International Journal of Medical and Health Research
ISSN: 2454-9142
www.medicalsciencejournal.com
Volume 4; Issue 5; May 2018; Page No. 28-32

Organogenesis & histogenesis of kidney in human fetuses at different weeks of gestation

Arpan Haldar[1*], Dr. Manisha R Gaikwad[2], Soumya Chakraborty[3], Dipti Basu[4], Provas Banerjee[5]

[1] Senior Resident, Department of Anatomy, All India Institute of Medical Sciences, Bhubaneswar, Odisha, India
[2] Additional Professor and Head, Department of Anatomy, AIIMS Bhubaneswar, Odisha, India
[3] Professor and Head, Department of Anatomy, ESI-PGIMSR, Joka, Kolkata, West Bengal, India
[4] Professor of Anatomy & Principal, Hi-Tech Medical College & Hospital, Rourkela, Odisha, India
[5] Professor and HOD, Department of Anatomy, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha India

Abstract
Kidneys develop in early in 5th week and start to function around 9th week in the intermediate mesoderm of human embryos as metanephric kidney. Kidney is covered by a thick capsule made up of fibrous tissue beneath which cortico-medullary differentiation is well marked. Glomerulus with afferent & efferent arterioles are present in kidney. PCT, DCT, Collecting tubules & Duct of Bellini visible in medulla. Cortico-medullary junction well differentiated &Cortex is more than Medulla. Lobar & interlobar arteries seen in renal corpuscles. Lobulation & medullary rays visible in cortex. Between medullary rays multiple crescentic glomeruli visible. Bowman's Capsule & subcapsular space present. These structures are absent in younger foetuses & develop in increasing gestational age but the kidney in foetuses are lobulated which is absent successively. Aborted human foetuses without obvious congenital anomaly of gestational age between 12 weeks and 36 weeks collected and processed for histological sections by H/E stain. This study was done to correlate the chronological pattern of kidney development in this geographical eastern region of India, Odisha & compare the results from other researchers nationwide & worldwide.

Keywords: intermediate mesoderm, metanephric kidney, collecting tubules, duct of Bellani

