Morphometric Evaluation of Blood Pressure Regulating Organs in Teddy Goats (*Capra hircus)* in Relation to Age and Sex

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ARTICLE HISTORY

ABSTRACT

In this study the heart, kidneys and adrenal glands of 36 teddy goats (*Capra hircus)* of both sexes, divided in 3 age groups viz. kids (6-12 months), adults (13-21 months) and old (22-24 months) were collected after slaughter. Immediately after collection, absolute and relative weights, length, width, thickness, circumference and volume of all organs were recorded. Shape of the heart was cone like and the coronary groove was filled with fat. None of the anatomical parameters of the heart, kidneys and adrenal glands differed between male and female goats, except that absolute weight of the right kidney and volume of right and left kidneys were higher in males than in females (P<0.05). Absolute and relative weights of the heart, volume, length, circumference, right atrial wall thickness and right ventricle wall thickness were higher in old than in kids or adult animals (P<0.05). No difference was seen in various anatomical parameters between the right and the left kidneys. However, values of most of the anatomical parameters were higher in old than in kids or adult goats (P<0.05), except relative weight of the organ and thickness of medulla, which did not differ among animals of three age groups. For adrenals, the absolute weight and length of the left organ were higher than the right (P<0.05). Similarly, absolute weight, length and width were higher in old than in kids (P<0.05). It is conceivable from these findings that goat has a stable cardiovascular system. The development of heart, kidneys and adrenals showed an increase parallel to the advancing age to adjust with the increasing blood pressure due to physiological development process. Sex, however, played a secondary role.

To cite this article: Shah M, AS Qureshi, S Rehan and R Hussain, 2010. Morphometric evaluation of blood pressure regulating organs in teddy goats (*Capra hircus)* in relation to age and sex. Pakistan Vet J, 30(1): 49-52.

INTRODUCTION

Heart diseases have become the number one killer in the world. The rate of cardiac diseases increased so sharply between the 1940 and 1967 that the World Health Organization (WHO) rightly called it the world's most serious epidemic. According to WHO estimates, 17.5 million people around the globe died of cardiovascular diseases (CVD) during 2005. More than 600 million people with high blood pressure are at risk of heart attack, stroke and cardiac failure. In 2005, CVD contributed to nearly one-third of global deaths. By 2015, the WHO estimates nearly 20 million human CVD deaths worldwide (WHO, 2009).

Kidneys play an important role in maintaining the normal blood pressure through regulation of water excretion. A change within a species is only possible by variation in filtering surface of renal corpuscle. Besides, the renin-angiotensin-aldosteron system (RAAS) plays an important role in the blood pressure regulation (Saavedra and Trimmermans, 1994). Simultaneously, landmark clinical studies have demonstrated that inhibition of these systems significantly reduces morbidity and mortality from a wide spectrum of cardiovascular diseases including myocardial infarction, heart failure and diabetes. Width of zona glomerulosa of adrenals and the cell nucleus size of the endocrine cells are also very important in this regard. Hence, morphometric evaluation of blood pressure and blood volume related organs i.e., heart, kidneys and adrenal glands is critically important to determine the etiology and pathogenesis of different diseases related to cardiovascular system. In this connection, some research work has been conducted to improve the basic information on the morphology of these organs in

indigenous livestock species, including buffalo (Hussain and Qureshi, 2007) and dromedaries (Rehan and Qureshi, 2006). The present work was designed to add to the basic knowledge information about the age and sex related anatomical changes in blood pressure regulating organs of goats. Needless to emphasize that ascertaining standard structural values of these organs in health will be supportive for clinical and applied studies on these vital organs.

MATERIALS AND METHODS

A total of 36 clinically healthy teddy goats (*Capra hircus*) of either sex (18 males, 18 females) comprising three age groups of equal size viz, kids (6-12 months), adults (13-21 months) and old (22-24 months) were used in this study. Age of these animals was determined by dentition (Jaudas and Mobini, 2006). The samples of the heart with pericardium, the left and right kidneys and the left and right adrenal glands alongwith fat tissue were collected from each animal immediately after slaughter at the Faisalabad Municipal abattoir during winter season (October, 2005 to March, 2006). All organs were weighed with the help of an electrical weighing balance.

