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Histomorphometrical studies on the postnatal alterations in the renal corpuscle of Indian domestic pig (*Sus scrofa domesticus*)

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Abstract
Histomorphometrical studies were conducted to measure the growth changes in renal corpuscle (RC) and glomerular size in subcapsular, midcortical and juxtamedullary zones of postnatal porcine kidney. The study was carried out in the Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar on eighteen pairs of fresh kidney specimens collected from slaughter houses in and around Hyderabad. There was a significant increase in RC diameters in all the three zones as age advanced. Larger RCs were seen in the juxtamedullary zone of groups I and II while no significant change was observed in the mean diameters of RC between the three zones of Group III. There was a significant increase in glomerular diameters in all the three zones with age. The mean diameters of the glomeruli were highest in the Juxtamedullary zone in Groups I and II while there was no significant variation in the mean diameter of glomeruli among the three zones in Group III. Number of RCs decreased as age advanced in the Subcapsular and midcortical zones while there was no significant decrease in number of RCs in the juxtamedullary zone. The renal corpuscles were numerous in the subcortical zones of the kidneys.

Keywords: Renal corpuscle, glomerulus, diameter

Introduction
The highly stratified mammalian kidney is a vital organ and exhibits significant cellular complexity and functional diversity. The newborn kidney is functionally non-efficient with low glomerular filtration rate, limited capacity to reabsorb sodium and a low ability to concentrate urine. The knowledge of age-related changes in renal corpuscle (RC) has important clinical significance as they are associated with a declining renal function. Future studies may permit manipulation of observed alterations and help in retardation of premature renal aging. The present study was aimed to obtain anatomical information about age related postnatal morphometrical changes of renal corpuscle in the kidney of pig as it is now being used extensively in urological research.

Materials and Methods
The present investigation was carried out in the Department of Veterinary Anatomy, College of Veterinary Science, Rajendranagar, Hyderabad, India. Eighteen pairs of fresh kidney specimens were collected from three age groups *viz.*, Group I (0-4 weeks), Group II (4-8 weeks) and Group III (>10 weeks) of pigs at regular weekly intervals.
The following micrometrical observations were made using ocular and stage micrometers under light microscope after routine paraffin processing.

1. Size of the Bowman's capsule in 'µm' was noted in all three zones of renal cortex in all three postnatal groups.
2. Size of the glomerulus in 'µm' was recorded in all three zones of renal cortex in all three postnatal groups.
3. Number of renal corpuscles per unit area was recorded in three zones of Groups II and III.

The collected data was analysed statistically using one way ANOVA and the means were tested for significance by Turkey's HSD test using SPSS (2009) [16] Version 16.0.

The present investigation and its experimental design were approved by the Institutional Animal Ethics Committee vide No.39/24/IAEC-Pig/ C.V.Sc./ Hyd. Dt: 12.06.2021.

Results

The renal corpuscles were arbitrarily divided into subcapsular, mid-cortical and juxtamedullary in position (Fig 1).

Subcapsular zone

The mean diameters of the RCs, glomeruli and urinary space in the subcapsular zone were significantly higher in III Group than in I and II. However, the diameters of the above mentioned parameters showed no significant variation between Groups I and II. The number of renal corpuscles were ennumerated in Groups II and III after the disappearance of nephrogenic zone in which fully formed nephrons were not present. There was a significant decrease in the number of renal corpuscles in Group III compared to Group II (Table 1).

Midcortical zone

The mean diameters of the RCs, glomeruli and urinary space in the midcortical zone were higher in Group III than in Groups I and II. No significant variation was observed in the diameters between Groups I and II. However significant decrease was observed in the number of RC per unit area of midcortical region in Group III than in Group II (Table 2).

Juxtamedullary zone

Significant increase was observed in the mean diameters of the RCs, glomeruli and urinary space in the juxtamedullary zone in Group III. No significant variation was observed in their diameters between Groups I and II. No significant variation was recorded in the number of RC per unit area between Groups II and III in the juxtamedullary zone. The diameters of RC, glomeruli and urinary space increased in the juxtamedullary zone as age advanced while the number of RCs were constant in the juxtamedullary zone. (Table 3).

