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EARLY EMBRYONIC DEVELOPMENT OF THE CAMEL METANEPHROS

(With 6 Figures)

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التطور الجنينى المبكر للكلية الدائمة للجمل

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أجـــرى هذا البحث على خمسة عشر جنيناً لجمل وحيد السنام يتراوح أعمارهم بين ٢,٤ سم الـــى ٧,٨ ســـم. وقد أظهرت هذه الدراسة أن أول ظهور للكلية كان عند عمر٢,٦ سم حيث شـــوهد الـــبرعم الحالبي محاطا بالنسيج المولد للكلية الدائمة. وعند عمر ٢,٨ سم إنقسم هذا البرعم الحالبى الى أربعة إنقسامات، كل إنقسام من هذه الانقسامات محاطا بقلنسوه من النسيج المولـــد للكلـــية الدائمـــة وفى عمر ٥,٣ حتى ، ٥,٥ سم تستمر الكلية الدائمة فى التميز مع الزيادة فى الحجم مكونة ثلاث صفوف من الكريات الكلوية وهذا التميز يزداد من الخارج إلى الداخـــل. بيـــنما عند عمر ٦سم تكتمل تكوين الكلية مكونه من كريات كلوية وأنبيبات ملتفة علوية وسفلية وأنبيبات مجمعة.

SUMMARY

The study of the development of the one- humped camel metanephros was carried out on 15 embryos ranged from 2.4 cm to 7.8 cm CVRL. At 2.6 cm CVRL the metanephros was firstly observed, consisting of uretric bud surrounded by metanephrogenic tissue. At 2.8 cm CVRL the uretric bud is divided into four generations which are caped by metanephrogenic tissue. At 3 cm CVRL the metanephros is invaginated in the caudal pole of the mesonephros. At 5.3 – 5.5 cm CVRL the metanephros is continuous in enlargement and differentiation containing three concentric rows of metanephric corpuscles and the degree of differentiation increases from outward to inward. At 6 cm CVRL the metanephros has metanephric corpuscles, proximal and distal convoluted tubules and collecting tubules.

Key words: *Development, Metanephros, Camel.*

INTRODUCTION

The development of the mammalian kidney passes through three major stages. The first two stages are transient, only the third and last persists as a functional kidney. The knowledge of the kidney development is very important. It can explain the causes of some congenital anomalies; also, it helps in identification of cellular differentiation of some tumors. Therefore, the aim of the present work is to give some information about the early development of the kidney in camel.

MATERIALS and METHODES

The present study was carried out on 15 embryos of the one humped camel (Camelus dromedarius), collected from Cairo slaughter-house. The CVR length of these embryos was 2.4, 2.6, 2.7, 2.8, 3, 3.5, 3.8, 4.2, 4.7, 5.3, 5.5, 6, 6.5, 7.3 and 7.8 cm. After slaughtering of the dams, the embryos were collected and immersed in 10% formalin. The specimens were dehydrated in graded alcohol series, cleared in methyle benzoate, embedded in paraffin. The specimens were cut off serially in the lumbar region of the body. The prepared sections were stained with Haematoxylin and Eosin (Harris, 1900) to study the general histomorphological characters of the metanephros.

RESULTS

At 2.4 cm CVR length, the mesonephros is represented by narrow strip along the roof of the abdominal cavity. The gonad appears as a narrow strip along the ventromedial aspect of the middle third of the mesonephros. The metanephros was not observed yet.

At 2.6 cm CVR length, the premordium of the metanephros was observed. The metanephros is located caudomedial to the mesonephros. It is represented by the distal part of the uretric bud which is surrounded by metanephrogenic tissue (Fig. 1). As a result of the appearance of the metanephros, the mesonephros become relatively small and insinuated between the enlarged liver cranially and the metanephros caudally.

At 2.7 cm CVR length, the uretric bud extends craniodorsally and medially to gain the roof of the abdominal cavity, therefore the metanephros is located dorsomedial and caudal to the adjacent mesonephros (Fig. 2). The metanephrogenic tissue which caps the distal

part of the uretric bud can be subdivided into two zones; an outer thin loose zone, represents the primordium of the renal capsule and an inner thick dense zone represents the primordium of the secretory part of the kidney.

