Morphological Study of The Pancreas and Duodenum in Adult Guinea Pigs (*Cavia porcellus*)

F. J. Al-Saffar [1] and Riyadh H. Nasif [2]

[1]*Department of Anatomy, College of Veterinary Medicine, University of Baghdad, Baghdad, Iraq*
[2]*Department of Anatomy, College of Science, University of Diyala, Diyala, Iraq*

ABSTRACT

The present study aimed to investigate the morphological features of the pancreas and duodenum of the adult males and females guinea pigs. Eight animals of each sex were collected to conduct this project. The selected organs were photographed in situ and macro morphometric measurements were conducted on them. Gross findings revealed that the pancreas of guinea pig was of compact type, of two lobes (right and left) connected by large central part (body). The organ drains the pancreatic secretion toward the last part of the ascending duodenum via minor pancreatic duct with absence of major pancreatic duct. The duodenum of the guinea pig was very short and V-shaped. The beginning of the duodenum contains duodenal papilla in which found central orifice for the exit of bile secretions of the common bile duct. In conclusions, the present findings showed the presence of only one minor pancreatic duct and such result was significantly different than most rodents by having major pancreatic duct. The duodenum in the studied guinea pigs was characteristically very short and V-shaped differently to other animals that have U-shaped and long duodenum.

Key words: Pancreas, Duodenum, Morphology, Guinea pigs

Introduction

Domestic guinea pigs (*Cavia porcellus*) are a descendant of the wild cavy (*Cavia aperea*) which is considered one of the common rodents lived in South America. This species is herbivorous rodent. They are characterized by their stocky body, short neck and limbs and they are more closely related to porcupines than mice and rats (1, 2). They are now widely distributed because of its popularity as a pet
and a food source. This species is commonly used in biomedical research, for example in studies of the human immune system, since immunological genes of guinea pig are more similar to human than those from mouse so that considered one of the gold standards for modelling human disease (3) beside others lab animals such as the rabbit (4). Pancreas is an organ of special interest from a medical viewpoint as it is the target of two major diseases that are diabetes mellitus and pancreatic cancer. It is to be hoped that a better understanding of the morphology of this organ will eventually contribute to the development of novel therapies for the treatment of either or both of the above diseases (5).The duodenum is well known as the first segment of the small intestine which is in mammalian animal species characterized grossly by a typical U-shaped morphology with two limbs generally designated as descending and ascending duodenum. The latter two limbs are surrounded the right or head part of the pancreas (6).

In veterinary field, cats are commonly suffered pancreatitis and tumors in both pancreas and duodenum. They were usually affected by obstruction of the pancreatic duct in the exocrine portion associated with the inflammation of bile duct and adenocarcinoma of the duodenum (7, 8, 9, 10, 11).

Up to date there is no research available in the current literatures conducted to describe the morphology of the pancreases and duodenum of the adult guinea pigs and there is paucity of work focused only on the pathological aspect and

*Correspondence: Fayak1955@gmail.com
Department of Anatomy, College of Veterinary Medicine, University of Baghdad, Iraq. Received: 6 November 2019. Accepted: 12 December 2019, Published: 28 June 2020.

concerned diseases of these organs in rabbit (12) and other species as it was mentioned above.
The current study was realized that the data which may be obtained will provides basic scientific information to conduct physiological and pharma-ceutical researches that are related to the diseases of pancreas and duodenum mentioned in the above. Certainly, the obtained data will provide good animal model for both veterinary field in animals and public health in human. Accordingly, to the above reasons the current study was conducted to study the morphology of both pancreas and duodenum of adult male and female guinea pigs to accomplished better understanding data on both organs.

Materials and Methods

Experimental design

This study was carried out after approval of the scientific committee of department of Anatomy and Embryology, College of Veterinary Medicine, University of Baghdad and accordance the international standards of animal welfare.