Group I

Diameter of the RCs varied in the three zones of renal cortex in Group I. The diameters of RCs were significantly higher in juxtamedullary zone in Group I. The diameters of RCs in the midcortical region were comparable with both subcapsular and juxtamedullary zones of Group I. The glomerular diameters were significantly higher in midcortical and juxtamedullary zones when compared to subcapsular zones in Group I. There was no statistically significant variation in the glomerular diameters between midcortical and juxtamedullary zones. However, the urinary space diameter remained constant in all the zones of Group I (Table 4).

Group II

Diameter of the RCs also varied in the three zones of renal cortex of Group II. The diameters of RCs and glomeruli were slightly larger in juxtamedullary zone followed by midcortical and subcapsular zones in Group II. The diameters of RCs and glomeruli in the midcortical zones were comparable with the subcapsular and juxtamedullary zones of Group II. There was no significant variation in the urinary space between the three zones of Group II. The number of RCs per unit area varied significantly among the three zones of Group II. Highest number of renal corpuscle were observed in the subcapsular zone followed by midcortical and subcapsular zones (Table 5).

Group III

There was no significant change in the diameter of RCs, glomeruli and urinary space in between the three regions of the renal cortex in Group III. However, the number of RCs per unit area decreased significantly in the juxtamedullary zone of Group III (Table 6).

Discussion

Kriz and Kaissling (1992) [10] in mammals and Al-Jeboril *et al*. (2014) [1] in white rabbits divided the RCs into cortical, mid-cortical and juxtamedullary renal corpuscles based on their distribution from capsule to the medulla which is akin to our classification in the present study.

Between zones

The mean diameters of the RCs, glomeruli and urinary space in the subcapsular, midcortical and juxtamedullary zones were significantly higher in Group III than in I and II whereas the diameters of the above mentioned parameters showed no significant variation between Groups I and II. These findings concur with Kittelson (1917) [9] who reported that there was a constant increase in average diameter of renal corpuscles from three weeks to the adult rats. These records further concord with observations of Arataki (1926) [2], Webb (1968) [17] and Stanchev *et al.* (2018) [15] who reported that there was a progressive increase in the size of glomeruli with age in both superficial and juxtamedullary regions in rat kidney. In line with these reports, Ichikawa *et al.* (1979) [8] have also reported that increase in the glomerular surface area available for filtration contributed to the rise in the ultrafiltration coefficient which rises with age in rats. Olivetti *et al.* (1980) [13] reported that urinary space diameter increased as age advanced in rats.

However there was a significant decrease in the number of renal corpuscles in Group III compared to Group II in both subcapsular and midcortical zones which is contrary to findings of Bonvalet *et al.*, (1972) [3] who reported that the number of glomeruli increased markedly until 100 days of age and remained fairly constant afterwards in rat kidneys. However consistent with our observations, Horster *et al.* (1971) [6] documented that the total number of glomeruli seemingly declined during the postnatal development of kidney due to the increase in cortical volume with age in dogs. No significant variation was recorded in the number of RC per unit area between Groups II and III in the juxtamedullary zone. Similarly, no significant change was observed in the number of corpuscles from three weeks of age to maturity in rats (Kittelson. 1917) [9] and in the developing canine kidney (Eisenbrandt and Phemister 1979) [4].

Between groups

Diameter of the RCs and glomeruli varied in the three zones of renal cortex in Group I and II while was no significant change was observed in Group III. The diameters of RCs were significantly higher in juxtamedullary zone in Groups I and II. The diameters of RCs in the midcortical region were comparable with both subcapsular and juxtamedullary zones of Group I and II. The glomerular diameters were significantly higher in juxtamedullary zone than in the subcapsular zone of Group I and II. Similar observations were made by Olivetti *et al.* (1980) [13] in rats Ichii *et al.* (2006) [7] in rodents, Seal (2019) in guinea pigs and Al-Jeboril *et al.* (2014) [1] in rabbits. They stated that the juxtamedullary RCs were largest among the three zones. In contrary, Mbassa (1988) [11] reported that superficial renal corpuscles were larger than the juxtamedullary ones in *Bos taurus*. Yadava and Calhoun (1955) [18] further reported that the glomeruli were larger in juxtamedullary region than the cortical region in the pig, horse, dog, and cat.

However, the diameters in midcortical zone was significantly higher than those in the subcapsular zone in Group I while they were comparable with subcapsular and juxtamedullary zones in Group II. There was no statistically significant variation in the glomerular diameters between midcortical and juxtamedullary zones in Group I. There was no significant change in the diameter of RCs, glomeruli and urinary space in between the three regions of the renal cortex in Group III. This is in line with the findings of Olbing *et al.* (1973) [12] who stated that the glomeruli in the inner zone were larger than those in the outer zone but this difference vanished as the kidney grew in size in dogs.

