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Original Article

# Pancreatic Surface Morphology and its Classification

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## Abstract

**Introduction:** Anomalies and variants of development of the pancreas are relatively frequent. These variations can often lead to misdiagnosis and unnecessary medical procedures. Although, pancreatic diseases are a constantly researched field, fundamental research is relatively understudied and re-evaluation of the pancreatic morphology is performed rarely.

**Aim:** The goal of the current study was to analyse pancreatic surface morphology by means of macroscopic anatomical dissection of 78 organ complex.

**Material and methods:** The anatomy of the pancreas was studied by means of macroscopic anatomical dissection. The study was performed on 78 organ complexes (the pancreas, spleen, and duodenum with surrounding abdominal fat) donated to the department of human anatomy from patients who died of causes not related to pancreatic diseases. The organs were fixed in a 10% formalin solution separately to accurately preserve their forms. The organs were measured by a caliper.

**Results:** The lie of the pancreas was classified according to Kreel and co-workers into 6 types: oblique shape in 11.54% of cases, sigmoid – 30.77%, transverse – 25.64%, horseshoe – 11.54%, L-shaped – 14.1%, and inverted V shape in 5.13%. Moreover, there were two possible L-shapes, the classical (8.97%) and inverted L-shape (5.13%). In one case, the pancreas had an unusual M-shape (1.28%). One specimen was a case of short pancreas (1.28%). Surface clefts were encountered in 17.95% of cases and in 5.13% of these cases, there was a branch of the splenic artery.

**Conclusions:** The current study demonstrates variations in the lie of the pancreas as well as several new possible variants. Moreover, we propose a modified classification based on these findings. Therefore, the pancreas can have an oblique, sigmoid, transverse, horseshoe, L shape, inverted L, inverted V, and M shaped lie. Pancreatic clefts are another frequently encountered variation that should be kept in mind. The size of the pancreas alone is variable and should be analyzed together with its structure to avoid possible misinterpretation.

## Keywords

dissection, pancreas, pancreatic clefts, short pancreas

## INTRODUCTION

Pancreas is a complex organ of the endocrine system and gastrointestinal tract, which lies deep in the retroperitoneal space, making it one of the most inaccessible organs of the abdominal cavity. Moreover, pancreas is one of the most "unforgiving organs" and surgeons often try to avoid unnecessary palpation of the gland.[1]

The incidence and prevalence of pancreatic diseases tends to rise while the mortality and morbidity remains high. Pancreatic cancer ranks the 11th most common cancer in the world, causing 4.5% of all cancer deaths. It is also

one of the most complicated cancers to manage with an overall poor survival.[2] Although pancreatic diseases are constantly researched, fundamental research is relatively understudied and re-evaluation of the pancreatic morphology is performed. The morphology of the pancreas is variable and is important to consider in imaging and surgery.

Anomalies and variants of development of the pancreas are relatively frequent. Anomalies are also known as birth defects, congenital disorders or congenital malformations. Compared to anomalies, developmental variations represent different types of normal development. Developmental variations are not associated with disease but may present a diagnostic challenge or lead to complications during invasive procedures. In general, there are three groups of pancreas anomalies: migration anomalies, fusion anomalies and anomalies that affect the number and form, or only the configuration of the main pancreatic duct.[3] Variations of shape, position, direction and vascularization of the pancreas are a group of variation, which is usually not included within these three categories often due to their relatively modest clinical significance.[4]

## AIM

The present anatomical study describes several anatomical variations of the pancreas with an overview of its surface morphology and morphometry.

## MATERIALS AND METHODS

The anatomy of the pancreas was studied by means of macroscopic anatomical dissection. The study was performed on 78 organ complexes (the pancreas, spleen and duodenum with surrounding abdominal fat) donated to the department of human anatomy from patients who died of causes not related to pancreatic diseases. The organs were fixed in a 10% formalin solution separately to accurately preserve their forms. The organs were measured by a caliper. The length of the pancreas was measured from the duodenal margin to the tail. The height and width of the gland was measured at the largest points of the head, body, and tail. In case the organ had a sinuous trajectory it was straightened for proper measuring. The variations in the lie of the pancreas were classified according to Kreel and co-workers based on the surface morphology, spatial orientation, and duct trajectory of the gland.[5,6] The study was conducted according to the ethical laws of the institution and was approved by the ethical commission (19.08.2018, No. 80).