Following collection, gross anatomical parameters including shape, weight, dimensions (length, width, and circumference) of heart were measured with the help of a measuring tape. Length was measured from pulmonary vein to the apex of the heart; the width was measured from the coronary groove, while the circumference was measured around the coronary groove. Thicknesses of walls of the heart were measured after opening using vernier's caliper. The length of each kidney and adrenal gland was measured from cranial to the caudal pole; the width was measured from the lateral border to medial border, while circumference was measured around the wide axis of the gland. Thicknesses of renal cortex and medulla were also measured. The volume of the each organ was measured from the water displaced, using a graduated cylinder.

Mean values (± SEM) for each parameter for three age groups and two sexes were calculated. In order to ascertain the magnitude of variation in these mean values among animals of various groups the data were subjected to statistical analysis using two factor completely randomized design under analysis of variance. Duncan's multiple range (DMR) test was applied for multiple means comparison, where necessary. Statistical analysis was performed by using the statistical computer software Minitab (Mtb13) and MSTAT-C.

RESULTS AND DISCUSSION

Heart

The heart was conically pointed and the coronary groove was filled with white fat. These findings are in line with those described by Reece (2004) in goats. Mean absolute heart weight was recorded as 94.47 ± 5.86g (Table 1). Schroeder (1986) reported higher value of 185-246g in goats of different age groups without specifying the breed. Difference might be apparently due to lower body weight of the breed (teddy goat) under study. Mean relative heart weight of 36 teddy goats was recorded as 0.44 ± 0.01%, which is similar to 0.46% in goats reported by Michaelsson and Ho (2000).

Mean heart volume was recorded as 89.23 ± 4.99 cm^3, while the values of mean thickness of right and left atrial wall from auricle region were 0.15 ± 0.01 and 0.25 ± 0.02 cm, respectively. The mean thickness of right and left ventricular wall at the midpoint, between atrioventricular orifice and apex of heart, was recorded as 0.39 ± 0.02 and 0.99 ± 0.05 cm, respectively (Table 1). Mean values for the length, width and circumference were 7.89 ± 0.14, 5.56 ± 0.20 and 14.30 ± 0.34 cm, respectively.

There was no significant difference in the absolute and the relative weights of heart with respect to sex (Table 1). Similarly, the volume, length, width and circumference of the heart, thickness of right and left atrial wall from auricle region, thickness of right and left ventricular wall at the midpoint between atrioventricular orifice and apex of heart remained unaltered between the two sexes (Table 1). Schroeder (1986) reported relative heart weight of 0.51 and 0.49% in males and females, respectively. However, Seifert *et al.* (1991) reported that relative heart weight was higher in female teddy goats compared to males; there was a gradual decrease in relative heart weight up to 12 months of age and thereafter it showed a consistent increase.

The absolute and relative weight of the heart did not show significant variation between the kids (72.61 ± 3.96g) and adults (77.62 ± 5.00g), however, it showed significant (P<0.05) increase in old animals (133.19 ± 9.03g). A similar trend was recorded for the volume, length, circumference, right atrial wall thickness and right ventricular wall thickness of the heart (Table 1), indicating that the size of heart was considerably larger in old as compared to younger age-groups. These findings are in line with those described by Schroeder (1986). Large size of the heart in old animals can be correlated with the increased body weight and size.

However, the mean thickness of left atrial wall from auricle region remained unaffected with advancing age in goats. The left ventricular wall of adults and old animals was significantly (P<0.05) thicker than the kids, indicating powerful ventricular walls in adults than kids, but no further change was observed during the age period of 22-24 months (Table 1).

Kidneys

Kidneys of both sides were unilobar, bean shaped and had smooth surface, enclosed by a thin capsule. The right kidney had a deeper indentation at the hilus than the left one. The mean absolute weights of left (39.4 ± 3.65g) and right kidneys (36.9 ± 2.04g) of goats were lower than those reported by Smith and Sherman (1994) in adult goats (100-160g) and Khan *et al.* (2003) in adult male (right = 66.41 ± 10.0g; left = 65.67 ± 9.97g) and female goats (right = 66.34 ± 10.98g and left = 65.40 ± 11.0g). These lower values for teddy goats can be attributed to

their small size. Similarly, the mean relative weights of right and left kidneys (0.18 ± 0.01%) were lower than 0.27-0.29% described by Wittmann (1959). So, these low relative weights can be characteristic of teddy goat breed.

Mean length, width and circumference of left and right kidneys of goats were less than those reported by Khan *et al.* (2003; right = 6.10 ± 0.40, 3.60 ± 0.50, 9.54 ± 1.10 cm; left = 6.30 ± 0.39, 3.59 ± 0.47, 9.49 ± 0.99 cm), while the mean thickness of medulla for both kidneys was recorded as 1.54 ± 0.05 cm for the right kidney and 1.56 ± 0.07 cm for the left kidney. The volume of the right and left kidneys was recorded as 35.82 ± 2.12 and 38.89 ± 3.18 cm^3 respectively (Table 2).

The absolute weight of right kidneys of male goats was significantly (P<0.05) higher than females, while no such difference was found for left. However, mean length, width, circumference, thickness of renal cortices and thickness of medulla for both kidneys were found statistically same in both sexes (Table 2). For both kidneys, volume in the male was higher than in females (P<0.05).

Absolute weight, length and width of both right and left kidneys were significantly (P<0.05) higher in old animals than those recorded in kids and adults. The difference between the latter two age groups was non significant (Table 2). The same was true for the circumference and volume of the left kidney. However, the relative weight and the mean thickness of medulla for both kidneys were non-significantly different among the goats of three age groups (Table 2).

Adrenal glands

Shape of the right adrenal was different from that of the left. The left adrenal was longer and flatter than right, the latter was bean shaped. The right and left adrenal glands weighed 0.78 ± 0.04 and 0.92 ± 0.04g, respectively, indicating significantly (P<0.05) lighter right adrenal than left one (Table 3). While relative weight for

both (right and left) adrenal glands was the same (0.01% each). Left adrenal gland (2.03 ± 0.04 cm) was significantly (P<0.05) longer than the right one (1.48 ± 0.04 cm). Prasad and Sinha (1981) reported mean values of 2-3 cm, so smaller values of width in the present study indicate smaller adrenals of teddy goats. There was no significant difference between the width of right and left adrenals (0.87 ± 0.03 and 0.87 ± 0.02 cm, respectively). Mean values for the circumference of right and left adrenals were recorded as 2.72 ± 0.08 and 2.62 ± 0.07 cm, respectively, while volume of the right and left adrenal glands averaged 1.08 ± 0.05 and 1.07 ± 0.03 cm^3, respectively (Table 3). Absolute weight, relative weight, length, width, circumference and volume of both adrenal glands did not differ between animals of the two sexes (Table 3).

Right adrenal gland showed significantly (P<0.05) higher absolute weight in adult and old goats than kids, whereas left adrenals in old animals were found significantly (P<0.05) heavier than the kids but not adults. However relative weight of both adrenals remained unaltered with advancing age. The same was true for the circumference and volume of both adrenals (Table 3).

No significant difference was found with respect to age for length of right adrenal gland, but the left adrenal glands of adults and old goats were significantly (P<0.05) longer than those of kids. Width of right adrenals in old goats was significantly (P<0.05) higher than adults.

Conclusion

It is conceivable from these findings that goats have a relatively more stable cardiovascular system. The development of heart, kidneys and adrenals showed an increase parallel to the advancing age to adjust with the increasing blood pressure due to physiological development process. Sex, however, played a secondary role.

Table 1: Mean values (± SEM) of different anatomical parameters of heart of teddy goats of two sexes and three age groups

Parameters	Overall average	Sex		Age groups		
		Male	Female	Kids	Adults	Old
Absolute weight (g)	94.47 ± 5.86	99.88 ± 10.47	89.06 ± 5.32	72.61 ± 3.96^B	77.62 ± 5.00^B	133.19 ± 9.03^A
Relative heart weight (%)	0.44 ± 0.01	0.42 ± 0.01	0.46 ± 0.02	0.41 ± 0.02 ^{B}	0.44 ± 0.02 ^{B}	0.46 ± 0.02 ^{A}
Volume (cm^3)	89.23 ± 4.99	93.56 ± 11.15	84.9 ± 4.60	65.85 ± 5.48^B	74.42 ± 5.26^B	127 ± 9.08^A
Length (cm)	7.89 ± 0.14	8.08 ± 0.23	7.71 ± 0.16	7.38 ± 0.22^B	7.57 ± 0.17^B	8.74 ± 0.16^A
Width (cm)	5.56 ± 0.20	5.60 ± 0.36	5.52 ± 0.19	4.76 ± 0.40^B	5.56 ± 0.23^{AB}	6.36 ± 0.24^A
Circumference (cm)	14.30 ± 0.34	14.33 ± 0.58	14.26 ± 0.37	13.22 ± 0.57^B	13.55 ± 0.48^B	16.12 ± 0.32^A
Right atrial wall thickness (cm)	0.15 ± 0.01	0.14 ± 0.01	0.15 ± 0.01	0.14 ± 0.01^B	0.12 ± 0.01^B	0.18 ± 0.01^A
Left atrial wall thickness (cm)	0.25 ± 0.02	0.27 ± 0.03	0.24 ± 0.01	0.28 ± 0.05	0.22 ± 0.01	0.25 ± 0.01
Right ventricular wall thickness (cm)	0.39 ± 0.02	0.39 ± 0.03	0.39 ± 0.02	0.36 ± 0.02^B	0.34 ± 0.03^B	0.46 ± 0.02^A
Left ventricular wall thickness (cm)	0.99 ± 0.05	0.94 ± 0.06	1.04 ± 0.05	0.84 ± 0.06^B	1.07 ± 0.10^A	1.06 ± 0.07^A

