Histogenesis of human fetal kidney from 14 weeks to 36 weeks: a study

Divya Jain Pokarna¹, K. Kshitija²*, Seethamsetty Saritha³

¹Student, Kamineni Academy of Medical Sciences and Research Centre, LB Nagar, Hyderabad, Telangana, India
²Department of Pathology, Bhaskar Medical College and General Hospital, Hyderabad, Telangana, India
³Department of Anatomy, Kamineni Academy of Medical Sciences and Research Centre, LB Nagar, Hyderabad, Telangana, India

Received: 01 September 2019
Revised: 04 September 2019
Accepted: 27 September 2019

*Correspondence:
Dr. K. Kshitija,
E-mail: kshiti80@yahoo.co.in

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: The knowledge of fetal human Kidney morphology and developmental anatomy is very important for prenatal diagnosis of disorders such as Wilms’ tumor, hydronephrosis and congenital malformation etc.

Methods: The study was carried out on 40 kidneys procured from 20 spontaneously aborted fetuses (11 males and 9 females) ranging from 14wks-36wks of gestation, after confirming their age through CRL they were grouped and then processed to form slides and stained with haematoxylin and eosin and seen under light microscope.

Results: All kidneys were lobulated at early gestational age and became fused by 36 wks. Corticomedullary junction and preformed collecting tubules were seen clearly by 18wks. Well differentiated PCT and DCT were formed by 19-23 wks. Well-formed pyramids by 28 wks and medullary rays by 29 weeks were clearly distinguished. Loop of Henle developed and distinguished by 28 wks. Increased vascularity was seen by 32-36 wks. Nephrogenic zone and undifferentiated mesenchyme decreased and matured glomeruli increased by 36 wks.

Conclusions: The present study gave emphasis to the development of each component in medulla and cortex of kidney.

Keywords: Corticomedullary junction, Distal Convolutes tubules, Intrauterine growth retardation, Loop of henle, Proximal convoluted tubules

INTRODUCTION

Prenatal development is a pivotal period for human development and kidneys have been known to play a vital role in development of fetus.

It is important to know the normal developmental anatomy and histogenesis of kidney to understand the origin of various pathological conditions related to genetic and congenital domain of kidneys. The development of kidney has been known to follow an evolutionary pattern. It develops from the intermediate mesoderm in cranio-caudal direction passing through pronephros, mesonephros and metanephric stage. Finally permanent functioning kidneys develop from metanephros in the lumbosacral segment. They develop early in 5th week and start to function around 9th week.¹

The functioning kidney has two parts 1- The collecting part which develops from ureteric/Mesonephric duct and 2- The excretory part which develops from metanephric blastema. Local mesenchyme migrates into metanephric blastema to form Glomeruli and vasa recta. In brief, the ureteric bud developing from the mesonephric duct dilates and form ampulla and branches itself. The mesenchymatous tissue
epithelializes and forms vesicles which fuse with the branched ampulla to form a Nephron.2

Due to these sequences of development, macroscopically the fetal kidney has about 12 lobes but these are fused in adults to a present a smooth capsulated surface.3

Microscopically kidney is composed of many tortuous closely packed uriniferous tubules bound by little connective tissue in which runs blood vessels, lymphatic’s and nerves.4

The kidney plays an essential role in maintaining homeostasis in body. It also excretes metabolic wastes and regulates certain hormones production.5

The permanent kidneys become functional in intrauterine life and urine produced by them is added to amniotic fluid from 10th week of gestation.6

The present study shows the correlation between histogenesis of foetal kidney in particular phases during foetal development and their respective gestational age. An attempt was made to compare the findings of our study with that of the other authors in relation with the gestational age of fetus.

METHODS

The present study was carried out in the Department of Anatomy, KAMSR, LB Nagar; Hyderabad (Telangana), India. The materials of the present study were collected for a period of 1 year.

Inclusive criteria

The fetuses taken were unclaimed spontaneously aborted or still born ranging from gestational age 14 weeks to 36 weeks (11 males and 9 females).

Exclusive criteria

The twins and the fetuses with congenital abnormalities were excluded.

These fetuses were obtained from department of Obstetrics and Gynecology, KAMSR, LB Nagar; Hyderabad (Telangana), India.

Methodology

The materials for present study were 20 fetuses (11 males and 9 females) with gestational age ranging from 14-36 weeks. The known gestational age of fetuses were then correlated with the respective CRL according to Textbook of Embryology by Hamilton, Boyd and Mossman (Table 1),3 with an osteometric board having mm scale. It helped to confirm their registered gestational age, to rule out any IUGR and conveniently group them into 5 groups according to their gestational age (Table 2).

The fetuses were embalmed and then kept in 10% formalin for 24 hours. The kidneys were then dissected, observed for any gross abnormalities, cleared and then processed for dehydration. Next after embedding, the paraffin block were prepared. Seven micrometer sections were taken with rotary microtome and stained with hematoxylin and eosin, observed under microscope and then micro photographed.

This process was followed after taking permission from the Kamineni Institutional Ethics Committee (Registration No. ECR/58/Inst/AP/2013/RR-16) at KAMSRC and Kamineni hospitals, LB nagar, Hyderabad.

Table 1: Textbook of Human Embryology by Hamilton, Boyd and Mossman.

