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Age-related gross morphometry studies of stomach in Indian domestic pigs (*Sus scrofa domesticus*)

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Abstract
In this research, the stomach of pigs in all postnatal groups was a "C" shaped organ with two curvatures *viz.,* greater and lesser, and a conical diverticulum projecting caudally. Stomach mucosa showed four distinct zones *i.e.,* pars oesophagea, cardiac, fundic, and pyloric regions which were visible from 21 days onwards. The internal surface had rugae seen from group I onwards. Pars oesophagea, was whitish followed by a light grey colored cardiac region. The fundic region appeared reddish-brown and lacked mucosal folds, while the pyloric region was pinkish-white with few mucosal folds and a prominent bulge known as "torus pyloricus."This study revealed that the mean length of greater, lesser curvatures, and average width of the flaccid stomach, increased with age. In G-I, II, and III, the width at fundic region was higher than the cardiac diverticulum and pyloric sphincter. The average weight of a flaccid stomach and the capacity of the stomach showed an increase with age. Overall, the size of the stomach increases in all age groups for weight, volume, and length. Studied.

Keywords: Postnatal, stomach, glandular, non-glandular

Introduction
Domestic pigs are omnivores and have a complex stomach, falling between that of a carnivore and an herbivore. (Dressman and Yamada, 1991) [6]. The pig's stomach, also known as the ventriculus, is a large, hollow, muscular organ located between the esophagus and small intestine, caudal to the diaphragm. (Hussein and Khalid, 2019) [11]. It is located cranially to the visceral surface of the liver and posteriorly to the diaphragm, with the spleen to its left and the intestinal mass caudoventrally. (Sujana *et al*., 2017) [23]. The pig's stomach is divided into four regions: the pars oesophagea, cardiac, fundic, and pyloric. (Rouchey, 2009) [20].

Material and Methods
The present study was conducted in the Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad. Indian domestic Pig stomachs will be collected at regular weekly intervals from a minimum of eighteen (18) healthy Pigs, irrespective of their breed, sex, and nutritional status from local slaughterhouses in and around Hyderabad. The specimens will be divided into three groups *viz* Group I Piglets (birth to 4 weeks), Group II (wearers to 10 weeks), and Group III (Adults - above 10 weeks).
To study the morphological features of the pig's stomach, the samples were gently dissected and cleaned. Both external and internal features were observed and recorded, along with Figures. The weight of the specimens was calculated in grams using an electronic weighing balance on a flaccid stomach. Morphometrical observations of the stomach such as the length (in cm) of greater and lesser curvatures were made by thread and scale technique and tabulated. Width (in cm) was taken at three different regions of the flaccid stomach – one closer to the diverticulum, the second at the midpoint (fundus), and the third nearer to the pyloric sphincter. Volume of the stomach was calculated by assuming the stomach as a sphere and by using the formula $V=\frac{4}{3}\pi\left[\frac{L}{2\pi}\right]^3$. Volume was calculated from the greater curvature assuming its length to be the circumference of the stomach.

Results and Discussion

In the present investigation, the stomach of an Indian domestic pig in all post-natal groups was a simple "C" shaped hollow organ which is similar to the morphological feature of the stomach observed by Miller (1979) [16] in dogs, pig and Dyce *et al*. (2010) [7] in domestic animals, Chandana *et al.* (2013) [4] in albino rat and Shmreen (2016) [22] in guinea pig. The above authors stated that the stomach was simple (unilocular) smooth and homogenous externally without any demarcation which is similar to the observation of the stomach of pigs in all groups in this study. In contrast, Ranjan and Das (2018) [19] reported a 'J' shaped stomach in rabbits.

The stomach of the pig in this study showed a blind diverticulum which was similar to the reports in Babirusa pigs and Eurell and Frappier (2006) [6], Bal *et al.* (2007) [3] and Dyce *et al.* (2010) [7] in pigs. They stated that the presence of a conical diverticulum projecting caudally from fundic part was a unique feature in pigs.

Stomachs of pigs in all specimen groups revealed greater and lesser curvatures which is akin to observations made by Trang *et al.* (2012) [24] in pigs, Miller (1979) [16] in dogs, Mahdi (2013) [15] in rabbits, Shmreen (2016) [22] and Raja *et al.* (2022) [18] in guinea pigs. In the current study, the greater curvature of the stomach of the pig was longer than the lesser curvature which is consistent with the findings of Ranjan and Das (2018) [19] in rabbits. Unlike these observations, Trang *et al.* (2012) [24] mentioned that minor curvature of pig stomach was longer than major curvature.

The inner surface features of the Group I pig stomach showed various transverse ridges (rugae), oriented longitudinally and transversely. These findings are in accordance with the observations of Scopin *et al.* (2011) [21] in Laonastes Aenigmamua, Shmreen (2016) [22], and Raja *et al.* (2022) [18] in guinea pigs. In groups II and III stomach mucosa was divided into fundic and pyloric regions. This differentiation was consistent with reports of Greenwood (1885) [9] in pigs, Adams (2004) [1] in dogs, Dyce *et al.* (2010) [7] in domestic animals, and Sujana *et al.* (2017) [23] in pigs.

