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Morphometric values during metanephrus development in *Camelus dromedarius* in the first half of foetal life

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Abstract

The development of the metanephrus in 25-450 mm VRL *Camelus dromedarius* fetuses was studied. The work involved morphometric evaluations of histological sections of the metanephrus. The areas of cortex and medulla and their ratio related to embryo-foetal age were obtained. The number of glomeruli were determined and their density was calculated. The morphometric data attributed to the metanephrus during development were compared and agree with similar observations of the adult camel kidney.

Introduction

The mammalia metanephrus or kidney arises from two separate grafts (metanephric blastema and ureteric blad) which then grow and permeate each other. Nephrons develop from the first graft, while the collecting duct system, renal pelvis and ureter develop from the ureteric blad. During development, the renal corpuscles and part of the renal tubules are localised in the external parts of the kidney and constitute the renal cortex; the internal parts of the kidney are devoid of renal corpuscles, but are occupied by the distal limbs of loops of Henle, collecting ducts which constitute the renal medulla. A study of camel metanephrus development could help to explain the particular anatomo-physiological characteristics of the adult kidney which produces highly concentrated urine. This specific function is possible because the camel kidney is very sensitive to the vasopressine hormone (Mac Farlane et al. 1971), and its anatomical features, such as the length of the loops of Henle, permit extensive tubular reabsorption (Abdalla and Abdalla 1979; Schmidt-Nielsen and Schmidt-Nielsen, 1952; Rabhi et al. 1996). As noted by Sperberg (1944) in different mammals living in arid habitats, some anatomical structures of the kidney vary. Moussa (1982) also noted that in the JG complex of the one-humped camel there were granular cells containing renin involved in a hypertensive effect by means of its action on angiote-nsin, giving a sodium retaining effect by stimulating aldosterone production.

This paper analyses morphometrically and reports some measurements made on the metanephrus structures of the one-humped camel in the first half of foetal life in an attempt to trace the development of characteristic structures concerning the renal anatomy and physiology.

Material and Methods

Twenty-nine kidneys of *Camelus dromedarius* embryos and fetuses with VRL ("Vertebral Rump Length" is the distance between the occipital protuberance and the base of the tail) between 25 and 450 mm were examined. Foetal ages ranging from 2 to 6 months were estimated from the regression equation of foetal age with VRL (Canavese and Benvenuti 1982). The material sampled was embedded in paraffin and cut with a Leitz microtome; the 5-8 µm thick sections were stained with hematoxylin-eosin and Van Gieson and observed under L.M. Morphometric analysis was carri-ed out on the sagittal and cross serial sections cut through the kidney ilus of embryos of 80-450 mm VRL, observed under a Dokumator Zeiss image reader or Leitz-Neo-Promar microscopy. The images were proj-ected and drawn on paper; then, with a Schlumber-ger 6451 graphic table and "3-D RECON" software (obtained from the High Voltage Electron Microscopy Laboratory of Colorado University), area values for cortex, medulla, pelvis (that is, each tissue excluded from the cortex and medulla, such as pelvis adipose and connective tissues or blood vessels and the pelvis cavity according to Dunnill and Halley 1973) and the number of glomeruli were obtained. The ratios between cortical and medullar area and glomerular density, referring to the cortical area, were calculated.

Statistical analysis. The length and width of all the metanephroi were measured and the regression and correlation coefficient (r^2) with VRL were calculated. Mathematical equations was used in each instance, with a criterion for accepting the models being that the correlation coefficient (r^2) exceeded 0.7. The variation of cortical and medullar surfaces relating to the VRL was fitted to the polynomial model ($y=a+bx+cx^2+dx^3$), whereas to correlate the ratio of the areas with VRL, the exponential model ($y= a*exp^{(bx)}$), where x is VRL (mm), was chosen (SAS, 1988).

