RESEARCH ARTICLE

Gross Morphometry and Histometry of Pancreas in Postnatal Indian Pigs (*Sus scrofa domesticus*)

Srija Bushapaka[1*], Vinayasheela Santhapuri[1], Padmasri Banda[1], Sampath Kumar Bogapathi[2]

Abstract

The present study was conducted to evaluate the gross morphometry and histometry of the pancreas in different postnatal age groups of Indian domestic pigs (*Sus scrofa domesticus*) such as pancreas weight, pancreatic lobes length and width, capsule thickness, acini and islet diameter. Pancreases were collected from 18 apparently healthy animals irrespective of sex from local slaughter houses in and around Hyderabad and were categorized into three age groups: Group I (0-4 weeks), Group II (4-10 weeks), Group III (>10 weeks) with six specimens in each group. The pancreas weight showed progressive increase with advancing age with the lowest value recorded in Group I (0-4 weeks) and the highest in Group III (>10 weeks) with highly significant difference among groups. A strong positive correlation was also observed between body weight and pancreas weight (p=0.991). The mean length of pancreatic lobes increased progressively and significantly with the advancing age with greatest lobe length recorded in splenic lobe of Group III (12.08 ± 0.84 cm) and least length in connecting lobe of Group I (2.42 ± 0.46 cm). The mean width of all the pancreatic lobes increased progressively with advancing age with greatest width noticed in splenic lobe (4.62 ± 0.50 cm) of Group III and least width in duodenal lobe of Group I (0.88 ± 0.22 cm). The study provides basic information, which is very useful for identification of any pathological changes and for further studies such as porcine islet transplantation. Histometry included capsule thickness, acini and islet diameter of which capsule thickness increased significantly (p = 0.005) from 116.89 ± 13.74 µm (Group I) to 337.49 ± 41.12 µm (Group III). Acinar diameter and Islet diameter showed an increase in all the lobes from Group I to Group III. The splenic lobe showed a significant age-related differences in acinar diameter (p= 0.005) and islet diameter (p=0.008), whereas the connecting and duodenal lobes showed no significant differences. Thus, post-natally pancreas undergone gross and histological changes.

Key words: Age-related changes, Gross weight, Lobe morphometry, Porcine pancreas, Capsule thickness, Acini Diameter, Islet Diameter, Postnatal development.

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Introduction

Pancreas is a small gland positioned close to duodenum and is present dorsally in the abdominal cavity with softer texture and more loosely arranged tissue (Dyce *et al*., 2017). Pancreas typically has a body, right lobe and left lobe (Konig and Liebich, 2007). The pancreas is a vital internal organ involved in converting nutrients from the diet into forms that can be utilized by body cells for energy. Histologically, the exocrine portion of the pancreas was a large, lobulated compound tubuloacinar gland that secretes digestive enzymes including amylase, lipase and trypsin. These enzymes act on partially digested food that enters the duodenum from the stomach. The endocrine component consisted of the islets of Langerhans, which were present as clusters or scattered among the acini, containing mainly alpha (α), beta (β), and delta (δ) cells secreting glucagon, insulin, and somatostatin respectively. Together, these hormones maintain normal blood glucose balance (Eurell and Frappier, 2006). Any disturbance in its normal activity can adversely influence overall health and metabolic balance (Karpinska and Czauderna, 2022).

So, the objective of the present study was to record all the gross morphometrical and histometrical measures related to pancreas from various postnatal age groups of Indian domestic pigs, which may be helpful to identify gross pathological changes.

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Materials and Methods

Present study was carried out in the Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad (Telangana, India). Pancreases were collected from 18 apparently healthy Indian domestic pigs (*Sus scrofa domesticus*) irrespective of sex from local slaughter houses in and around Hyderabad and were categorized into three age groups. Group I (0-4 weeks), Group II (4-10 weeks), Group III (>10 weeks) with at least six specimens in each group. All the gross specimens were subjected to gross morphometrical studies including weight (gm) and dimensions of the pancreatic lobes. The cleaned and wiped samples were weighed using a digital weighing balance. The length (l) of the three lobes was measured along the long axis (in cm) from cranial to caudal ends and the width (w) of each lobe was taken in multiple regions using a measuring tape and the values were subjected to obtain the average width.

