various types was made with this in mind. It can be seen in figures 2 and 3, representing Groups I and II, that obstruction of the duct system at the major papilla would cause stagnation mainly in the lower part of the head. The open minor papilla, however, would secure the continuous flow of secretory products from the tail, body, superior and antero-inferior lower part of the head, into the duodenum. Group III - ansa pancreatica - can be considered an intermediate group. Of the twenty four cases in this group, eight (thirty three percent) showed an open minor papilla, while in the remaining cases the secondary outlet was closed. In all cases of Group IV the accessory duct was partly or completely obliterated, thus preventing the outflow of pancreatic products into the duodenum in case of occlusion of the major papilla.

Previous classifications of the pancreatic duct pattern have mainly been made on a morphological basis, without giving attention

to the functional aspects. The first systematic arrangement of the pancreatic ducts was reported by Keyl ('25) who divided the system into five groups, commencing with the embryonic form and progressing to the case in which the accessory duct is absent. Cases with a partial or totally obliterated accessory duct were, depending on the degree of obliteration, divided into two separate groups. Though this is correct from a morphological aspect, from a functional standpoint it does not hold, since in both cases the accessory channel is unable to act as a safety valve when the major papilla becomes obstructed. The same applies to the classification proposed by Naatanen ('42) and Millbourn ('50). None of the above mentioned authors describe the ansa pancreatica Group III, which in our series was introduced as the intermediate form between a closed and open Santorini duct. Though it has been impossible for us to trace these cases in their illustrations, most probably this particular duct arrangement was found, but divided over the various groups. The only indication of the existence of the ansa pancreatica was found in the work of Cordier and Arsac ('52). These authors, in making a classification based on pancreatography, have given particular attention to fusion of secondary ducts. They mention a common channel between secondary ducts, comparable with the "ansa pancreatica", and consider this pattern in a special group. As our classification is based on the anatomical pattern of the ducts as well as on a functional aspect (the possibility of the minor papilla acting as a safety valve), it has been impossible to compare the results of this work with classifications provided by other authors.

ANATOMY OF THE PANCREATIC DUCTS.

Thirteen of the specimens examined showed a duct pattern in which apparently the dorsal and ventral pancreatic buds had failed to fuse. In figure 1 it can be seen that the ventral pancreatic duct consists of a main stem, entering the duodenum at the major papilla, and two branches, called the inferior and superior branch of the ventral pancreatic duct. As this pattern was found in all thirteen cases, it most likely reflects the duct system in the ventral pancreas of the embryo.

Indeed, Jankelowitz (1895), describing the ventral pancreatic bud in the embryo, states that it consists of two lobes of which the left is located slightly lower than the right. These two lobes were shown to fuse during the 7 to 10 mm stage (Delmas, '40). Odgers ('30), examining an 11.4 mm embryo in which the two ventral lobes had fused, showed the presence of two ducts, of which one coursed to the right in a slightly upwards direction, while the other coursed to the left in a downwards direction. It is, therefore, assumed that, after rotation of the ventral pancreas into its final position, the cranially coursing duct of the right lobe is represented by superior branch of the ventral duct, while the caudally coursing duct is comparable to the inferior branch. While in the embryonic type the superior branch of the ventral pancreatic duct by-passes the dorsal pancreatic duct, it suggests strongly that under normal conditions this branch fuses with the dorsal duct and participates in the formation of the combined pancreatic duct or duct of Wirsung. Indeed, in none of the specimens in which the combined pancreatic duct was formed, could any trace be found of the superior branch of

the ventral duct as a separate duct.

Theoretically, it seems possible that under certain conditions the right lobe of the ventral bud rotates normally, while the left lobe does not move. The annular pancreas seems to be the result of such a failure. Baldwin ('10), Millbourn ('50) and Anderson and Wapshaw ('51) describing the annular pancreas, report that the duct of Wirsung is normal, indicating that the superior branch of the ventral duct system has fused with the dorsal system. The duct draining the lobe located in front and on the right side of the duodenum, starts at the tip of this lobe, courses around the posterior aspect of the duodenum and enters into the duct of Wirsung or opens directly into the common bile duct shortly before it enters into the duodenum. From the results of this work it appears that this duct represents the inferior branch of the left lobe of the ventral bud, which has failed to rotate dorsally. Thus, under normal conditions, the superior branch of the ventral pancreatic duct fuses with the dorsal pancreatic duct, and participates in the formation of the combined duct, while the inferior branch representing the left lobe of the ventral bud, drains the posterior surface of the lower part of the head.

The inferior branch of the dorsal pancreatic duct found in 92% of our adult specimens seems to be formed by the joining of a number of small collecting ducts in the anterior part of the head of the pancreas. This channel drains upwards and terminates in the accessory duct, or - in the embryonic type - the duct of the dorsal pancreas. Originating from the dorsal pancreas, the position of this duct indicates that in at least 92% of the adult cases, the

anterior aspect of the head of the pancreas, that is, those parts in contact with the first, second and third part of the duodenum, is formed from the dorsal outgrowth. This corresponds with the findings of Delmas ('40) and Bossy ('59), who both suggest that the anterior portion of the head of the pancreas originates from the dorsal anlage, while the posterior surface of the head finds its origin in the ventral anlage. On the contrary, Baldwin ('10) and Russa and Vaida ('59) have shown that the dorsal pancreas did not completely cover the anterior aspect of the ventral pancreas. Since their findings were based on observations of subjects showing multiple congenital defects, including non-fusion of the pancreas, it is thought possible that in these cases the development of the dorsal pancreas was not completely normal.

It was suggested by Kleitsch ('55) that the adult pancreas be considered as a bilobed organ, each part being more or less a separate unit with an independent duct system and a separate arterial supply. In addition, he reported that both parts in the adult could be easily separated. Indeed Charpy (1898) and Opie ('03) have previously shown that this plane of cleavage exists in fixed or macerated specimens. While in our specimens representing the embryonic type (Group I), the dorsal and ventral anlage could be separated easily, thus confirming the observations of Bossy ('59) and Baldwin ('10), in none of the specimens of the other groups could this plane of cleavage be found. Not only was fusion of the parenchymal tissue intimate, but the inferior branch of the ventral pancreatic duct was able to pass from the posterior side towards the anterior surface, while the inferior branch of the

dorsal duct penetrated towards the posterior surface. The interlacing of the secondary ducts and parenchyma, as well as the close relationship of this region to the portal vein, would make a surgical separation of either one of the embryological anlagen extremely difficult.

Considering the ease with which two ducts in an embryo may fuse, it is not surprising to find a fusion between the inferior branches forming a new connecting loop, the ansa pancreatica. It is, however, surprising that the ansa pancreatica was found mainly in those cases in which the accessory pancreatic duct had partly obliterated, and lost its connection with the combined pancreatic duct. Only two cases were seen in which the ansa pancreatica and an open accessory duct were present simultaneously. This observation suggests that the ansa pancreatica has been formed in an attempt to compensate for loss of the direct shunt (duct of Santorini) between the combined duct and the duodenum. Though, morphologically this seems to be possible, functionally the ansa pancreatica has not been able to replace the accessory duct. Analysis of the minor papilla showed that in fourteen of the twenty one cases of this group, the papilla was non-patent and the flow of secretion products was in the direction of the combined duct. It may, however, be that, at an earlier age, the ansa pancreatica, while opening at the minor papilla, has been functioning as a replacement of the accessory duct.

