Developmental changes in human fetal kidney

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Abstract:

Aims and objectives: It is necessary to know the normal developmental Anatomy of the kidney to understand certain prenatal disorders like polycystic kidney, hydronephrosis and Wilms’ tumour. A detailed description of histological development of kidney is scarce. Therefore the present study is an attempt to further the anatomical knowledge in histogenesis of kidney. Materials & Method: The study was carried out in the department of Anatomy, Mount Zion Medical College, Adoor, Kerala. 30 dead born fetuses (gestational age range from 11 weeks to 36 weeks) were utilized for the study. Tissue specimen from the kidneys were stained with Hematoxylin and Eosin and examined under light microscope. Results: Nephrogenic zone was identified up to 34 wks of gestation. Cortex was clearly distinguished from medulla at 14 th wk of fertilization. Different shapes [S & C] of glomeruli were identified in the second trimester. At 24 th wk, proximal convoluted tubule [PCT], distal convoluted tubule [DCT], collecting duct and thin and thick segment of loop of Henle were identified clearly. Conclusion: The pathological conditions of the kidney can be diagnosed at the earliest by understanding the normal histological development of the kidney at various stages. This study would be helpful for understanding the normal histological development of kidney.

Keywords: kidney, histogenesis, glomeruli, nephrogenic zone, fetus

Introduction

Kidney plays an essential role in maintaining homeostasis of the body. It excretes metabolic waste products and maintains electrolyte and water balance. The Urogenital system develops from the intermediate mesoderm. The part of the urogenital ridge giving rise to the urinary system is the nephrogenic cord. There are three sets of kidneys that develop in human embryos. The first set is rudimentary, the Pronephros and the second set is Mesonephros, well developed but functions briefly. Metanephros, the permanent kidney develops from two sources, the ureteric bud and metanephric blastema. The ureteric bud that develops from mesonephric duct has cranial and caudal ends. The cranial end of ureteric bud undergoes repetitive branching events, forming the branches which differentiate into collecting tubules. The first four generations of tubules enlarge and fuse to form the major calyces and second four generations coalesce to form the minor calyces. The arched collecting tubule induces mesenchymal cells in the metanephric blastema to form small metanephric vesicles. The metanephric tubules, elongated part of metanephric vesicles, are invaginated by glomeruli. The tubules differentiate to form proximal convoluted tubules [PCT], distal convoluted tubules [DCT] and Henle’s loop. Nephron formation is complete at birth except in premature infants. At the 10th week of intrauterine life, the kidneys become functional and the glomerular filtration begins.

Detailed histological development of kidney is essential to detect congenital pathologies of the kidney and thus to reduce complications by taking appropriate measures. This study was done to further the existing anatomical knowledge in histological development of kidney.

Materials and Method

The study was carried out in the department of Anatomy, Mount Zion Medical College, Adoor, Kerala. 30 dead born fetuses [gestational age range from 11 weeks to 36 weeks] were procured from the department.
of Obstetrics and Gynecology, Mount Zion Medical College, Adoor, Kerala. Due ethical clearance was obtained. A midline incision was made in the abdomen and both kidneys were resected from all fetuses. In both kidneys, middle segment at the level of hilum was cut by two parallel incisions 5mm apart then processed, stained with Hematoxylin and Eosin and studied with adeltavision trinocular microscope under 10x40X views. The histology pattern of kidneys was studied under three groups. Distribution of study sample based on fetal age is given in Table 1.

**Results:**

The specimens were processed and detailed microscopic anatomy was studied.

**Group I [less than 16wks]**

Fetal kidney had a thin capsule made of fibrous tissue. The outer cortex was difficult to distinguish from the inner medulla till 12th week. There were many indentations on the surface of the cortex. A cluster of undifferentiated mesenchymal tissue was noticed. At 14th week, the cortex was clearly differentiated from medulla [fig.1]. Nephrogenic zone was noted with various stages of developing glomeruli in the cortex. The capillaries were found in the Bowman's capsule. In the peripheral region of the cortex, S shaped and crescent shaped glomeruli were seen [with columnar to cuboidal lining epithelium] at 14-16 wks of gestation [fig.2]. At the corticomedullary junction many developing juxta medullary glomeruli and undifferentiated tubules lined by cuboidal epithelium were seen [fig.3]. In medulla, undifferentiated mesenchymal tissue was found.