Animal collection and study design

Clinically healthy sixteen adult guinea pigs (eight of six months aged males and females guinea pigs with mean weights of 508.88±2.28, 511.62±2.91gm, respectively) were bought from local farms at Diyala province and they were caged in the animal house till their euthanasia and dissection to obtain their pancreas and duodenum. Each selected animal was euthanized prior to its dissection by intra-venous injection of overdose of 140 mg/kg of sodium Phenobarbital (Euthasol; Delmarva Laboratories, Midlothian, VA) (13). After that, the animal was dissected on a dissecting board. The abdominal wall was opened to view the abdominal viscera, then the pancreas lobes were pointed out and their location and relationship with duodenum and other digestive organs were photographed in situ. The topography and shape of the organs was studied and documented with aid of digital camera. Macroscopic measurements such as weight, relative weight, length and relative length of each organ were measured after their extirpation. The data on various macromorphometric was presented in table. The table includes estimation of weights and lengths of pancreatic lobes as well as estimation of the weights and lengths of descending and ascending duodenum in adult female and male guinea pigs.

Statistical analysis

Statistical calculations were carried out with the SPSS 15.0 for windows software package. All numerical values were express as the mean ± standard error (SE). For comparisons parametric differences between the two genders and the statistical significance were assessed by student *t* - test. The significance level was set at $p< 0.05$.

Results

Pancreas

The gross examination showed that pancreas of adult guinea pigs composed of three irregular lobes. According to the location of lobes inside

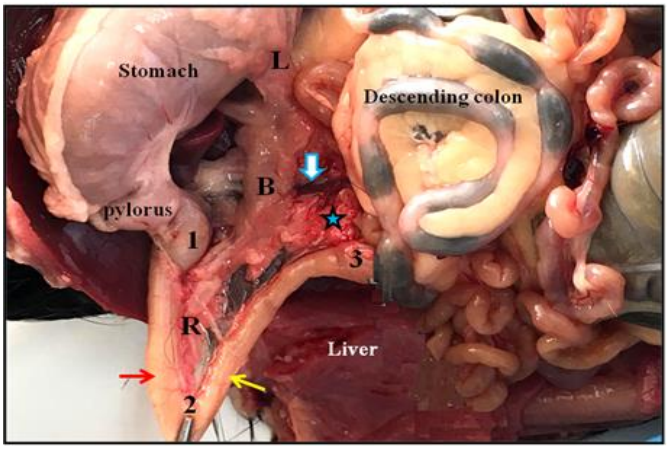

Figure 1. Mesentery hold and fixed right (R), body (B) and left (L) pancreatic lobes with the aid of the surrounding labeled organs.

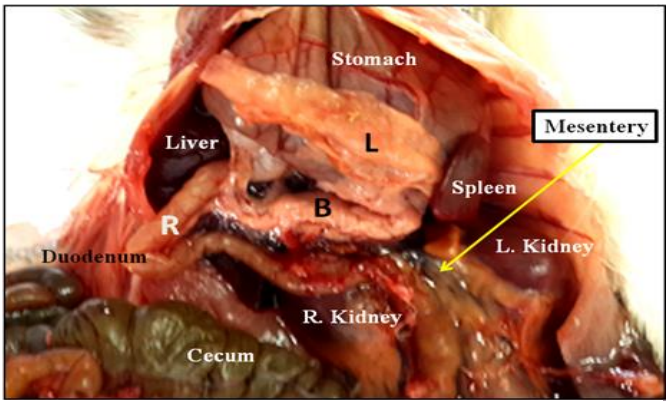

Figure 2. In situ pancreatic lobes such as right (R), body (B) and left (L), part of body connected to ascending duodenum (blue star), descending duodenum (red arrows), ascending duodenum (yellow arrow), portal vein (white arrow), 1st (1), 2nd (2) and 3rd (3) duodenal flexures.

the abdominal cavity and their relationships with the adjacent digestive organs, they were named as right (duodenal), body and left (splenic) lobes (Figure 1, 2, 3).

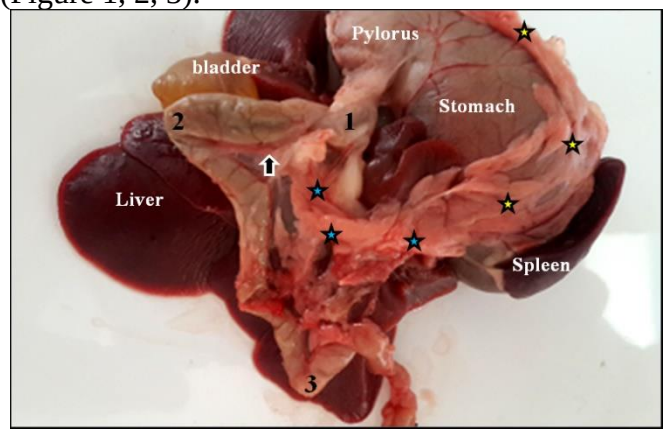

Figure 3. Dissected out pancreatic lobes with adjacent organs. It showed body (blue stars),

The type of pancreas in the guinea pigs was compact; characterized distinctly with gross lobulation apparently observed with naked eyes and the organ was light pinkish in color (Figure 4).