### Statistical analysis

The obtained data were analysed using descriptive statistics and Kruskal-Wallis test by SPSS 20. A $p$ value of less than 0.05 was considered statistically significant. Normal distribution was assessed based on skewness, kurtosis, the Shapiro-Wilk test, and histogram.

## RESULTS

Shapiro-Wilk test demonstrated a normal distribution of the data ($W(77)=0.98$, $p=0.09$), with skewness of −0.14±0.27 and kurtosis of 0.37±0.54.

The variations in the lie of the pancreas were classified into 6 types: oblique **(Fig. 1)**, sigmoid **(Fig. 2)**, transverse **(Fig. 3)**, horseshoe **(Fig. 4)**, L-shaped **(Figs 5A, 5B),** and inverted V shape **(Fig. 6)**. The pancreas had an oblique trajectory in 9 cases (11.54%), sigmoid in 24 cases (30.77%), transverse in 20 cases (25.64%), horseshoe in 9 cases (11.54%), L-shaped in 11 cases (14.1%) and inverted V shape in 4 cases (5.13%). Moreover, there were two possible L-shapes, the classical **(Fig. 5B)** 7 out of 11 cases (8.97%) and inverted L-shape **(Fig. 5A)** 4 out of 11 cases (5.13%). In one case, the pancreas had an unusual M-shape (1.28%) and was not included in the analysis **(Fig. 7)**. We also encountered a case of a short pancreas (1.28%). In this case, the head and the body were of the same size and the length of the gland was 10.20 cm **(Fig. 8)**. The descriptive statistics of the morphometric data is presented in **Table 1**. The morphometric data according to the position of the gland is presented in **Table 2**. The trajectory of the ducts corresponded to the surface morphology. The Kruskal-Wallis test demonstrated no differences in size between trajectories of the pancreas **(Table 2)**. Surface clefts were encountered in 14 cases (17.95%) and in 4 (5.13%) of these cases, there was a branch of the splenic artery.

