STUDY OF THE POSTNATAL GROWTH OF THE KIDNEY OF THE ALBINO RAT

THESIS
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OF THE MASTER DEGREE OF ANATOMY
(M.Sc.)

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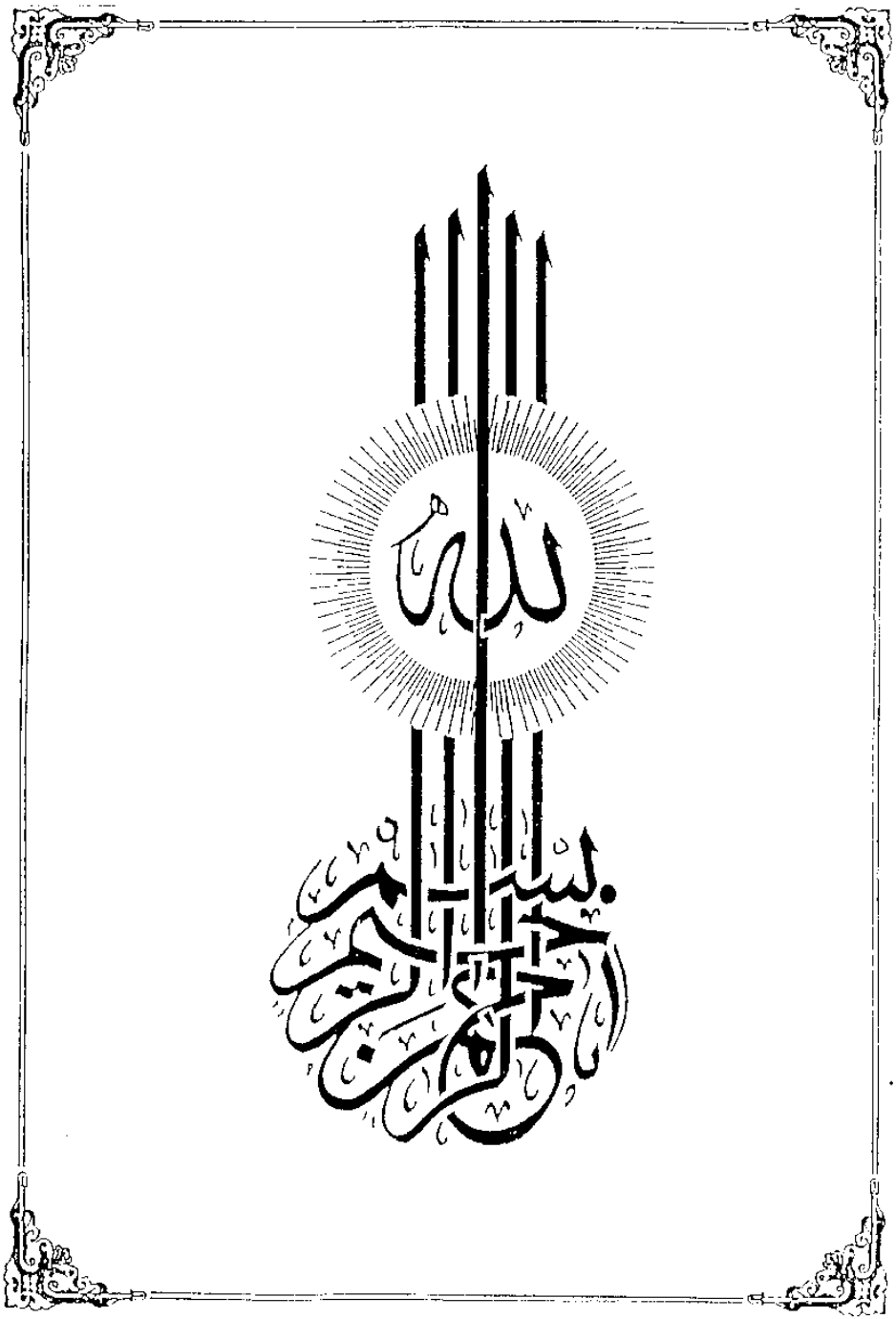

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Introduction & Aim Of The Work

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INTRODUCTION

It was reported that in human kidney all nephrons were formed at birth and during postnatal period, only morphological and functional maturation took place in already formed nephrons (Mac Donald and Emery, 1959; Ahmed, 1983; Cormack, 1987). On the other hand, the neonate kidney, in most mammals including rat, was not mature and nephrogenesis comprising the formation of new nephrons and their definitive maturation continued during the postnatal life (Leeson, 1957; Nash and Edelmann, 1973; Lackovic and Mujovic, 1980). Accordingly, the newborn rats were unable to produce a highly concentrated urine and that this capacity developed with age (Trimple, 1970; Spitzer and Brandis, 1974).

