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The pancreatic ductal system and biliaropancreatic union: a study of 50 cases

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SUMMARY

Since its discovery in the 17th century, the anatomy of the pancreatic ductal system and its variations has been studied by numerous authors around the world, and Argentina is not an exception. Nevertheless, most of these researches were carried out upon non representative or insufficient population samples in order to determine a reliable amount of evidence. Therefore, the purpose of this study was to detail the course and distribution of pancreatic ducts and their convergence with the bile duct in adult corpses in the Medicine Faculty of Buenos Aires University.

This scientific research has been developed under a non-experimental cross section descriptive design. Gross macroscopic classic dissection was performed in (n=50) adult human cadaveric pancreas-duodenum with no criteria of exclusion. The dissections were made using microsurgical tools and optical magnification devices. The measurements were obtained by means of a vernier caliper and a protractor. In addition, a digital photo camera was used in order to achieve the necessary photographic documentation of the results. The variables under study were recorded for statistic analysis.

The exocrine pancreas ducts and their union with the bile duct were dissected and exhibited in all anatomical pieces. The morphological patrons were established in terms of length and gauge of the principal and accessory ducts, number of tributaries, distribution and course within the gland. Finally, we registered the angle between principal pancreas duct and bile duct, and between principal and accessory pancreatic ducts. We evaluated the degree of duct suppression, and the features of the biliaropancreatic ampulla, and major and minor duodenal papillae. According to the results, there were patterns of distribution of pancreatic ducts and biliaropancreatic union that provide anatomical basis for an etiopathogenic analysis of acute biliary pancreatitis.

Key words: Pancreas – Pancreatic ducts – Biliaropancreatic union – Biliaropancreatic ampulla – Uncinate process – Duodenal papillae

INTRODUCTION

In 1642, Johann Georg Wirsung, as prosector of the University of Padua in Italy, discovered the pancreatic duct, which received its name for first time in 1685, honored by Van Horne, a colleague of the German Nation of Artists. On the other hand, the documentation of the accessory pancreatic duct has been attributed in an academic field to Giovanni Domenico Santorini, because of his observations in 1742 of major and minor duo-

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denal papillae in association with the pancreatic ducts. However, that duct previously had its first considerations with the antecedent of others scientific investigators like Wharton in 1656, Johann Rhode in 1646, Stensen and de Graaf in 1664 and inclusive the same Wirsung, who referred the existence of a second duct in one of his published letters.

Other significant findings were realized by Bidloo, who in 1685 provided the first description of duodenal papillae, biliaropancreatic union and biliaropancreatic ampulla.

Also, in 1720 Vater rewrote and defined the concept of biliaropancreatic ampulla, receiving its present name. Then, in 1887 Oddi described its sphincter, determining the biliaropancreatic ampulla complex. This complex was the element which Opie used as the anatomic baseline for the common canal theory of acute pancreatitis, proposed in 1901.

After that, the concept of exocrin pancreatic system and related structures started to have importance, taking precedent descriptions as a base to understanding the pancreatic ducts physiology. The incorporation of that knowledge permitted the elaboration of diagnostic and therapeutical procedures orientated to surgical access to the pancreatic ductal system.

Since its first description in the 17th century, the anatomy of the pancreatic ductal system and its variations has been the object of study by many authors around the world, and Argentina was not an exception. However, most local investigations were carried out with unrepresentative or insufficient series to determine reliable evidence. They focus on one characteristic of a specific portion of the biliaropancreatic system without making an integral relation to the regional anatomy.

This entails that the documented information about variables were focused on different groups with varied characteristics. In consequence, the results are discordant to unify global knowledge, and it is necessary to elaborate a statistical work including anatomical aspects about the pancreatic ductal system of a representative group.

This work aims to describe the course, distribution and prevalence of pancreatic ducts and its convergence with bile duct, and to elaborate a statistical database with the main anatomic characteristics of the biliaropancreatic system of adult human cadavers of Medicine Faculty of Buenos Aires University.