Results and Discussion

In one-humped camel fetuses of about 200-250 mm VRL, when the mesonephrus regresses (Canavese and Ibrahim 1985; Colitti et al 1988) the metanephrus development is at a very advanced stage and it is possible to observe medullar rays, renal pyramids, major renal calices and dilated vessels. The nephron induction is

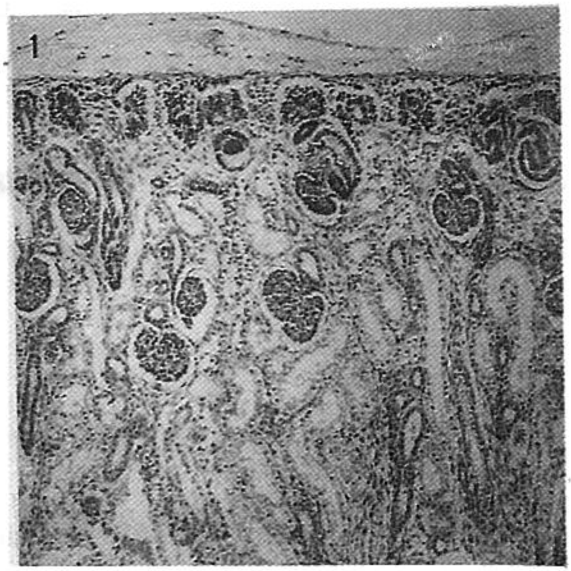

Fig. 1: *Dromedary foetus. 320 mm VRL.* Metanephrus. x20.

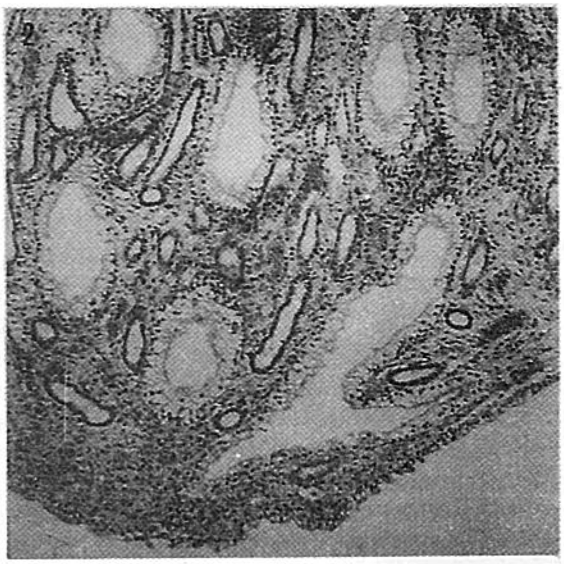

Fig. 2: *Dromedary foetus. 320 mm VRL.* Metanephrus. x21.

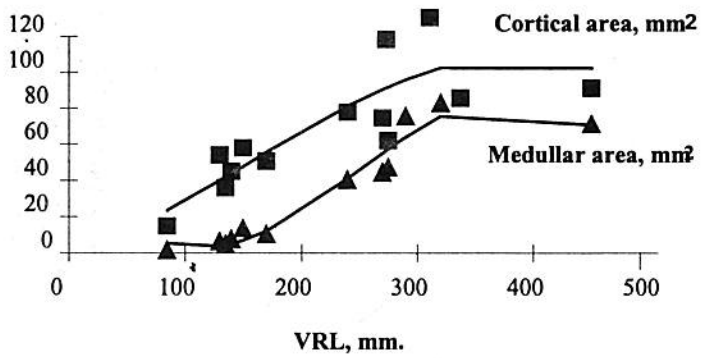

Fig. 3: Distribution and regression plots of the medullar and cortical surfaces relating to embryo-foetal ages.

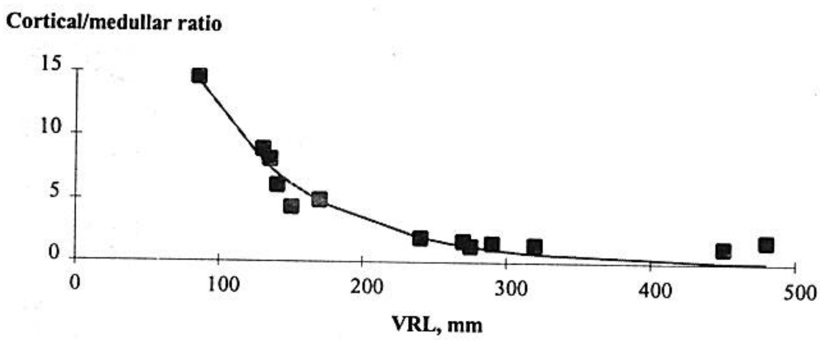

Fig. 4: Distribution and regression plot of the ratio between cortical and medullar surfaces relating to embryo-foetal ages.

