



PRENATAL MORPHOGENESIS AND MORPHOMETRY OF PANCREAS IN CROSS BRED GOATS*

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Abstract

Morphogenesis of pancreas was studied during prenatal period in goats using 30 embryos. The dorsal pancreatic primordium was identified in the dorsal mesogastrium in 40 days-old embryos between the distal end of foregut and the developing spleen. The ventral primordium was seen sprouting from the hepatic diverticulum between the distal end of foregut and liver. Later the two primordia fused to form a single mass that was visible in the mesoduodenum in embryos of 61 days of development. The size of lobes increased with advancement of foetal age and by 91 days of development, the pancreas assumed a butterfly shape with right and left lobes connected by narrow body. The pancreas was lobulated, light pink in colour, soft in consistency and fragile. The length, width and thickness of entire pancreas and different lobes of pancreas showed an increasing trend with advancement of foetal age. These parameters showed a significant positive correlation with foetal age and body weight. Likewise, the weight and volume of the entire pancreas and its divisions increased with increase in foetal age. A significant positive correlation was noticed between the weight and volume of whole pancreas and its divisions and the foetal age

and body weight. All these parameters during prenatal period differed significantly from those during postnatal period.

Key words: Morphogenesis, Morphometry, Pancreas, Goat

The mammalian pancreas is a unique gland composed of both exocrine and endocrine components that are closely related. In most of the mammals, pancreas develops from dorsal and ventral pancreatic buds that are endodermal outgrowths of the caudal part of foregut. Cells from the pancreatic buds proliferate and differentiate to ducts and secretory acini. Some cells which lose their connection with the duct system develop into islets of Langerhans. The ducts of dorsal and ventral pancreatic buds may persist as major and minor pancreatic ducts or one of them may disappear depending upon the species. The processes involved in the prenatal morphogenesis of pancreas in goats are poorly understood. Understanding the development of the pancreas in goats will add on information to the existing scientific knowledge and thereby to advances in medical science. Hence, this study has been undertaken with the objective of generating baseline data on the morphogenesis of pancreas in goats by tracing the normal developmental pattern during the prenatal period.

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Materials and Methods

Prenatal studies were conducted on 30 goat embryos available in the department museum and those collected from clinics and farms. Immediately after collection, the body weight and crown rump length (CRL) of the embryos were recorded. The age of the foetuses was calculated from the formula derived by Singh *et al.* (1979) for goat foetuses. Based on the age, foetuses were divided into five groups of six embryos each on monthly basis. The embryos were fixed *in toto* upto 59 days of age to locate the primordia and for studying the early stages of development of the pancreas. From the foetuses of later age groups, pancreases were harvested by careful dissection. Length, width and thickness of the whole pancreas and lobes of pancreas were measured by using a Vernier caliper. Weight of the pancreas and different lobes of pancreas was measured by using an electronic balance. Volume of the whole pancreas and its lobes was estimated by using water displacement method. After recording the morphological parameters, the specimens were fixed in 10% Neutral buffered formalin and Bouin's solution and were processed for routine paraffin embedding technique. Sections of 5-7 μ m thickness were stained by Ehrlich's Haematoxylin and Eosin (H&E) staining technique (Luna, 1968) and were examined under light microscope.

Results and Discussion

The dorsal pancreatic primordium was identified in 40 days-old goat embryos in the dorsal mesogastrum between the distal

end of foregut and the developing spleen (Fig. 1) while the ventral primordium was seen sprouting from the hepatic diverticulum between the distal end of foregut and liver. By 58 days, the dorsal and ventral primordia appeared as evaginations on either side of the mesentery (Fig. 2). Later the two primordia fused to form a single mass in the mesoduodenum. These findings are in agreement with the observations made by Nickel *et al.* (1979) and Mc Geddy *et al.* (2006) in domestic animals, Slack (1995) and Norris (2007) in mammals, Murtaugh (2007) in mouse and Gupta *et al.* (2014) in buffalo foetuses. Yang *et al.* (2011) observed the pancreatic primordia in human beings at six weeks of gestation. Singh and Sethi (2012) observed that in buffalo foetuses, the pancreas developed as a thin sheet in the mesentery between liver and duodenum at 47 days of age and by 65 days the two pancreatic primordia were clearly differentiated. Singh *et al.* (2014) found that at in foetal goats at 42 days of gestation, the primordia of pancreas were present in close proximity to the developing duodenum and abomasum. In foetuses from 91 days of development as well as in postnatal animals, the pancreas assumed a butterfly shape with right and left lobes connected by a narrow body (Figs. 3) and were lobulated, light pink in colour, soft in consistency and fragile. In reindeer calves, the pancreas was slightly yellowish, soft and lobulated and consisted of right and left lobes (Nikander, 1990). Islam (1993) reported that the pancreas of dwarf goat was triangular in shape and light pink in colour.