MATERIALS AND METHODS

Design: non-experimental cross section descriptive study, according to the 'Strobe statement'. Material: it was performed with (n=50) adult human cadaveric pancreas-duodenum, fixed in 5% v/v formol. The dissection of cadaveric material and the investigation were made in three consecutive phases.

Phase I

A register was made of dimensions of pancreatic portions, including ubication of uncinated process respect superior mesenteric vessels. Then the relation of the pancreatic tail with the splenic hilium was evaluated, classifying three positions in the frontal plane: subhilium, hilum and suprahilium.

Phase II

Using microsurgical instrumental and optic magnification elements, dissections were made of duodenum-pancreas, as well as some tests which are detailed next.

A) Duodenal dissection: an incision was made in the right side of the descendent portion of the duodenum to see major and minor duodenal papillae.

B) Pancreas dissection: the anterior approach was selected to visualize the course of each duct. Previously, the superior mesenteric vessels were taken as a reference to find the pancreatic duct in the neck of the pancreas. The anatomical reference point were selected in terms of the bibliography which says that the pancreatic duct comes from a posterior plane in the tail to an anterior plane in the neck, and again to posterior in the head looking for the bile duct. Then the dissection continued in a proximal and distal way. It was meticulous in the head to find accessory and uncinated ducts.

Progressing with the dissection of the principal duct, its position was classified in thirds (superior, middle and inferior) regarding glandular tissue. Later, tributaries of each duct were quantified. The ductal locations in a coronal plane were also classified in thirds (superior, middle and inferior). Finally bilaropancreatic and pancreato-pancreatic unions were described, together with existence of bilaropancreatic ampulla, the degree of duct suppression and morphologic patterns of opening into the major and minor duodenal papillae.

To confirm permeability of both duodenal papillae and existence of biliaropancreatic common canal (preduodenal and intraduodenal), it was necessary to do following tests:

1) Permeability test: both pancreatic ducts were canalized individually by a catheter Angiocath®

N° 24, and were injected with saline colored with methylene blue. It was considered positive if it emerged from the corresponding papilla into the duodenum, and negative if it did not.

2) Common channel test: it consisted of checking the existence of a biliaropancreatic common channel preduodenal or intraduodenal. The retropancreatic choledocus was canalized with a catheter Angiocath® N° 14, and was injected with saline colored with methylene blue. Previously, the major duodenal papilla was clamped to avoid the flowing into the duodenal lumen. It was considered positive if the injected solution on the choledocus progressed into the pancreatic duct, and it was possible to see the expansion of the respective duct. It was considered negative if it was impossible to check that reflux.

Phase III

After exhibition of ducts, measurements of length, diameter and angles were made with a vernier caliper and a protractor. During the investigation, the results were photographically recorded. Data were tabulated according to the variables in study, and then analyzed statistically.

RESULTS

Correspondent measurements were made according to the dimensions of each part of the pancreatic gland (see Fig. 1): head, neck, body and tail. Because of its proximity, anatomical similitude and obtained data, it is possible to divide the pancreas in two portions: on the one hand, head and neck; on the other, body and tail.

In the studied group, head and neck had an average length of 40.86 mm (rank 58-19 mm; mode 35 mm), and an average thickness of 8.02 mm (rank 28-2 mm; polymodal distribution). Body and tail had an average length of 136.64 mm (rank 186-100 mm; mode 135 mm), and an average thickness of 7.96 mm (rank 19-3 mm; mode 5 mm).

The uncinated process deserves a particular description because of its variability. Its conformation on adult people depends on the embryological fusion of ventral and dorsal buds. Its important relation with superior mesenteric vessels has anatomical and surgical interest. In our study we found that this process reaches only superior mesenteric vein in 58% of the cases, do not reach vessels in 22% and in a 20% exceeds the superior mesenteric artery. In a 100% the uncinated process was found posterior to those vessels, and they had a close relationship that hind the dissection.