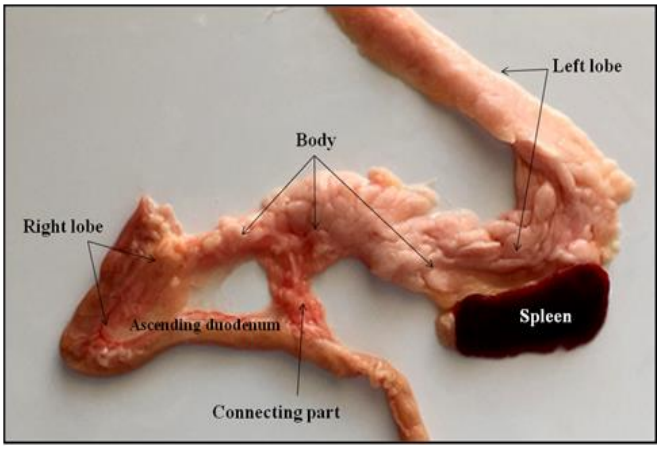

Figure 4. Dissected pancreatic lobes showed gross lobulation of pancreatic lobes.

All of pancreatic lobes were suspended and fixed in situ by the mesentery and the surrounding or adjacent organs such as stomach, spleen, liver, duodenum, kidneys and descending colon. The right lobe was located on the right side of the abdominal cavity. It was the smallest lobe compared with the body and left lobes. This lobe was bounded by the short V-shaped duodenum, that is to say located between the descending and ascending limbs of the duodenum. The pancreatic tissue in this lobe adhered to the descending duodenum only, extended as ribbon-shaped thin compact structure downward between the 1st duodenal flexure to the end part of the descending duodenum (Figure 5).

The body of pancreas was connected to both right and left lobes without distinct demarcation.

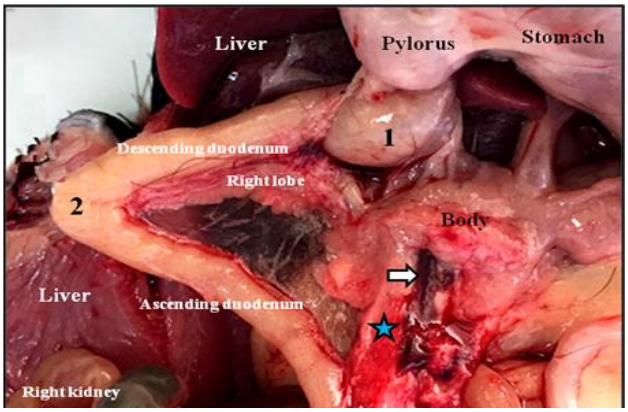

Figure 5. Right lobe closely adherent to the descending duodenum. Connecting part between the body and ascending duodenum (blue star) with adjacent portal vein (white arrow). The figure showed 1st (1) and 2nd (2) duodenal flexures.

It appeared shorter but thicker than the left lobe and in another aspect; it was thicker and longer than the right lobes. The body was enforced toward the stomach, bounded by pylorus, duodenum and descending colon. A small part was extended from the body connecting it to the last part of the ascending duodenum before the latter winding to the left side to continue as a jejunum. In fact, this part carried the minor pancreatic duct where it was directed toward the ascending duodenum to empty the pancreatic secretion (Figure 6, 7).

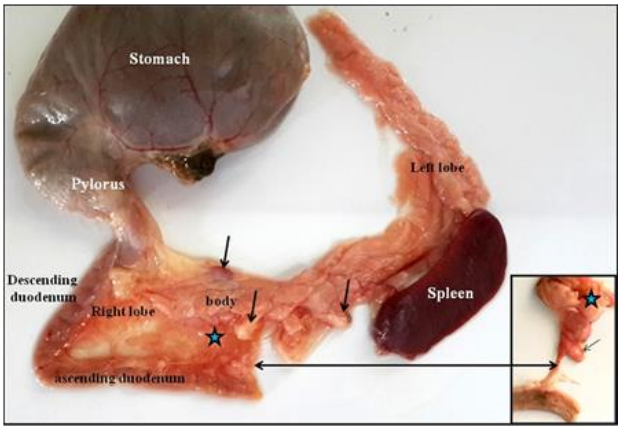

Figure 6. Minor pancreatic duct running through the connecting part of the body (blue star) toward the ascending duodenum. The figure showed many lymph nodes (black arrows).