Different superscripts in the same row indicate significantly different values (P<0.05).

Table 2: Mean values (± SEM) of different anatomical parameters of kidneys of teddy goats of various groups

Parameters	Side	Overall average	Sex		Age groups		
			Male	Female	Kids	Adults	Old
Absolute weight (g)	Right	36.9 ± 2.04	39.3 ± 3.44	34.6 ± 2.2*	28.60 ± 1.22^B	32.10 ± 2.14^B	50.30 ± 2.96^A
	Left	39.4 ± 3.65	37.57 ± 2.14	35.7 ± 2.30	29.20 ± 1.10^B	31.80 ± 2.37^B	51.70 ± 3.11^A
Relative weight (%)	Right	0.18 ± 0.01	0.17 ± 0.01	0.19 ± 0.01	0.16 ± 0.01	0.180 ± 0.01	0.18 ± 0.01
	Left	0.18 ± 0.01	0.17 ± 0.01	0.19 ± 0.01	0.17 ± 0.01	0.180 ± 0.01	0.18 ± 0.01
Length (cm)	Right	5.5 ± 0.10	5.59 ± 0.16	5.40 ± 0.12	5.20 ± 0.09^B	5.20 ± 0.14^B	6.14 ± 0.14^A
	Left	5.7 ± 0.17	5.63 ± 0.10	5.50 ± 0.12	5.30 ± 0.12^B	5.30 ± 0.14^B	6.25 ± 0.14^A
Width (cm)	Right	3.6 ± 0.06	3.6 ± 0.11	3.63 ± 0.10	3.34 ± 0.06^B	3.50 ± 0.09^B	4.00 ± 0.08^A
	Left	3.4 ± 0.08	3.54 ± 0.07	3.60 ± 0.10	3.30 ± 0.05^B	3.40 ± 0.14^B	3.90 ± 0.09^A
Circumference (cm)	Right	9.9 ± 0.23	9.86 ± 0.37	9.91 ± 0.30	8.60 ± 0.27^C	9.90 ± 0.32^B	11.10 ± 0.22^A
	Left	9.95 ± 0.29	9.96 ± 0.21	9.90 ± 0.30	9.10 ± 0.14^B	9.80 ± 0.43^B	11.00 ± 0.19^A
Thickness of cortex (cm)	Right	0.67 ± 0.02	0.67 ± 0.04	0.67 ± 0.03	0.60 ± 0.02^B	0.60 ± 0.04^B	0.78 ± 0.04^A
	Left	0.69 ± 0.03	0.68 ± 0.02	0.68 ± 0.02	0.70 ± 0.02^A	0.60 ± 0.03^B	0.74 ± 0.03^A
Thickness of medulla (cm)	Right	1.54 ± 0.05	1.45 ± 0.07	1.60 ± 0.05	1.50 ± 0.06	1.40 ± 0.06	1.66 ± 0.10
	Left	1.56 ± 0.07	1.58 ± 0.04	1.60 ± 0.06	1.50 ± 0.07	1.50 ± 0.09	1.70 ± 0.08
Volume (cm^3)	Right	35.82 ± 2.12	39.2 ± 3.61	32.4 ± 2.05*	25.80 ± 1.28^C	$34.1 \pm .36^B$	47.60 ± 2.9^A
	Left	38.89 ± 3.18	35.9 ± 1.98	32.9 ± 2.21*	27.15 ± 1.62^B	33.8 ± 3.30^B	46.70 ± 2.5^A

Different superscripts in the same row indicate significantly different values (P<0.05). Asterisk (*) indicates significant difference between organs of two sexes.