The relationship between the pancreas tail and the spleen is variable. Dissections evidenced that in a 52% the pancreas reached the spleen hilum (hilum position). In the remaining 48% the tail of the pancreas was infrahilum (did not reaches the spleen hilum and was inferior and posterior to that). Suprahilum positions were not found.

The pancreatic ductal system:

Pancreatic duct [of Wirsung]

Pancreatic duct forms embryologically at the sixth week of development from fusion of distal portion of the dorsal pancreatic duct and the entire ventral pancreatic duct. In adults, the pancreatic duct has a course among major axis of the gland from left to right crossing the tail, body, neck and head (see Fig. 2). In its course it receives tributaries from the surrounding tissue. In the head of the pancreas the duct approaches to the inferior edge of the retropancreatic portion of the choledocus to lead into the major duodenal papilla. Those openings can be individual, or present biliaropancreatic convergence before they arrive to the duodenal wall.

Pancreatic duct location into the gland can be classified according to thirds on a frontal plane: superior third in 22%, middle third in 62% and inferior third in 16%. On the other hand, it can be classified according to the horizontal plane, 18% in an anterior third, 50% in a middle third and 32% in a posterior third.

Fig. 1. Anterior view of the duodenum and pancreatic ductal system.

Fig. 2. Anterior view of the pancreatic duct. Note rare loop (arrow) on its way up to the neck.

It was possible to evaluate the location of the pancreatic duct according to its vertebral level. In a 52% it was in L1, in a 26% in L2 and in a 22% superior to T12.

Respecting to its dimensions, diameter and length of each part of the pancreas were determined (the results were divided in head and neck, and body and tail because each of them had similar characteristics). The measures were:

The diameter of head and neck was average 3,44 mm (rank 6-1 mm; mode 4 mm) and diameter of body and tail was average 2.34 mm (rank 6 -1 mm, mode 2 mm).

The results of the length of head and neck were average 34.84 mm (rank 71-12 mm; mode 40 mm) and of body and tail was average 122.82 mm (rank 155-74 mm, mode 121 mm), having as a total length average 157.66 mm.

Little tributaries were counted, which drained exocrine secretion from the gland to the pancreatic duct. They were classified according to their length in long or short, to the angle with the duct in right or acute angles, and finally depending whether they alternated between superior and inferior tributaries.

In the head and the neck they were average 12.54 with a wide rank between 34 and 4 and a media of 10. The analysis evidenced that in most of the cases (43.33%) tributaries were preponderantly short, in a 33.33% were long only, and in a 23.33% had mixed characteristics. The tributaries drained in a right angle in a 64.28% of the cases, and in an acute angle in the remaining 35.71%. The alternation between superior and inferior tributaries was de rule in a 66%.

In the body and the tail of the pancreas, because of their bigger extension, the average was higher. It was 36.9, with a rank between 71 and 10 with a polymodal distribution. Most of them have a short course (63.33%), only long courses in 16.66% and with mixed characteristics in 20%. They drained principally in a right angle (68.96%), and alternating between superior and inferior tributaries in the 86.66%.

Fig. 3. Anterior view of tributaries of the pancreatic ducts.

Accessory pancreatic duct [of Santorini]

The accessory pancreatic duct forms embryologically from the proximal segment of the dorsal duct. It comes from the pancreatic duct in the head of the pancreas, and has a course from left to right to lead in the descendant portion of the duodenum into the minor duodenal papilla, which is more anterior and superior than the major. In its course it receives tributaries from the anterior and superior portion of the head of the pancreas (see Fig. 3).

In the population under study, the total absence of accessory pancreatic duct was found in 38% of the cases, and it was prevalent in 62%. In that last group the suppression grade was analyzed, and the results are detailed as follows: it opens into the minor papilla in 28%, leads blindly into the duodenal wall in 28% and does not reach the duodenum in 6%. Respecting to its dimensions, the average diameter was 1.9 mm (rank 4-1 mm; mode 2 mm) and the average length was 29.48 mm (rank 65-9 mm, polymodal distribution).

