

## Relative Position of Kidney in Developing Foetuses

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**Abstract:** The kidneys are developed in a craniocaudal sequence from pronephros, mesonephros and metanephros. The pronephros is rudimentary and the non-functional, second is short functioning and third is permanent kidney. The ascent of the kidney from the pelvic region to the abdomen is seen by the end of the 9<sup>th</sup> week along with rotation from anterior to medial aspect. During ascent, failure to alter the position results in ectopic kidneys with or without rotational changes. So, kidneys from 20 human foetuses of different gestational age groups were studied to see the relative position of kidney. Meticulous dissection was done specifically from anterior aspect to observe the level of upper pole, hilum and lower pole of both the kidneys in relation to vertebral column and to each other, any abnormality in position during the ascent of kidney. From early gestational age to the later part, all the kidneys except two cases were found in abdominal position by the side of the vertebral column. The position varied from T<sub>10</sub> to L<sub>5</sub> vertebral body along with hila facing anteromedially in early gestational ages to medially in later age groups. The left cross renal ectopia with fusion of similar lower poles of both kidneys forming "L-shaped" unsymmetrical horseshoe kidney with rotational anomaly and rotational anomalies in bilateral kidneys with more rare excessive rotation of left kidney were found in two different cases. The knowledge of kidney position in different gestational age will be of immense value to the clinicians of related specialities.

**Key Words:** Ascent of kidney, Crossed renal ectopia, Rotational anomaly.

### I. Introduction

In intrauterine life the permanent kidney appears in the form of three slightly overlapping kidney systems in a craniocaudal sequence.<sup>1</sup> Initially, lying in the sacral region close to each other, the kidneys later shift to a more cranial position in the abdomen at the end of embryonic period, due to diminution of the body curvature<sup>1,2,3</sup> and by the rapid longitudinal growth of the body in the lumbar and sacral segments and the decrease in the lumbar flexion of the embryo.<sup>2,3</sup> In the pelvis the permanent kidneys lie close to each other but after the ascent, they move further apart. Failure to alter the position results in ectopic kidneys.<sup>3,4</sup> One kidney crossing to the other side results in crossed renal ectopia with or without fusion<sup>3</sup> where one kidney wanders to the contra-lateral side and its ureter crosses the median plane.<sup>4</sup> Initially, the hilum faces ventrally. During ascent, the kidneys rotate medially almost 90° and the hilum faces anteromedially. Abnormal rotation of the kidneys is often associated with ectopic kidneys.<sup>3</sup> Ventral facing hila are seen in rotational absence of kidneys whereas the dorsally or laterally faced hila are seen in hyper rotation or reverse rotation of kidneys respectively.<sup>5</sup> The present study is an attempt to obtain some information on the positional level of kidney in relation to vertebral column in developing fetuses.

### II. Materials & Method

This study was done in the Department of Anatomy, Regional Institute of Medical Sciences, Imphal, in 20 foetuses from 14 to 40 weeks of gestational ages (GA), which were collected from Obstetrics & Gynaecology Department in RIMS Hospital, Imphal, as a product of MTP (under MTP Act, 1971) & stillbirth with due permission from concerned authorities and persons. Institutional Ethical Clearance was taken. Immediately after collection, GA (gestational age) was determined by Crown-Rump length (CRL) and maternal history. Foetuses were immersed and fixed in 10% formalin for two weeks. They were divided into 4 groups: Group I - 14 to 20 weeks GA, Group II - 21 to 28 weeks GA, Group III - 29 to 35 weeks GA, Group IV - 35 weeks & above GA. The kidneys were exposed anteriorly through an abdominal midline vertical incision from xiphoid to pubic symphysis and extended to each side by incising on the subcostal line above and below the line joining pubic symphysis to anterior superior iliac spine. Intraperitoneal organs were removed. Peritoneum, pararenal fat, renal fascia, perirenal fat, fibrous capsule were removed. Later on, the blood vessels were excised for proper visualization of the vertebral column. The position of the kidneys in relation to vertebral column counting from the sacral promontory was evaluated. The positional landmarks of the upper pole, hilum and lower pole for each sided kidney were evaluated with a perpendicular line by placing a thick thread. The corresponding vertebral body or intervertebral disc space was recorded.