Table 3: Mean values (± SEM) of various anatomical parameters of adrenals of teddy goats of various groups

Parameters	Side	Overall average	Sex		Age groups		
			Male	Female	Kids	Adults	Old
Absolute weight (g)	Right	0.78 ± 0.04*	0.79 ± 0.06	0.78 ± 0.06	0.62 ± 0.09^B	0.81 ± 0.04^A	0.92 ± 0.06^A
	Left	0.92 ± 0.04	0.87 ± 0.06	0.98 ± 0.07	0.77 ± 0.10^B	0.90 ± 0.05^{AB}	1.10 ± 0.05^A
Relative weight (%)	Right	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.003 ± 0.00	0.004 ± 0.00	0.003 ± 0.00
	Left	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.004 ± 0.00	0.01 ± 0.00	0.004 ± 0.00
Length (cm)	Right	1.48 ± 0.04*	1.44 ± 0.05	1.51 ± 0.07	1.51 ± 0.09	1.48 ± 0.06	1.44 ± 0.08
	Left	2.03 ± 0.04	1.98 ± 0.05	2.09 ± 0.06	1.86 ± 0.06^B	2.08 ± 0.06^A	2.16 ± 0.05^A
Width (cm)	Right	0.87 ± 0.03	0.91 ± 0.04	0.84 ± 0.04	0.84 ± 0.05^B	0.91 ± 0.03^{AB}	0.99 ± 0.04^A
	Left	0.87 ± 0.02	0.81 ± 0.02	0.93 ± 0.03	0.81 ± 0.02^B	0.85 ± 0.03^B	0.94 ± 0.05^A
Circumference (cm)	Right	2.72 ± 0.08	2.69 ± 0.11	2.75 ± 0.13	2.45 ± 0.18	2.92 ± 0.09	2.79 ± 0.11
	Left	2.62 ± 0.07	2.64 ± 0.12	2.59 ± 0.11	2.38 ± 0.16	2.74 ± 0.08	2.74 ± 0.11
Volume (cm^3)	Right	1.08 ± 0.05	1.03 ± 0.05	1.13 ± 0.07	1.02 ± 0.02	1.07 ± 0.08	1.16 ± 0.12
	Left	1.07 ± 0.03	1.04 ± 0.06	1.10 ± 0.03	1.03 ± 0.02	1.03 ± 0.05	1.15 ± 0.08

Different superscripts in the same row indicate significantly different values (P<0.05). Asterisk (*) indicates significant difference from the organ of the other side.

REFERENCES

Hussain R and AS Qureshi, 2007. Age related changes in the morphometric parameters of the heart, kidneys and adrenal glands of Nili-Ravi buffalo (*Bubalus bubalis*). Italian J Anim Sci, 6: 995-998.

Jaudas U and S Mobini, 2006. The Goat Handbook. Barron's Educational Series, New York, USA.

Khan H, MM Rind, R. Ahmad, N. Ahmad and G. Shah, 2003. Gross anatomical study on normal kidneys of adult goat. J Anim Vet Adv, 2(9): 539-541.

Michaelsson M and SY Ho, 2000. Congenital Heart Malformations in Mammals. World Scientific Publishing Co, Philadelphia, USA.

Prasad GR and RD Sinha, 1981. Micrometric observations on the adrenal glands of domestic animals. Indian J Anim Sci, 51: 1144-1147.

Reece WO, 2004. Functional Anatomy and Physiology of Domestic Animals. 3rd Ed, Lippincott Williams and Wilkins Co, Philadelphia, USA.

Rehan S and AS Qureshi, 2006. Morphometric analysis of heart, kidneys and adrenal glands in dromedary camel calves. J Camel Pract Res, 14(1): 27-31.

Saavedra JM and PB Trimmermans, 1994. Angiotension receptors. Plenum Publishing Corp., New York, USA.

Sajonski H and A Smollich, 1990. Cells and Tissues. 7th Ed, S Hirzel Verlag Leipzig, Leipzig, Germany.

Schroeder L, 1986. Morphological und physiological data of domestic and laboratory animals. S Hirzel Leipzig, Germany.

Seifert H, M Reissmann and S Wuschki, 1991. First results from a teddy goat population on the reproduction performance and concurrent studies on the body and cardiac mass development. Wiss Zschr D HU-Berlin, R Agarwiss, 40: 21-28.

Smith MC and DM Sherman, 1994. Goat Medicine. Lea and Febiger, Philadelphia, USA.

Wittmann E, 1959. The absolute and relative weight of kidneys of horse, cattle, calf, pig, sheep and goat. PhD Thesis, Humboldt University of Berlin, Germany.

WHO, 2009. Cardiovascular diseases. World Health Organization, http://www.WHO.int/cardiovascular_diseases/en