Distinctly, the connecting part of this lobe crossed adjacently by the dorsal passage of the portal vein.

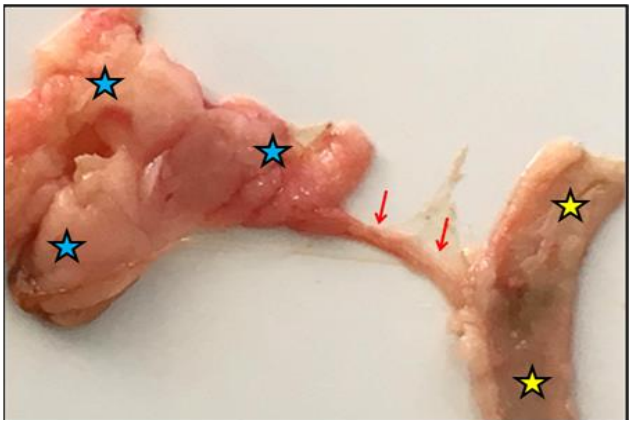

Figure 7. Minor pancreatic duct (red arrows) run through the connecting part of body (blue stars) toward the ascending duodenum (yellow stars).

The left lobe was the longest lobe compared with body and right lobes. The lobe was located at the left side of the abdominal cavity bounded by the spleen and stomach and it was related to the left kidney and the descending colon (Figure 3). It extended as a thin, flattened ribbon over the parietal surface of the stomach then between the two
extremities of the spleen, running along the gastric surface of this organ. The lobe was held by the mesentery and enforced toward the stomach by the third duodenal flexure, beginning part of the jejunum and the distal colon as well as the left kidney (Figure 1).

Macro morphometric measurements of the pancreatic lobes were listed in table 1. The table showed the weight, relative weight, length and relative length of each lobe for both male and female studied animals. The mean lengths of right, body and left lobes were 0.6 cm, 3.9 cm and 7.1 cm in females. Similarly, in males, the lengths were 0.6 cm, 3.8 cm and 6 cm. The mean ± S.E. total lengths of the pancreas in females and males were 11.6 ± 0.04 cm, 10.4 ± 0.11 cm, respectively. The relative lengths of the pancreas in females and males were 46.03 %, 42.44 %, respectively

The mean weights of right, body and left lobes were 0.21 gm, 1.08 gm and 0.91 gm in females. Similarly, in male, the weights were 0.15 gm, 1.21 gm and 0.93 gm. The total weights of the pancreas in females and males were 2.20 ± 0.21 gm, 2.29 ± 0.09 gm, respectively. The relative weights of the pancreas in females and males were 0.43 %, 0.45 %, respectively (Table 1).

Pancreatic duct

The gross examination revealed the presence of minor pancreatic duct only and absence of the major pancreatic duct in the pancreas of adult male and female guinea pigs. This duct formed in the body and directed toward the third part of the ascending duodenum through the connecting part of the body.

Markedly, this duct passes parallel to the portal vein (Figure 6, 7). Examination by dissecting microscope revealed the presence of the common bile duct that was formed by the union the common hepatic duct with cystic duct with no evidence of the presence of major pancreatic duct. The common bile duct conveys and empty bile secretion into the duodenal lumen in the first duodenal flexure (Figure. 8, 9, 10).

Statistical analysis of pancreas

Statistical analysis of the gross morphometric measurements revealed non-significant differences in the body weights and measurements of the pancreatic lobes between

Table 1. Means of weights and lengths of pancreatic lobes in male and female guinea pigs

Measurements	Sex	Lobes				
		Right	**Body**	**Left**	**Total weight**	**Relative weight**
Weights (gm)	**Female**	0.21	1.08	0.91	2.20±0.21	0.43 %
	Male	0.15	1.21	0.93	2.29±0.09	0.45 %
Lengths (cm)	**Sex**	**Right**	**Body**	**Left**	**Total length**	**Relative length**
	Female	0.6	3.9	7.1	11.6±0.04	46.03 %
	Male	0.6	3.8	6	10.4±0.11	42.44 %
Body weight of females (Mean ± SE)		511.62±2.91				
Body weight of males (Mean ± SE)		508.88±2.28, 511.62±2.91, respectively				
Body length of females (Mean ± SE)		25.2±0.09				
Body length of males (Mean ± SE)		24.5±0.13				