**Group II [16-28 wks]**

Lobulated kidney covered by well-defined capsule was found. Cortex was easily distinguishable from medulla. In the outer zone of the cortex glomeruli, Bowman's capsule, proximal and distal convoluted tubules were seen [fig.4]. Inner zone of the cortex presented with collecting tubules lined by cuboidal epithelium. At 18th wk, the proximal convoluted tubules were differentiated from distal convoluted tubules. The PCT was lined by cuboidal epithelium with more brush border than the DCT. At 24th wk, the corticomedullary junction was clearly identified. Medulla presented with collecting tubules, thin and thick segment of loop of Henle.

**Group III [>28wks]**

Corticomedullary junction was discernible. Nephrogenic zone was noted till 34wks of gestation. Cortex filled with different stages of developing glomeruli and PCT [darkly eosin stained] and DCT [lightly eosin stained] were identified [Fig.6]. At 36 wks, well-developed vascular structures with tuft of capillaries present in the Bowman's capsule were noted. In the medulla, well developed collecting tubules and perceptible thin segment lined by squamous epithelium and thick segment lined by cuboidal epithelium of loop of Henle were identified [Fig.5].

**Discussion**

The kidneys are developed from genito urinary ridge present in the intermediate mesoderm. It starts developing as early as 4th wk of intrauterine life. The nephrogenic zone is seen till 34 wks of gestation. Sadiqali et al, noted that the nephrogenic zone was seen up to 36wks. Campos et al, mentioned that the nephrogenic zone was clearly seen up to 3rd month after birth denoting that development and maturation occurs in post-natal life also.

In our study fetal lobulations were seen markedly during early fetal life then disappears during the latter period of gestation. Corticomedullary junction was not distinguished till 12th wk of gestation, but well appreciated at 14th wk of fertilization. Hosaptna et al, stated that the corticomedullary junction was discernible at 16th wk. But, Maria et al, mentioned that the corticomedullary differentiation completed between 25-30 wks.

The cortical thickness increases with advancing fetal age. Beneath the capsule, the developing glomeruli were seen in different shape and size. The 'S' and 'C' shaped glomeruli were seen at 12th week of fertilization. Similar findings were noted by Sadiqali et al, in early phase of development.

In our study, the proximal and distal convoluted tubules were differentiated at 18th wk. Sudha et al, had similar findings but Tank et al, stated that the
Table 1: Distribution of study sample based on gestational age

<table>
<thead>
<tr>
<th>Groups</th>
<th>I</th>
<th>II</th>
<th>III</th>
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<tr>
<td>Gestational age</td>
<td>&lt;16 wks</td>
<td>16-28 wks</td>
<td>&gt;28</td>
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<tr>
<td>Number of fetuses</td>
<td>9</td>
<td>13</td>
<td>8</td>
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Fig. 1: 14wks of gestation [10x view]
1. Cortex  2. Medulla

Fig. 2: 16 wks of gestation [cortex] [40x view]
1.'S' shaped glomeruli; 2. Crescent shaped glomeruli

Fig. 3: 17 wks of gestation [40 x views]
Undifferentiated PCT and DCT in medulla

Fig. 4: 24wk of gestation [40x view]
1. Proximal convoluted tubule; 2. Distal convoluted tubule
3. Collecting duct; 4. Thin segment of loop of Henle

Fig. 5: 32 wks of gestation [40x view]
1. Thick segment of loop of Henle; 2. Thin segment of loop of Henle

Fig. 6: 36wks of gestation [40x view]
1. Glomerulus; 2. Bowman's capsule

differentiation between the PCT and DCT were observed clearly by 17th wk of fertilization

According to Rao et al, the thin and thick segment of the loop of Henle were identified as early as 16th wk of fertilization and more mesenchymal tissue were found. In our study, at 18th wk the loop of Henle and more mesenchymal tissue were identified.
In our study, the mature renal corpuscles were seen in the deeper part of cortex but developing bilobed glomerulus were seen beneath the capsule. Khayati et al. and Maria et al. had similar findings.

According to Chikkannaiah et al, the histological assessment of the number of glomeruli can be used for the estimation of age. Due to less number of fetuses and lack of glomerular analysis, the age estimation of a fetus cannot be done in our study.

Sunita et al. stated that the corticomedullary junction was not distinguished in 22 wk fetus due to cystic transformation of medulla in polycystic kidney disease. Hindrickx et al. also identified cystic dilatations more in medulla than cortex in polycystic kidney disease.

**Conclusion**

The pathological conditions of the kidney can be diagnosed at the earliest by understanding the normal histological development of the kidney at various stages. This study would be helpful for understanding the normal histological development of kidney.

**References**


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