Micrometrical assessments including capsule thickness, mean acini diameter and islets diameter were performed using a Labomed microscope integrated with MICAPS image analysis software. They were performed within a uniformly calibrated microscopic area measuring 1.09×10^5 μm^2 at 40x magnification.

The data collected was analyzed statistically using One-way ANOVA (Snedecor and Cochran, 1994) and the means were tested for significance by Tukey's HSD test using SPSS Version 27.0.

Results and Discussion

Weight of Pancreas Vs Age

In the present investigation the lowest weight recorded was 1.23 gm in the day old pig (Group I) and the highest was 169.38 gm in 14 month old (Group III) pig. There was steady and marked increase in mean pancreatic weight from age Group I, II to Group III ranging from 6.87 ± 2.03, 26.05 ± 2.82 to 107.68 ± 14.29 gm, with Group III exhibiting substantially greater pancreatic mass than Groups I and II. Statistically, there was significant variation in pancreas weight among the groups ($p<0.001$), Group III had significantly ($p<0.001$) higher pancreas weight compared to Group I and Group II, whereas the difference between Group I and II was not statistically significant ($p > 0.05$). These findings were consistent with early postnatal studies in lambs (Guilloteau *et al*., 1983) and mice (De Assis *et al.,* 2002), four months of age to adulthood in pigs (Iniyah *et al*., 2018) and neonatal to adult stages in ovine species (Rafiq *et al.,* 2024).

A strong positive correlation between body weight and pancreatic weight ($\rho = 0.991$, $p<0.001$) suggested that pancreatic growth closely followed overall somatic growth during postnatal development reflecting on-going anatomical and functional maturation of the gland. Similar reports were noted by Lopez *et al*. (1997) in suckling goat kids and De Assis *et al*. (2002) in mice.

Morphometry of Pancreatic Lobes

The pancreas comprised of three distinct lobes: Splenic lobe (left lobe), Duodenal lobe (right lobe), and Connecting lobe (body) (Fig. 1). The study demonstrated a progressive increase in the length and width of the splenic, duodenal and connecting lobes with advancing age and marked enlargement was noted in Group III (Table 1) (Fig. 2-6). These findings were in accordance with the observations of Iniyah *et al.* (2018) in Large White Yorkshire and Desi pigs from early age to adulthood, Rafiq *et al*. (2024) in postnatal age groups of Gurez sheep, and Rajathi *et al*. (2022) in guinea pig from early postnatal stage to adulthood.

Table 1: Mean length (cm) and width (cm) of pancreatic lobes among different age groups of domestic pigs (Mean ± SE, n=6)

Parameter	Age group	Splenic lobe	Duodenal lobe	Connecting lobe
Lobe length	Group I	5.25 ± 0.69^a	4.20 ± 0.78^a	2.42 ± 0.46^a
	Group II	8.03 ± 0.25^b	7.02 ± 0.21^b	4.96 ± 0.54^b
	Group III	12.08 ± 0.84^c	10.63 ± 0.41^c	7.22 ± 0.49^c
Lobe width	Group I	1.30 ± 0.23^a	0.88 ± 0.22^a	1.07 ± 0.21^a
	Group II	2.45 ± 0.17^a	1.84 ± 0.05^a	2.52 ± 0.11^b
	Group III	4.62 ± 0.50^b	3.84 ± 0.46^b	4.15 ± 0.45^c

Means with different superscripts (a, b, c) within the column differ significantly at $p<0.05$ (Tukey's HSD test).

