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Original Research Article

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

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ABSTRACT

Background: The knowledge of fetal human Kidney morphology and developmental anatomy is very important for prenatal diagnosis of disorders such as Wilm's tumor, hydronephroses and congenital malformation etc.
Methods: The study was carried out on 40 kidneys procured from 20 spontaneously aborted fetuses (11males 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 haemtoxylin 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, KAMSRC, 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 36weeks (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, KAMSRC, LB Nagar; Hyderabad (Telangana), India.

Methodology

The materials for present study were 20 fetuses (11 males and 9 females) with gestational age ranging from 14-36weeks. 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).[7] 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.

Age(in lunar months)	Crown rump length in mm
3	55
4	100
5	150
6	200
7	230
8	265
9	300
10	335

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

Groups	Gestational age in weeks	Number of fetuses
A	14-18	3
B	19-23	5
C	24-28	3
D	29-32	4
E	32-36	5

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 16weeks 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.

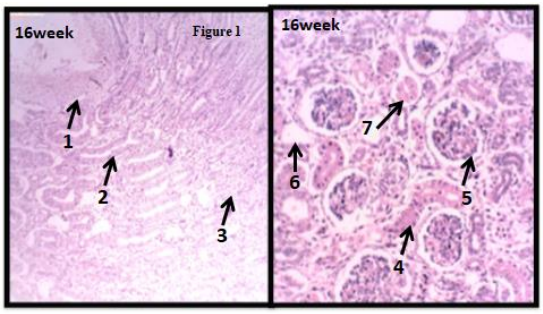

Figure 1: Medulla and Cortex 14-18 weeks, 1. Renal Pelvis 2,4. Collecting ducts 3. Undifferentiated. Mesenchyme 5. Glomerulus 6. Nephrogenic vesicle 7. Convoluted tubules (H and E, x10)

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 (24-28weeks): 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).

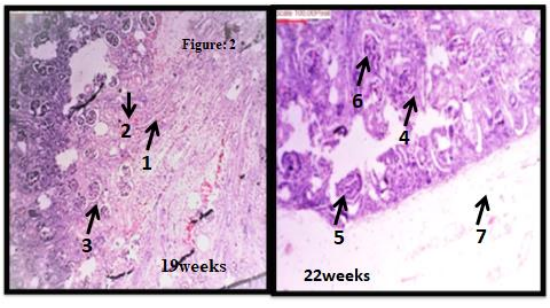

Figure 2: Cortex 19-23 weeks, 1.Collecting tubules 2.Corticomedullary junction 3.Glomeruli 4.'c' shaped glomeruli 5.'s' shaped glomeruli 6.'v' shaped glomeruli 7. Connective tissue between lobules (H and E, x10).

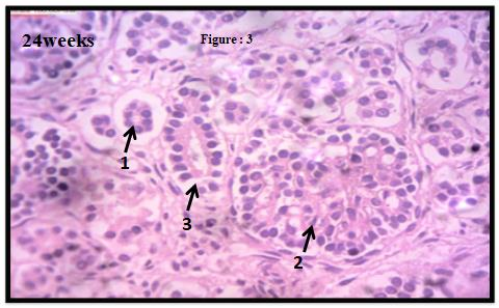

Figure 3: Cortex 24-28 weeks, 1.Proximal convoluted tubule 2.Glomeruli 3.Distal convoluted tubule (H and E, x40).

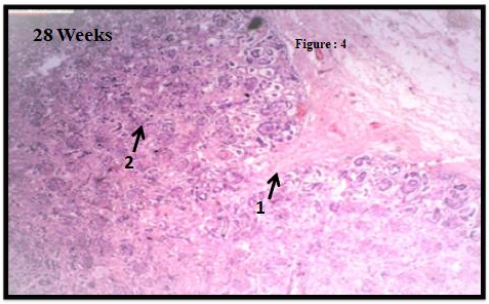

Figure 4: Cortex 24-28 weeks, 1. connective tissue between lobules 2. connective tissue in kidney parenchyma(H and E, x4).