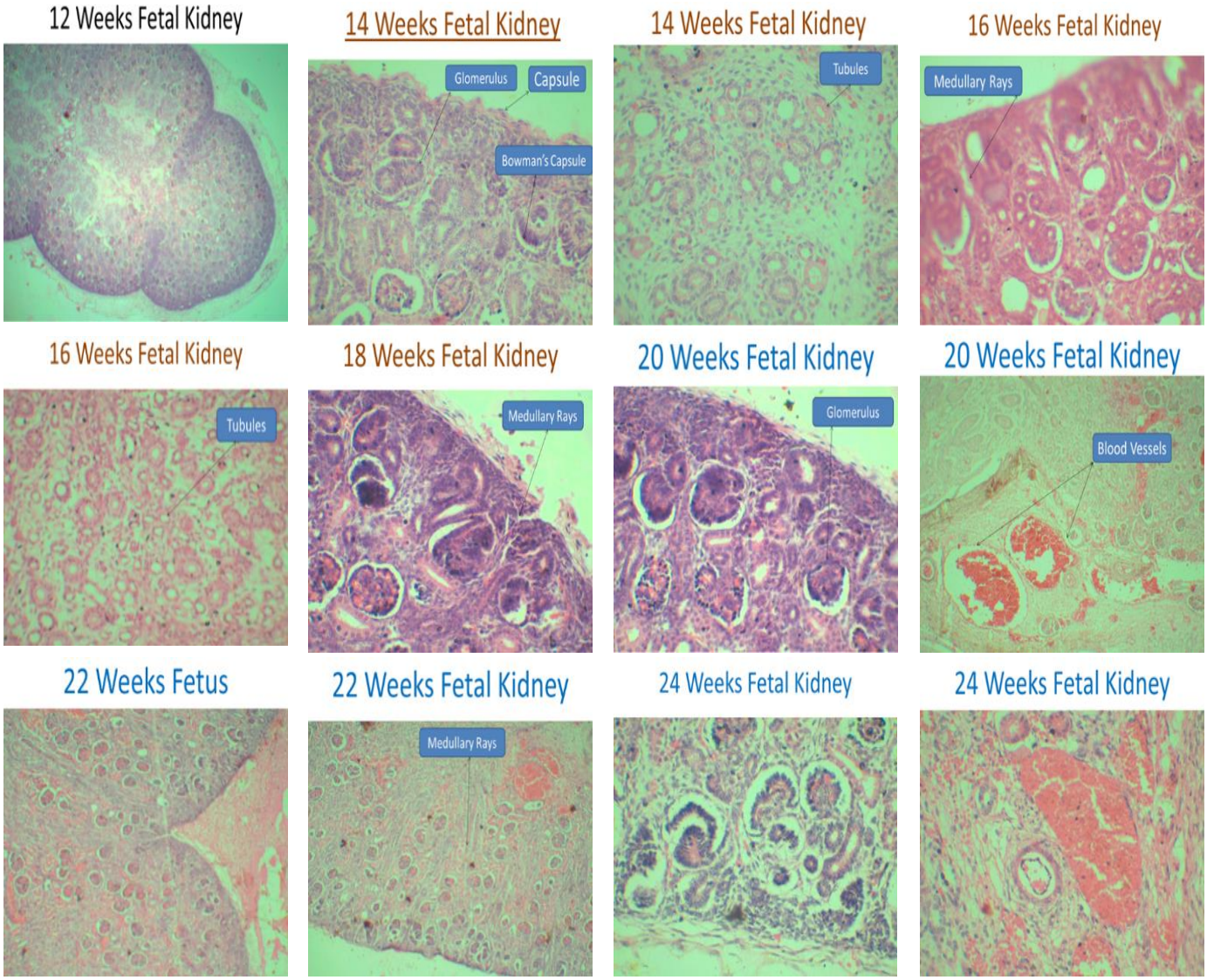
Introduction
Kidneys develop in early in 5th week and start to function around 9th week in the intermediate mesoderm of human embryos as pronephric kidney, mesonephric kidney and metanephric kidney [1]. Metanephros remain as permanent kidneys & pronephros and mesonephros disappear. It develops from 2 sources-metanephric diverticulum (ureteric bud) forming the collecting part & metanephric mass of intermediate mesoderm (metanephrogenic blastema) forms the secretory part [2]. Kidney is covered by a thick capsule made up of fibrous tissue beneath which cortico-medullary differentiation is well marked. Glomerulus with afferent & efferent arterioles are present in kidney [3]. PCT, DCT, Collecting tubules & Duct of Bellini visible in medulla. Cortico-medullary junction well differentiated &Cortex is more than Medulla [4]. Lobar & interlobar arteries seen in renal cospuscles. Lobulation& medullary rays visible in cortex [5]. Between medullary rays multiple cresenteric glomeruli visible. Bowman's Capsule & subcapsular space present [6].