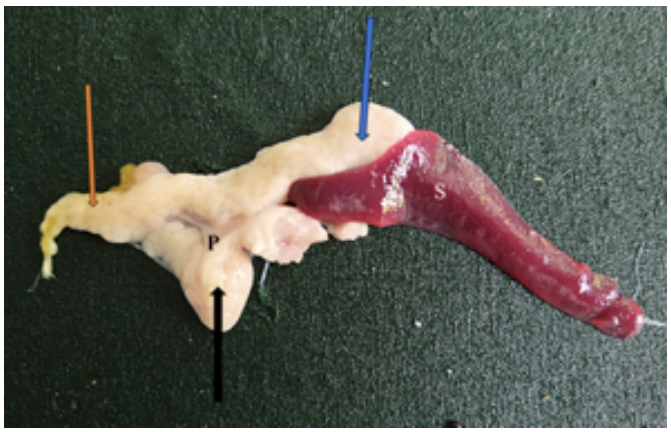


Fig. 1: Pancreas of 3 day old (Group I) piglet showing splenic lobe (blue arrow), connecting lobe (black arrow), duodenal lobe (orange arrow), portal vein (P) and spleen (S).

Throughout all age groups, the splenic lobe consistently exhibited the greatest mean length followed by the

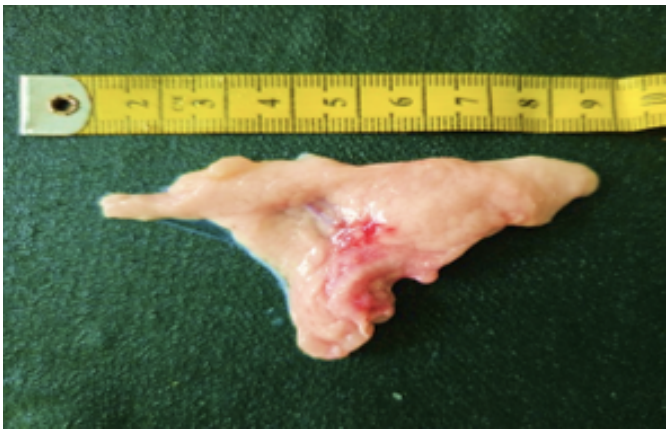


Fig. 2: Pancreas of 7 day old (Group I) piglet

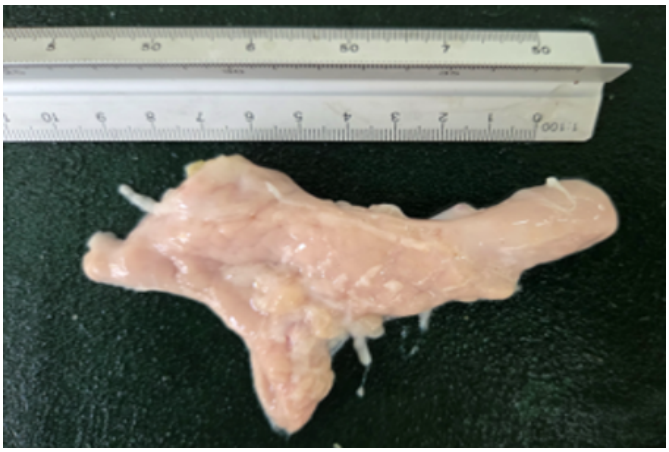


Fig. 3: Pancreas of 37 day old (Group II) piglet



Fig. 4: Pancreas of 55 day old (Group II) piglet

duodenal lobe, while the connecting lobe remained the shortest whereas mean width was highest in splenic lobe followed by connecting lobe and duodenal lobe (Fig.1) which was partially in agreement with Iniyah *et al*. (2018), who observed that splenic lobe had greatest mean length and width followed by connecting lobe and duodenal lobe in