At 2.8 cm CVR length, the distal dilated end of the uretric bud, the renal pelvis bifurcates into two branches, from these branches secondary branches bud out. The branching process is repeated still further in radial direction till the fourth branches. These branches are the primordia of the collecting tubules. The terminal end of the tubules become somewhat ampullated and are capped by metanephrogenic tissue. Some masses of the metanephrogenic tissue are located at the angle of these tubules therefore the kidney appear to be consists of two layers an outer thin dense layer; the cortex and inner thick and loose layer; the medulla. The cortex consists of the third and fourth branches of the collecting tubules as well as the nephrogenic mass which caps the terminal end of these tubules and thus which are located at the angle of the collecting tubules. The medulla contains the first and second branches which are scattered in the mesenchymal tissue of the medulla.

At 3 cm CVR length, the metanephros is invaginated in the medial aspect of the caudal pole of the mesonephros.

At 3.5 and 3.8 cm CVR length, the metanephros is embedded in the dorsal surface of the mesonephros at the junction of its caudal 2/3 (Fig. 3). The metanephros is located at the level of the most caudal ¼ of the gonad. On the other hand medially the metanephros comes in contact with the gonad and separating from it by subcardinal vein. The cortex includes 2-3 concentric rows of metanephric corpuscles. The differentiation of the metanephrogenic corpuscles increases from outward to inward. The medulla contains mainly mesenchymal tissue and few collecting tubules (Fig. 4).

At 4.2 cm CVR length, due to continuous regression of the mesonephros, the metanephros replaces the area which are previously occupied by the caudal pole of the mesonephros while the gonad migrates caudally to become just cranial to the metanephros. The metanephros enlarges and becomes nearly the same size of the gonad.

At 4.7 cm CVR length, the metanephros enlarges in size and occupying the space located in the middle part of the mesonephros. Therefore the metanephros is related ventrally to the gonad from which it is separated by the subcardinal vein and the mesenchymal band which connecting the two parts of the mesonephros medially (Fig. 5). Structurally, the cortex becomes more differentiated and increases in

thickness on the expense of the medulla (Fig. 6). The hilus is directed ventrally.

At 5.3 and 5.5 cm CVR length, the enlargement and differentiation of the metanephros continue.

At 6 cm CVR length, the metanephros is still larger than the gonad and extends somewhat cranial to the level of the gonad. The renal pelvis is wide and lined by simple columnar epithelium with basally located nuclei and the lumen contains structureless materials. The surface area of the cortex is larger than that of the medulla which contains some collecting tubules scattered within the mesenchyme. As the cortex contains the renal corpuscles, the convoluted tubules and the collecting tubules, consequently the metanephros in this age is functional.

The proximal convoluted tubules are numerous with narrow lumen and lined with cuboidal cells with acidophilic cytoplasm. The distal convoluted tubules are less in number with irregular branched border has wide lumen and the cytoplasm is lightly stained. The collecting tubules are larger in size and diameter lined by simple columnar epithelium with round basically located nuclei.

At 6.5, 7.3 and 7.8 cm CVR length, the metanephros is located at the sublumbar regions taking the permanent position of the kidney on either sides of the median plane related medially to aorta, caudal vena cava, renal artery, ureter and sympathetic nerve trunk. Cranially the left metanephros comes in contact with the spleen and the hilus is directed ventrally. The peripheral part of the cortex has undifferentiated metanephric corpuscles and tubules, while the middle part of the cortex containing differentiated metanephric corpuscles and surrounded mainly by proximal convoluted tubules. The distal convoluted tubules are related mainly to the adjacent collecting tubules. The medulla remains mesenchymal in structure with few collecting tubules and on the expense of medulla the cortex increases in thickness.

DISCUSSION

At 2.6 cm CVR length camel fetuses the metanephros was firstly observed consisting of uretric bud surrounded by metanephroginic tissue.

At 2.7 cm CVR length, the differentiation of the uretric bud to the collecting part of the kidney and the metanephrogenic tissue to the secretory part takes place. Similar results were observed by many

authors who stated that the development of the metanephros is dependent on two components, the metanephric blastema and the uretric bud. The metanephric mesenchyme produces the components of the nephron; meanwhile, the uretric bud; derived from the mesonephric duct; provides the collecting duct system (Hamilton and Mossman, 1976; Canfield, 1980; Ammar *et al.*, 1982; Moustafa and Enany, 1985 and Kaufman, 1992).