Although age-related morphological changes in the postnatal life had been previously reported in the kidney of different mammals (Leeson, 1957; Fris, 1980), however, those done on rat's kidney were dealing especially with the development of glomeruli (Arataki, 1926; Lackovic and Mujovic, 1980). Thus, it became the aim of the present work to study the postnatal growth of the rat's kidney including the gross anatomy and the histological picture so as to correlate structure with function.

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Review Of Literature

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REVIEW OF LITERATURE

(I) ANATOMY OF THE KIDNEY

Arataki (1926) reported that, in the albino rat, the female kidneys were 8% less in weight than those of the male.

Mac Kay and Mac Kay (1927) described the relation at different ages of kidney weight to the measurements of body weight, body length and body surface in albino rat. In relation to body weight, kidney weight decreased with increasing age, reaching a minimum value at about 200 days of age in male (equivalent to about 300 gm body weight) and for females at about 150 days (equivalent to about 200 gm body weight). While in relation to body length, it increased with age attaining a maximum value at about the same age. On the other hand, the kidney weight had practically the same relation to body surface at all ages. The authors also found that the female rat had 15% less renal tissue per unit of body surface than the male rat.

Sperber (1944) had described some of the macroscopic features of the kidney of *Aplodontia rufa*, and showed that it was non-lobated, with a relatively small amount of medullary substance compared with the cortical mass. There

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was a very small pelvis, which was devoid of minor and major calyces, in the lateral wall of which lay the small area cribrosa.

Stoerk and Zucker (1946) described the postnatal growth of the kidney in relation to body weight in albino rats from birth to 40 weeks. They found that the relative growth of the kidney might be divided into three phases. The ratio of the kidney weight to body weight increased during the first phase (first week of postnatal life); approximately constant during the second phase (2^{nd} week to the 5^{th} week) and definitely decreased during the third phase (6^{th} week to the 40^{th} week).

Webster, Liljegren and Zimmer (1947) reported that variations in the weight of kidneys of normal animals at autopsy might be attributed to various genetic, metabolic, physiologic, environmental or technical factors. It might also be caused by differences in sex, species, breed, strain, body weight, rate of growth or endocrine activity. Variations in the kidney weight might also be due to age, size, senility or diet. Other factors were; physical condition, shock, exhaustion, exercise, technique of killing and dissection. Environmental factors, such as general care, housing, light, temperature and season might also be considered.

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Vimtrup and Schmidt-Nielsen (1952) found that the gross anatomy of the Kangaroo rat kidney was similar to that of other small rodents which usually excreted a very concentrated urine. The kidney of Kangaroo rat possessed well developed renal medulla and an exceptional long tapering renal papilla which projected down into the renal pelvis and ureter.

Sisson and Grossman (1959) described the gross anatomy of the kidney of the horse, ox, sheep, pig and dog. They reported that the right kidney of the horse was commonly heavier than the left being 700 gm, but the reverse was frequent. The right kidney measured 15 cm in length and in width and 5 cm in thickness while the left kidney was considered longer and narrower. The two kidneys differed in position; the left being situated nearer to the median plane than the right and further back so that the hilus was opposite to the posterior extremity of the right one. The left kidney was at a lower level than the right since it extended from the 18^{th} rib (last rib) till the level of the 3^{rd} lumbar vertebra while the right was opposite the 16^{th}, 17^{th} and 18^{th} ribs and extended to the level of the first lumbar vertebra, but the left kidney was noticeably more variable in position than the right. The authors also noticed that the kidney of the horse was not papillated but the inner central part of the medulla formed a concave

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ridge termed the renal crest which projected into the pelvis of the kidney. Its surface was known as the area cribrosa since it carried numerous small openings at which the renal tubules opened into the pelvis of the kidney.

Sisson and Grossman (1959) also described the gross anatomy of the kidney of the ox and mentioned that the left kidney in contrast to that of the horse was heavier than the right. The right kidney measured about 20-22.5 cm in length, 10-12 cm in width, 5-6 cm in thickness. Although the left kidney was 2-5 cm shorter than the right, yet its posterior end was much more thicker than that of the right one. They added that the kidney of the ox was superficially divided into polygonal lobes by fissures of variable depths while that of the horse had a smooth surface. The kidney lobes varied in size and were commonly about 20 in number. The left kidney differed in form from the right one, when the lumen was full it pushed the kidney backward and across the median plane so that it was situated on the right side, behind and at a lower level than the right kidney. When the lumen was not full the left kidney might lie partly to the left of the median plane. In addition, the kidney of the adult ox possessed three surfaces; dorsal, ventral and luminal surface in contradistinction to the horse which possessed two surfaces; ventral and dorsal.