The urinary space diameter remained constant in all the zones of Group I, II and III. In contrary, Olivetti *et al.*, (1980) [13] reported that the bowmans space was higher in renal corpuscles of juxtamedullary zones than the subcapsular and midcortical zones in young and adult rats.

The number of RCs per unit area varied significantly among the three zones of Group II and III. Highest number of renal corpuscle were observed in the subcapsular zone followed by midcortical and juxtamedullary zones (Table 5). These findings concurred with the reports of Kriz and Kaissling (1992) [10] in mammals, Al-Jeboril *et al*., (2014) [1] and Fayez *et al.*, (2014) [5] in rabbits. However these findings disagree with the observations of Horster *et al*., (1971) [6] who stated that the fraction of total number of glomeruli were lowest in the subcapsular zone and highest in the midcortical zone in dogs.

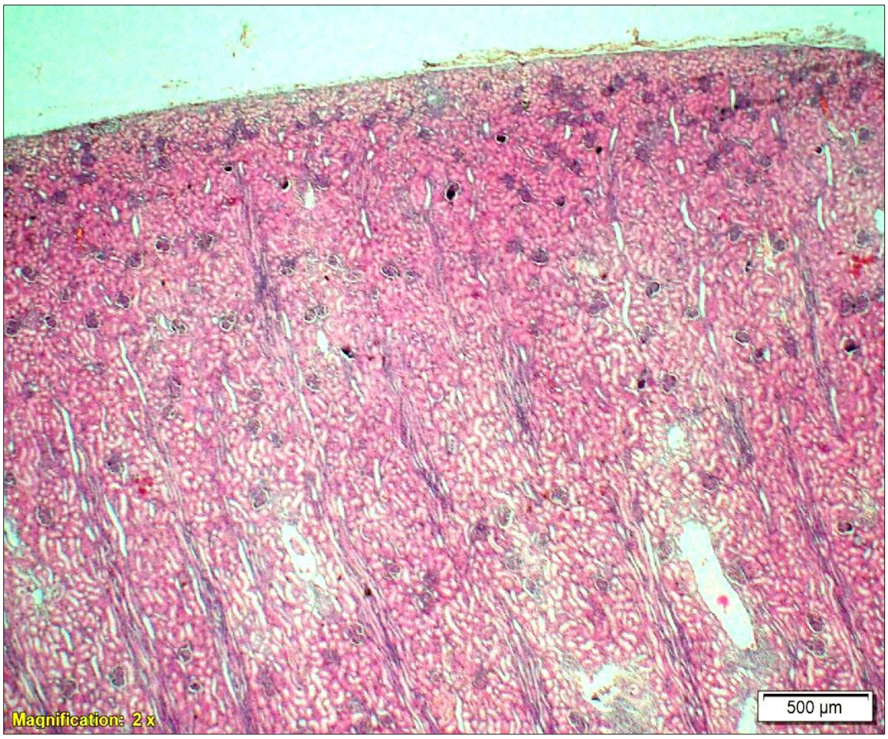

Fig 1: Photomicrograph showing the distribution of renal corpuscles in the subcapsular (SC), midcortical (MC) and juxtamedullary (JM) zones. H &E 20X

Table 1: Comparison of the mean diameters of RC, Glomerulus, Urinary space and Number of RCs per unit area (490512.47 sq. µm) in the subcapsular zone of groups I, II and III.

	Group I	Group II	Group III
RC DIAMETER (µm)	62.97±1.97^{a}	74.29±0.78^{a}	102.46±6.91^{b}
GLOMERULUS DIAMETER (µm)	54.86±1.43^{a}	63.49±0.93^{a}	85.90±5.94^{b}
URINARY SPACE (µm)	8.15±1.27^{a}	10.79±0.88^{a}	16.55±1.82^{b}
NUMBER OF RC		11.28±0.33^{a}	6.5±0.44^{b}

$^{a, b}$ Values with different superscripts in a row differ significantly (p<0.05).

Table 2: Comparison of the mean diameters of RC, Glomerulus, Urinary space and Number of RCs per unit area (490512.47 sq. µm) in the midcortical zone of different groups I, II and III.