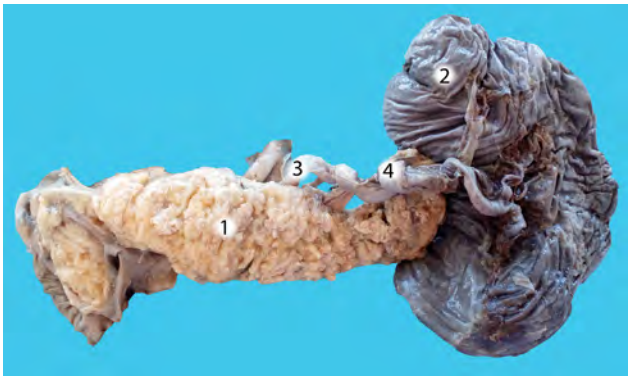


**Figure 1.** Oblique trajectory. 1. pancreas, 2. spleen, 3. splenic artery, 4. splenic vein.

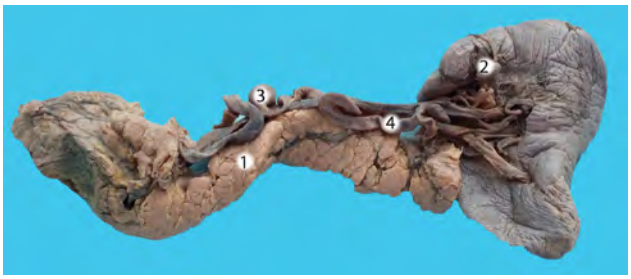


**Figure 2.** Sigmoid trajectory. 1. pancreas, 2. spleen, 3. splenic artery, 4. splenic vein.

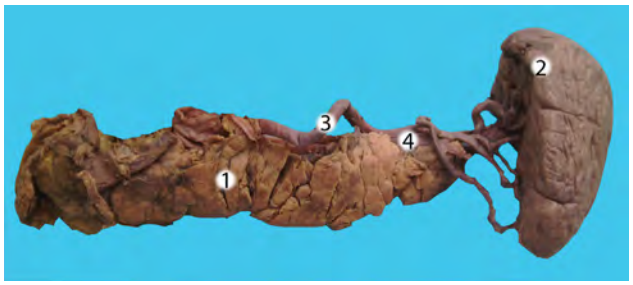


**Figure 3.** Transverse trajectory. 1. pancreas, 2. spleen, 3. splenic artery, 4. splenic vein.


**Figure 4.** Horseshoe shape. 1. pancreas, 2. splenic artery, 3. spleen, 4. duodenum.

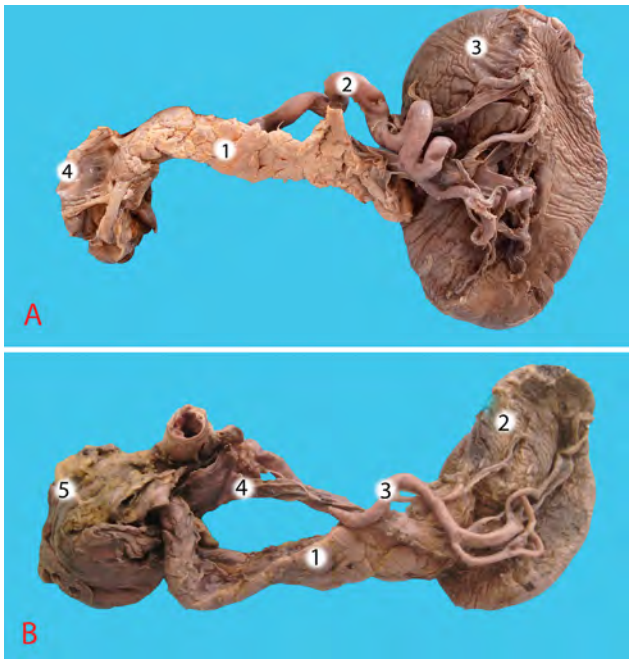


**Figure 5. A**. Inverted L shape. 1. pancreas, 2. splenic artery, 3. spleen, 4. duodenum. **B**. Classical L shape. 1. pancreas, 2. spleen, 3. splenic artery, 4. splenic vein, 5. duodenum.

## DISCUSSIONS

The shape and trajectory of the pancreas is an understudied subject although the pancreas is frequently evaluated