Uncinated process tributary

The uncinated process tributary is the most important and constant tributary of the uncinated process and the head of the pancreas. It begins in the uncinated process and receives little ducts from this portion of the gland, has a vertical course from inferior to superior, and has a variable lead that can be into the pancreatic duct in the head or into the accessory duct or inclusive together with the choledocus (see Fig. 5).

According to our dissections, the uncinated pro-

Fig. 4. Anterior view of accessory pancreatic duct.

cess tributary have a prevalence of 78%, understanding that its absence (22%) corresponds to the impossibility of identify a preponderant duct, because the drain of the gland is by multiple little and short ducts with variable directions and leads into pancreatic and accessory duct, if it exists.

In 52% of the cases it was only one duct with a average diameter of 1.32 mm (rank 3-1 mm; mode 1 mm) and an average length of 21.74 mm (rank 62-9 mm; polymodal distribution) according to the extension of the uncinated process. Also, it can exist more than one duct, can be double (12%), triple (8%) or multiple (6%).

It is important to describe a case when one duct divides on two and then they unify again in one duct. This case is similar to a "vasa aberrans" anastomosis and it is not described in the bibliography.

Respecting to the lead of the uncinated process tributary, according to its embryological development, in most cases it leads into the pancreatic duct (67%), and in the remaining cases into de accessory pancreatic duct (33%). In one of the cases in which the uncinated process tributary leads into the pancreatic duct it was directly into the biliaropancreatic convergence (with ampulla), setting a triple leading choledocus-pancreatic-uncinated (see Fig. 6). The common channel test was done with injection and clamp of major duodenal papilla to evidence reflux to the others ducts and it was negative, then it is possible to say that each duct had an own canal into the ampulla. Seeing from the duodenal lumen only one hole was observed and was considered as the three ducts converging to a common canal into the papilla but not into the ampulla.

In the cases when the duct was double, triple or multiple, they use to lead into the same pancreatic or accessory pancreatic duct. However, they were cases when it was not respected and each duct had a different course leading into the pancreatic duct or the accessory pancreatic duct, then the uncinated process drained in both ducts.

Biliaropancreatic union

Biliaropancreatic union Bile duct

Average diameter of pancreatic portion of the choledocus was 6.55 mm (rank 11-3 mm; mode 5 mm). It was classified according to its relation with the pancreas head. It is partially covered by pancreatic tissue on 42%, completely covered in 46% and discovered completely in 12%.

Biliaropancreatic convergence

It is impossible to refuse the anatomical, physiological, pathological, clinical and surgical importance of the angle between choledocus and pancreatic duct. It was 38.88º (rank 70-10º; mode 30º). The distance from bilaropancreatic convergence to major duodenal papilla was measured: average 8.8 mm (rank 19-3 mm; mode 10 mm). Later the common channel test was made. It was positive in 54% of the cases (existence of common channel) and negative in 38% (absence of common channel). It is important to say that it was impossible to do the test in 8% of the cases because of technical difficulties (impossibility to canalize ducts, damages of ducts that allow important leaks of solution, absence of choledocus on anatomical piece, etc).

The biliaropancreatic ampulla (of Vater) represents a variety in the biliaropancreatic confluence. It constitutes a dilation of the conflu-

Fig. 5. Anterior view of the uncinate tributary flowing into the accessory pancreatic duct.

Fig. 6. Anterior view of the biliaropancreatic ampulla.

ence between the main bile duct and the pancreatic duct near the duodenal wall before it opens in the duodenal lumen. The prevalence, according to our series, is of 22% approximately (see Fig. 7). We emphasize the fact that it is a common misuse of the term 'papilla' to refer to any kind of biliaropancreatic convergence. This is a mistake because the existence of the papilla is not constant and its prevalence is extremely low. It stands out that the majority of the biliaropancreatic confluences do not present this kind of dilation; it is simply a variety.