	Group I	Group II	Group III
RC DIAMETER (µm)	68.75±1.82^{a}	77.34±1.30^{a}	112.81±7.80^{b}
GLOMERULUS DIAMETER (µm)	59.55±1.24^{a}	65.92±1.22^{a}	94.72±7.18^{b}
URINARY SPACE (µm)	9.20±1.19^{a}	11.42±0.86^{a}	18.08±1.68^{b}
NUMBER OF RC		7.11±0.25^{a}	5.55±0.43^{b}

$^{a, b}$ Values with different superscripts in a row differ significantly (p<0.05)

Table 3: Comparison of the mean diameters of RC, Glomerulus, Urinary space and number of RCs per unit area (490512.47 sq. µm) in the juxtamedullary zone of groups I, II and III.

	GROUP I	GROUP II	GROUP III
RC DIAMETER (µm)	70.14±1.45[a]	80.59±1.24[a]	124.28±9.61[b]
GLOMERULUSDIAMETER (µm)	60.12±0.1[a]	68.02±1.13[a]	102.40±8.19[b]
URINARY SPACE (µm)	10.01±1.39[a]	12.57±0.97[a]	21.88±2.41[b]
NUMBER OF RC		4.89±0.21[a]	4.39±0.14[a]

[a, b] Values with different superscripts in a row differ significantly ($p<0.05$).

Table 4: Comparison of the mean diameters of RC, Glomerulus, Urinary space and number of RCs per unit area (490512.47sq.µm) in different regions of Group I.

	SCZ	MCZ	JMZ
RC DIAMETER (µm)	62.97±1.97[a]	68.75±1.82[ab]	70.14±1.42[b]
GLOMERULUS DIAMETER (µm)	54.86±1.43[a]	59.55±1.24[b]	60.12±0.81[b]
URINARY SPACE (µm	8.15±1.27[a]	9.20±1.19[a]	10.01±1.39[a]

[a, b] Values with different superscripts in a row differ significantly ($p<0.05$).

Table 5: Comparison of the mean diameters of RC, Glomerulus, Urinary space and number of RCs per unit area (490512.47sq.µm) in different zones of Group II.

	SCZ	MCZ	JMZ
RC DIAMETER (µm)	74.29±0.78[a]	77.34±1.30[ab]	80.59±1.24[b]
GLOMERULUS DIAMETER (µm)	63.49±0.93[a]	65.92±1.22[ab]	68.02±1.13[b]
URINARY SPACE (µm)	10.79±0.88[a]	11.42±3.68[a]	12.57±0.97[a]
NUMBER OF RC	11.28±0.33[a]	7.11±0.25[b]	4.89±0.21[c]

[a, b] Values with different superscripts in a row differ significantly ($p<0.05$)

Table 6: Comparison of the mean diameters of RC, Glomerulus, Urinary space and number of RCs per unit area (490512.47 sq.µm) in different zones of Group III.

	SCZ	MCZ	JMZ
RC DIAMETER(µm)	102.46±6.91[a]	112.81±7.80[a]	124.28±9.61[a]
GLOMERULUS DIAMETER (µm)	85.90±5.94[a]	94.72±7.18[a]	102.40±8.19[a]
URINARY SPACE (µm)	16.55±1.82[a]	18.08±1.68[a]	21.88±2.41[a]
NUMBER OF RC	6.5±0.44[a]	5.55±0.43[ab]	4.39±0.14[b]

[a, b] Values with different superscripts in a row differ significantly ($p<0.05$)

Conclusion

RC and glomerular diameters in all the three zones increased as age advanced due to increase in demand for filtration. Larger RCs and glomeruli were seen in the juxtamedullary zone of groups I and II. The presence of fully formed larger glomeruli in the juxtamedullary zone and immature nephrons in the subcapsular zone in the early postnatal life confirms that nephrogenesis proceeds centrifugally. There was no significant change in the mean diameters of RCs and glomeruli between the three zones of Group III. Renal corpuscles were numerously detected in the subcortical zones of the kidneys in Groups II and III. Number of RCs decreased as age advanced in the subcapsular and midcortical zones while no significant change was observed in the juxtamedullary zone. Decrease in the number of RCs might be due to the increase in other cortical components like interstitium and other tubular components with age.

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Conflict of Interest

There is no conflict of interest among the authors.

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