In the non-glandular region the mucous membrane of the esophagus was extended over the gastric surface around the cardia which is akin to reports of Eurell and Frappier (2006) [6], Dyce *et al.* (2010) [7] and Sujana *et al.* (2017) [23] in pigs. They reported that the non-glandular region was the first and it was small and whitish, followed by a light grey-colored large cardiac region limited by a small dilated pouch called diverticulum with mucosal folding.

The cardiac region was large and occupied nearly half of the stomach, a characteristic feature also observed by Eurell and Frappier (2006) [6], Dyce *et al*. (2010) [7], Sujana *et al.* (2017) [23] in pigs. This observation is partially in agreement with Greenwood (1885) [9] who stated that the cardiac region occupied one-third of the stomach. Khaleel and Ghafi (2012) [12] in rabbits, and Chandana *et al.* (2013) [4] in rats stated that the cardiac gland region was a narrow band at the junction of the non-glandular and glandular stomach.

The fundic gland region is well developed in all domestic species *i.e.,* in carnivores it occupies over half of the stomach, over one-third in horses, and approximately one-fourth in pigs (Dellmann and Brown, 1976) [5]. In the present study also the fundic part occupied one-fourth region of the stomach without mucous folds which is in contrast to the findings of Greenwood (1885) [9], Nitovski *et al*. (2015) [17], and Hussein and Khalid (2019) [11] who stated that the fundic region consisted folded mucous membrane with a mottled appearance. This feature observed in this study is in agreement with the findings of Mac Lean (1948) [14] and Sujana *et al.* (2017) [23] in pigs. Fundic region lined the body of the stomach except for lesser curvature which is in confirmation with Babirusa, Dyce *et al*. (2010) [7], and Nitovski *et al*. (2015) [17] in pigs. The pyloric region was pinkish white with a bulged torus pyloricus at the pyloric sphincter region in pig stomach in this study which is consistent with observations made by Bal *et al*. (2007) [3] in pigs, Eurell and Frappier (2006) [6] in ruminants and pigs, Dyce *et al*. (2010) [7] and Laerke and Hedemann (2012) [13] in pigs and Mahdi (2013) [15] in the rabbit.

In the present study, the mean length of greater and lesser curvature in group III was higher than in groups I and II specimens. Our findings are similar to the observations by Raja *et al.* (2022) [18] in guinea pigs. The average width of the flaccid stomach at the cardiac diverticulum, fundus, and nearer to the pyloric sphincter increased with age. The mean width of the stomach at the fundus was higher in all groups than the width at the cardiac diverticulum and pyloric sphincter which is similar to the observations made by Sujana *et al.* (2017) [23] in pigs.

The average weight of flaccid stomach in group I noted is 0.022 ± 0.004 kg which is similar to the findings of Byanet *et al.* (2010) [2] who reported that the mean stomach weights of the African giant pouched rats was 0.028.81 ± 0.93kg. The group II and group III average weights of flaccid stomachs were 0.022 ± 0.004 kg, 0.159 ± 0.028 kg, and 0.422 ± 0.024 kg respectively which correlates with the findings of Guise *et al.* (1995) [10], Laerke and Hedemann (2012) [13] and Sujana *et al.* (2017) [23] in pig. The size of the stomach increased concerning weight, volume, and length in all age groups studied which is akin to the reports of Raja *et al.* (2022) [18] in all postnatal age groups of guinea pigs.

Table 1: Show the mean values of the parameters studied

Table I	Mean length(cm)		Weight (kg)	Volume (Litters)
	Greater curvature	Lesser curvature		
Group I	14.93 ± 1.936	3.28 ± 0.27	0.022 ± 0.004	0.45 ± 0.067
Group II	28.32 ± 2.93	16.23 ± 1.14	0.159 ± 0.028	0.73 ± 0.052
Group III	38.27 ± 1.07	19.23 ± 1.41	0.422 ± 0.024	1.56 ± 0.098

Table 2: The mean values of the parameters studied

Table II	Width (cm)		
	Conical diverticulum	Fundic region	Pyloric region
Group I	4.217 ± 0.34	4.86 ± 0.29	3.28 ± 0.25
Group II	6.983 ± 0.78	8.967 ± 0.86	6.033 ± 0.52
Group III	10.30 ± 0.95	13.9 ± 1.51	9.43 ±1.56

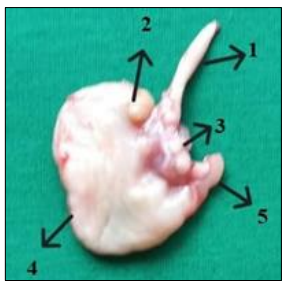

Fig 1: Stomach of group I (0 day) piglet showing (1) oesophagus, (2) diverticulum, (3) lesser curvature, (4) greater curvature and (5) duodenum.