Table 1

FETUSES		METANEPHRUS						
ROUPS	VRLength	LENGTH	WIDTH	TOTAL	CORTICAL	MEDULLAR	PELVIC	C/M
I	80-85	7.6±0.28	3.5±0.55	16.26	15.08 (92.74)	1.03 (6.33)	0.15 (0.93)	16.64
II	130-140	11.9±0.81	5.8±0.3	51.16	42.67 (83.40)	5.56 (10.87)	2.93 (5.73)	7.67
III	150-170	16.3±1.3	7.1±0.38	68.70	53.19 (77.42)	11.21 (16.32)	4.30 (6.26)	4.74
IV	210-240	21.0±0.53	8.8±0.33	138.40	80.23 (57.97)	42.65 (30.82)	15.52 (11.21)	1.88
V	270-290	22.9±0.4	9.2±0.08	155.19	84.18 (54.24)	55.23 (35.59)	15.78 (10.17)	1.52
VI	320-450	24.6±0.21	9.4±0.14	200.60	103.35 (51.52)	76.71 (38.24)	20.54 (10.24)	1.35

shown particularly underneath the metanephric capsule from foeti with 240 mm VRL and persists again in older fetuses (Fig.1). The considerable development of loops of Henle tubular tracts is evident particularly from foeti of 240-300 mm VRL, when the values of the medullar area approach those of the cortex; in these cases, loops of Henle reach near the apices of the pyramids and are numerous among terminal collector ducts (Fig. 2).

As the values reported in Table I show, the distribution of the length and width of the foetal meta-nephroi as a function of the VRL and the regression equations demonstrated a significant correlation betw-een VRL (that is between the age of the fetuses) and the length measurements (r^2 = 0.706; S.E.= 3.44). The cortical surface in the different groups of embryos and fetuses increased from 15.1 to 103.3 mm^2 following the polynomial model: $y= -2.366+2.296x+0.104x^2-0.0023 x^3$, ($r^2$ = 0.952; S.E. = 7.42) where x is the VRL (mm); for the medullar surface, which increased from 1.03 to 76.7 mm^2, the equation was $y= 58.114-10931x+ 0.627x^2- 0.0084x^3$, ($r^2$ = 0.794; S.E. =15.52) (Fig.3). The pelvis area increased from 0.15 to 20.5 mm^2. The ratio between the cortical and medullar surface decreased gradually from 14.6 to 1.3, according to the exponential model $y= 42.81e^{(-0.129*x)}$, (r^2 = 0.945; S.E. = 0.944) (Fig.4).

The data in figures 3 and 4 show that, at the beginning of development, the most of the metanephrus was formed by cortical tissues. This part continued to be larger than the medulla even though it decreased in percentage compared to the medullar area. The renal medulla, in 210-240 mm VRL fetuses increased very quickly, approaching the cortical area values. The cortex occupied about 92.7% of the metanephrus area in the first group of fetuses, this rate decreased slowly to 51.5% in the last group, similar to the volume percentage (51.4) in the adult camel (Abdalla and Abdalla 1979). The renal medulla occupied 6.3% by area of metanephrus in the first group of foeti, and this rate increased to 38.2% in the last group, similar to the volume percentage (38.8) in the adult camel (Abdalla and Abdalla 1979). The ratio of the area between cortex and medulla was 14.6 in the younger fetuses and 1.3 in the group ranging from 320-450 mm VRL. This could indicate that there was an increase of Henle's loops and the ability to concentrate urine.