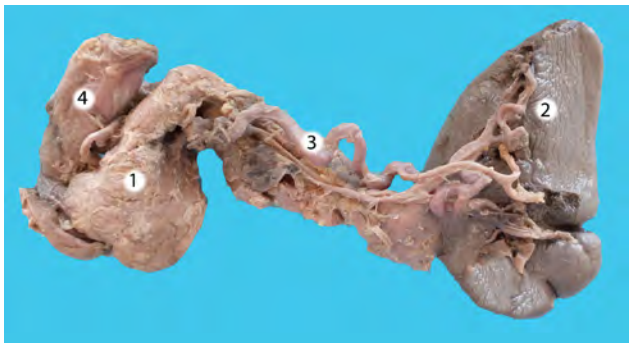


**Figure 6.** Inverted V shape. 1. pancreas, 2. splenic artery, 3. spleen, 4. duodenum.

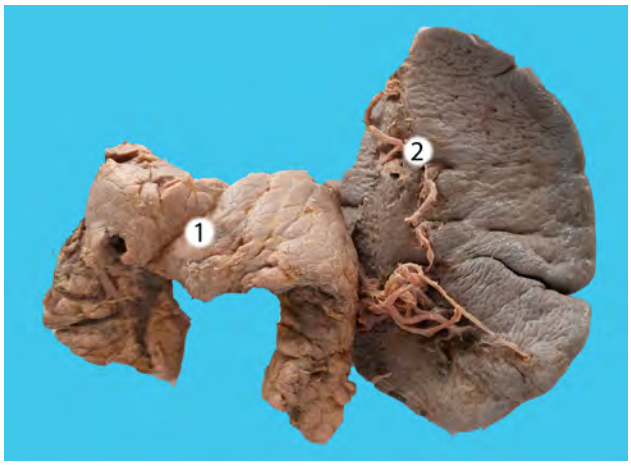


**Figure 7.** M-shape. 1. pancreas, 2. spleen.

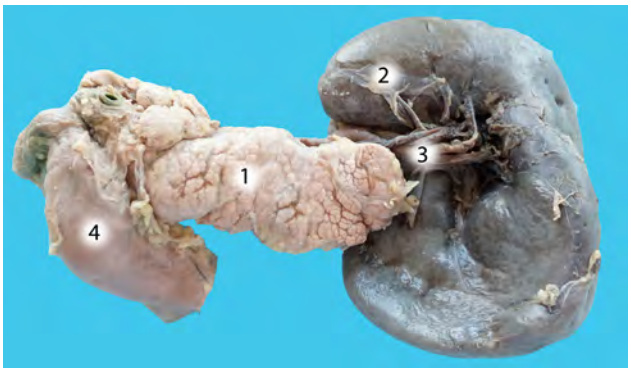


**Figure 8.** Short pancreas. 1. pancreas, 2. spleen, 3. splenic artery, 4. duodenum.

on CT and MRI scans. During imaging examination, this is the organ that can potentially lead to a misdiagnosis.[7,8] The diagnosis of pancreatic diseases generally requires the combined use of different imaging modalities, allowing a more complex evaluation of the gland and adjacent soft tissues.[9] Congenital anomalies and normal variants of the pancreas can present a diagnostic challenge when encountered during diagnostic procedures.[10,11] Moreover, they are often incidentally detected due to the increasing



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**Table 1.** Descriptive statistics

| | N | Minimum | Maximum | Mean | Standard deviation |
|---|---|---|---|---|---|
| Head height (cm) | 77 | 3.30 | 7.30 | 5.10 | 1.01 |
| Head width (cm) | 77 | 0.40 | 8.00 | 2.04 | 1.64 |
| Body height (cm) | 77 | 1.70 | 5.00 | 3.09 | 0.69 |
| Body width (cm) | 77 | 0.40 | 4.00 | 1.24 | 0.75 |
| Tail height (cm) | 77 | 0.80 | 4.30 | 2.51 | 0.85 |
| Tail width (cm) | 77 | 0.30 | 2.50 | 1.02 | 0.63 |
| Length (cm) | 77 | 10.20 | 21.40 | 17.07 | 2.37 |

**Table 2.** Mean values of different pancreas shapes

| | N | Oblique | Sigmoid | Transverse | Horseshoe | L-shaped | Inverted V |
|---|---|---|---|---|---|---|---|
| Head height (cm) | 77 | 5.00±1.00 | 5.13±0.31 | 4.78±0.30 | 5.65±0.56 | 5.08±0.45 | 5.05±0.16 |
| Head width (cm) | 77 | 1.50±0.20 | 1.95±0.22 | 1.25±0.11 | 3.83±0.19 | 1.68±0.30 | 1.72±0.23 |
| Body height (cm) | 77 | 3.20±0.50 | 3.21±0.22 | 2.98±0.22 | 2.93±0.47 | 3.35±0.21 | 3.01±0.50 |
| Body width (cm) | 77 | 2.75±1.25 | 1.20±0.12 | 1.07±0.19 | 1.28±0.40 | 1.15±0.35 | 1.23±0.15 |
| Tail height (cm) | 77 | 2.30±0.70 | 2.63±0.26 | 2.38±0.34 | 2.63±0.40 | 2.60±0.50 | 2.70±0.28 |
| Tail width (cm) | 77 | 1.10±0.70 | 0.93±0.15 | 0.98±0.26 | 1.30±0.41 | 0.65±0.18 | 1.01±0.21 |
| Length (cm) | 77 | 16.85±0.85 | 17.09±0.79 | 18.30±0.38 | 16.45±0.67 | 15.75±1.75 | 16.57±0.44 |
| Total (n) | 77 | 9 | 24 | 20 | 9 | 11 | 4 |