As the ansa pancreatica forms a connection between the ventral and dorsal ducts, theoretically it should be able to replace the normal connection between the two systems, in case the superior

branch of the ventral duct bypasses the dorsal duct, thus failing to form the normal combined pancreatic duct, as seen in the "embryonic" type. Indeed, four specimens were found in which the ansa pancreatica formed the main connection between the two duct systems. In these cases the ansa showed a loop, with its convexity towards the duodenum. This ductular "ring" has been previously reported by Baldwin ('11), Reinhoff and Pickrell ('45) and Millbourn ('50), but no explanation for this abnormal duct pattern has been offered.

Comparison Between Results obtained by Dissection and Radiography.

The appearance of the combined pancreatic duct in a radiograph usually corresponded with the findings at dissection, except in regard to the "Stenosing Isthmus" - a narrowing of the combined pancreatic duct in the neck of the gland. This narrow part in the combined pancreatic duct was found in 56% of the specimens examined radiologically, and in 28% of the dissected cases. This difference seems rather high when compared with the results of Ledger ('52) who found it only occasionally and the findings of Birnstingl ('59) who showed that it was a normal finding in 3% of his cases. Though no reasonable explanation can be offered for this difference, the fact remains that a stenosis may occur in the combined pancreatic duct of a normal gland. The frequent visualising of the stenosing isthmus radiologically, in this series, suggests that great care should be given to this region when studying an operative pancreatogram, as a tumour or cystic lesion in the neck of the gland could possibly result in a similar narrowing of the

combined pancreatic duct.

After investigation had shown that the pancreas was developed from a dorsal and ventral outgrowth, it was surprising to find that the accessory duct was absent in one of the hundred and forty four cases examined by dissection. Although this corresponds with the results of Charpy (1898) who located the accessory duct in all except one specimen, Baldwin ('11), Heinhoff and Pickrell ('45) and Kleitsch ('55), who, likewise using dissection to examine their specimens, found an accessory duct in all the cases in which they sought it. On the other hand, it can indeed readily be accepted that the accessory duct was found in only 92% of the cases, when examined radiologically. The duct of Santorini may not be in direct contact with the combined pancreatic duct or, as Birnstingl ('59) reported, may be obstructed by inspissated mucinous material or calcified concretions, so that the flow of micropaque into the accessory system is prevented.

When comparing the inferior branches of the dorsal and ventral pancreatic ducts, they were found to be present in 86% and 100% respectively, of the specimens examined by dissection, and 80% and 90% of the cases studied radiologically. This difference, between the techniques, may be explained by several factors. In some specimens the inferior ducts although present, are extremely fine and difficult to identify on a radiograph. In a number of cases the duct systems appeared to be superimposed, that is, the accessory duct may be located over the combined pancreatic duct and the inferior branch of the dorsal duct over the inferior branch of the ventral pancreatic duct. This single image effect is partly due

to the close proximity of the ducts in the gland, and partly due to rotation of the superior aspect of the pancreas forward during positioning for radiography. The gland in situ may not show this over lapping of ducts, but on the other hand, this congruent apposition may occur with greater frequency in the body. All these variations contribute to the decreased number of relevant ducts seen on the radiograph.

The radiographs not only differ from the dissected specimens, but also individual films show marked variation. While the accessory duct in one case stood out clearly, in another case it was very small. Similarly, the ramifications would show in one specimen, while in others they would not be visible at all. These differences most likely depend on the resistance of the ducts, and the volume and pressure with which the micropaque was injected. Patency of the minor papilla and possible leakage of the radiopaque media, either from around the cannula inserted in the combined pancreatic duct or into the pancreatic tissue which was occasionally traumatised in removal from the body, are the main factors controlling the amount of micropaque distending the duct system.

The volume of micropaque required to fill the pancreatic duct system was usually 2cc., whereas 0.5cc. would distend the ventral pancreatic ducts in the "embryonic" form. Obviously, Mann and Giordano ('23) experimentally producing pancreatitis by injecting 10cc. of sterile bile into the pancreatic duct system, disrupted the ducts, thus allowing pancreatic enzymes and bile to penetrate into pancreatic tissue resulting in acute pancreatic necrosis.

Willis ('48) suggested that the frequency of the tumours, as

seen in the higher ratio of carcinoma occurring in the head of the pancreas than in the body or the tail, would be found to be nearly proportional to the relative amounts of pancreatic tissue in the different parts of the gland (fig. ?). Another explanation for the possible origin of the neoplasm is found in the presence of cystic structures. Although Anderson ('48) states that more cysts of the pancreas occur in the body and tail than the head, the results of this series as well as those of Birnstingl ('59) show clearly that more retention cysts are found in the head of the pancreas than in other parts. This latter author also observed, histologically, "adenomatoid hyperplasia" of the duct epithelium in the cysts at the ampulla of the accessory duct. Furthermore, in the present study, since six of the eight cases in which multiple small cysts were demonstrated at the termination of the accessory duct in the duodenum, were of male origin the possibility arises that there is a relation between the presence of pancreatic cysts, carcinoma of the head of the pancreas and the sex of the patient.

RELATION OF ANATOMY TO PATHOLOGY

Paxten and Payne ('48), Morse and Aschs ('49), Edlund ('50), Fallis ('51) and Bell ('58) found that the frequency of pancreatitis in the female is higher than in the male, the ratio varying from three to one or three to two. Searching for a possible explanation, Hjorth ('47) examined the pancreatic duct system in one hundred specimens and found the accessory duct of Santorini opening into the duodenum in 44 $\pm$ 7% of the male and in only 14 $\pm$ 4% of the female cases. Thus, an occlusion of the main pancreatic duct at

the level of the major papilla would in the majority of the female cases, completely block the outflow of pancreatic secretory products, favouring inflammatory processes, while in the male the accessory duct would act as a shunt and permit drainage of the gland by way of the minor papilla. It is clear from this work, however, that this observation could not be confirmed, as thirty nine (58%) of the female and thirty eight (49%) of the male cases showed a safety valve mechanism in the form of an open minor papilla and patent accessory duct. Thus, whatever the reason for occlusion may be there is no indication in our material that stagnation in the duct system leading to inflammatory processes will occur more frequently in female than in the male.