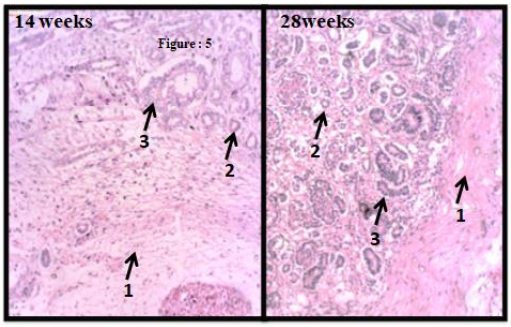

Figure 5: 1. Undifferentiated mesenchyme at 14 weeks and 28 weeks 2. Convoluted tubules 3. Collecting tubules. (H and E, x10).

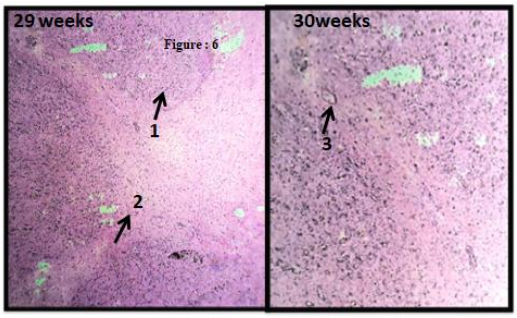

Figure 6: Cortex 29-32 weeks, 1. Pyramids 2. Renal cortical columns 3. Artery development between two pyramids (H and E, x4).

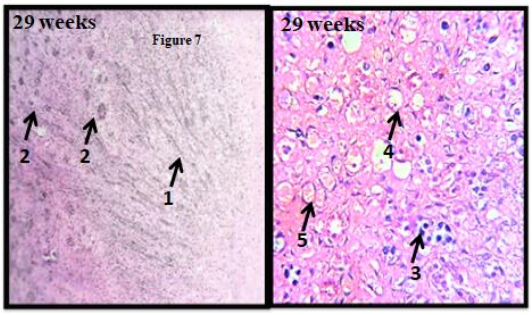

Figure 7: Medulla 29-32 weeks, 1. Medullary rays 2. Mature glomeruli towards center than immature glomeruli 3. Thick ascending Loop of Henle 4. Thin descending Loop of Henle 5. Vasa recta (H and E, x4).

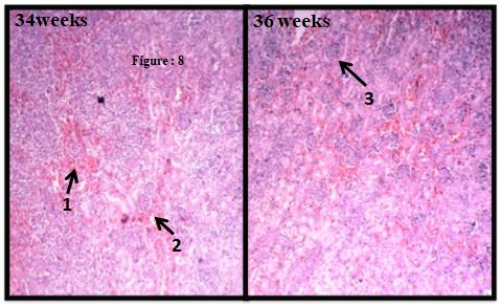

Figure 8: Cortex 32-36 weeks, 1. Increased vascularity 2. Group of juxta cortical glomeruli 3. Cortex under capsule(H and E, x10).

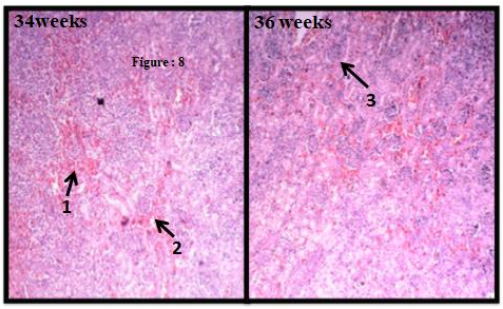

Figure 9: Medulla 32-36 weeks, 1. Tightly packed Loop of Henle 2. Grouping of collecting ducts 3. Renal pelvis (H and E, x10).

Group D (29-32weeks): Cortex: Juxtacortical glomeruli arranged themselves in groups of 2-3. The glomeruli have developed lobulation. Matured glomeruli are towards centre and immature towards periphery. Medullary rays are well developed by 29weeks along with development of arteries and renal cortical columns on either side of developed pyramids. (Figure 6).

Medulla: Loops of Henle are surrounded by vasculature which could be Vasa recta (Figure 7).

Group E (32-36 weeks): Cortex: Well developed compact thick capsule is seen. Lobules have fused by 36 weeks. Connective tissue, undifferentiated mesenchyme are reduced giving a compact look to the well distinguished cortex and medulla. Fully matured tubules and lobulated glomeruli are seen (Figure 8).

Medulla: The magnified visual field is covered with cut section of LOH with interstitial space showing rich vascularity. Collecting tubules which were scattered are organized in groups forming duct of Bellini. Renal pelvis is well developed, lined by transitional epithelium and with its own vasculature (Figure 9).

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.[2] 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 is 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.[2] 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.

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REFERENCES

1. Tank KC, Saiyad SS, Pandya AM, Akbari VJ, Dangar KP. A study of histogenesis of human fetal kidney. Int J Biol Med Res. 2012 Jan;3(1):1315-21.
2. Sharma S, Raina S. Study of human fetal kidney. Int J Anat Res. 2014;2(4):785-90.
3. Dyson M. Urinary System In: Gray`s anatomy. Williams PL, Bannister LH, Berry MM, Collins P, et al. eds. 38th ed. Publisher: Churchill Livingstone, New York, Edinburgh; London, 1995: 1815-1828.
4. Young B, Lowe JS, Stevens A, Heath JW. Urinary system In Wheater's functional histology. Whitehouse A. Eds. 5th ed. Publisher: Churchill Livingston; UK, 2006: 302-320.
5. Merkel CE, Karner CM, Carroll TJ. Molecular regulation of kidney development: is the answer blowing in the Wnt?. Pediatr Nephrol. 2007 Nov 1;22(11):1825-38.
6. Ram KS , Sharma A , Sahni D, Chawla K, Singh HJ. Developmental Changes in Histology Of Human Fetal Kidney. IJSRM. 2014;2(9):1394-1400.
7. Hamilton WJ, Boyd JD, Mossman HW. Human Embryology (Prenatal development of form and function). Human Embryol. 1945:172-7.
8. Solanke K, Bhatnagar R, Dibyajyoti B. occurring during development of kidney in 12wk-35wk human fetu. Available onl Article History. 2017.
9. Mamatha Hosapatna, Hemalatha Bangera, Anne D Souza, Aswin Das, Supriya, Antony Sylvan D Souza, et al. Histological differentiation of human fetal kidney. IAIM. 2015;2(7):49-54.
10. Patil DS, Patil DP, Mane DA. Histogenesis of Human Fetal Kidney.
11. Potter L. Development of the human glomerulus. Arch Pathol. 1965;80:241-255.
12. Syed SA, Joshi RA, Herekar NG. Histogenesis of Kidney in Human Fetuses. Int J Recent Trends Scie Technol. 2012;3(2):44-8.
13. Mishra S, Dinesh A, Kaul JM. Morphological and morpho-metrical study of human renal development during midgestation period. J Anat Soc India. 2006;55(2):5-10.
14. Rao BN, Padmini MP. Prenatal histogenesis of kindey in human foetuses. International J Basic Appl Med Sci. 2012;2:144-7.
15. Vinci L, Locci A, Gerosa C, Puddu M, Ottonello G, Fanos V, et al. Structural and cellular changes in fetal renal papilla during development. J Pediatr Neonatal Indiv Med (JPNIM). 2017 Feb 25;6(1):e060136.
16. Takano K, Kawasaki Y, Imaizumi T, Matsuura H, Nozawa R, Tannji M, Suyama K, Isome M, Suzuki H, Hosoya M. Development of glomerular endothelial cells, podocytes and mesangial cells in the human fetus and infant. Tohoku J Exp Med. 2007;212(1):81-90 .
17. Lizardo-Daudt HM, Edelweiss MI, Santos FT, Schumacher RD. Diagnosis of the human fetal age based on the development of the normal kidney. J Brasileiro de Patolo Med Laborat. 2002;38(2):135-9.
18. Sampaio FJ. Analysis of kidney volume growth during the fetal period in humans. Urol Res. 1992 Jun 1;20(4):271-4.

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