1- *Left lobe was longer than body and right lobes.*
2- *The left lobe was lighter in weight compared to the body lobe but heavier than that weight of the right lobe.*

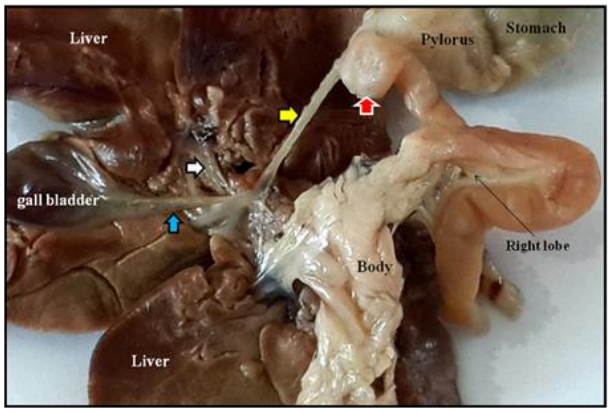

Figure 8. Union of cystic duct (blue arrow) with common hepatic duct (white arrow) to form common bile duct (yellow arrow), pass through 1st duodenal flexure (red arrow).

adult male and female guinea pigs implicated in this research.

In another aspect, the analysis revealed significant ($p < 0.05$) higher length (longer) of splenic lobe than gastric and duodenal lobes as well as significant ($p < 0.05$) lighter weight of splenic lobe compared to the gastric lobe but heavier than that weight of the duodenal lobe.

Duodenum

The duodenum in adult guinea pigs appeared noticeably short V-shaped tubular organ that was positioned at the right side of the abdominal cavity. It was suspended together with the pancreas to the dorsal wall of the abdominal cavity via the duodenal mesentery. Cranially, it joined to the pylorus of the stomach where it formed the first duodenal flexure. Caudally, the ascending part of the duodenum was short and shifted to left side to the jejunum. The reflection of the ascending duodenum to the left side of the abdominal cavity formed the third duodenal flexure. The site of joining descending with ascending limbs of the duodenum formed the second duodenal flexure which was the apex of the V-shape of the organ (Figure 5). Duodenal papilla was detected just about 1.5 cm distance below the duodenum-pylorus junction after the common bile duct enters the wall of the proximal part of the duodenum. The papilla views small opening to discharge the secretion of the common bile duct, through which the secretion convey to the proximal part of the descending duodenum (Figure 9, 10).

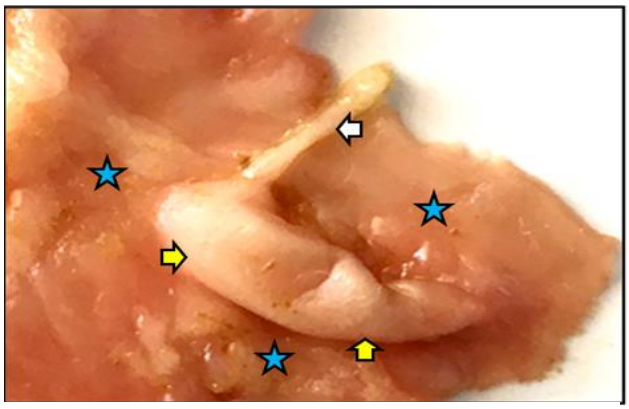

Figure 9. Common bile duct (white arrow) opened through ampulla (yellow arrows) present on the wall of 1st flexure of the duodenum (blue stars).