**III. Results**

Among the 20 number of foetuses, two foetuses were found as anomalous. So 18 of the foetuses were included in the study to see the position and the other two were described separately. All the kidneys were found intrabdominally, at lumbar region by the side of the vertebral column. The distribution of the foetuses was as follows:

**Table 1:** Distribution of foetuses in different age groups.

Group	Gestational Age	No. Of Foetuses	Percentage (%)
I	14-20	5	25
II	21-28	6	30
III	29-34	5	25
IV	35 & above	4	20
Total		20	100
Anomaleous fetus		2	10
1.Fusion anomaly		1	5
2.Rotational anomaly		1	5

**Table 2:** Maximal positional level range of upper and lower poles of right and left Kidneys in different gestational age groups with exception in the groups.

Group	Vertebral Level Of Kidney		
	Parts Of Gestational Age	Right Kidney	Left Kidney
I (14-20 weeks)	Earlier part	Same level (T <sub>12</sub> -L <sub>3</sub> )	Same level (T <sub>12</sub> -L <sub>3</sub> )
	Later part	Right lower (T <sub>11</sub> -L <sub>4</sub> )	Left higher (T <sub>11</sub> -L <sub>3-4</sub> )
	Exception	Left crossed fused renal ectopia (5% cases)	
II (21-28 weeks)	Earlier part	Same level (T <sub>11</sub> -L <sub>3</sub> )	Same level (T <sub>11</sub> -L <sub>3</sub> )
	Later part	Right lower (T <sub>11</sub> -L <sub>3,4</sub> )	Left higher (T <sub>11,12</sub> -L <sub>3</sub> )
	Exception	-	
III (29-34 weeks)	Earlier part	Right lower (T <sub>11</sub> -L <sub>4</sub> )	Left higher (T <sub>11</sub> -L <sub>3-4</sub> )
	Later part		
	Exception	One case (5% cases): right kidney higher (T <sub>12</sub> -L <sub>4</sub> ) and left kidney (T <sub>12</sub> -L <sub>1</sub> to -L <sub>4,5</sub> intervertebral disc) level	
IV (35 weeks & above)	Earlier part	Right lower (T <sub>11</sub> -L <sub>5</sub> )	Left higher (T <sub>10,11</sub> -L <sub>4,5</sub> )
	Later part		
	Exception	Rotational anomaly in both the kidneys (5% cases)	

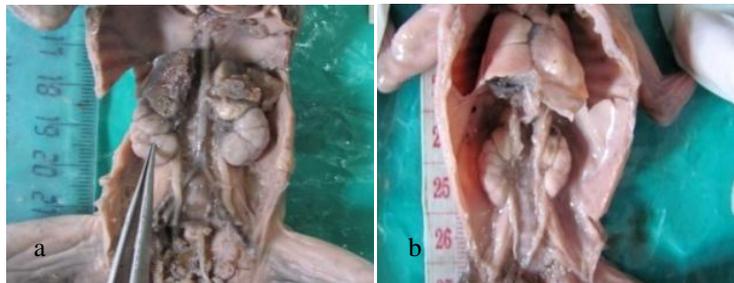
**Table 3:** Maximal positional range of hila and the positional changes of both the Kidneys from each other in different gestational ages.

Group	Parts Of Gestational Age	Hilar Position		Hilar Direction	Position Of Poles From Each Other
		Right Kidney	Left Kidney		
I (14-20 weeks)	Earlier part	Same level (L <sub>2</sub> )		Anteromedial	Lower poles nearer than upper poles
	Later part	Varied from (L <sub>1</sub> -L <sub>2</sub> ) level			
II (21-28 weeks)	Earlier part	Same level (L <sub>1</sub> -L <sub>1,2</sub> )		Anteromedial	Lower poles nearer than upper poles
	Later part	T <sub>12</sub> -L <sub>1</sub> to L <sub>1,2</sub> level	L <sub>1</sub> -L <sub>1,2</sub> level		
III (29-34 weeks)	Earlier part	T <sub>12</sub> -L <sub>1</sub> to L <sub>2,3</sub> level		Anteromedial	Upper and lower poles almost at the same distance
	Later part			Medially	
IV (35 weeks & above)	Earlier part	T <sub>12</sub> -L <sub>1</sub> to L <sub>3</sub> level	L <sub>1</sub> -L <sub>3</sub> level	Medially	Upper and lower poles almost at the same distance
	Later part				

**Anomalies observed were:**

**Case1:** A foetus of 18 weeks of gestational age was found with absent left kidney with two kidneys present at right side. The right kidney was more or less vertical. The upper pole was at T<sub>11</sub> vertebral level, hilum was medially faced at L<sub>2</sub> level and lower pole at L<sub>3</sub> vertebral level. The ectopic left kidney was found on right being smaller than the right, oval shaped and lower pole fused with the lower pole of the right kidney. Both the poles and hilum were facing upwards and at the same level of L<sub>1,2</sub> intervertebral disc level. Both the ureters were not crossing to each other and the left one crossed the midline to reach left side.