The number of cases of pancreatitis gradually increased over the first four decades and reached a maximum in the fifth to the seventh decades. When Bell ('58) studied the incidence of pancreatitis, he found that in 78% of his cases the disease occurred after the age of forty years. Though the higher incidence of pancreatitis in the older age groups might be explained by an increasing number of cases with a closed minor papilla, resulting in the loss of the "safety valve" shunt mechanism suggested by Hjorth ('47), the results of this work (Table III) demonstrate that in adults no change in the patency of the minor papilla occurs with increasing years in either sex. Examination of the twenty foetal cases showed that the minor papilla was patent in all except one. In the infants, likewise, the minor papilla was found to be patent in the majority of cases (85%) but obliteration is commencing; and by the age of forty years, the ratio of obliterated minor papilla

to patent ones is constant. This indicates that the increase in incidence of pancreatitis after the age of forty is not associated with an increase in the number of obliterated minor papilla.

Another possible cause of pancreatitis is the reflux of biliary products into the pancreatic duct system. Baldwin ('11), Cameron and Noble ('24), Nuboer ('31), Mehnan ('38), Naatanen ('42), Millbourn ('44), Hjorth ('47), Singh ('56) Judy and Thompson ('58) examined, therefore, the relation between the common bile duct and the duct of Wirsung. It was found that the number of specimens with a separate outlet for each duct varied from 38% to 8%. This is in agreement with the results of this work (see Table V). The number of cases in which the ducts entered the duodenum as a common channel, varied from 91% to 61%, while in our material this was found to be the case in 73% of the 95 specimens. As this classification does not give any information concerning the length of the common channel, it does not precisely indicate whether or not reflux of biliary products into the pancreatic duct system will occur.

The other workers who thought reflux possible in only 3 - 5% of their specimens have used a far stricter criteria. Sterling ('54) states that the reflux is possible only in those cases in which the common channel commences in the proximal third of the ampulla of Vater; Job ('26) suggests that the common channel has to be larger than 5mm. to make reflux possible. Howard and Jones ('47) found that reflux of bile is dependent on the length of the common channel and Reinhoff and Pickrell ('45) suggested that the reflux can only take place when the length of the common channel is more than 2mm. A calculus with a diameter of 4 mm. obstructing the

major papilla may well prevent reflux if the length of the common channel is only one to two mm. This material was, therefore, classified in those with: (a) separate openings, (b) a common channel of 2mm. or less, (c) a common channel of 3mm. or more. Considering those specimens in which reflux of biliary products is assumed to be possible (Table V), it appeared that 52% of the male and 46.6% of the female cases showed such an anatomical arrangement. This shows that when strict criteria applied to the present study there is no significant difference between the male and female cases. Even including these cases in which the length of the common channel was less than 2 mm., indicating that it is doubtful whether reflux would occur when these specimens are in situ, no sex difference was revealed. Thus, there is no indication that reflux of biliary products will occur more frequently in the female than in the male.

Though a common channel will facilitate reflux of biliary products into the pancreas, it will similarly allow pancreatic products to flow into the bile duct and gall bladder, when the pressure of the pancreatic ducts is higher than in the bile duct. Indeed, Westphal ('23), Wolfer ('31), Bisgard and Baker ('40) and Hjorth ('47) have demonstrated that pancreatic products may flow into the gall bladder and stimulate the formation of cholelithiasis. There was no significant difference found between the sexes, neither with regard to the length of the common channel between the bile and pancreatic ducts (Table V), nor to closure of the minor papilla, which may result in a higher pressure in the pancreatic duct system. Therefore, our material shows that this reflux of

pancreatic products should not occur more frequently in the female than in the male.

Another possible way of explaining the higher frequency of pancreatitis in the female would be the existence of a special relation between the patency of the accessory duct and the length of the common channel. If, in the male specimens, a common channel of more than 2mm. (reflux possible) is accompanied by a safety valve mechanism (open accessory duct and patent minor papilla), while in the female this safety mechanism would not exist, the female specimens might well show a higher incidence of inflammatory processes. It appeared, however, from this series (Table VI) that in twenty six (56.5%) of the male and twenty one (52.5%) of the female specimens in which reflux was possible, respectively twelve (26%) and twelve (30%) cases were accompanied by a safety mechanism. Statistical analysis showed that this difference is not significant.

Summarizing, it can be stated that no significant difference between the male and female duct patterns was found, neither in regard to an open accessory duct, nor to the relation of common bile duct and combined pancreatic duct, nor to the relation of an open accessory duct and a common channel in the ampulla of Vater.

BIBLIOGRAPHY

ALMEIDA. A.L. de and GROSSMAN.M.I. 1952. Experimental production of pancreatitis with ethionine. Gastroent. 20, 554 - 577.

ANDERSON.J.R. and WAPSHAW.H. 1951. Annular pancreas. Brit. J.Surg 39, 43 - 49.

ANDERSON.W.A.D. 1951. Pathology. C.V. Mosby Co. St. Louis 906.

BALDWIN.W.M. 1910. An adult human pancreas showing an embryological condition. Anat.Rec. 4, 21 - 22.

---------- 1910. A specimen of annular pancreas. Ibid. 4, 299 - 304.

---------- 1911. Pancreatic duct in man together with a study of the microscopic structure of the minor papilla of the duodenum. Ibid. 5, 197 - 228.

BELL E.T. 1958. Pancreatitis. Surgery. 43, 527 - 537.

BERNARD. C. 1856. As quoted by Boyden E.A. 1936.

BIDLOO.G. 1685. As quoted by Rienhoff W.F. & Pickrell K.L. 1945.

BIRNSTINGL.M. 1959. A study of pancreatography. Brit.J. Surg. 47, 128 - 139.

BISGARD.J.D. and BAKER C. 1940. Studies relating to the pathogenesis of cholecystitis, cholelithiasis and acute pancreatitis. Ann.Surg. 112, 1006 - 1034.

BOSSY.J. 1959. A Propos de la persistance des deux ebauches. Pancreatiques chez l'adulte. Arch anat. 42, 121 - 126.

BRAUS.H. 1934. Anatomic des Menschen. Julius Springer, Berlin, 2nd edition. Bd.II. 308.

CAMERON.A.L. and NOBLE.J.F. Reflux of bile up the duct of Wirsung caused by an impacted biliary calculus. An anatomical study concerning its possibility. J.A.M.A. 82, 1410 - 1414.

CHARPY.A. 1898. Variétes et anomalies des canaux pancréatiques. J.de L'Anat.et Phys.34, 720 - 734.

CLIFTON.E.E. 1956. Carcinoma of the pancreas. Am. J.M.21, 760 - 780.

CORDIER.G. and ARSAC M. 1952. Le canal de Wirsung. Chir. 68, 505 - 517.

DELMAS.A. 1940. Les ébauches pancréatiques dorsales et ventrales, leurs rapports dans la constitution du pancréas definitif. Ann d'Anat. Path. 16, 253 - 266.

DOUBILET.H. 1947. Pancreatic reflux deliberately produced. Surg. Gynae., & Obst. 84, 710 - 715.

DOUBILET. H. and MULHOLLAND J.H.1948. Recurrent acute pancreatitis; Observations on etiology and surgical treatment. Ann.Surg. 128, 609 - 638.

DRAGSTEDT. R.L., RAYMOND H.E. and ELLIS.J.C. 1934. Pathogenesis of acute pancreatitis. Arch.Surg. 28, 232 - 291.