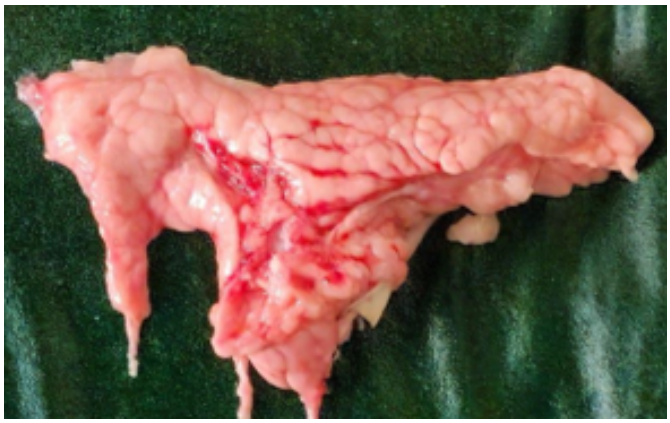


Fig. 5: Pancreas of 5 month old (Group III) pig

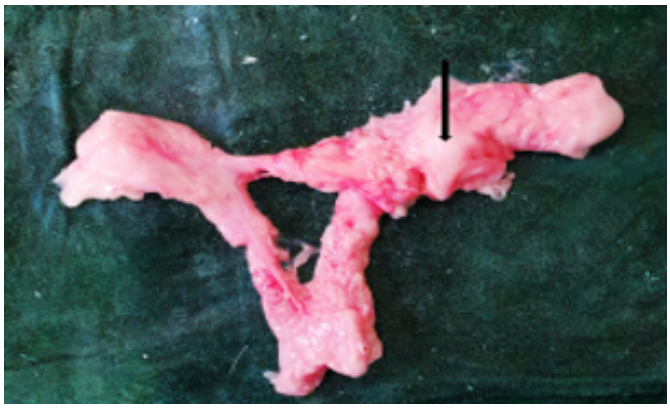


Fig. 6: Pancreas of 9 month old (Group III) pig with adipose tissue (black arrow).

adult pigs. Greatest lobe length was recorded in splenic lobe of Group III (12.08 ± 0.84 cm) and least length was noted in connecting lobe of Group I (2.42 ± 0.46 cm), whereas greatest width was noticed in splenic lobe (4.62 ± 0.50 cm) of Group III and least width was noticed in duodenal lobe (0.88 ± 0.22 cm) of Group I.

Statistical analysis revealed a highly significant difference ($p<0.001$) in the length of splenic, duodenal and connecting lobes among three groups. Pairwise variation between all groups for splenic and duodenal lobes ($p<0.05$) was hypothesized while connecting lobe length also differed significantly between Group I and II ($p=0.006$), Group I and III ($p<0.001$) and Group II and III ($p=0.015$) (Table 1). Significant differences among age groups ($p<0.001$) were also noted for width of splenic, duodenal and connecting lobe. The splenic lobe width in Group III was significantly higher than other two groups ($p<0.001$), while Groups I and II did not differ significantly ($p=0.064$). For the duodenal lobe, Group III varied significantly from Groups I and II ($p<0.001$). In the connecting lobe, significant differences were observed between Group I and II ($p=0.008$), Group I and III ($p<0.001$) and Group II and III ($p=0.004$) (Table 1).

Histometry of Pancreas

Mean capsule thickness increased progressively with increasing age. Group I exhibited the lowest mean capsule thickness (116.89 ± 13.74 µm), whereas Group III exhibited the highest value (337.49 ± 41.12 µm) (Table 2). The average capsule thickness across all groups was 261.87 ± 34.95 µm. Significant difference (p=0.005) in capsule thickness among the three groups was observed. However, no significant difference was observed between Group II and Group III (p=0.995). Similar findings were reported by Prashar (1998) in buffalo with capsule thickness increasing as age advanced from neonatal to prepubertal and to pubertal stages.

Table 2: Mean capsule thickness (µm) of pancreatic lobes among groups (Mean ± SE)

Age Group	N	Mean ± SE
Group I	6	116.89 ± 13.74^{a}
Group II	6	331.23 ± 65.37^{b}
Group III	6	337.49 ± 41.12^{b}

Means bearing different superscripts (a, b) differ significantly at $p < 0.05$ (Tukey's HSD).

