

PRENATAL DEVELOPMENT OF THE FOETAL KIDNEY IN GOAT- A BIOMETRICAL APPROACH

Tanvi Mahajan¹, Kamal Sarma², Jonali Devi³ and D. Chakraborty⁴

Division of Veterinary Anatomy, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu-181 102, Jammu and Kashmir, India

ABSTRACT

Received on: 17.07.2017

Accepted on: 25.08.2017

The present study was conducted on the kidneys of 22 goat foetii. These were then divided into three groups based on their estimated ages viz. Group 1 (below 50 days of gestation), Group 2 (between 50-100 days of gestation) and Group 3 (above 100 days of gestation up to full term) containing 6 number of foetii in each group. All the biometrical parameters under study (viz. length, width and thickness, weight, volume and shape index) of the kidneys increased significantly between each age group. Again, it was also found that such overall increase of the values pertaining to the said parameters were highly significant ($P < 0.01$) between different age groups. It was found that, the body weight of the foetii of different age groups showed highly significant ($P < 0.01$) positive correlation with various biometrical parameters of the kidney (metanephros). This indicated that mean values of these biometrical parameters increased with the increase in foetal body weight as the gestational ages of these goat foetii advanced.

Key words: Biometry, kidney, goat foetii

Introduction

Kidneys are the main organs of urinary system which are responsible for regulation of fluid volume, acid base balance and electrolyte composition (Banks, 1993). The development of kidney is a complicated process in all the mammals as it develops into pronephros, mesonephros and metanephros (Patten, 1953; Arey, 1962; Rouiller and Muller, 1969; Balinsky, 1970; Dyce *et al.*, 1987 and Latshaw, 1987). The pronephros and mesonephros degenerated during prenatal life but the metanephros forms in lumbar region and remains on the functional kidney in adults. The development of metanephros started from ureteric bud and nephrogenic blastema during prenatal life (Dubois, 1969; Balinsky, 1970; Carlson, 1985 and Latshaw, 1987). The development of metanephros in animals follows an accelerated time course when compared with the human (Canfield, 1980). In ungulates, it becomes functional at an early embryonic age due to low permeability of placenta (Davies, 1952). Paucity of available literature on the biometry of the kidney in goat foetii prompted this present study.

Materials and Methods

The present study was conducted on 22 goat foetii which were collected from the slaughter houses in and around Jammu city. They ranged from early pregnancy to near full term. Immediately after collection, the umbilical cords of these foeti were ligated properly and were cleaned with cotton soaked with water to remove the amniotic fluid. The weight of each foetus was recorded with the help of analytical balance. The approximate age of the foetii were calculated by putting the body weight values in the formula postulated by Singh *et al.* (1979) for estimation of age in goat foetii as mentioned below-

Formula for estimation of foetal age in goat (Singh *et al.*, 1979).

$$W^{1/3} = 0.096 (t-30).$$

Where, W= body weight of foetus in gm.

t= age of the foetus in days.

The collected foetii were then divided into three groups based on their estimated ages viz. Group I (below 50 days), Group II (between 50 to 100 days) and Group III (above 100 days of age), each group containing 6 number of foetii in each group. After estimation of age, the kidneys were used for biometrical studies. It included the recording of-

- i. Length (cm): Distance between two extremities of the kidneys.
- ii. Width (cm): Distance between two borders of the kidneys.
- iii. Thickness (cm): Distance between two surfaces of the kidneys.
- iv. Weight (g): It will be recorded using monopan electronic balance.
- v. Volume (ml): By water displacement method (Barnwal and Sinha, 1981).
- vi. Shape Index = width/length \times 100 (Barnwal and Sinha, 1981).

Results and Discussion

In the present study, the measurements pertaining to the mean values for length of the kidneys in the goat foetii of group-I were recorded as 0.434 ± 0.04 cm and 0.45 ± 0.04 cm for left and right kidneys, respectively (Table 1a). The overall value being 0.442 ± 0.04 cm. Again, the mean values for length of the kidneys in the goat foetii of group- II were found to be 1.12 ± 0.11 cm and 1.16 ± 0.12 cm for left and right kidneys, respectively. The overall value being 1.146 ± 0.12 cm. The mean values for length of the kidneys of the goat foetii pertaining to group- III were recorded as 2.08 ± 0.15 cm and 2.15 ± 0.16 cm for left and right kidneys, respectively, the overall value was 2.12 ± 0.16 cm. Comparable values were also reported in goat foetii by Malik and Vaish (1998) and Choudhury (2001). The length of the kidneys increased significantly ($P < 0.05$) between each group in both left and right kidneys. Also, analysis of variance indicated a highly significant ($P < 0.01$) overall variation in length of the kidney between different age groups under study. Such trend of growth was in accordance with the findings of Patten and Carlson (1977), who reported that variable growth and structural