**Case 2:** In a foetus of 35 weeks gestational age, both the kidneys and ureters were found in front of the vertebral column. The right kidney was found shorter, broader and obliquely placed from L<sub>1</sub>-L<sub>3</sub> vertebral level with hilum facing superomedially. The right upper pole was at L<sub>1</sub> level, hilum at L<sub>2</sub> level and lower pole at upper border of L<sub>3</sub> vertebral level. The left kidney was longer. The upper pole was found at lower border of T<sub>11</sub> vertebral level, hilum at L<sub>2</sub> level, facing posteromedially, lower pole at lower border of L<sub>3</sub> vertebral level. The distance between the two upper poles was more than the distance in between two lower poles. The surface of both the kidneys lost fetal lobulation and became smooth.



**Fig 1:** a) Foetus of 14 weeks of gestational age. Both the kidneys are at same level, lower poles are nearer than the upper poles, hila facing anteromedially, b) Foetus of 16 weeks of gestational age. Right kidney is lower than the left kidney, lower poles are nearer than the upper poles, hila facing anteromedially.



**Fig 2:** a) Foetus of 22 weeks of gestational age. Both the kidneys are in same level, lower poles are nearer than the upper poles, hila facing anteromedially. b) Foetus of 29 weeks of gestation. Right kidney is lower than the left kidney, lower poles are nearer than the upper poles, hila facing anteromedially.



**Fig 3:** a) Foetus of 30 weeks of gestation. Left kidney is lower than the right kidney, lower poles are nearer than the upper poles, hila facing medially. b) Foetus of 38 weeks of gestation. Right kidney is lower than the left kidney, lower poles are nearer than the upper poles, hila facing medially.



**Fig 4:** a) Foetus of 18 weeks of gestational age with left crossed fused renal ectopia. b) Foetus of 35 weeks of gestational age with superomedial (right) posteromedial (left) rotational anomaly.

#### **IV. Discussion**

The paired kidneys lie on each side of the vertebral column with much variation in the position to vertebral column.<sup>6</sup> The kidneys ascend from the pelvis to their permanent location in the upper lumbar region<sup>5</sup> at their adult position by ninth week.<sup>3</sup> In the present study of the foetuses from 14 to 40 weeks of gestational ages, all the kidneys were found in lumbar region and by the side of the vertebral column. All the kidneys attained their adult position. According to Hollinshead (1972), there is much variation in the position of the kidney relative to the vertebral column. In cadaver, the upper pole of left kidney varies from T<sub>10</sub> vertebra to L<sub>1</sub> disc and the lower pole from L<sub>1</sub> disc to L<sub>5</sub> vertebra, while the right kidney is slightly lower than the left kidney and the upper pole being from T<sub>11</sub> to L<sub>2</sub> and lower pole from L<sub>2</sub> to the lumbo-sacral disc.<sup>6</sup> In our study, in all the Groups except earlier part of Group I, II & III except a single case in group III, the right kidney was found lower than the left kidney. The upper pole of left kidney varies from T<sub>10-11</sub> disc level to T<sub>11-12</sub> disc level and lower pole L<sub>3</sub> level to L<sub>4-5</sub> disc level. The upper lobe of the right kidney was found at T<sub>11</sub> level with variability in individual cases of each group and lower pole at L<sub>3-4</sub> disc level to L<sub>5</sub> vertebra. The bi-lobed liver initially is of equal in size. Rapid proliferation of the cells and accumulation of erythroblast causes increase in liver size till 35 mm stage, however, in later stage diminish hepatic growth rate affects more in left lobe than the right lobe and initial symmetry in both lobes is lost.<sup>2</sup> As a result of mass of the liver, in most individuals, the right kidney lays 1 to 2 cm lower than the right.<sup>7</sup> This is not invariable and in some instances the right kidney may be higher than the left.<sup>5,7</sup> In the present study, the earliest of development in group I and II, both the kidneys are found at the same level, which may be explained by the equal growth of bi-lobe of liver. In present series of 20 foetuses, one case was found being left kidney lower than the right one. During ascent, the kidneys rotate medially and the hilum initially facing anteriorly faces medially.<sup>1,7</sup> In part, as a result of the contour of the psoas muscle, the lower pole of either kidney lies further from the midline than those doses the upper lobe and the upper pole tilt medially at a slight angle. The kidneys do not lie in the same coronal plane and the lower pole of the kidney lies slightly more anterior than the upper pole. The medial aspect of each kidney was rotated anteriorly on a longitudinal axis with the renal vessel and pelvis exiting the hilum medially in a relative anterior direction.<sup>8</sup> In present study, in early age group the hila were found anteromedially but in later gestational age groups, hila were found medially. This was also observed by Ningthoujam et al. as indentation of hilum at term along the medial border from anterior surface in foetal period. During foetal period, the lower poles being nearer then the upper poles but near the term, the gradual axis changes separates the lower pole more than the upper pole as in adults.<sup>9</sup> The medial border of both the kidneys is not parallel as lying by the side of the psoas major muscles and upper poles are nearer than the lower poles.<sup>6</sup> In the present study, in foetuses of early Group I & II, the lower poles were found nearer than the upper poles but in later stage, Group III & IV both the upper and lower poles were found parallel to each other.