DREILING. D.A., RICHMOND.A. and FRADKIN.N.F. 1952. The role of alcohol in the etiology of pancreatitis; Gastroent. 20, 636 - 646.

EDLUND.Y. 1950. Acute necrosis of the pancreas. Acta Chir.

Scandinav. 99, 497 - 517.

FALLIS.L.S. 1951. Acute pancreatitis. J. Internat. Coll. Surgeons. 16, 337 - 341.

FARBER.E. and POPPER H. 1950 - Production of acute pancreatitis with ethionine and its prevention with methionine. Proc.Soc. Exp.Biol. 74, 838 - 840.

FELIX.W. 1892. Zur Leber Und pankreasentwickelung. Arch. f. Anat. u. phys. - Anat.Abteilung. 282 - 322.

FIELD.E.J. and HARRISON.R.J. 1947. Anatomical terms - their origin and derivation. W. Heffer & Sons, Cambridge. 161.

GARDNER.E. and GRAY.D.J. and O'RAHILLY.R. 1960. Anatomy.W.B. Saunders & Co. Philadelphia, 1st.edition. 508.

GLISSON. 1654. As quoted by BOYDEN E.A. 1936.

GRAAF. Regner de. 1671. As quoted by Rienhoff W.F. and Pickrell K.L. 1945.

HAFFERL.A. 1953. Lehrbuch der Topographischen Anatomie. Springer, Berlin. 1st. edition. 454.

HAMBURGER.O. 1892. Zur Entwickelung der Bauchspeichel drüse des Menschen. Anat. Anz.Centrablatt. 7, 707 - 711.

HELLY.K.K. 1898. Beitrage zur Anatomie des Pankreas und seiner Ausfubrungsgänge. Arch.f. Mikr.Anat.u. Ent. 52, 773 - 793.

---------- 1901. Zur Pankreasentwickelung der Sangethiere. Ibid 57, 271 - 335.

HENDRICKSON.W.F. 1898. Musculature of extra-hepatic biliary system, including duodenal portion of common bile duct

and of sphincter. Bull. Johns Hopkin's Hosp. 9, 221 - 232.

HJORTH.E. 1947. Contributions to the knowledge of pancreatic reflux as an etiological factor in chronic affections of the gall bladder. Acta. Chir.Scandinav. 96, Supp. 134, 7 - 76.

HOFFMAN 1641. - As quoted by Baldwin W.M. 1911.

HOLLINGSHEAD.W.H. 1956. Anatomy for surgeons. Hoeber - Harper, New York. Vol. 2.430.

HOWARD.J. and JONES.R.1947. Anatomy of the pancreatic duct - acute pancreatitis. Am.J.M.Sc. 214, 617 - 623.

INGALLS.N.W. 1907. Beschreibung eines Menschlichen Embryos von 4.9 mm. Arch.f.Mikr.Anat.u.Ent. 70, 506 - 576.

JANKELOWITZ.A. 1895. Ein junger menschlichen Embryo und die Entwicklung des pankreas bei demselben. Arch.f. Mikr. Anat.u. Ent., 46, 702 - 707.

JOB.T.T. 1926. Anatomy of the duodenal portion of bile and pancreatic ducts. Anat.Rec.32, 212 - 213.

JOSKE.R.A. 1955. Pancreatitis. B.M.J. 2, 1477 - 1481.

JUDD.E.S. 1931. Relation of liver and pancreas to infection of the gall bladder. J.A.M. Ass.77, 197 - 200.

JUDY.M.E. and THOMPSON.W.H. 1958. Anatomical studies of the main pancreatic duct. J. Indiana State Med.Ass. 51, 310 - 313.

KEYL.R. 1925. Uber die Beziehungen des Santorinischen Ganges zum Zwolffinger darm und zum Wirsungschen

Gang.Morph.Jahr. 345 - 381.

KLEITSCH.W.P. 1955. Anatomy of the pancreas. A.M.A. Arch. Surg. 71, 795 - 802.

LANGERHANS.P. 1867. As quoted by Rienhoff W.F. and Pickrell K.L. 1945.

LANE.M.A. 1907. The cytological characters of areas of Langerhans. Am.J.Anat. 7, 409 - 422.

LEDGER.L. 1952. Radiological and surgical exploration of the pancreas and transpapillary drainage. J.Chir. 68, 518 - 536.

LETULLE.J. and NATTAN-LARRIER L. 1898. Region Vaterienne du duodénum et ampoule de vater. Bull. Soc.Anat.de Paris 73, 491 - 494.

LIEDBERG,N. 1941. Erfahungen mit srimarer Cholangiographie, unter besonderer Berucksichtigurg etwaiger Schädigungen des Pancreas. Acta.Chir.Scandinav. 85, 261 - 280.

LUIM.R.,PORTSMOUTH.N.H. and MADDOCK.S. 1948. Aetiology of acute pancreatitis. An experimental study. Surg. 24, 593 - 604.

LOCKHART.R.D., HAMILTON.G.F. and FYFE.F.W. 1959. Anatomy of the human body. Faber and Faber.1st. edition 534.

MANN.F.C. and GIORGANO A.S. 1923. Bile factor in pancreatitis. Arch. Surg. 6, 1 - 30.

MEHNEN.H. 1938. Die Bedeutung der Mundungsverhaltnisse von Gallen und Pankreasgang für die Entstehung der Gallensteine. Arch.f.Klin.Chir. 192, 559 - 570.

MILLBOURN.E. 1944. Gall pankreasgangarnas anatomi och dess betydelse for uppkomst av pankreas symptom vid choleduchussten och duodenal-resektion. Nord.med. 23, 1293 - 1296.

---------- 1950. On the excretory ducts of the pancreas in man. Acta Anat. 9, 1 - 34.

MORSE.L.J. and ACHS S. 1949. Acute pancreatitis, a clinical evaluation and review of 154 Cases. Ann Surg. 130, 1044 - 1058.

MYERS.W.K. and KEEFFER.C.S. 1934. Acute pancreatic necrosis in acute and chronic alcoholism. New Eng. J. Med. 210, 1376 - 1380.

NÄÄTÄNEN.E. 1942. Uber die gegenseitigen Beziehungen Zwischen den pankreasgängen und den Gallengängen. (Zeit f. Anat. u. Ent.) III, 348 - 354.

---------- 1942. Uber die Pankreasgänge mit besonderer Berucksichtigung des Vorkommens eines Ductus Santorini, Ibid. III, 355 - 364.

NUBOER, J.F. 1931. Studien uber das extrahepatische Gallenwegssystem. Frank Zschr.f. Path. 41, 198 - 249.

ODDI.I.R. 1887. D'une disposition und sphincter spéciale de l'ouverture du canal choledoque. Arch.Ital.de Biologie. Tome 8, 317 - 322.

OPIE.E.L. 1901. The relation of cholelithiasis to disease of the pancreas and to fat necrosis.

A.J.M. Sci. 121, 27 - 43.

---------- 1903. The anatomy of the pancreas. Bull. Johns Hopkins Hosp. 14, 229 - 232.