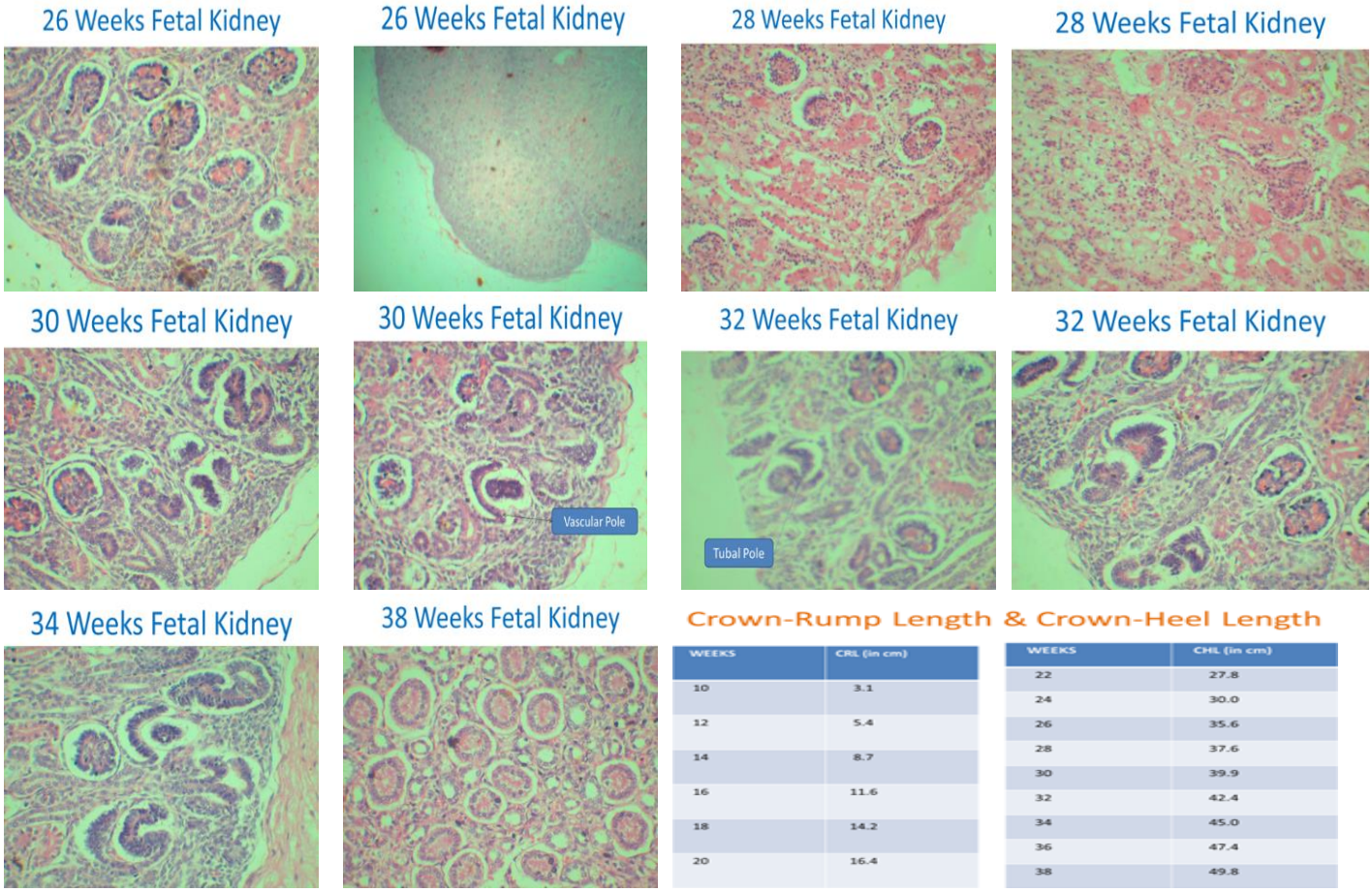
Aims and Objectives
The present study aims to study histogenesis and development of human kidney in prenatal period to observe microscopic structure of kidney at various gestational age groups and its future implications in cadaveric renal transplantations in renal failure patients.

Materials & Methods
This study was done to correlate the chronological pattern of kidney development in this geographical eastern region of India, Odisha & compare the results from other researchers nationwide & worldwide. This is a hospital based, observational, cross sectional study conducted at Hi- Tech Medical Colleges & Hospital, Bhubaneswar, India by the Department of Anatomy in collaboration with Department of Obstetrics & Gynaecology from November 2011 to June 2013 on thirty two aborted human foetuses without obvious congenital anomaly of gestational age between 12 weeks and 36 weeks collected within 6 hours of delivery by spontaneous miscarriages & therapeutic legal abortions. Study samples were arbitrarily divided into groups of biweekly gestational age by duration of amenorrhoea from medical records & ultrasound fetometry after receipt of informed consent from mother and legal guardians. Fetuses were immediately fixed in 10% Formalin for 1-2 hrs. Kidney dissected by Dissecting Microscope, fixed in 10% Formalin for 48-72 hrs. After fixation by formalin, the tissues were transferred to 30%, 50%, 70%, 90% and Absolute alcohol each for 30 minutes. This ascending grading of the dehydrating fluid was done because when alcohol mixes with water, it produces diffusing current which can damage the tissues. Then the tissues were put in xylol for 24 hours to clear the residual alcohol. These tissues were processed for paraffin sections by tissue blocking