The number of glomeruli on sagittal median sections of kidney increased from 86 to 775 in the groups, whereas the glomerular density, referred to the cortical surface, was quite constant but had lower values (4.3-5.7 glomeruli/mm^2) in the first three groups and was higher in the others (7.4-8.1 glomeruli/mm^2). The progressive increase of the glomerular number related to embryo-foetal age is connected to their continuous formation, but the temporal expression of the glomerular density per unit area showed that from 210-240 mm VRL to 320-450 mm VRL fetuses it was possible to note a sharp nephronic induction, particularly underneath the metanephric capsule. Canfield (1980) demonstrated in the bovine metanephrus that nephron induction ceased around 28 weeks, but the tubular structures increased from 28 weeks until birth. Kittelson (1917), in his study of the rat kidney, reported that glomeruli continued to be formed after birth and this agree with successive observations of postanal nephrogenesis in the rats (Goncharevskaya and Dlouhá 1975; Goncharevskaya 1977). In contrast, Dunnil and Halley (1973) revealed that there was no postnatal formation of glomeruli in human kidneys and the full complement was present at birth . The diameter of glomeruli in the adult camel was 245± 10μm (Abdalla and Abdalla 1979), much higher than the 115± 11μm in the fetuses studied. This comparison suggests that as the glomeruli take shape, they increase again for a short time before achieving the final dimension of the adult. Canfield (1980) reported that in the bovine the glomeruli continue to increase in size after birth.

After comparing the foetal values with the data of the adult camel (Abdalla and Abdalla 1979) it was possible to state than the former are coherent for a given age, and at half way through foetal life they reach the adult values. Apart from the further metanephrus development, the ratio between cortex and medulla areas seems, at this time, already defined.

References

1. Abdalla MA and Abdalla O. Morphometric observations on the kidney of the camel, *Camelus dromedarius*. J Anat 1979; 129 (1): 45-60.

2. Canavese B and Benvenuti C. Dimensioni fetali di *Camelus dromedarius* e loro distribuzione nel corso di un anno. Boll Sci Fac Zoot Vet Univ Naz Somala 1982; 3: 115-124.

3. Canavese B and Ibrahim AM. La regressione del mesonefro in *Camelus dromedarius* durante la vita embrio-fetale. Boll Sci Fac Zoot Vet Univ Naz Somala 1985; 6: 9-13.

4. Canfield P. Development of the bovine metanephrus. Anat Histol Embryol 1980; 9: 97-107.

5. Colitti M, Canavese B, Oberosler R. La regressione del mesonefro di *Camelus dromedarius* al MO e al SEM: nota preliminare di struttura. Atti S I S V et. 1988; 42: 125-126.

6. Dunnill MS and Halley W. Some observations on the quantitative anatomy of the kidney. J Pathol 1973; 110: 113-121.

7. Goncharevskaya OA. Midcortical and juxtamedullary nephrons during postnatal ontogenesis of the rat. Arch Anat Histol Embryol 1977; 72: 20- 26.

8. Goncharevskaya OA and Douhá H. The development of various nephron generations during postnatal ontogenesis of the rat. Anat Rec 1975; 182: 367- 375.

9. Kittelson JA. The posnatal growth of the kidney of the albino rat, with observations on an adult human kidney. Anat Rec 1917; 13:385.

10. Mac Farlane WV, Howard B, Haines H et al. Hierarchy of water and energy turnover of desert mammals. Nature 1971; 234: 483- 484.

11. Moussa MHG. Histomorphological study of the JG complex of the one-humped camel (*Camelus dromedaruis*). Anat Histol Embryol 1982; 11: 50- 55.

12. Rabhi M, Ugrumov MV, Goncharevskaya OA et al. Development of hypothalamic vasopressin system and nephrons in *Meriones shawi* during ontogenesis. Anat Embryol 1996; 193: 281- 296.

13. SAS. SAS/STAT. Users' Guide. Release 6.03. 1988. Ed. SAS Institute Inc., NC. USA

14. Schmidt-Nielsen K and Schmidt-Nielsen B. Water metabolism of desert mammals. Physiol Rev 1952; 32: 135- 165.

15. Sperber I. Studies on the mammalia kidney. Zoologiska Bidrag fran Uppsala 1944; 22: 249- 432.

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