ODGERS.P.N.B. 1930. Observations in the development of the ventral pancreas in man. J.Anat. 65, 1 - 7.

PAXTON.J.R. and PAYNE.J.H. 1948. Acute pancreatitis. A statistical study of 307 established cases of acute pancreatitis. Surg.Gynec. & Obst. 86, 67 - 75.

PFEFFER.R.B., STEPHENSON.H.E. and HINTON. J.W. 1953. The effect of morphine, demerol and codeine on serum amylase values in man. Gastroent. 23, 482 - 486.

PHISALIX 1888. As quoted by Thyng F.W.1908.

PROBSTEIN.S.G., JOSHI.R.A. and BLUMENTHOL.H.T. 1957. Atheromatous embolization - acute pancreatitis, etiology. A.M.A. Arch. Surg. 75, 566 - 572.

RIENHOFF.W.F. and PICKRELL.K.L. 1945. Pancreatitis. Arch. Surg. 51, 205 - 219.

ROBBINS.S.T. 1957. Textbook of Pathology. W.B. Saunders Co., Philadelphia and London, 866 - 888.

RUSSA.I.G. and VAIDA A. 1959. Neue Befunde Zur Entwicklung der Bauchspeicheldruse. Acta Anat. 38, 114 - 125.

SAINT.E.G. 1954. Acute pancreatitis. M.J. Aust. 2, 536 - 543.

SANTORINI.G.D. 1775. As quoted by Rienhoff W.F. and Pickrell

K.L. 1945.

SINGH.I. 1956. Observations of the mode of termination of the bile and pancreatic ducts; Anatomical factors in pancreatitis. J.Anat.Soc.India, 5, 54 - 60.

SIWE.S.A. 1927. Pankreasstudien. Morph.Jahrb. 57, 84 - 307.

STERLING.J.A. 1954. The common channel for bile and pancreatic ducts. Surg. Gynec. & Obst. 98, 420 - 424.

THYNG.F.W. 1907. Models of the pancreas. Am. J. Anat. 7, 489 - 503.

WANGENSTEIN.O.H., LEVER N.L. and LANSON M.H. 1931. Acute pancreatitis Arch. Surg. 23, 47 - 73.

WARREN.K.W. and CATTELL R.B. 1959. Pancreatic Surgery. New Eng. J.M. 261, 280 - 288.

WESTPHAL.K. 1923. Muskelfunktion Nerven system u. Pathologie der Gallenwege I, II, III, Ztschr.Klin Med.96, 22 - 150.

WILLIS.R.A. 1948. Pathology of Tumours. Butterworth & Co., Bell Yard, Temple Bar. 443 - 451.

WIRSUNG.J.G. 1642. As quoted by Field E.J. & Harrison R.J. 1947.

WOLFER.J.A. 1931. Role of pancreatic juice in the production of gall bladder disease. Surg. Gynec. & Obst. 53, 433 - 445.

WOODBURNE.R. and OLSEN L.L. 1951. The arteries of the pancreas.

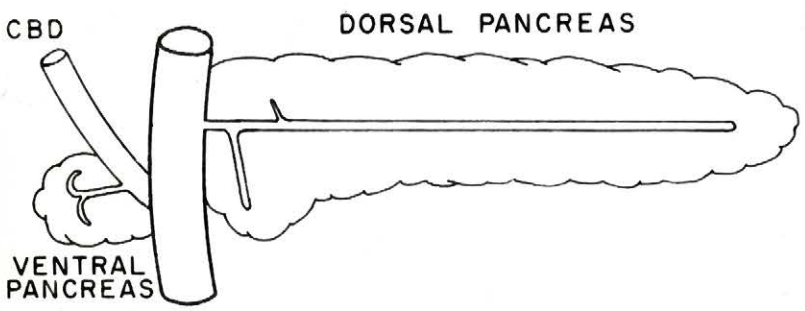
Anat. rec. III, 255 - 270.

WOODBURNE R.I. 1957. Essentials of human anatomy. Oxford University Press. New York. 1st edition. 406.

ZIMMERMAN.J. 1889. Rekonstructionen eines Menschlichen Embryos von 7 m.m. Anat.Anz. 4, 139 - 144.

FIGURE I.

DIAGRAM OF THE HUMAN PANCREAS BEFORE ROTATION (6 mm. STAGE.) THE DORSAL PANCREAS IS SEEN ARISING FROM THE DUODENUM, AND THE VENTRAL OUTGROWTH FROM THE COMMON BILE DUCT.



BEFORE ROTATION

FIGURE 2.

THE PANCREATIC DUCT SYSTEM IN DIAGRAMATIC FORM. THE DORSAL AND VENTRAL PANCREATIC DUCTS ARE DEMONSTRATED WITH THEIR MAIN BRANCHES.

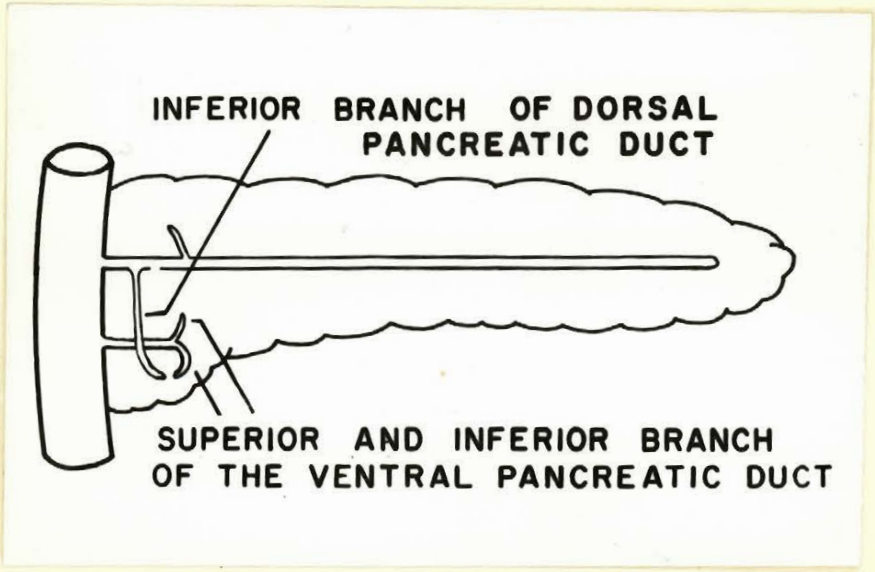

INFERIOR BRANCH OF DORSAL
PANCREATIC DUCT
SUPERIOR AND INFERIOR BRANCH
OF THE VENTRAL PANCREATIC DUCT

FIGURE 3.

RADIOGRAPH OF THE VENTRAL PANCREATIC DUCT SYSTEM. THE MAIN STEM IS SEEN ENTERING THE DUODENUM AT THE MAJOR PAPILLA, THE SUPERIOR BRANCH OF THE VENTRAL DUCT COURSING UPWARDS AND THE INFERIOR BRANCH RUNNING DOWNWARDS. (HALF NORMAL SIZE).