(Paraffin Embedding). 3 pots of hard paraffin were taken; paraffin was melted in the incubator at 56 degrees, as hard paraffin is ideal for materials which are to be cut in thin sections about 5 mu. The tissue was put in the first pot containing equal parts of paraffin and xylol and then changed to second and third pots containing only fresh melted paraffin at 90 minutes interval. Then the tissues were mounted in fresh melted paraffin with L-Block. The L-Block was then trimmed to a rectangular shape. Then the L-Block was fixed with the block holder (choke) and the block holder was clamped in the rotary microtome. 5 mu sections were cut in rotary microtome. The microtome was revolved at 40 rpm and ribbon was formed. Then the ribbon was put in tissue flotation bath. Albuminised slide was then made by putting a drop of Mayor's albumin (equal parts of glycerine and egg white) and spreading it uniformly by rubbing with finger. The piece of ribbon was then taken on the slide and dried at room temperature. The slide was then put in the warming table. When the paraffin melted the slide was put into xylol for 2-3 minutes because xylol removes paraffin. Then the tissue was put in decreasing grades of alcohol (Absolute alcohol,90%,70%,50% and 30%) then was put in the prepared Harris Alum Haematoxylin (nuclear) stain for 7 minutes and lastly washed with distilled water.2-3 drops of 1% acid alcohol (1cc Hcl in 75% alcohol) was added to remove the excess stain beyond the nucleus. The slide was then put in running tap water for 30 minutes to develop haematoxylin colour (bluish). Then the slides were again dipped in ascending grades of alcohol (30%, 50%, and 70%) and then put in eosin Y (cytoplasmic) stain for 30 seconds. Then the slide was washed with absolute alcohol for a few seconds so that excess of eosin was removed and lastly the slide was placed in xylol. The slide was then taken out from xylol and then put in 1-2 drops of DPX (Adhesive agent) and a cover slip was put on it and pressed slightly so that air bubbles were removed. Sections were then seen in light microscope under low power 10X followed by high power 45X magnification. Thereafter photomicrographs were taken by camera using microscope adapter.

Observations





WEEKS	CRL (in cm)
10	3.1
12	5.4
14	8.7
16	11.6
18	14.2
20	16.4

WEEKS	CHL (in cm)
22	27.8
24	30.0
26	35.6
28	37.6
30	39.9
32	42.4
34	45.0
36	47.4
38	49.8

Fig 1

In 12 Weeks Fetal Kidney- Cortex & Medulla couldn't be differentiated in the peripheral region. There are number of nephric vesicles formed by condensation of disorganised mesenchymal cells.

In 14 Weeks Fetal Kidney- Lobes seperated only in superficial part of cortex & in deeper part of cortex they were fused with each other. Kidney covered by a thin capsule made up of fibrous tissue beneath which cortico-medullary differentiation was not well marked. Cortex is more than Medulla.

In 16 Weeks Fetal Kidney- Capsule is visible, just deep to it multiple glomerulus present in cortical part. Capsular space well visible. Bowman's Capsule & subcapsular space present. Definite medulla present.

In 18 Weeks Fetal Kidney- Medullary Rays visible. Between medullary rays multiple cresenteric glomeruli visible. Medulla with Tubules visible. In 18 Weeks Fetal Kidney Lobules & Capsule present. Medullary Rays visible in cortex. Both PCT & DCT clearly visible. Large blood vessels seen in medulla. Connective tissue in between tubules are plenty. Tubules arranged in groups separated by connective tissue in cortex. Peripheral Part of cortex renal cospuscles are smaller size but Juxta-Glomerular part of cortex renal cospuscles are larger in size.

In 20 Weeks Fetal Kidney- Renal cospuscles visible. Many blood vessels seen in medulla. Collecting tubules visible in medullary region. Medullary rays visible in cortex.

In 22 Weeks Fetal Kidney- Lobulation still present. Many blood vessels in medulla. Renal cospuscles more compact towards periphery of cortex. PCT & DCT visible.

In 24 Weeks Fetal Kidney- Collecting tubules present in medullary region. Lobulation & medullary rays visible. Renal cospuscles in cortex. Thin capsule present.

In 26 Weeks Fetal Kidney- Thin capsule visible below which developing glomerulus not well differentiated. PCT & DCT present in deeper part of cortex with fully developed renal cospuscles. Lobulation are still present. Loops of Henle & connective tissue visible. Occasionally some blood vessels are seen in the field.

In 28 Weeks Fetal Kidney- Nephrogenic zone thin under capsule. Large amount of blood vessels seen. Collecting tubules & Loops of Henle seen in medullary region.

In 30 Weeks Fetal Kidney- Nephrogenic zone very reduced. Duct of Bellini & collecting tubules clearly seen in medulla. PCT, DCT& Loop of Henle seen. Cortico-medullary junction well differentiated. Vascular pole of renal corpuscles formation visible.

In 32 Weeks Fetal Kidney- Vascular pole exists in renal corpuscles. Capsule well demarcated. Nephrogenic zone is very thin. PCT, DCT, Collecting tubules & Duct of Bellini visible.

In 34 Weeks Fetal Kidney- Glomerulus with afferent& efferent arterioles visible. Other findings are similar.

In 36-38 Weeks Fetal Kidney- Cortex is more than Medulla. Lobar & interlobar arteries seen. Other findings are similar.

OBSERVATIONS (Left Kidney)

WEEKS	LENGTH (in cm)	BREADTH (in cm)	WIDTH (in cm)	WEIGHT (in gm)
10	**1.1**	**0.5**	**0.3**	**0.2**
12	1.2	0.6	0.6	0.31
14	1.4	0.9	0.7	0.6
16	1.4	0.8	0.6	0.9
18	1.8	0.9	0.8	1.0
20	1.3	0.9	0.7	1.08
22	1.6	0.8	0.9	1.2
24	**0.9**	**1.0**	**1.0**	**1.8**
26	2.0	1.2	1.0	0.6
28	1.9	1.0	0.9	1.5
30	2.0	1.5	0.8	1.9
32	3.4	2.1	1.6	2.9
34	3.9	2.7	1.8	3.8
36	4.7	3.2	2.1	4.3
38	**5.2**	**3.6**	**2.8**	**4.9**

OBSERVATIONS (Right Kidney)

WEEKS	LENGTH (in cm)	BREADTH (in cm)	WIDTH (in cm)	WEIGHT (in gm)
10	**1.0**	**0.6**	**0.4**	**0.22**
12	1.0	0.6	0.6	0.3
14	1.4	1.0	0.9	0.7
16	1.2	0.7	0.6	0.88
18	1.4	0.7	0.8	1.18
20	1.4	0.8	0.8	1.2
22	1.5	0.9	0.7	1.17
24	**1.0**	**0.8**	**0.6**	**1.7**
26	1.7	1.3	1.1	0.6
28	1.0	1.1	0.9	1.45
30	2.0	1.6	0.8	2.0
32	3.2	1.9	1.7	2.7
34	3.7	2.2	1.9	3.2
36	4.3	2.8	2.3	3.9
38	**5.1**	**3.2**	**2.5**	**4.2**

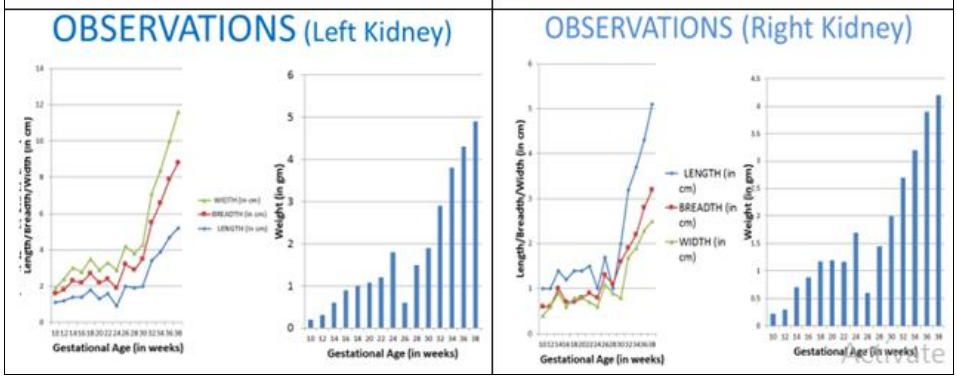


Fig 2

Discussion

Human fetal kidneys showed lobulation which was well marked in early weeks of fertilization, as weeks of fertilization increased, lobulations were less marked. The lobes were seperated only in the superficial part of cortex & in deeper part of cortex they were fused with each other [7]. Kidney was covered by a thin capsule made up of fibrous tissue. In early weeks of fertilization, only immature glomeruli present just beneath capsule. Beneath the capsule the cortico-medullary differentiation was not well marked in earlier weeks of fertilization, during later weeks fertilization increased cortex & medulla were very well differentiated [8]. The thickness of cortex & medulla were increased with increase in weeks of fertilization. In superficial part of cortex, nephrogenic zone was very large at lower weeks of fertilization but during later stages of fertilization increased size of nephrogenic zone decreased [9]. Deep to nephrogenic zone, but in the superficial part of cortex, the various stages of developing glomeruli were seen in different stages of development. As weeks of fertilization increased number of mature glomeruli increased which were present in deeper parts of cortex [10]. In earlier weeks of fertilization in between the developing glomeruli within the connective tissue, the developing tubules were seen, as weeks of fertilization increased they differentiated into proximal & distal convoluted tubules at 17 weeks of fertilization [11]. Medulla contains undifferentiated mesenchymal tissue which decreased with increase in fertilization age [12]. As the age of fetus increased the numbers of mature tubules were increased & connective tissue was decreased. With increase in age of fertilization vascularity of both cortex cortex & medulla was increased. Nephrogenic zone was observed upto 32 weeks of fertilization. Size of nephrogenic zone was decreasing while size of cortex & medulla increased with increase in fetal age [13].

Conclusion

Present work may prove useful in defining fetal kidney diseases such as agenesis, hypoplasia, multicytic kidney, polycystic kidney etc. more precisely using the most modern invasive or non-invasive imaging technique [14]. From the current study one can conclude that major part of development of fetal kidney occurs during mid-gestational period & continues until the last week of 3rd trimester of gestation [15].

Acknowledgement

The corresponding author acknowledges the support and guidance received from Prof. Dr. Shyamal Kumar Basu.

References

1. Abrahamson V, Glomerulo genesis DR. in developing kidney. Semin Nephrol. 1991; 11:375-389.
2. Bannister LH, *et al*. Embryology and Development-Urinary and Reproductive System. In Gray's Anatomy; Churchill Livingstone, 1995, 174-192.
3. Development Urinary and Reproductive System. In Gray's Anatomy; Churchill Livingstone, 1995, 174-192.
4. Fujikara T, Froehlich LA. Birth weight, gestational age, and renal glomerular development as indices of fetal maturity. Am.J.Obstet.Gynecol.1972; 113:627-631.
5. Hamilton WJ, Boyd JD, Mossman HW. Growth of the embryo and fetal development of external form.
6. Nyengaard JR, Bendsten TF. Glomerular Number and Size in Relation to Age, Kidney weight, and Body surface in normal man. The Anatomical Record. 1992; 232:194-201.
7. Osathanondh V, Potter EL. Development of Human Kidney as Shown by Microdissection. I. Preparation of tissue with Reasons for possible misinterpretations of observations. Arch Pathol. 1963; 76:271-276.

8. Potter EL, Thierstein ST. Glomerular Development in the Kidney as an index of fetal maturity. J Pediatr. 1943; 22:695-706
9. Sadler TW. Urogenital System. In Langman's Medical Embryology; Lippincott Williams & Wilkins, 2004, 321-362.
10. Sampaio FJB, Aragao AHM. Study of fetal kidney length growth during the second and third trimesters of gestation. Eur Urol. 1990; 17:62-65.
11. Lechner MS, Dressler GR. The molecular basis of embryonic kidney development. Mech Dev. 1997; 62(2):105-20.
12. Saxen Z. Organogenosis of the Kidney. Cambridge: Cambridge University Press, 1987.
13. Gomez RA, Norwood VF, Tufro-McReddie A. Development of the kidney vasculature. Microsc Res Tech. 1997; 39(3):254-60.
14. Perantoni AO. Renal development: perspectives on a Wnt-dependent process. Semin Cell Dev Biol. 2003; 14(4):201-8.
15. Wallner EI, Carone FA, Abrahamson DR, Kumar A, Kanwar YS. Diverse aspects of metanephric development. Microsc Res Tech. 1997; 39(3):261-84.