¹Part of M.V.Sc. Thesis ²Associate Professor and corresponding author, email id: kamalsarma73@yahoo.com.; ³Associate Professor, Division of Veterinary Physiology & Biochemistry; ⁴ Assistant Professor, Division of AGB, F.V.Sc. & A.H., SKUAST-J, R.S. Pura, Jammu-181 102 (Jammu and Kashmir).

diversities at different stages of development of an organ is a normal phenomenon for accommodating and moulding of the organ. Also, it was observed that there was a significant growth of the kidneys (metanephros) in later stages of gestation than the earlier stages. A similar pattern of growth was also reported earlier in the kidney of pig foetii (Sarma and Ahmed, 2007) in other organs like scrotum (Malik *et al.*, 1995) in foetal goats.

The mean values for width of the kidneys of the goat foetii pertaining to group- I were recorded as 0.316 ± 0.02 cm and 0.316 ± 0.02 cm for left and right kidneys, respectively (Table 1a). The overall value being 0.316 ± 0.02 cm. Similarly, the mean width of the kidneys of the goat foetii of group-II were recorded as 0.822 ± 0.08 cm and 0.823 ± 0.07 cm for left and right kidneys, respectively. The overall value being 0.822 ± 0.08 cm. The measurements of the mean width of the kidney in the goat foetii pertaining to group- III were recorded as 1.49 ± 0.10 cm and 1.47 ± 0.10 cm for left and right kidneys, respectively with the overall value as 1.48 ± 0.10 cm. Again, the mean thickness of the kidneys in the goat foetii of group-I were recorded to be 0.26 ± 0.03 cm and 0.26 ± 0.03 cm for left and right kidneys, respectively with an overall value of 0.26 ± 0.03 cm. Similarly, the mean values for thickness of the kidneys in the goat foetii pertaining to group-II were recorded as 0.69 ± 0.07 cm and 0.73 ± 0.07 cm for left and right kidneys, respectively. The overall value being 0.71 ± 0.07 cm. Again, the measurements pertaining to the mean thickness of the kidney of the goat foetii of group-III were recorded as 1.27 ± 0.05 cm and 1.25 ± 0.08 cm for left and right kidneys, respectively (Table 1a). The overall value being 1.26 ± 0.06 cm. Almost similar values of the metanephros was reported in foetal goat (Choudhury, 2001) and higher values in prenatal camel kidneys in comparable age groups (Salehi and Morovati, 2012). It was observed that the width and thickness of the kidneys differed significantly ($P < 0.05$) between each group in both left and right kidneys. Also, there was a highly significant ($P < 0.01$) overall variation in width of the kidney between different age groups. Such increase in width and thickness was also reported in goat foetii (Gopinath *et al.* 1997).

In the present study, the weight of the kidneys of goat foetii pertaining to group-I could not be measured due to very small size of the same. However, the measurements pertaining to the mean weight of the kidneys of the goat foetii of group-II were recorded as 0.68 ± 0.15 g and 0.68 ± 0.16 g for left and right kidneys, respectively (Table 1b). The overall value being 0.68 ± 0.16 g. Also, the mean weight of the kidneys of the goat foetii pertaining to group-III were recorded as 3.10 ± 0.53 g and 2.95 ± 0.56 g for left and right kidneys, respectively. The overall value being 3.02 ± 0.54 g. The weight of the kidneys significantly ($P < 0.05$) increased between groups II and III in both left and right kidneys. Also, there was a highly significant ($P < 0.01$) overall variation in weight of the kidney between different age groups under study (Table 2a). Again, the weight of the left kidney was found to be significantly higher ($P < 0.05$) than that of the right one in third trimester fetuses. This was in accordance with the findings of Salehi and Morovati (2012) in camel foetii and Sarma and Ahmed (2007) in crossbred pig foetii. The overall gain in weight of the kidney corresponded closely to the gain in body weight of the foetus with increase in foetal CRL and age. Similar pattern of growth of the metanephric kidney in regard to its weight was reported in goat foetii (Gopinath *et al.*, 1997 and

Choudhury, 2001). In contrast to the present findings, Sarkar *et al.* (1977) reported gradual increase in weight of kidney in pig from 5.1 gm at birth to 29.5 gm at day 50 of age. Eisenbrandt and Phemister (1979) studied the growth rate of kidney in dogs and recorded a quantitative increase in weight from 22 to 200 days of age. Punita (1995) observed an abrupt and disproportionate increase in weight of the kidneys in goats between 6 and 12 months of age as compared to that on 0-3 months of age range.