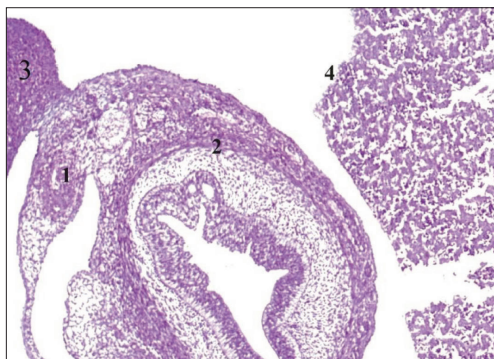


Fig. 1. Location of dorsal pancreatic primordium (40 days of gestation). H&E. x 100

1. Dorsal mesogastrum
2. Developing stomach
3. Developing spleen
4. Liver

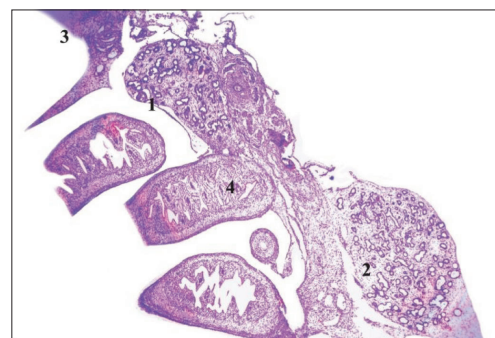


Fig. 2. Location of dorsal and ventral pancreatic primordia (58 days of gestation). H&E. x 40

1. Dorsal primordium
2. Ventral primordium
3. Developing stomach
4. Developing intestine

However, Hussain (2010) described the shape of pancreas in goats as an oak leaf appearance with a large right lobe and a small left lobe.

The length, width and thickness of whole pancreas showed an increasing trend with advancement of foetal age. Length of the pancreas increased significantly from third to fifth month of development. Increase in width of pancreas showed a significant difference only between foetuses of third and fourth month of foetal life. Even though the width and thickness of pancreas increased from third to fifth month of development, a significant increase was noticed only between third and fifth foetal months. Length, width and thickness of the whole pancreas were positively correlated with age, body weight and the same parameters of its individual lobes at $P < 0.01$ level (Tables 1 and 2).

The mean length of right and left lobes and the body of pancreas during prenatal period increased with the advancement of foetal age (Fig. 4). The increase in mean length of the right lobe in third, fourth and fifth months showed a significant difference, while that of

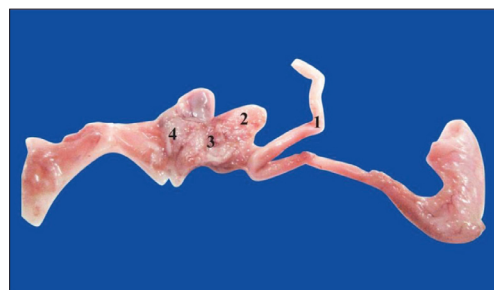


Fig. 3 Ventral view of pancreas (91 days of gestation)

1. Duodenum
2. Right lobe
3. Body of pancreas
4. Left lobe

Table 1. Pearson's correlation coefficients (r) of various parameters of whole pancreas with parameters of different lobes of pancreas during prenatal period

Parameters of lobes of pancreas	Length of Pancreas (mm)	Width of Pancreas (mm)	Thickness of pancreas (mm)	Weight of pancreas (g)	Volume of pancreas (cm ³)
Length of right lobe (mm)	0.939**	0.917**	0.911**	0.893**	0.891**
Width of right lobe (mm)	0.935**	0.887**	0.930**	0.877**	0.875**
Thickness of right lobe (mm)	0.702**	0.709**	0.969**	0.963**	0.964**
Weight of right lobe (g)	0.694**	0.707**	0.911**	0.990**	0.990**
Volume of right lobe (cm ³)	0.714**	0.726**	0.932**	0.996**	0.997**
Length of body of pancreas (mm)	0.919**	0.907**	0.896**	0.842**	0.840**
Width of body of pancreas (mm)	0.869**	0.820**	0.746**	0.612**	0.611**
Thickness of body of pancreas (mm)	0.910**	0.835**	0.857**	0.702**	0.699**
Weight of body of pancreas(g)	0.810**	0.834**	0.900**	0.922**	0.924**
Volume of body of pancreas(cm ³)	0.802**	0.840**	0.893**	0.913**	0.914**
Length of left lobe (mm)	0.955**	0.916**	0.866**	0.827**	0.826**
Width of left lobe (mm)	0.953**	0.941**	0.877**	0.866**	0.864**
Thickness of left lobe (mm)	0.740**	0.709**	0.971**	0.910**	0.911**
Weight of left lobe (g)	0.688**	0.700**	0.924**	0.988**	0.989**
Volume of left lobe (cm ³)	0.689**	0.701**	0.924**	0.988**	0.989**

**Correlation is significant at the 0.01 level (2-tailed).

the body of pancreas and left lobe increased significantly only by fifth month of prenatal life. The mean width of the lobes of pancreas in different age groups also increased with progress of age (Fig. 5). The increase in the width of right lobe was significant in all age groups, but that of the body of pancreas and left lobe showed significant increase only by fifth month of foetal age. The mean thickness of both lobes and the body of pancreas showed an increasing trend with advancement of foetal age (Fig. 6) and the increase was significant only by fifth month for the right lobe and body of pancreas. However, the thickness of left lobe was increased significantly by fourth month itself. The mean length, width and thickness of all the lobes of pancreas showed a significant correlation with age and body weight at $P < 0.01$ level (Table 2).