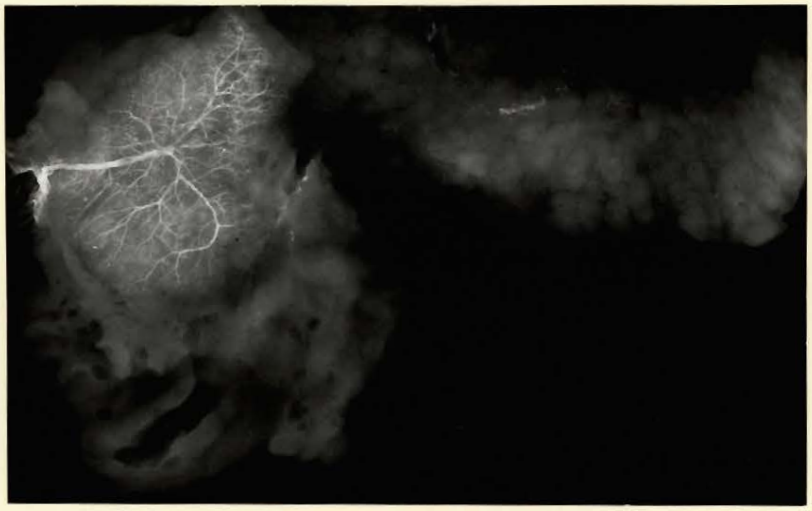


FIGURE 4.

RADIOGRAPH OF VENTRAL AND DORSAL DUCT SYSTEMS IN THE ADULT HUMAN'S PANCREAS. THE SUPERIOR BRANCH OF THE VENTRAL DUCT IS SHOWN BY PASSING THE DORSAL PANCREATIC DUCT, THE INFERIOR BRANCH OF THE DORSAL DUCT DRAINING THE ANTERIOR ASPECT OF THE LOWER PART OF THE HEAD AND THE INFERIOR BRANCH OF THE VENTRAL DUCT SYSTEM IS VISIBLE DRAINING THE POSTERIOR ASPECT OF THE HEAD. (HALF NORMAL SIZE).

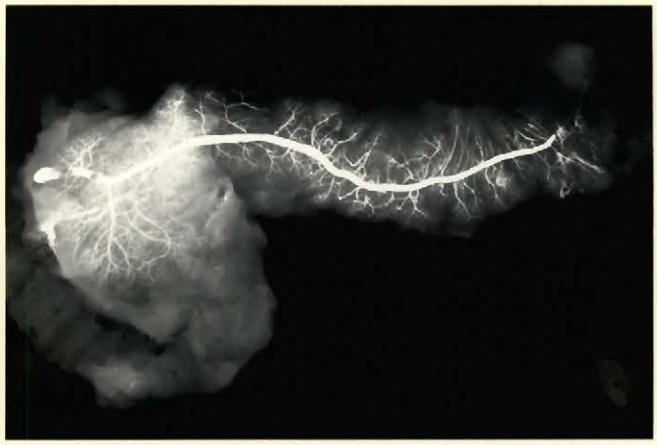


FIGURE 5.

RADIOGRAPH OF THE DORSAL PANCREATIC DUCT SYSTEM IN THE ADULT HUMAN. THE DORSAL DUCT IS DEMONSTRATED DRAINING THE TAIL, BODY AND HEAD OF THE GLAND, AND IS JOINED BY ITS INFERIOR BRANCH BEFORE TERMINATING IN THE DUODENUM AT THE MINOR PAPILLA. (HALF NORMAL SIZE).

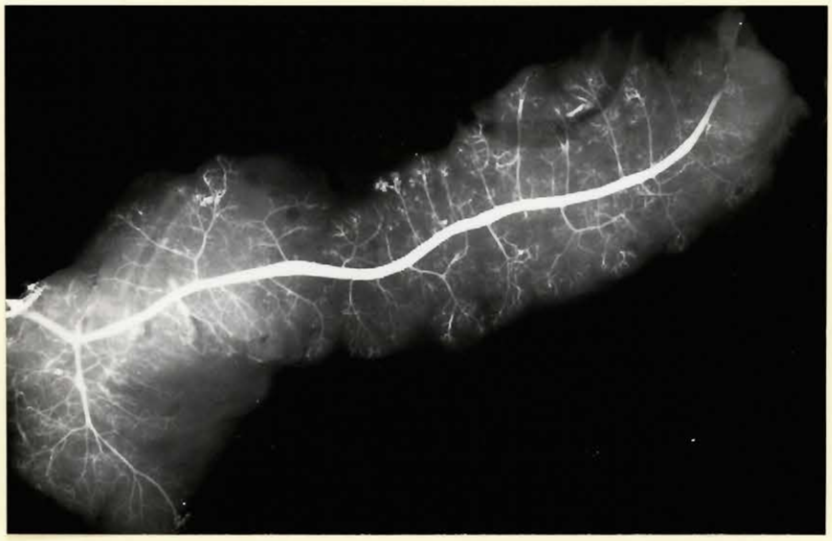


FIGURE 6.

PANCREATIC DUCT SYSTEM IN WHICH DORSAL AND VENTRAL PANCREATIC DUCTS HAVE FUSED TO FORM THE COMBINED PANCREATIC DUCT (WIRSUNG) AND THE ACCESSORY PANCREATIC DUCT (SANTORINI) ENTERING THE DUODENUM AT THE MINOR PAPILLA.

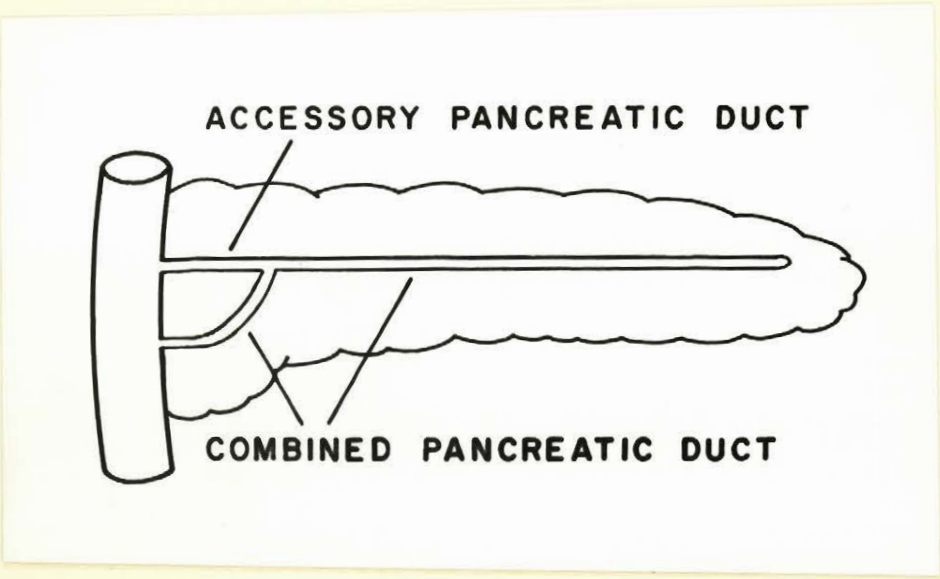

ACCESSORY PANCREATIC DUCT
COMBINED PANCREATIC DUCT

FIGURE 7.