accessibility of diagnostic imaging and some may present with symptoms.[12,13] Kreel et al. reported that the pancreas had an oblique trajectory in 36.6%-37% of cases, sigmoid in 18.18%-27%, transverse in 2%-2.6% of cases, horseshoe shape in 7%-7.79%, L-shaped in 26%-27%, and inverted V shape in 1%-1.30% of the cases.[5,6] Others report that some of these forms are relatively uncommon.[1] The trajectory and shape of the pancreas is a complex and overlapping subject. The original works of Kreel et al. are on pancreaticograms, section, microscopic, and histologic examination. The authors also pay attention to the trajectory of the gland based on its position within the abdominal cavity. The current study aims at assessment of the variations in the lie of the gland by means of macroscopic dissection. In our research, the most prevalent position of the pancreas was sigmoid (30.77%) and transverse (25.6%), followed by L-shaped (14.1%). Horseshoe shape and oblique lie were relatively uncommon. The rarest shape based on Kreel's classification was an inverted V. Nevertheless, we encountered another rare shape in a form of a letter M in one case (1.28%). We also consider that there are two possible L shapes: a classical and inverted. A schematic representation of all of the encountered variations in the lie is presented in **Fig. 9**.

It is also worth mentioning that the lie of the pancreas dictates the position of the tail relative to the spleen. In our research the tail was at the level of the upper 1/3 in cases of inverted L-shaped (5.13%), at the level of the middle 1/3 in cases of oblique and transverse position (overall 37.18%), and at the level of inferior 1/3 in cases of sigmoid, horseshoe, L-shaped and inverted V (overall 56.41%). Therefore, there are mainly three possible types of relationship between the tail and the spleen **(Fig. 10)**. The M-shaped pancreas had its tail at the border of the spleen and was directed inferiorly but not overlapping the spleen **(Fig. 7)**.

The size of the pancreas is a controversial subject as it depends on multiple factors including the method and population that was studied. Sulochana and Sivakami reported that the length of the pancreas varied between 9.2 and 24 cm.[1] This is similar to the work of Kozu who reports the length between 10 and 23 cm.[14] Nevertheless, others report a different normal length of the pancreas. Gore considers the length between 15-20 cm, Mullholand and Simeone – 12–20 cm and Anacker 16.5–27 cm.[15-17] The differences in the minimum length is of particular interest since it helps to differentiate the short pancreas. In our study, we had one case of a short pancreas with a length of 10.20 cm which would be normal according to some of the reports. In our cadaver series, 10.20 cm was the shortest length as other specimens measured more than 12.20 cm. This is also confirmed on the basis of the histogram. The definition of a short pancreas therefore is vague and, in our opinion, requires further research. Short pancreas results due to hypoplasia or agenesis of the ventral or, more commonly, the dorsal bud. This can be an isolated anomaly or in combination with heterotaxia syndromes.[18] Sulochana and Sivakami report width of the head of 2–3.7 cm, body – 2.2–4.7 cm, tail – 1.8–3.5 cm.[1]