Fig. 7. Rear view of preduodenal biliaropancreatic convergence with ampulla.

Fig. 8. Anterior view of biliaropancreatic intramural convergence.

Fig. 9. Anterior view of preduodenal biliaropancreatic convergence without ampulla.

Morphological pattern (see Figs. 7, 8, 9)

To sort the biliaropancreatic union, two points were taken into consideration:

- Opening of the biliopancreatic ducts in the duodenum.

- Common channel test, to expose the existence of a biliaropancreatic union or two separated ducts (convergence of both ducts without union).

Through these two criteria, the openings of the ducts were rated in seven different types:

1. Two independent openings in two different places.

2. Preduodenal convergence: before reaching the duodenal wall.

a) Without ampulla and a negative test = independent ducts (shotgun barrels) b) Without ampulla and a positive test = convergent ducts (common channel) c) With ampulla and a negative test = independent ducts (shotgun barrels) d) With ampulla and a positive test = convergent ducts (common channel)

3. Intraduodenal convergence: in the major duodenal papilla. a) intrapapillary common channel b) papilla with two independent ducts (shotgun barrels)

The sum of 2b (30%) and 2d (14%) constitutes the 44% of the cases; this means that in those cases where there is a preduodenal biliopancreatic convergence, 44% possess a common duct. If in addition we added 10% of 3a (intrapapillary common channel) there are a total of 54% of cases where there is a biliopancreatic union, that is, all cases in which the common channel test was positive. The remaining 46% constitutes the cases where both ducts are independent and each end in a different opening in the duodenum. Including in these cases varieties: 2a, 2c, 3b and 1.

Duodenal papillae: Major duodenal papilla (see Fig. 10)

It is located near the left edge of the descending portion of the duodenum and corresponds to an eminence around the opening of the pancreatic and choledocus ducts.

In its upper part it shows an horizontal mucous fold [suprampullary fold] and in its lower part

there is a vertical fold that helps to fix the ampulla [frenulum of ampulla]. As an anatomical reference, we evaluated the distance between the ampulla and the pylorus considered as a constant repair.

The average distance to the pylorus was found to be 78.52 mm (rank 120-42 mm, mode 50 mm). Therefore, the location of the ampulla after the pylorus is highly variable and can be located very near of it, or very far.

This information is of essential importance in endoscopic procedures of the duodenum, particularly in cases where it is desired to evaluate the ampullary and periampullary regions, both for diagnostic as possible treatments.

Minor duodenal papilla (see Fig. 11)

Structure located above the major papilla, slightly more in an anterior plane. It is similar in structure to the greater but has smaller dimensions and is much more variable. In fact, its existence is unrelated regarding persistent accessory pancreatic duct and permeable, because there are cases where the duct reaches the duodenum with large caliber and yet, in the absence of minor papilla cannot pour its contents into the duodenum. In contrast there are cases of bigger papillae that match a suppressed (partial or total) accessory duct. Its prevalence in our series corresponds to 56% of the cases studied and the distance between both is an average of 19.17 mm (rank 44-10 mm; polymodal distribution).

Fig. 10. Intraduodenal view of major duodenal papilla.