LINE DIAGRAM OF THE PANCREATIC DUCT SYSTEM. THE "ANSA PANCREATICA" IS SHOWN FORMED BY THE PROXIMAL PART OF THE ACCESSORY DUCT, THE INFERIOR BRANCH OF THE DORSAL DUCT AND THE INFERIOR BRANCH OF THE VENTRAL DUCT.

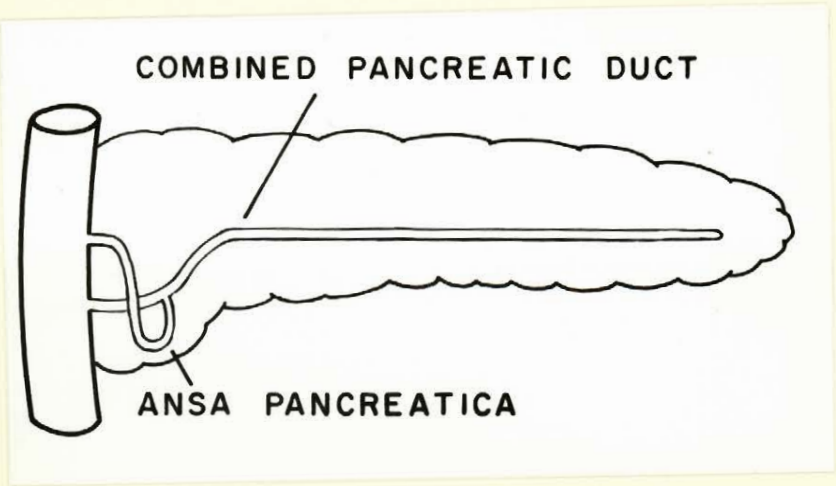

COMBINED PANCREATIC DUCT
ANSA PANCREATICA

FIGURE 8

THE DUCT SYSTEM OF THE PANCREAS SHOWN RADIOLOGICALLY AFTER INJECTION OF TWO CUBIC CENTIMETRES OF MICROPAQUE. THIS FILM SHOWS THE ANSA PANCREATICA ARISING FROM THE INFERIOR ASPECT OF THE COMBINED PANCREATIC DUCT IN THE HEAD AND TERMINATING AT A PATENT MINOR PAPILLA. (HALF NORMAL SIZE).

FIGURE 9.

PANCREATIC DUCT SYSTEM SHOWING OBLITERATION OF THE ACCESSORY DUCT AT ITS ENTRANCE INTO THE DUODENUM.

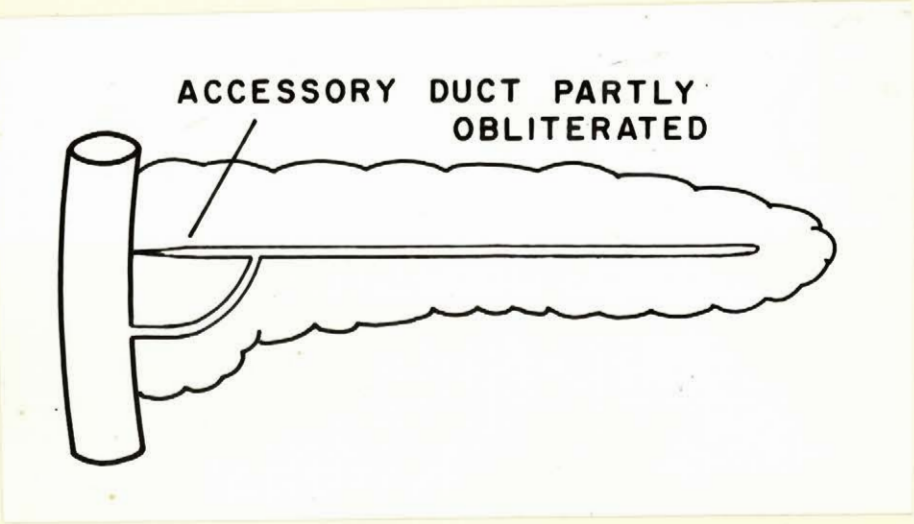

ACCESSORY DUCT PARTLY
OBLITERATED

FIGURE 10.

REPRESENTATION OF THE DUCTS OF THE PANCREAS. THE ACCESSORY DUCT IS SHOWN OBLITERATED AT ITS ENTRANCE INTO WIRSUNG'S DUCT.

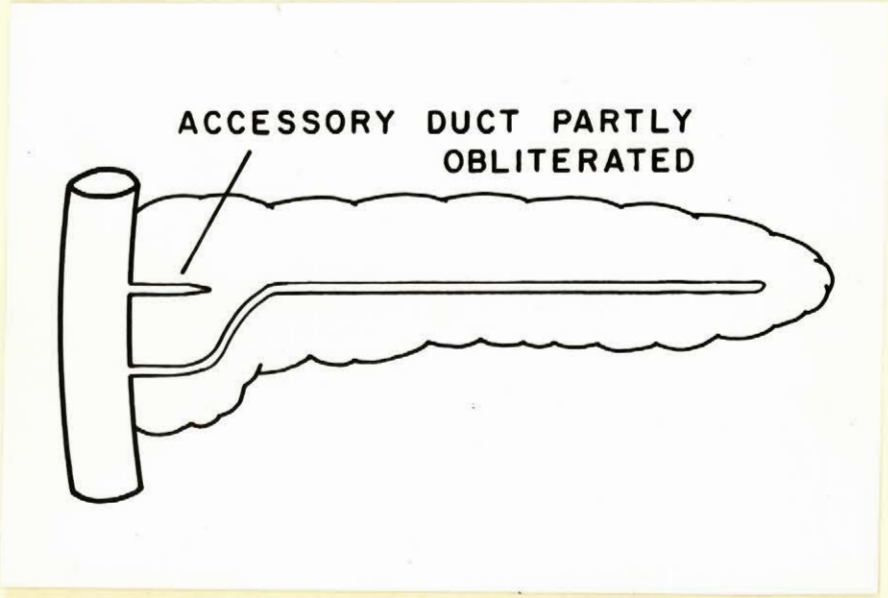

ACCESSORY DUCT PARTLY
OBLITERATED

FIGURE 11.

RADIOGRAPH OF THE PANCREATIC DUCT SYSTEM FILLED WITH A MICROPAQUE SOLUTION. THIS SPECIMEN SHOWS AN OBLITERATED MINOR PAPILLA SURROUNDED BY SMALL DILATED CYSTS. THE INFERIOR DUCT OF THE VENTRAL PANCREAS IS ALSO SEEN DRAINING THE UNCINATE PROCESS AND CURVING BACK TOWARDS THE DUODENUM. (HALF NORMAL SIZE).