The mean values for volume of the kidneys in goat foetii pertaining to group-I could not be measured due to very small size of the same. The mean values of volume of the kidneys in the goat foetii of group-II were recorded as 0.78 ± 0.10 ml and 0.78 ± 0.14 ml for left and right kidneys, respectively (Table 1b). The overall value being 0.78 ± 0.11 ml. Again, the mean volumes of the kidney in the goat foetii of group-III were recorded as 3.50 ± 0.40 ml and 3.75 ± 0.47 ml for left and right kidneys, respectively. There was a significant ($P < 0.05$) increase in volume of the kidneys between groups-II and III for both left and right kidneys with a highly significant ($P < 0.01$) overall variation in volume of the kidney between different age groups under study. This showed that the kidneys (metanephros) had a significantly more growth in terms of its volume in the later parts of gestation period as compared to the earlier one. Similar growth of the kidney in regard to its volume had been reported in pig foetii (Sarma and Ahmed 2007). However, Salehi and Morovati (2012) observed that the volume of the left and right kidneys showed significant increase in values between first and second trimester in camel foetii. This finding was in contrast to the present work.

In this study, the mean values of shape index of the kidneys of the goat foetii of group-I were recorded as $52.58 \pm 13.42\%$ and $50.94 \pm 13.22\%$ for left and right kidneys, respectively (Table 1b). The overall value being $51.76 \pm 13.24\%$. Again, the same values of group- II were recorded to be $73.27 \pm 1.55\%$ and $71.81 \pm 2.00\%$ for left and right kidneys, respectively with an overall value of $72.54 \pm 1.41\%$. Also, the mean values for shape index of the kidney of the goat foetii pertaining to group- III were recorded as $71.64 \pm 1.45\%$ and $68.45 \pm 1.33\%$ for left and right kidneys, respectively. The overall value being $70.05 \pm 1.29\%$. However, unlike the other biometrical parameters, the shape index of the kidneys showed no significant ($P < 0.05$) variation between the age groups (Table 2b).

It was found that, the body weight of the foetii of different age groups showed highly significant ($P < 0.01$) positive correlation with various biometrical parameters of the kidney (metanephros) *viz.* length, width, thickness, shape index, weight and volume (Table 3). This indicated that mean values of these biometrical parameters increased with the increase in foetal body weight as the gestational ages of these goat foetii advanced. The highly significant correlation showed by these parameters confirmed not only a mere relationship but also their role in allometric growth of the kidney at all the prenatal age groups. Similar findings were also previously reported in goat foetii (Gopinath *et al.*, 1997).

Again, studies on the percent of growth between different age groups pertaining to various biometrical parameters revealed that, the mean length, width and thickness of the kidneys (metanephros) increased 38.57%, 38.44% and 36.77% between age groups- I and II,

Table 1a: Biometry of the kidney in goat foetii at different age groups.

	Length (cm)			Width (cm)			Thickness (cm)		
	Left	Right	Overall	Left	Right	Overall	Left	Right	Overall
Gp I	0.434 ^a ± 0.0414 (06)	0.450 ^a ± 0.0404 (06)	0.442 ^a ± 0.0407 (06)	0.316 ^a ± 0.0248 (06)	0.316 ^a ± 0.0234 (06)	0.316 ^a ± 0.0218 (06)	0.260 ^a ± 0.0346 (06)	0.268 ^a ± 0.0320 (06)	0.264 ^a ± 0.0322 (06)
Gp II	1.124 ^b ± 0.116 (10)	1.169 ^b ± 0.127 (10)	1.146 ^b ± 0.121 (10)	0.822 ^b ± 0.0838 (10)	0.823 ^b ± 0.0785 (10)	0.822 ^b ± 0.0805 (10)	0.698 ^b ± 0.0795 (10)	0.737 ^b ± 0.0761 (10)	0.718 ^b ± 0.0771 (10)
Gp III	2.087 ^c ± 0.159 (06)	2.155 ^c ± 0.166 (06)	2.121 ^c ± 0.160 (06)	1.490 ^c ± 0.103 (06)	1.472 ^c ± 0.103 (06)	1.481 ^c ± 0.101 (06)	1.273 ^c ± 0.0543 (06)	1.258 ^c ± 0.0876 (06)	1.266 ^c ± 0.0689 (06)

Figures in parenthesis are number of animals; Values with different superscript differ significantly.