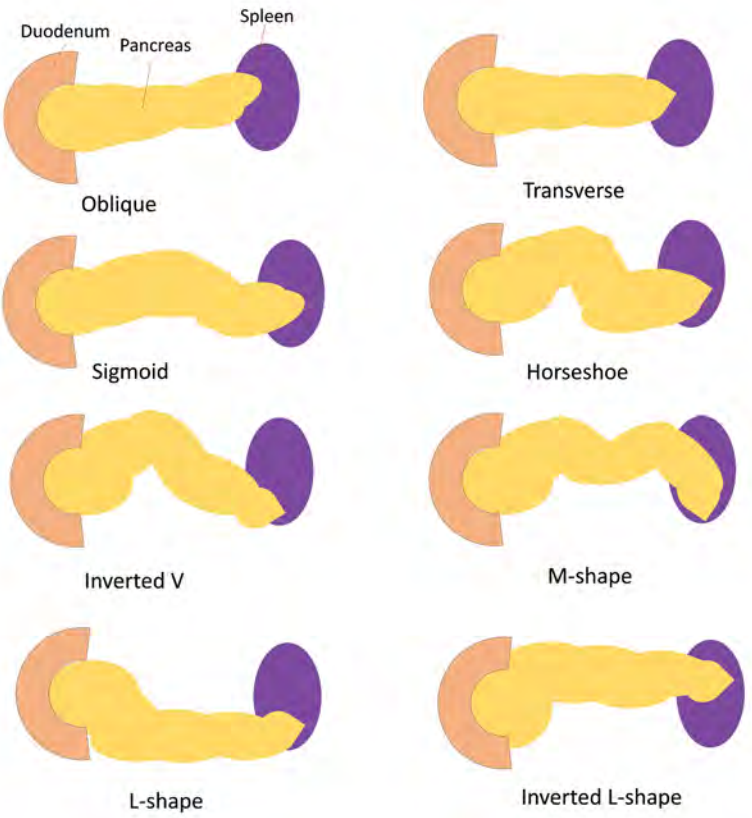


**Figure 9.** Classification of the variations in the lie of the pancreas.

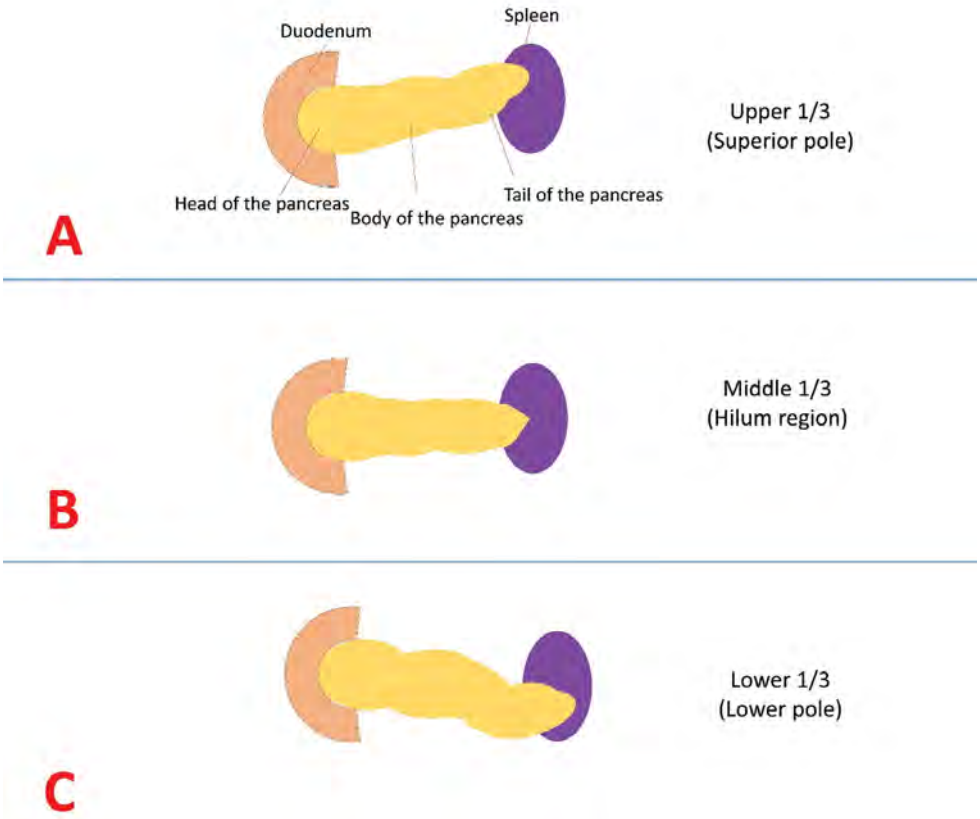


**Figure 10.** Relationship between the tail of the pancreas and spleen. **A**. upper pole, **B**. hilum region, **C**. lower pole.