A positive trend was noticed in the weight gain of pancreas as the foetal age advanced and in all age groups a significant difference in weight gain was noticed. Weight of pancreas showed a significant correlation with age, body weight and weight of all lobes at $P < 0.01$ level. Weight of all divisions of pancreas also showed a corresponding increase with age. Weight of right lobe and body of pancreas increased significantly from fourth month of foetal life, but that of the left lobe showed a significant increase only by the last month of gestation. Weight of different lobes showed a significant correlation with age, body weight and weight of whole pancreas at $P < 0.01$ level. The per cent contribution of weight of right lobe, body and left lobe to the weight of whole pancreas was 51 per cent, nine per cent and 40 per cent, respectively.

Table 2. Pearson's correlation coefficients (r) of pancreatic parameters during prenatal period with age and body weight

Sl. No.	Pancreatic parameters	Correlation with age (r)	Correlation with body weight (r)
1.	Length of pancreas (mm)	0.949**	0.874**
2.	Width of pancreas (mm)	0.861**	0.831**
3.	Thickness of pancreas (mm)	0.779**	0.843**
4.	Weight of pancreas (g)	0.696**	0.877**
5.	Volume of pancreas (cm ³)	0.693**	0.874**
6.	Length of right lobe (mm)	0.902**	0.952**
7.	Width of right lobe (mm)	0.920**	0.943**
8.	Thickness of right lobe (mm)	0.666**	0.819**
9.	Weight of right lobe (g)	0.674**	0.874**
10.	Volume of right lobe (cm ³)	0.692**	0.880**
11.	Length of body of pancreas (mm)	0.876**	0.874**
12.	Width of body of pancreas (mm)	0.772**	0.660**
13.	Thickness of body of pancreas (mm)	0.897**	0.798**
14.	Weight of body of pancreas (g)	0.735**	0.840**
15.	Volume of body of pancreas (cm ³)	0.733**	0.830**
16.	Length of left lobe (mm)	0.909**	0.891**
17.	Width of left lobe (mm)	0.910**	0.938**
18.	Thickness of left lobe (mm)	0.709**	0.775**
19.	Weight of left lobe (g)	0.644**	0.818**
20.	Volume of left lobe (cm ³)	0.646**	0.819**

**Correlation is significant at the 0.01 level (2-tailed).

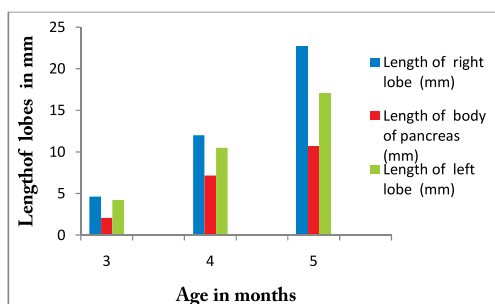


Fig. 4. Age related changes in the length of different lobes of pancreas in the prenatal period

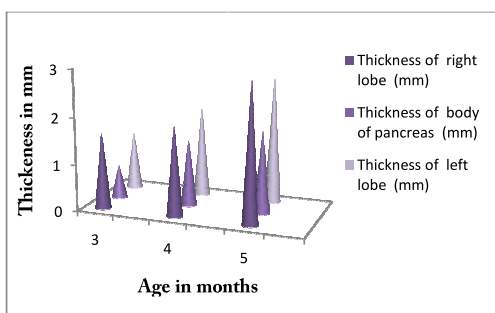


Fig. 6. Age related changes in the thickness of different lobes of pancreas in the prenatal period

Age related changes in the volume of pancreas in prenatal group showed an increasing trend with age and the increase was significant from fourth month of foetal life. A significant correlation was observed between volume of pancreas and age ($r = 0.693$), body weight ($r = 0.874$) and volume of its lobes ($P < 0.01$). These findings were in total agreement with those of Lopez *et al.* (1997) in goat kids, Mubiru and Xu (1997) in newborn piglets, Taga *et al.* (1998) in mice and Kim *et al.* (2009) in rats and Hassunuma and Taga (2002) in Syrian golden hamster. Volume of different lobes of pancreas in the prenatal period increased with advancement of age and the increase was significant from fourth month of foetal life. Volume of different lobes of pancreas showed significant correlation with age, body weight and volume of whole pancreas at $P < 0.01$ level.

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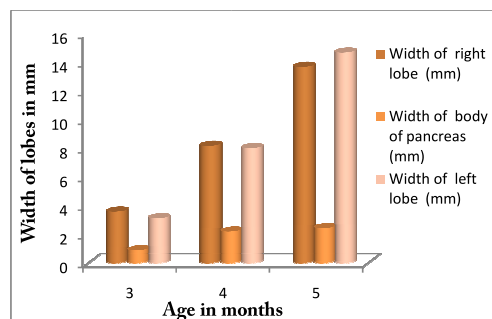


Fig. 5. Age related changes in the width of different lobes of pancreas in the prenatal period

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