In present study, acini exhibited different sizes ranging from 49.12-51.8 µm. This study was partially consistent with Dhilleswara Rao *et al*. (2022) who noted that the average diameter of acini in pig was between 35 and 50 µm. In contrast, buffalo acini were in range of 20-60 µm while comparatively smaller range was noticed with 20-40 µm in goats and 20-30 µm in dogs. Acini were formed by clusters of secretory pyramidal epithelial cells with a single nucleus and were arranged around a narrow central lumen, giving them a chiefly alveolar appearance (Fig.8). The mean acinar diameter increased as age advanced in all lobes with splenic lobe showing greatest mean acinar diameter of 67.47 ± 3.85 µm in Group III and least was noticed in duodenal lobe (44.95 ± 1.38 µm) in Group I (Table 3). Altogether, the acini from all samples in Groups I, II and III ranged in size from 49.12 to 51.8 µm. Mean acini diameter of the splenic lobe increased from Group I to Group III. These findings were consistent with different age groups of buffaloes (Prashar, 1998) and partially in agreement with Meshram *et al.* (2001), who noted that acini were larger in adult and kids than in younger goats, while the connecting lobe and duodenal lobe increased from Group I to Group III with no statistical significance among groups suggesting that acinar growth is more prominent in the splenic lobe, while the other lobes acinar sizes remained relatively stable with increasing age, which is in accordance with Rasheed *et al*. (2021) who noted that the dimensions of exocrine cells remained statistically unchanged in developmental stages of indigenous Iraqi rabbits.

Table 3: Mean acini diameter (µm) of pancreatic lobes among groups (Mean ± SE)

Group	N	Splenic lobe	Connecting lobe	Duodenal lobe
Group I	6	49.10 ± 1.91^{a}	46.26 ± 2.88	44.95 ± 1.38
Group II	6	61.14 ± 3.86^{ab}	49.15 ± 3.24	47.54 ± 4.78
Group III	6	67.47 ± 3.85^{b}	50.67 ± 1.48	50.28 ± 1.99

Means bearing different superscripts differ significantly at $p < 0.05$ (Tukey's post hoc test).

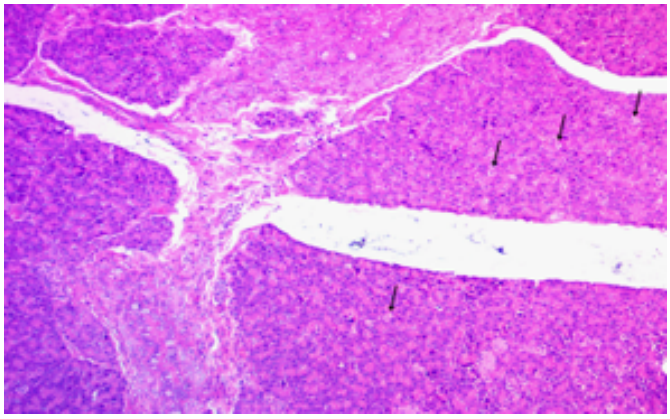


Fig. 7: Photomicrograph showing C/S of 21 day old (Group I) pig pancreas with scattered islets (black arrow) in the parenchyma of splenic lobe. H&E 10x

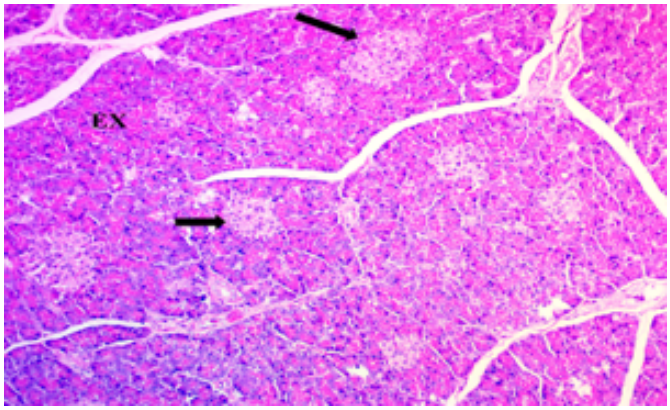


Fig. 8: Photomicrograph showing C/S of the splenic lobe of a 2 month old (Group II) pig with round-shaped islets (black arrow) and exocrine parenchyma (EX). H&E 10x

The Islets of Langerhans were distributed irregularly as small cell aggregates to large clusters within the exocrine pancreatic tissue and appeared in a range of shapes, including round, oval, irregular and elongated, of which the round shape became predominant with the advancement of age (Fig. 7-9). The mean islet diameter of splenic lobe increased with age in all lobes with greatest 121.73 ± 12.85 µm in Group III and least 73.62 ± 5.13 µm in Group I (Table 4). Mean islet diameter of all the lobes increased from Group

Table 4: Mean islet diameter (µm) of pancreatic lobes among groups (Mean ± SE)

Group	N	Splenic lobe	Connecting lobe	Duodenal lobe
Group I	6	73.62 ± 5.13[a]	84.51 ± 9.36	84.65± 13.52
Group II	6	104.76 ± 8.22[ab]	97.34 ± 15.50	88.21 ± 7.58
Group III	6	121.73 ± 12.85[b]	105.92 ± 11.84	88.90 ± 7.31

Means bearing different superscripts differ significantly at $p < 0.05$ (Tukey's HSD)

I to Group III. This observation is justified by the studies of Mansouri *et al.* (2006) in Mehraban sheep, who noted that the islet diameter increased from the fetal period to the newborn and sexually mature stages, besides right lobe showing a decline in diameter among the groups. Similarly, both small and large pancreatic islets increased in overall dimensions with maturation in guinea pig pancreas (Rajathi *et al.*, 2022) and the pancreatic islets increased noticeably in size with age from 4 years to 18 years (Rashwan, 2023) in Egyptian one-humped camels.

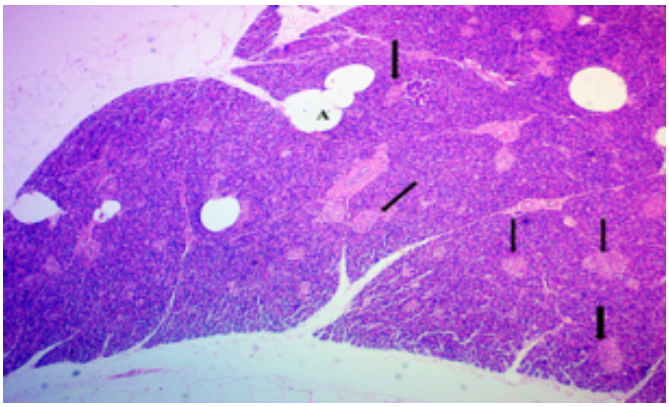


Fig. 9: Photomicrograph showing C/S of 14 month old (Group III) pig splenic lobe with high density islets (black arrow) with adipose tissue (A) in the pancreatic parenchyma. H&E 4x

The acinar ($p=0.005$) and islet diameter ($p=0.008$) of splenic lobe varied significantly among the groups, whereas the acinar diameter of connecting lobe ($p=0.5090$) and duodenal lobe ($p=0.4979$) and the islet diameter of connecting lobe ($p=0.4960$) and duodenal lobe ($p=0.9486$) did not vary significantly. Acinar ($p=0.004$) and islet diameter ($p=0.006$) in splenic lobe of Group I and Group III varied significantly, whereas no pair wise ($p > 0.05$) significant difference was evident in connecting and duodenal lobes.

Conclusion

The pancreas weight, length and width of the pancreatic lobes of Indian domestic pig increased as age advanced. Pancreas undergoes postnatal changes grossly which are very useful for identification of any pathological changes. It is also very much useful for further studies such as porcine islet transplantation. Histometric development showed a progressive thickening of the capsule and enlargement of acini and pancreatic islets with more evident changes noticed in the splenic lobe than in the connecting and duodenal lobes indicating lobe specific changes of postnatal growth and maturation.

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