About 10% of all newborn have a developmental abnormality of urinary tract and several anomalies can arise from variations in the process of ascent.<sup>5</sup> Cases of ectopic kidney, unilateral or bilateral have been reported in literature regurly with an incidence 1:500 to 1:1100. Crossed renal ectopia refers as the kidney cross from left to right or vice-versa with moving one kidney to the opposite side following ascent of the other kidney and both the kidneys located in the same side and mostly fused called crossed fused ectopia.<sup>10</sup> Crossed fused renal ectopia is the second most common fusion abnormality of the kidney with an incident rate 1:1300 to 1:7500.<sup>11</sup> Commonly, the ectopic kidney is situated below the normal kidney and the lower pole of the latter is therefore fused with the upper pole of the former and two make an elongated mass and lie on the same side of the body. But sometimes the kidneys have undergone some rotation before fusion. Their ureters are completely separated and cross the opposite of the body to reach the bladder.<sup>6</sup> In case of end to end fusion, one kidney may be inclined to each other and when the angle approaches 90<sup>0</sup>, it is called "L-shaped" kidney. It is applicable to the cases where one lateral mass of the horseshoe kidney atrophies, leaving only the isthmus and the opposite lateral mass causing unsymmetrical horseshoe kidney.<sup>12</sup> In a study by ultrasonography, renal ectopia was found in 2% of the cases where crossed ectopic fused kidney was 0.04% of the cases.<sup>13</sup> In the present study, we found 10% of the anomalous cases during ascent of kidney with left sided crossed fused renal ectopia in 5% of cases which is higher in our study, may be due to less number of cases. The right kidney was more or less vertical with smaller, ovoid left ectopic kidney horizontally placed and lower pole fused with former, forming more or less "L-shaped". Both the poles and hilum were facing upwards due to rotational changes. Both the ureters were not crossing to each other and the left one crossed the midline to reach left side. Anomalies of renal rotation may or may not be associated with renal ectopia with fusion but may be exhibited by otherwise normal and properly placed kidneys. Anomalous rotation can be in the form of non rotation, incomplete rotation, reverse rotation and excessive rotation. The reverse and excessive rotation is rarer where renal pelvis may almost be in any position depending upon the degree of rotation.<sup>6</sup> If the hilum faces posteriorly than the rotation of the kidney proceeded too far.<sup>3,7</sup> In the present study, 5% of the cases (one case) both right and left kidney underwent rotational changes with right sided superomedially and left sided posteromedially.

## V. Conclusion

In early gestational age to the later part, all the kidneys except two cases were found in abdominal position by the side of the vertebral column with various vertebral positions. The gradual rotational changes in their axes and positional changes from each other in early gestational age to the term were well observed. The rare left cross renal ectopia with fusion of similar lower poles of both kidneys forming “L-shaped” unsymmetrical horseshoe kidney with rotational anomaly is a very rare entity found in our study. Similarly, rotational anomalies in bilateral kidneys with more rare excessive rotation of left kidney are immense value. We hope that, knowledge of kidney position in different gestational age with rare anomalies will be helpful to the clinician for early diagnosis and management.

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