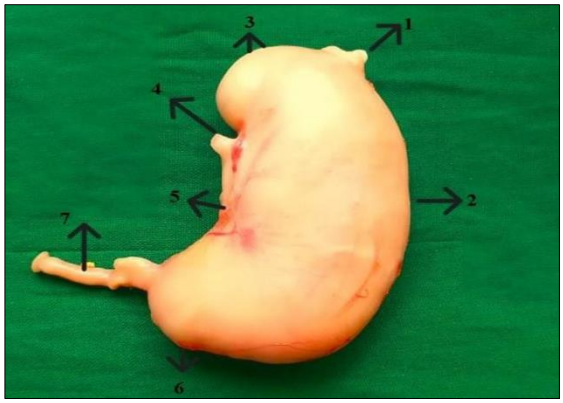

Fig 2: Stomach of group I (6 day) piglet showing (1) diverticulum, (2) greater curvature, (3) cardiac end, (4) oesophagus, (5) lesser curvature, (6) pyloric end and (7) duodenum.

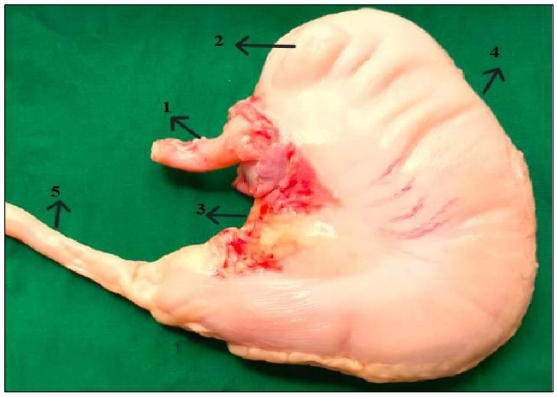

Fig 3: Sectional photograph showing internal structure of group I (0 day) piglet stomach (1) rugae and (2) oesophagus.

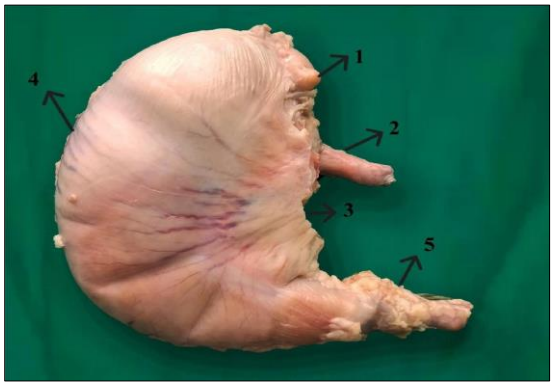

Fig 4: Photograph of stomach of group III adult pig showing (1) diverticulum, (2) oesophagus, (3) lesser curvature, (4) greater curvature and (5) duodenum.

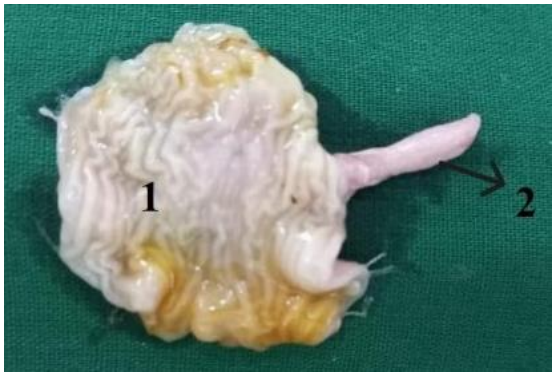

Fig 5: Sectional photograph showing internal structure of group I (0 day) piglet stomach (1) rugae and (2) oesophagus.

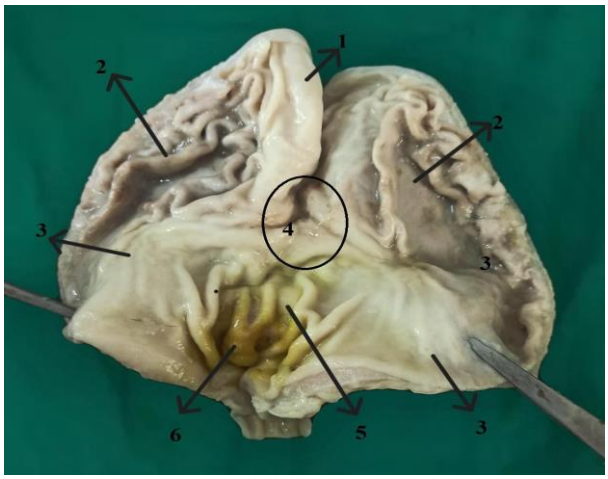

Fig 6: Sectional photograph showing internal structure of group II pig stomach (1) diverticulum, (2) cardiac, (3) fundic, (4) non-glandular region (5) pyloric and (6) torus pyloricus.

Conclusion

This study provides a comprehensive understanding of the morphological changes in the postnatal pig stomach, highlighting age-related variations in size, structure, and mucosal characteristics. These findings contribute valuable insights into the developmental aspects of the pig stomach.

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