The kidneys of the sheep were also described by Sisson and Grossman (1959) who found that they were smooth in outline

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without any superficial lobations. In position, they resembled those of the ox except that the right one was usually a little further back and placed under the first three lumbar transverse processes. Each kidney measured 7.5 cm in length and 5 cm in width and its thickness was a little more than 3 cm. The average weight of each was about 112 gm. In addition, the kidney possessed two surfaces; dorsal and ventral which were convex.

According to Sisson and Grossman (1959), the kidneys of the pig were more flattened dorsoventrally, more elongated, and smaller at the extremities than those of the dog. Each kidney measured about 200-250 gm in weight and 12.5 cm in length and 6.25 cm in width. They added that, the pelvis of the kidney was funnel-shaped, divided into two major calyces which gave off eight to twelve minor calyces, each of the latter surrounded a papilla.

The authors also described the kidneys of the dog and reported that the left kidney exhibited positional variation which was related to the degree of fullness of the stomach. They added that the kidney was related to the body of the second, third and fourth lumbar vertebrae when the stomach was empty. When the stomach was full, its anterior pole might be opposite the posterior pole of the right kidney.

Pfeiffer (1968) injected latex *(in vivo)* into the ureter of *Aplodontia rufa*, beavers, pig, opossum, dog,

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sheep and rat and described the latex casts in the pelves of these animals. He observed that there were at least two types of mammalian pelves; in type I, e.g. *Aplodontia rufa* the pelvis was simple uncomplicated, without fornices (secondary or specialized), folds or extensions, with an expanded ureteral ending. The medulla had no inner zone, and the outer zone lacked the presence of special projections into the pelvis called secondary pyramids. In a second representative of type I, e.g. beaver, the pelvis gave rise to two calyces. The pelvis and calyces of the domestic pig resembled those of the beaver except that there were multiple calyces. Type II pelvis was far more extensive and the pelvic wall was thrown into elaborate folds reaching deep into the outer medulla and giving rise to leaf-like processes of the pelvis referred to as specialized fornices. In the rat, these specialized fornices consisted of a pair of processes extended towards the anterior poles of the kidney (anterior fornices) and towards the posterior poles (posterior fornices) and of a pair projected from the middle of the kidney (medial fornices). In this type of pelvis, the medulla composed of a clearly defined inner and outer zone and was surrounded by the pelvic lumen. At certain points, the evaginations of the pelvis by these specialized fornices penetrated the kidney parenchyma in such a way that ridges of the medullary outer zone (secondary pyramids) extended from the

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base of the primary pyramid to the lateral walls of the pelvis. The number of secondary pyramids, and therefore the number of specialized fornices, varied according to the species. In the opossum three pairs of secondary pyramids were observed while in the rat, two pairs were present.

Trimple (1970) studied the cortical and medullary thickness of the kidney of 10 and 20 days old rats. In 10 days old rat, the cortical thickness was 0.7 mm, the medullary thickness was 2.5 mm and the medullary-cortical ratio was 3.6. In 20 days old rat, the cortical thickness was 0.8 mm, the medullary thickness was 4.0 mm and medullary-cortical ratio was 5.0. Concerning the development of the pelvis at the kidney, he could not demonstrate the specialized fornices on the 3rd postnatal day. However, he found that they appeared at 10th day and by the 20th day of age, fornices were well developed and extended into the kidney between the cortex and the outer zone of medulla.

Tisher (1971) reported that, in most mammals there was a good correlation between the ability of the animal to concentrate urine maximally and the relative length of its renal medulla. The total length of the medulla was only greater than the thickness of the cortex and the ratio of cortex to medulla was 0.79 in the mammalian kidney. The kidney of the Rhesus monkey possessed blunted papilla which

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extended into a renal pelvis which was simple or rudimentary in structure and did not possess specialized fornices. Tisher (1971) added that, in man, the ratio of cortex to medulla on sagittal section was 0.34 which was significantly less than that of the Rhesus monkey. This difference was largely due to the presence of a well-developed inner medulla in the human kidney, since the thickness of the renal cortex and outer medulla was similar in man and the Rhesus monkey.

Cooper and Schiller (1975) described the kidneys of the guinea pig and found that each was approximately 18-21 mm in length and 12-14 mm in width. The right kidney was more cranial than the left. Since the cranial pole of the right kidney was at the level of twelfth intercostal space and that of the left at the thirteenth rib, the caudal pole of right kidney extended to the level of third lumbar vertebra, and that of the left reached the fourth lumbar vertebra. The authors also noticed that the ovaries in the female guinea pig were attached to the peritoneum covering the ventral aspect of the kidneys by a fold which extended from the broad ligament.

Abdalla and Abdalla (1979) studied the kidneys of the camel (*Camelus dromedarius*) and observed that the medulla was highly thickened. Its ratio to that of cortex was

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