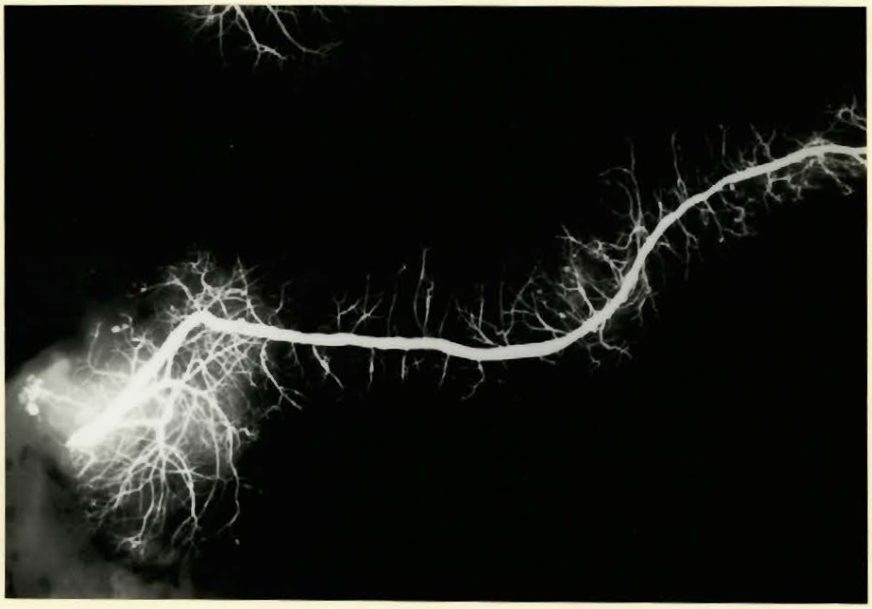


FIGURE 12.

RADIOGRAPH OF THE PANCREATIC DUCT SYSTEM AFTER IT IS DISTENDED WITH RADIOPAQUE MATERIAL (MICROPAQUE). THIS SHOWS THE ACCESSORY DUCT AND COMBINED PANCREATIC DUCT ASSOCIATED WITH SMALL UNILOCULAR AND MULTILOCULAR CYSTS IN THE HEAD OF THE PANCREAS. (HALF NORMAL SIZE).

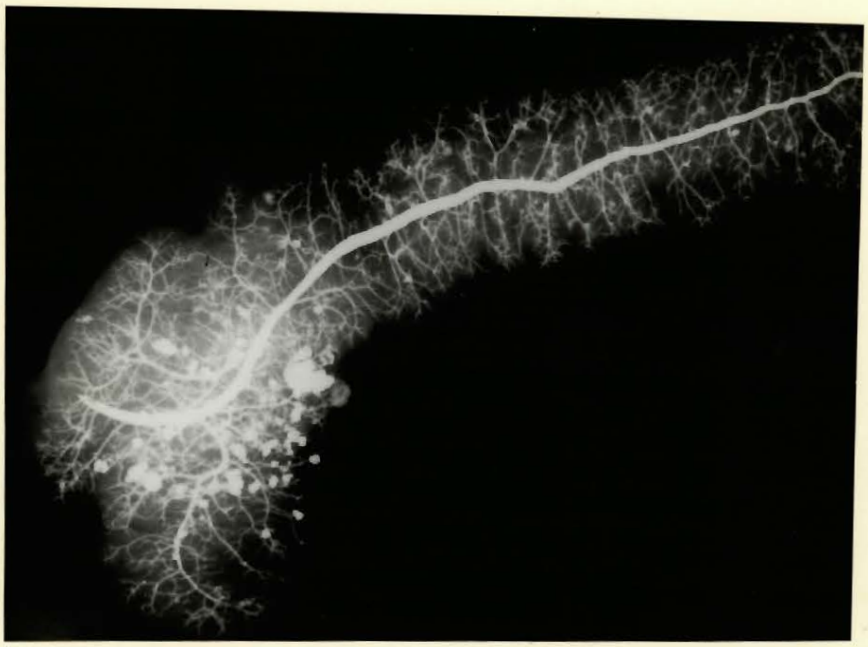


FIGURE 13.

RADIOGRAPH OF A PANCREATIC DUCT SYSTEM AFTER INJECTION OF MICROPAQUE. THE INFERIOR DUCT OF THE VENTRAL PANCREAS IS SHOWN TOGETHER WITH A COMBINED DUCT WHICH HAS AN ISTHMUS PRESENT IN THE NECK. A PAUCITY OF SMALL DUCTS IS NOTED THROUGHOUT THE GLAND. (HALF NORMAL SIZE).

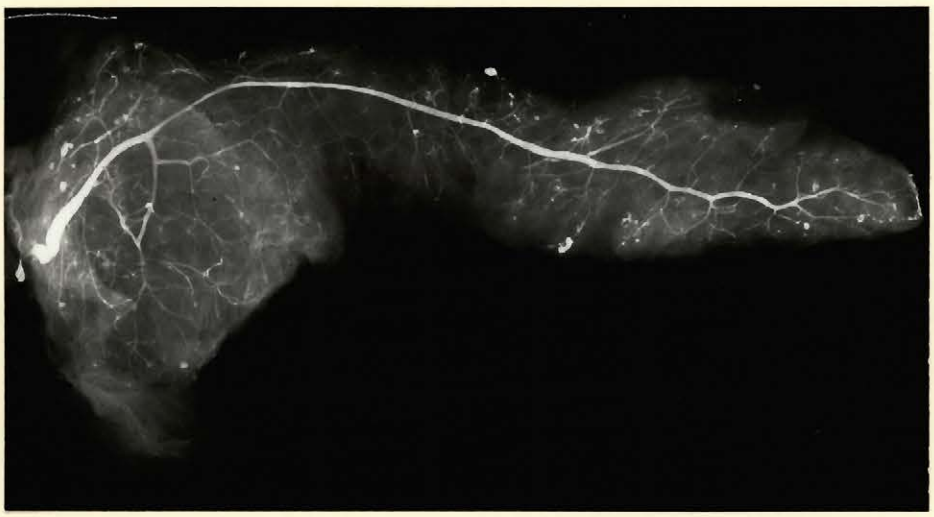


FIGURE 14.

RADIOGRAPH OF THE PANCREATIC DUCT SYSTEM IN MAN. THIS FILM SHOWS A DILATATION OF THE COMBINED DUCT AND INFERIOR DUCT OF THE VENTRAL PANCREAS IN THE HEAD. THE ACCESSORY DUCT WAS SLIGHTLY LARGER THAN NORMAL AND THE MINOR PAPILLA FREELY PATENT. (HALF NORMAL SIZE).

FIGURE 15.

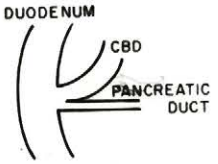
Scheme to show the relationship of the common bile duct to the pancreatic duct.

Type I. (a) Embryonic type; (b) pancreatic and common bile ducts enter the duodenum separately.

Type II. The pancreatic and common bile duct have a common channel of 1-3 mm. in length.

Type III. Common channel of 4-11 mm. in length.

TYPE I



TYPE II

TYPE III