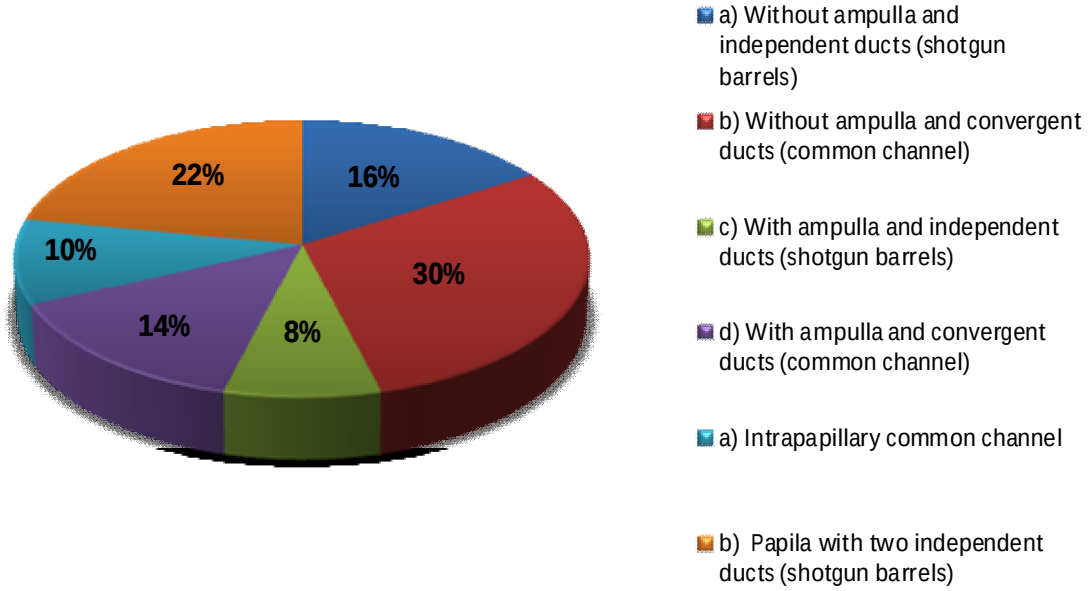
DISCUSSION

This work is a preliminary study whose results are partial. However, the population used will continue growing and acquiring a greater degree of evidence. However, we believe that the sample is adequately representative of the adult population of the city of Buenos Aires when compared with series of other studies on the same subject and with similar design features and research method. The most relevant data obtained are the prevalence of biliopancreatic ampulla, which in our series was 22% of the cases, and the prevalence of morphological patterns proposed on biliaropancreatic convergence: (see Fig. 12)

1. Two independent openings in two different places: 0%
2. Preduodenal convergence: before reaching the duodenal wall. (68%)
   a) Without ampulla and independent ducts (shotgun barrels):16%
   b) Without ampulla and convergent ducts (common channel): 30%
   c) With ampulla and independent ducts (shotgun barrels): 8%
   d) With ampulla and convergent ducts (common channel): 14%
3. Intraduodenal convergence: in the major duodenal papilla (32%)

Fig. 11. Intraduodenal view of minor duodenal papilla.

Fig. 12. Prevalence of morphological patterns



a) intrapapillary common channel: 10%

b) papilla with two independent ducts (shotgun bar rels): 22%

The most common pattern corresponds to the convergence of both duct systems in a preduodenal level (type 2, 68%). In turn, the majority of these cases did not show a biliopancreatic ampulla (2a and 2b, 46%), but a common channel (2b, 2d, 44%). This last fact contrasts with the cases in which the convergence is at intraduodenal level (type 3, 32%), because the cases where the ducts remain independent (3b, 22%) were twice the cases where there is not an intrapapillary common channel. Consequently, convergence in a preduodenal level implies the existence of a common channel while if the convergence is in a intraduodenal level the independence of the ducts is the rule.

Knowledge presented here about the most important characteristics of the entire ductal complex of the pancreas, reflected in the analyzed variables, is indispensable not only in the anatomical field, but also in the epidemiological, surgical and educational field. In this way, the production of morphological patterns in the population studied allows us to establish descriptive grounds that could justify etiopathogenic theories, for example, the causes of acute pancreatitis and choledochal hypertension syndrome, through morphological sciences. In turn, knowledge of the size, location and prevalence of both pancreatic ducts, and the understanding of the biliopancreatic union constitutes anatomical bases consistent with academic tools to be considered in surgical procedures. Finally, the development of a statistical support associated with rigorous description of the attributes on the biliopancreatic duct provides the possibility of developing a theorical framework suitable for the teaching of these structures and their relationships, which often result from a laborious understanding.

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