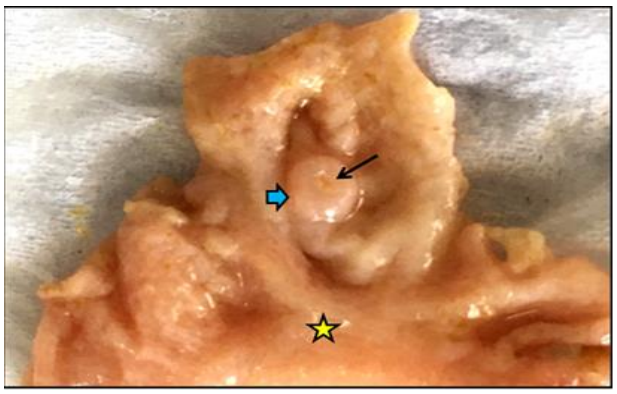

Figure 10. Internal view of the 1st duodenal flexure (yellow star) showed duodenal papilla (blue arrow) with its central opening (black arrow) of the common bile duct

Statistical analysis of duodenum

Macro morphometric measurements of the weights and lengths of descending and ascending duodenum in adult female and male guinea pigs were listed in table 2.

The table showed the mean length of descending duodenum was 3.4 cm and that of ascending duodenum one was 3.9 cm in females. Similarly, in males, the lengths were 3.4 cm and 4.2 cm, respectively. The total lengths of the descending duodenum and ascending duodenum in females and males were 7.3±0.02 cm, 7.6±0.01 cm, respectively. The relative length of the duodenum was 29.2% in females whereas these percentages were slightly higher (31.6%) in males (Table 2).

The mean of weight of the descending duodenum was 0.54 gm and that of the ascending one was 0.59 gm in females. Similarly, in males, the weights were 0.57 gm and 0.64, respectively. The total weights of the descending duodenum and ascending duodenum in females and males were 1.13±0.004 gm and 1.21±0.006 gm, respectively. The relative weight of the duodenum was 0.224%

Table 2. Micromorphometric measurements of weights and lengths of descending and ascending duodenum in adult female and male guinea pigs (*Cavia porcellus*)

Measurements	Sex	Descending duodenal	Ascending duodenum	Total weight	Relative weigh of duodenum
Weight (gm) (Means)	Female	0.54	0.59	1.13±0.004	0.224%
	Male	0.57	0.64	1.21±0.006	0.242%
Length (cm) (Means)	Sex	Descending duodenal	Ascending duodenum	Total length	Relative length of duodenum
	Female	3.4	3.9	7.3±0.02	29.2%
	Male	3.4	4.2	7.6±0.01	31.6%

in females whereas; this percentage was 0.242% in males (Table 1).

Discussion

Pancreas

The pancreas found of compact type in the adult studied guinea pigs which was dissimilar to other animal species that were possessed of mesenteric or diffused type of pancreas such as Wister and Sprague-Dawley rats (14) and in the domestic rabbit (15). In another aspect, the compact type of pancreas of guinea pigs was similarly recorded in humans and animals such as monkeys, minipigs, dogs, cats and hamsters (16, 17, 18).

The gross current findings showed three lobes in adult guinea pig pancreas. According to their positions inside the abdominal cavity and their locations and relationships with the other digestive organs were named into right, body and left lobes. Similarly, these lobes were called head (right), body and tail (left) in the rabbit (19). Differently described in the rat by having four lobes, that was lower duodenal, upper duodenal, gastric and splenic lobes (20). Differently in humans, the pancreas described as having head, neck, body and tail (21). In fact, these pancreatic lobes were sometime given other definite names as the right called duodenal and the left called splenic lobes (14). Obviously, in some animal species such as pig and ox, the right pancreatic lobe appeared closely related to the descending duodenum (22) and such observation was as same as in the current studied guinea pig, whereas, oppositely in the rabbit's pancreas the duodenal or right lobe observed closely adherent to the ascending limb of the duodenum (15).The body of the pancreas represented the connecting part between right and left lobes with the absence of distinct demarcation between these lobes. However, it was well characterized by the passage of the portal vein through it which was considered a good vessel marker in the previous researches (23, 24).

Current findings detected the presence of minor pancreatic duct only and the absence of the major pancreatic duct in the pancreas of adult male and female guinea pigs. This duct initiated in the body directly runs toward the third part of the ascending duodenum across connecting part of the body and opened into the duodenal lumen. These findings were corresponding with those found in other laboratory species such as rabbit (15, 19, 25). The presence of minor pancreatic duct in the guinea pig was dissimilar to those found in the other laboratory species by having major pancreatic duct as in mice (26, 27, 28), rats (13); Hamsters (29). As same as in guinea pigs, the presence of minor pancreatic duct and absence of the major one was similar to that found in pig and ox and dissimilar to those found in sheep and goat (30).