At 6 cm CVR length the metanephros has metanephric corpuscles, proximal and distal convoluted tubules as well as collecting tubules. The subsequent organogenesis of the kidney is believed to be controlled by a series of reciprocal inductive interactions between the uretric bud and the metanephric mesenchyme (Bard, 1992; Ekblom, 1992; Hardman *et al.*, 1994 and Saxen, 1987). The mesenchymal cells induce growth and repeated branching of the uretric bud, which eventually gives rise to the renal collecting system (Erickson, 1968; Grobstein, 1955). At the same time the tips of branching uretric bud induce the surrounding mesenchymal cells to condense into epithelial vesicles, which ultimately differentiated into the various segments of the nephron (glomeruli, proximal and distal tubules and Henle's loop) (Grobstein, 1955, 1956 and Saxen, 1970). Davies and Bard (1996) stated that the two intermediate mesodermal tissues; the uretric bud and the metanephrogenic mesenchyme interact and reciprocally induce each other to form the kidney. The metanephrogenic mesenchyme causes the uretric bud to elongate and branch. Davis *et al.* (1995) reported that the kidney epithelia have separate origin; collecting duct developed by uretric bud growth and arborisation and nephrons by induced mesenchyme- epithelium transition. These finding confirmed by present work and Majumdar *et al.* (2003).

In the present study at 2.7 cm CVR length camel fetuses the metanephrogenic tissue is subdivided into two zones; outer thin loose zone is the primordium of the renal capsule and an inner dense thick zone represents the primordium of the secretory part of the kidney. These results are similar to that observed by Arey (1965) in human embryo at 1.1 cm. On the other hand, the capsule of the kidney appears at 5 cm CVR length in camel (Ammar *et al.*, 1982) and at 4 - 5.5 cm CVR length in buffalo (Moustafa and Enany, 1985).

At 2.8 cm CVR length camel fetuses the distal dilated end of the uretric bud, the renal pelvis, is bifurcated to form the first branches from these branches secondary branches bud out. The branching process repeated still further in radial direction till the fourth branches. On the

other hand in human embryo, Arey (1965) and Sadler (2000) stated that the primitive renal pelvis splits into future major calyces each forms two new buds. These buds continue to subdivide until 12 or more generations of tubules have been formed until the end of the fifth month. Moreover in human embryo, Patten (1953) stated that the pelvic end of the diverticulum expands within its investing mass of metanephrogenic mesoderm and forms extensions cephalad and caudad which are called the major calyces. These soon show subdivisions which are known as the minor calyces. Meanwhile, from the tip of each minor calyx there arise numerous outgrowths which push radially into the surrounding mass of nephrogenic mesoderm. These outgrowths become hollow, forming the primary straight collecting tubules of the kidney. The group of straight collecting tubules associated with a minor calyx are the drainage channels for a natural unit of kidney structure. They, together with the tubules that develop from the immediately surrounding metanephrogenous mesoderm, constitute a renal lobe.

At 4.7 cm CVR length, the metanephros enlarges in size and occupying the space located in the middle part of the mesonephros therefore, it is related ventrally to the gonad. Similar results were observed by Gaber (2005) in the same animal.

While the metanephric primordium was pushed cephalad; it was increased rapidly in size and encroached on the space occupied by the mesonephros, this result agreed with Patten (1948) in the pig, Patten (1953) in human and Moustafa and Enany (1985) in buffalo.

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LEGENDS

Fig. 1: Transverse section in 2.6 cm CVR length camel fetus showing the primordium of the metanephros (H&E, X 250).
(1) Distal part of the uretric bud (2) Metanephrogenic tissue (3) Mesonephros

Fig. 2: Frontal section in 2.7 cm CVR length camel fetus showing the relation of the metanephros to the mesonephros (H&E, X 250).
(1) Uretric bud (2) Metanephrogenic tissue (3) Mesonephros

Fig. 3: Sagittal section in 3.8 cm CVR length camel fetus showing the metanephros is embedded in the dorsal surface of the mesonephros (H&E, X 25).
(1)Metanephros (2) Mesonephros (3) Gonad
(4) Lung (5) Diaphragm (6) Liver

Fig. 4: Sagittal section in 3.8 cm CVR length camel fetus showing the structure of the metanephros (H&E, X 100).
(1) Renal tubule (2) Cortex (3) Medulla
(4) Glomerulus (5) Bowman's capsule (6) Mesonephros
(7) renal capsule

Fig. 5: Sagittal section in 4.7 cm CVR length camel fetus showing the relation of the metanephros to the gonad (H&E, X 25).
(1) Metanephros (2) Mesonephros (3) Gonad
(4) Subcardinal vein (5) Mesenchymal fold

Fig. 6: Sagittal section in 4.7 cm CVR length camel fetus showing the structure of the metanephros (H&E, X 100).
(1) Cortex (2) Medulla (3) Renal corpuscle
(4) Mesonephros (5) Renal pelvis