Table 1b: Biometry of the kidney in goat foetii at different age groups.

	Weight (gm)			Volume (ml)			Shape Index (%)		
	Left	Right	Overall	Left	Right	Overall	Left	Right	Overall
Gp I	-	-	-	-	-	-	52.580 ± 13.427 (06)	50.940 ± 13.223 (06)	51.760 ± 13.247 (06)
Gp II	0.682 ^a ± 0.153 (11)	0.682 ^a ± 0.168 (11)	0.682 ^a ± 0.160 (11)	0.786 ^a ± 0.101 (07)	0.786 ^a ± 0.149 (07)	0.786 ^a ± 0.115 (07)	73.279 ± 1.559 (11)	71.819 ± 2.001 (11)	72.549 ± 1.415 (11)
Gp III	3.100 ^b ± 0.539 (06)	2.950 ^b ± 0.563 (06)	3.025 ^b ± 0.548 (06)	3.500 ^b ± 0.408 (06)	3.750 ^b ± 0.479 (06)	3.625 ^b ± 0.422 (06)	71.643 ± 1.457 (06)	68.457 ± 1.337 (06)	70.050 ± 1.298 (06)

Figures in parenthesis are number of animals; Values with different superscript differ significantly.

Table 2a: Results of analysis of variance of biometrical values of the kidney showing significance of difference between various age groups in goat foetii.

	DF	Length (cm)			Width (cm)			Thickness (cm)		
		Left	Right	Overall	Left	Right	Overall	Left	Right	Overall
Source of variation	MS									
Between Groups	2	3.848**	4.086**	3.966**	1.929**	1.863**	1.896**	1.436**	1.351**	1.392**
Residual	19	0.119	0.139	0.127	0.0580	0.0530	0.0540	0.0425	0.0467	0.0430
Total	21									

d.f. = Degree of freedom; S.S. = Sum of squares; M.S.S. = Mean sum of squares; ** = P<0.01

Table 2b: Results of analysis of variance of biometrical values of the kidney showing significance of difference between various age groups in goat foetii

	DF	Weight (gm)			Volume (ml)			Shape Index (%)		
		Left	Right	Overall	Left	Right	Overall	Left	Right	Overall
Source of variation	MS									
Between Groups	1	22.702**	19.973**	21.316**	23.802**	28.389**	26.045**	1008.972	983.340	994.595
Residual	15	0.752	0.839	0.787	0.494	0.709	0.536	376.342	373.204	363.869
Total	16									

d.f. = Degree of freedom; S.S. = Sum of squares; M.S.S. = Mean sum of squares; ** = P<0.01

Table 3: Correlation of various biometrical parameters of the kidney of goat foetii with body weight and CRL

	Length (cm)	Width (cm)	Thickness (cm)	Shape Index (%)	Weight (gm)	Volume (ml)
Body weight	0.934678**	0.917514**	0.898274**	-0.38736	0.986758**	0.885292**
CRL	0.976436**	0.975609**	0.974073**	-0.35706	0.887222**	0.853685**

respectively and 97.5%, 55.50% and 56.71% between age groups-II and III, respectively (Table 4). Also, the weight and volume of the kidneys (metanephros) increased 22.55% and 21.68% between age groups-II and III, respectively. This indicated a significant growth of the kidneys (metanephros) in later stages of gestation than the earlier stages. Such enhanced growth of the foetal kidney during the latter part of pregnancy was also reported in pig (Sarma and Ahmed 2007).

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Table 4: Percentage of increase in growth of the kidneys in goat foetii in terms of various biometrical parameters between different age groups

Parameters	Length (cm)	Width (cm)	Thickness (cm)	Weight (gm)	Volume (ml)
Age groups					
Between I & II	38.57 ^a	38.44 ^a	36.77 ^a	-	-
Between II & III	97.5 ^b	55.50 ^b	56.71 ^b	22.55	21.68

Values with different superscript differ significantly.

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