Duodenum

Grossly, location and the relationship of the duodenum in the studied guinea pigs revealed that the duodenum was the first part of the small intestine characterized, grossly by a short V-shaped tubular organ with two limbs designated as descending and ascending parts. The organ was clearly observed at the right side of the abdominal cavity and was held together with the pancreas to the dorsal wall of the abdominal cavity by a fold of the duodenal mesentery. Accordingly, these morphological findings being disagreement with those found in the domestic cat (17) and rabbit (31) where they referred that the duodenum was being very long which appeared as U shape-like tubular organ and into an "S" shaped curve respectively. The length being very long in these animals and the duodenum appeared U shape

whereas in the current studied guinea pig the duodenum was short and V shape. In these animal species which have a U-shaped duodenum there was a transverse part connect descending with ascending whereas, in the guinea pigs is absent and the connection as the apex of the V shape.
The ascending duodenum showed the entrance of the minor pancreatic duct in the guinea pigs. Similarly, in adult rabbits this duct was also recorded but in these animals, there was other pancreatic duct called accessory pancreatic duct opened at the point of connection the transverse part with the ascending part (15). Differently, in other species such as cat (23), mice (28), rats (14) and hamster (29) the presence only the major pancreatic duct which opened either separately or united to the common bile duct then opened in the proximal part of the duodenum.

Conclusions

Gross findings showed the presence of only one minor pancreatic duct in the pancreas of studied guinea pigs and such result was significantly different than most rodents by having major pancreatic duct and that in rabbit have two ducts i.e. the minor as well as an accessory duct. Many lymph nodes were grossly observed in the pancreas that was distributed in body, left and right lobes. The duodenum in the guinea pigs was characteristically very short and V-shaped differently to other animals that have U-shaped and long length duodenum.

Acknowledgements

The authors are greatly appreciated the Council of the College of Veterinary Medicine / University of Baghdad and the head of the Department of Anatomy, Histology and Embryology to provide facilities and support offered to conduct the present project. Great respect and special thanks to the Lecturer Dr. Almayahi, MS as she was the professional who assists in staining the histological slides of this research at Department of Anatomy, Histology and Embryology of the College of Veterinary Medicine / University of Baghdad.

Conflict of interest

The authors declare no conflict of interest

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دراسة شكليه للمعثكله والعفج لخنازير غينيا من الذكور والإناث

فايق جبار تقي الصفار رياض حميد نصيف المجمعي

[1]فرع التشريح والانسجه / كلية الطب البيطري/ جامعة بغداد
[2] كلية العلوم / جامعة ديالى

الخلاصة

أجريت هذه الدراسة لمعرفة التراكيب الشكلية للمعثكلة والعفج في خنازير غينيا البالغة من الذكور والإناث. إذ تم جمع ثمانية حيوانات من كلا الجنسين لتنفيذ هذه الأهداف. ومن ثم تم تصوير الأعضاء المختارة في الدراسة في مواقعها وتم اجراء القياسات الشكلية العيانية عليها. أظهرت النتائج العيانية أن المعثكلة في خنزير غينيا كانت من النوع المضغوط، وهي متكونة من فصين اثنين (الايمن والايسر) متصلين بواسطة جزء مركزي كبير (الجسم).يتم تصريف عصارة المعثكلة بواسطة قناة المعثكلة الثانوية في الجزء الصاعد من العفج ولا وجود لقناة المعثكلة الرئيسه. اظهرت النتائج العيانيه أن العفج في خنزير غينيا قصير جدا ويحتوي بدايتة على حليمة العفج التي تحتوي فتحة مركزية لخروج إفرازات الصفراء من القناة الصفراوية المشتركة في حين يتلقى الجزء الأخير من العفج الصاعد قناة المعثكلة الثانوية.

استنتجت الدراسة في النتائجالحاليةوجودقناةالمعثكلة الثانوية فقطوهذهالنتيجةكانتمختلفةبشكلٍكبيرٍعنمعظمالقوارضمنخلالوجودقناةالمعثكلة الرئيسية. كانالعفج فيخنازيرغينياالتيتمدراستهاقصيراًبشكلمميزوبشكل حرف في انكليزي وهو مختلفعنالحيواناتالأخربالتيفيهاالعفج طويل وبشكل حرف يو انكليزي.

الكلمات المفتاحية:المعثكلة،العفج، خنزير غينيا، إفرازات الصفراء.