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Kozu, on the other hand, considers that the width of the head is between 3.5 and 8 cm.[14] In our study, the width of the head was between 0.40–8.00 cm, body 0.4–4.00 cm, and tail 0.3–2.50 cm. It should be noted that pancreatic dimensions in clinical practice should be used purely appraisingly and assessed together with the clinical picture and structural changes.[19] Another strong point for the use of organ dimensions from imaging studies is the fact that formalin causes organ shrinkage and pancreas is particularly a sensible organ.[20,21]

Linear clefts are anatomical space between the lobules of the pancreas. They contain fat and often small vessels, which can be mistaken for pancreatic laceration. They are most prominent at the junction of the body and neck.[22] These lobular contour abnormalities can be seen in up to 35% of normal subjects. [22] In our study, surface clefts were encountered in 17.95%, and in 5.13% of these cases, there was a branch of the splenic artery. Clefts can be related to vascular supply of the pancreas since arterial supply plays an important role not only as source of nutrients but also in its organogenesis by regulating pancreas branching, differentiation, and growth.[23,24] This can be the case with some of the anatomical variations of the shape or surface morphology.[25] Pancreatic surface clefts can be mistaken for pancreatic injury and lead to unnecessary investigation or even surgery.[26]

The limitations of the current study are the small number of included cases. This is to some degree justified by the fact that anatomical dissection is a time consuming and difficult process. We also did not consider sex and age as the organs were donated anonymously and therefore these data cannot be included. The strong point is that this study is based on anatomical dissection, which has accurate and applicable data for the fundamental sciences as well as surgery.

## CONCLUSIONS

The current study demonstrates variations in the lie of the pancreas as well as several new possible variants. Moreover, we propose a modified classification based on these findings. Therefore, the pancreas can have an oblique, sigmoid, transverse, horseshoe, L shape, inverted L, inverted V, and M shaped lie. Pancreatic clefts are another frequently encountered variation that should be kept in mind. The size of the pancreas alone is variable and should be analysed together with its structure to avoid possible misinterpretation.

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# Морфология поверхности поджелудочной железы и её классификация

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## Резюме

**Введение:** Относительно часто встречаются аномалии и варианты развития поджелудочной железы. Эти вариации часто могут приводить к неправильному диагнозу и ненужным медицинским процедурам. Несмотря на то, что заболевания поджелудочной железы являются постоянно исследуемой областью, фундаментальные исследования относительно недостаточно изучены, а повторная оценка морфологии поджелудочной железы проводится редко.

**Цель:** Цель настоящего исследования состояла в том, чтобы проанализировать морфологию поверхности поджелудочной железы с помощью макроскопической анатомической диссекции 78 органов.

**Материалы и методы:** Анатомию поджелудочной железы изучали методом макроскопической анатомической диссекции. Исследование проведено на 78 комплексах органов (поджелудочная железа, селезёнка и двенадцатипёрстная кишка с окружающей брюшной клетчаткой), поступивших на кафедру анатомии человека от больных, умерших от причин, не связанных с заболеваниями поджелудочной железы. Органы фиксировали в 10% растворе формалина отдельно для точного сохранения их формы. Органы измеряли штангенциркулем.

**Результаты:** Положение поджелудочной железы было классифицировано по Kreel с соавторами на 6 типов: косая форма в 11.54% случаев, сигмовидная – в 30.77%, поперечная – в 25.64%, подковообразная – в 11.54%, L-образная – в 14.1%, и перевернутая V-образная форма у 5.13%. Кроме того, было две возможные L-образные формы: классическая (8.97%) и перевёрнутая L-образная (5.3%). В одном случае поджелудочная железа имела необычную M-образную форму. Один образец был случаем короткой поджелудочной железы (1.28%). Поверхностные расщелины встречались в 17.95% случаев, в 5.13% из них имелась ветвь селезеёночной артерии.

**Заключение:** Настоящее исследование демонстрирует варианты расположения поджелудочной железы, а также несколько новых возможных вариантов. Более того, мы предлагаем модифицированную классификацию, основанную на этих выводах. Поэтому поджелудочная железа может иметь косую, сигмовидную, поперечную, подковообразную, L-образную, перевёрнутую L-образную, перевёрнутую V-образную и M-образную форму. Расщелины поджелудочной железы являются ещё одним часто встречающимся вариантом, о котором следует помнить. Размер поджелудочной железы сам по себе является вариабельным, и его следует анализировать вместе с её структурой, чтобы избежать возможных неверных интерпретаций.

## Ключевые слова

диссекция, поджелудочная железа, панкреатическая расщелина, короткая поджелудочная железа