<table>
<thead>
<tr>
<th>Age (in lunar months)</th>
<th>Crown rump length in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>55</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>7</td>
<td>230</td>
</tr>
<tr>
<td>8</td>
<td>265</td>
</tr>
<tr>
<td>9</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>335</td>
</tr>
</tbody>
</table>

Table 2: Groups of fetuses in study according to their gestational age.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Gestational age in weeks</th>
<th>Number of fetuses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14-18</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>19-23</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>24-28</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>29-32</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>32-36</td>
<td>5</td>
</tr>
</tbody>
</table>

RESULTS

Group A (14-18 weeks): Kidney shows lobulation. Capsule is thin and wavy. Cortex: Large amount of undifferentiated mesenchyme is seen with nephrogenic zone below capsule. Zone of transition between cortex and medulla showing CMJ is seen by 16 weeks and well demarcated by 18 weeks. Hollow structures lined by single layer of cells were seen near the developing glomeruli, these were nephrogenic vesicle. It also showed many ‘V’ shaped developing tubules. Many cut sections of tubules not differentiated into PCT and DCT are seen. Medulla: preformed and developing collecting tubules are seen. Developing renal pelvis had single layered epithelium at 14 weeks and by 16 weeks it was multilayered (Figure 1). Group B (19-23 weeks): Cortex: S and C shaped tubules are seen in which vascular structure invaginate at its distal pole as glomeruli. Connective tissue between lobules can be seen. The cut section tubules in cortex have differentiated into PCT and DCT by 19 weeks.
They show different characteristic staining pattern. PCT are more in number with basophilic darkly stained cytoplasm and DCT have pale eosinophilic cytoplasm. Both are lined by cuboidal epithelium. PCT is lined by brush border and DCT have clear lumen. Medulla: It shows many cut section of tubules which may later develop into LOH (Figure 2).

Group C (24-28 weeks): Cortex: ‘C’ shaped tubules encompassing the glomeruli are seen. PCT developed proper brush border (Figure 3).

Medulla started to segregate into pyramids by 24 weeks and proper architecture is seen by 29 weeks. LOH have developed from the tubules in medulla and are distinguished into thick ascending limb lined by cuboidal epithelium and thin descending and a part ascending limb which is lined by flat epithelium. Medullary rays have started developing.

There is decrease in connective tissue in between the lobules of kidney and also in the parenchyma of kidney. Nephrogenic zone is in very less quantity accumulated below the capsule in the cortex. Undifferentiated mesenchyme is reduced and now compact (Figure 4 and Figure 5).
DISCUSSION

The kidney was lobulated in 12-13 lobes and showed signs of fusion as early as 14-16 weeks and was fused by term (36 weeks). The capsule became rigid with increasing gestational age. Nephrogenic zone which is darkly stained was present beneath the capsule was more marked in early gestational period and later it decreased with increasing fetal age but remained in accordance with Kirti Solanki et al and Mamatha Hospatna et al.8,9 Sudha Patil et al, aimed it to be disappeared by 38 weeks and Potter Let al claimed it to disappear by 36 weeks.10,11

Undifferentiated mesenchyme was till 36 weeks in accordance with Kirti Solanki et al, and Syed S. A et al.8,12 The CMJ was observed by 16weeks and was well demarcated by 18 weeks. Khayati Sant Ram et al found the differentiation after 18 weeks but It was in accordance with Sabita M et al.6,13 The evolution of renal corpuscle observed was as follow:

‘V’ shaped at 14-18 weeks. ‘S’ shaped at 19-23 weeks. ‘C’ shaped at 24-32 weeks and matured lobulated glomeruli at 29-32 weeks. These were similar to the findings of Bhattam Narsinga Rao et al and Takano K. et al.14,16 Though all the different developmental stages were found in almost all the gestational ages.

Many cut section of tubules were seen in cortex by 14-18 weeks. By 19weeks the tubules have differentiated into PCT and DCT. Tank KC et al found it by 17 weeks and Kirti Solanki et al first observed at 20 weeks. Mamatha Hospatna et al, found the differentiation as early as 16 weeks.1,8,9 Medullary rays were found well developed by 29weeks in cortex in accordance with Kirti Solanki et al.8

Medullary pyramids and renal cortical columns have started developing by 24 weeks and were distinct in accordance with Bhattam Narsinga Rao et al.14 Shallika Sharma et al, found renal pyramids by 16-18weeks.7 The proper architecture and arrangement of pyramids and renal columns are seen by 29 weeks. By 19-23 weeks medulla was filled with cut section of tubules. Few being performed and still forming collecting tubules and the others giving rise to LOH and vasa recta. It could be completely distinguished into thick and thin ascending
and thin descending LOH by 24-28 weeks. The surrounding vessels developed to give rise to vasa recta by 29 weeks. By 36 weeks it became the major component of medulla. This was in accordance with Mamatha Hospatna et al, and Laura Vinci et al.9,15 Takano K et al found the differentiation by 17 weeks.16

The developing renal pelvis showed single layer of cells at 14 weeks in accordance with Sabita M et al.13 By 16-20 weeks showed stratification in accordance with Shallika Sharma et al.5 In the interstitial spaces, huge number of blood vessels were found showing increase in kidney’s vasculature with time, in accordance with Laura Vinci et al.15 The arrangement of matured Glomeruli towards centre and immature towards periphery was in accordance with Khayati Sant Ram et al, and Maria H et al.6,17 The emphasis on genetic counseling and possibility of early prenatal diagnosis has stimulated interest in fetal kidney anatomy.18 The current study was done on 20 fetuses (11 males and 9 females) with gestational age ranging from 14-36 weeks. The findings of this study were found to be within the ranges of findings of other authors and also in the literature.

CONCLUSION

This study helps us to know the sequence of development of various parts of histogenesis of kidney and its correlation with the fetal gestational age. It focused mainly on morpho-histological changes during renal development in fetuses, both in the architecture of the medulla and cortex for understanding of congenital and pathogenesis of kidney.

ACKNOWLEDGEMENTS

Authors would like to thank the department of Anatomy Obstetrics and Gynecology and Pathology KAMSRC, for the help and moral support. Lastly, we will always remain grateful to all editors and publishers of all the Articles, Journals and Books from where needful information for this research study was taken.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES