

## Relationship between the Fetal body weight and the Fetal kidney weight at different gestational ages of developing human fetuses in Gujarati population.

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### Abstract:

**Introduction:** Human kidneys start developing around 5th week of gestation which continues to grow until the last month of pregnancy. Size and weight of kidney is dependent on the number and size of nephrons and the sequential changes in the weight of normal developing human kidney and its relation with the fetal weight during different gestational period is very important to diagnose any fetal abnormalities associated with abnormal kidney size. The aim of the present study was to establish the relationship between fetal body weight and fetal kidney weight at different gestational ages of developing human fetuses in the Gujarati population. **Material and methods:** Present study was conducted in the Department of Anatomy, B.J. Medical College, Ahmedabad, Gujarat, in collaboration with Department of Obstetrics and Gynecology, Civil hospital, Ahmedabad, Gujarat during the year 2013 to 2018 on 53 abortus/fetus of gestational age ranging from 14 to 40 weeks. **Results:** A continuous increase in the fetal as well as right and left kidney weight was observed which was slightly slowed down nearing the end of the gestation period. The rate of increase in total kidney weight and rate of increase in fetal body weight are not in linear fashion. Further the rate of increase in kidney weight is more as compared to rate of increase in fetal weight during 30-33 weeks of gestational age owing to the renal development in the latter part of the pregnancy. During the early stage of development, the rate of increase in both the kidneys were slow but as the fetal weight crosses 1000 gm, the kidney weight increases faster. **Conclusion:** Observations of the present study pertaining to fetal body weight as well as fetal kidney weight at different gestational ages of developing human fetuses can be used as reference parameters while performing routine perinatal postmortem examination.

**Key words:** Fetal Kidney, Fetal weight.

### Introduction:

The human kidneys are situated in the upper abdominal region on each side of vertebral column behind peritoneum.<sup>1</sup> They are surrounded by adipose tissues which act as cushion.<sup>2</sup> Both the kidneys develop in the pelvic region during early embryonic life. Later on they move to more cranial position in the abdomen.<sup>3</sup> Morphological formation of human fetal kidney commences from 5<sup>th</sup> week of

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intrauterine life and continues up to the last month of pregnancy.<sup>4</sup> Pronephros, mesonephros and metanephros are three overlapping kidney systems formed in cranial to caudal sequence during intrauterine life of the human being. Out of these three systems, metanephros forms the permanent kidneys in human being.<sup>5</sup> Size and weight of kidney is dependent on the number and size of nephrons.<sup>6</sup> Information regarding the sequential changes in the various parameters of normal developing human fetal kidney during different gestational period is very important to diagnose any fetal abnormalities associated with abnormal kidney size.<sup>7</sup> In the present study, we aimed to establish the relationship between fetal body weight and fetal kidney weight at different gestational ages of developing human fetuses in the Gujarati population.

### **Aims and objectives**

The aims and objective of the present study was to provide normal values of the fetal weight as well as right kidney weight and left kidney weight; to establish relationship between the fetal body weight and the fetal kidney weight; to provide practically useful growth curve of the fetal weight, fetal kidney weight and gestational age at different gestational ages of developing human fetuses in the Gujarati population.

### **Materials and methods**

Present study was conducted in the Department of Anatomy, B.J. Medical College, Ahmedabad, Gujarat, in collaboration with Department of Obstetrics and Gynecology, Civil hospital, Ahmedabad, Gujarat after obtaining requisite permission from the ethical committee, medical superintendent and concern heads of the departments. Present study was carried out from the year 2013 to 2018 on abortus/fetus collected from Department of Obstetrics and Gynecology, Civil hospital, Ahmedabad, Gujarat. 53 fetuses of gestational age ranging from 14 to 40 weeks were collected on the basis of following inclusion and exclusion criteria:

#### ***Inclusion criteria***

14-40 weeks of gestational age, detected by ultrasonography before abortion with normal obstetric history, clinical history available, free from observable and detectable abnormalities and patients willing to participate in study (parents have to fill consent form which is available in Gujarati, Hindi & English language).

#### ***Exclusion criteria***

Aborted fetuses below the gestational age of 14 weeks, fetus with any observable and detectable congenital anomalies, clinical history not available, formalin fixation before examination, hydrops fetalis, known abnormal karyotype or any other genetic disease, macerated fetuses, presence of congenital malformation, maternal or fetal infection, multiple pregnancies and patients not willing to participate in the study.

Fetuses were collected in sterilized container after cutting umbilical cord. Fetus collected from the labor room were brought to the department of Anatomy and immediately washed in to tap water. Each specimen has been provided with unique identity number. By using special ophthalmic instruments as well as small size anatomical dissection instruments,

fetuses were fixed in 10 % formalin. The weight of the fetus had taken before and after formalin fixation by digital weighing machine. The weight readings used in this study refer to weight of fetuses those have been fixed for about 2 weeks in 10% formalin. Formalin fixed specimens then dissected for retrieval of the kidneys and other organs. A vertical incision was made in the midline starting from the symphysis pubis to the xiphoid process. The organs were dissected by en block removal method. After removal of kidneys, each right and left kidney was weighed separately. Highly calibrated digital weighing machine, having capacity to measure weight with an error of 0.01 gram, was used to weigh the kidneys as well as whole fetuses.

### Observations / Results:

Out of 53 fetuses having gestational age ranging from 14-40 weeks, maximum number of fetuses were in gestational age of 17, 18 and 25 weeks (5 fetuses each), minimum number of fetuses were in gestational age of 21, 23, 26 and 39 weeks (1 fetus each). Fetuses were divided into 4 groups based on their gestational ages. These groups are based on developmental stages of the kidney.

**Table 1: Classification of fetuses on the basis of Gestational week (GW)**

Group	Age of fetus	Total No of fetuses	Percentage of fetuses
1	14-18 week	12	22.64
2	19-26 week	16	30.19
3	27-32 week	12	22.64
4	33-40 week	13	24.53

Table 1 show four groups based on Gestational Week (GW) in which Group 1 having fetuses of gestational age from 14-18 week, Group 2 having fetuses of gestational age from 19-26 week, Group 3 having fetuses of gestational age from 27-32 week and Group 4 having fetuses of gestational age from 33-40 week. Among total 53 fetuses, we received 12 fetuses in Group 1 (22.64%), 16 fetuses in Group 2 (30.19%), 12 fetuses in Group 3 (22.64%) and 13 fetuses in Group 4 (24.53%).

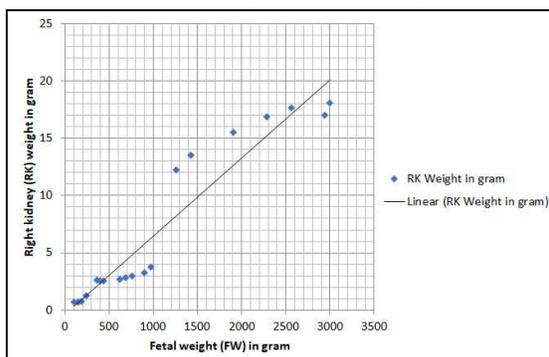
According to the data denoted in table 2, as the gestational age advances, the weight of fetus as well as the weight of right and left kidney is increasing. At the later part of pregnancy near the full term at 39 weeks of gestational age, there is slight decrease in the fetal weight as well as kidney weight is denoted. In the last column the ratio of total kidney weight and fetal weight is shown. From this ratio, we can say that the rate of increase in total kidney weight and rate of increase in fetal body weight are not in linear fashion. Further the rate of increase in kidney weight is more as compared to rate of increase in fetal weight during 30-33 weeks of gestational age. Looking at the above data, we can say that the rapid rise in fetal kidney weight and because of that the most of the renal development is occurring in the latter part of pregnancy.

The graph 1 and 2 show the comparison of fetal weight with the weight of right and left kidney respectively. It was observed that both the kidneys were growing at nearly same rate. As it is evident from the both the graphs, during the early stage of development, the rate of increase in both the kidneys were slow but as the fetal weight crosses 1000 gm, the kidney weight increases faster. Similar pattern of weight gain was observed in both the kidneys.

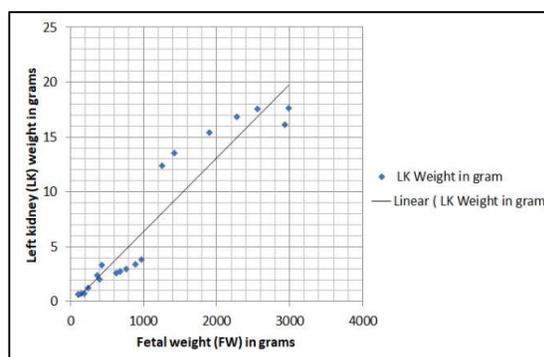
**Table 2: Mean fetal weight, mean kidney weight and ratio of total kidney weight/fetal weight**

Sr No	Gestational week (GW)	Number of fetuses	Range of FW (gm)	Mean FW (gm)	Mean RK Weight (gm)	Mean LK Weight (gm)	Total kidney weight/ Fetal weight
1	16	2	102-104	103	0.66	0.65	0.01
2	17	5	135 - 187	150.8	0.71	0.72	0.01
3	18	5	185 - 191	188.4	0.74	0.77	0.01
4	19	3	242 - 246	244.33	1.25	1.22	0.01
5	21	1	364	364	2.65	2.40	0.01
6	22	2	361 - 432	396.5	2.54	2.07	0.01
7	23	1	432	432	2.56	3.32	0.01
8	24	3	590 - 693	624.33	2.71	2.58	0.01
9	25	5	665 - 695	682	2.86	2.77	0.01
10	26	1	762	762	2.98	2.96	0.01
11	27	3	890 - 900	894.67	3.26	3.41	0.01
12	28	4	891 - 1010	975.25	3.78	3.85	0.01
13	30	3	1223-1290	1254.33	12.23	12.40	0.02
14	31	2	1395-1450	1422.5	13.50	13.50	0.02
15	33	3	1850-1982	1907.33	15.50	15.37	0.02
16	35	3	2256-2300	2281.67	16.87	16.87	0.01
17	36	3	2540-2599	2562.33	17.67	17.57	0.01
18	37	3	2967-3011	2992.67	18.07	17.60	0.01
19	39	1	2938	2938	17	16.10	0.01

**Graph 1: Comparison between fetal weight and fetal Right kidney weight**



**Graph 2: Comparison between fetal weight and fetal Left kidney weight**



**Table 3: Group wise mean fetal weight and mean fetal kidney weight**

Sr No	Group	Gestational age of fetus	Total number of fetus in group	Mean fetal weight (gram)	Mean right kidney weight (gram)	Mean left kidney weight (gram)
1	1	14-18 week	12	158.5	0.70	0.71
2	2	19-26 week	16	522.94	2.50	2.47
3	3	27-32 week	12	1099.42	8.19	8.29
4	4	33-40 week	13	2474.62	17.02	16.70

Table 3 shows the mean fetal weight, mean right kidney weight and mean left kidney weight as per the group distribution 1 to 4. It can be observed from the data in the table 3 that the rate of increase in the fetal kidney weight was high during the early stages of the development. In the first 3 group, there was almost 3 times increase in the weight of right fetal kidney as well as the weight of left fetal kidney. During the later part of pregnancy, at 33 – 40 weeks of the gestational period, the increase in the weight of the kidneys slows down as compared to earlier part of pregnancy, which is in contrast to what is observed in the fetal weight. Fetal weight rises rapidly during the later stages of gestation period.

## Discussion

The present study evaluated the relationship between the weight of the fetal kidney with the fetal weight. Many researcher from various regions have studied the similar parameters.

Sulak O et al<sup>8</sup> studied the size and location of the fetal kidneys in 344 fetuses to determine the morphometric development and location of the fetal kidneys in Turkish population. According to their study fetal weight as well as weight and volume of the kidneys increased as the gestational age increases during the fetal period. The ratio between kidney weights and fetal body weights were decreased as the gestational age advances. They found no statistical significant difference between sexes for the fetal weight as well as fetal kidney weight. In present study also, we found the positive correlation between the gestational age and fetal body weight, gestational age and fetal kidney weight as well as fetal body weight and fetal kidney weight as we move from group 1 to 4. Cussen L et al<sup>9</sup> studied mean organ weights of 1337 fetuses and infants having gestational age from 20-43 weeks in an Australian population. Same as that of present study, in their study also the fetal kidney gains more weight in the latter half of pregnancy. Guihard-Costa AM et al<sup>10</sup> studied carefully selected 673 fetuses autopsied in fetopathology units of pediatric hospitals in Paris. They found the mean body weight for the fetuses of the age of 15–18 weeks, 19–26 weeks, 27–32 weeks and 33–40 weeks to be 142.35, 498.47, 1363.7 and 2612.3 gm respectively. The weight of left kidney was found to be 0.42, 2.45, 6.55 and 11.52 gm respectively for the above mentioned age group whereas the weight of the right kidney was 0.41, 2.46, 6.4 and 11.14 gm respectively.

Maroun LL et al<sup>11</sup> studied various body parameters as well as fresh organ weights in 1800 human fetuses having gestational age ranging from 12-43 weeks in Denmark. They found that the mean fetal kidney weight increases as the gestational age as well as mean fetal weight advances, but all these parameters are reducing at variable rate as the maceration goes on. Phillips JB et al<sup>12</sup> studied 553 fetuses of gestational age from 12 weeks to 42 weeks in Australian population to establish a complete and accurate set of Australian reference ranges to be used during the routine perinatal post-mortem examination. They found the mean fetal weight in the gestational age group of 14 – 18, 19 – 26, 27 – 32 and 33 – 40 weeks to be 124.46, 552.69, 1363.23 and 2572.26 gm respectively. Gestational age beyond 19 weeks onwards, the mean fetal body weight in their study is more as compared to present study. The mean weight of the right kidney in previously mentioned age group of fetus was found to be 0.6, 2.81, 6.59 and 11.97 gm respectively, similarly for the same age groups, the weight of

the left kidney was found to be 0.6, 2.83, 6.64 and 12.07 gm respectively. All these parameters of weight of kidneys are less in Australian population as compared to Gujarati population of present study. Hansen K et al<sup>13</sup> studied the organ weights, body weight, and linear measurements for 597 fetuses and neonates with gestational ages ranging from 12 to 26 weeks in American population. The fetal body weight as well as fetal kidney weight of the Gujarati population is more as compared to American population studied by them for both the gestational age group of 14-18 weeks as well as 19-26 weeks.

**Table 4: Comparison of means of weight of fetal kidneys of various gestational age of present study with previous researchers**

Researcher	Population	Gestational age (week)	Mean fetal weight (gm)	Mean RK weight (gm)	Mean LK weight (gm)	Mean of combined kidney weight (gm)
<b>Sulak O<sup>8</sup></b>	Turkey	9-12	30	0.20	0.19	0.39
		13-25	293.10	1.15	1.14	2.29
		26-37	1424.48	4.38	4.37	8.75
		38-40	2819.20	7.37	7.22	14.59
<b>Cussen L<sup>9</sup></b>	Australia	20 – 27	634.3	-	-	6.75
		28 – 31	1323.7	-	-	13.85
		32 – 43	2675.5	-	-	25.6
<b>Guihard-Costa AM<sup>10</sup></b>	France	15 – 18	142.35	0.41	0.42	0.83
		19 – 26	498.47	2.46	2.45	4.91
		27 – 32	1363.7	6.40	6.55	12.95
		33 – 40	2612.3	11.14	11.52	22.66
<b>Maroun LL<sup>11</sup></b>	Denmark	14-18	115.7	-	-	1
		19-26	523.5	-	-	5.27
		27-32	1310.83	-	-	13.75
		33-40	2501.25	-	-	26.69
<b>Phillips JB<sup>12</sup></b>	Australia	14-18	124.46	0.6	0.6	1.20
		19-26	552.69	2.81	2.83	5.64
		27-32	1363.23	6.59	6.64	13.23
		33-40	2572.26	11.97	12.07	24.04
<b>Hansen K<sup>13</sup></b>	USA	14-18	115.2	-	-	1
		19-26	483.87	-	-	4.69
<b>Thakur R<sup>14</sup></b>	Chhatisgarh, India	14-18	-	0.76	0.75	1.51
		19-26	-	1.03	1.13	2.16
		27-32	-	2.97	3.10	6.07
		33-40	-	5.55	6.21	11.76
<b>Sunitha V<sup>15</sup></b>	Andhra Pradesh, India	14 – 18	-	0.36	0.36	0.72
		20 – 26	-	1.63	1.61	3.24
		28 – 32	-	3.81	3.83	7.64
		36 – 40	-	5.35	5.35	10.70
<b>Present study</b>	Gujarat, India	14-18	158.5	0.72	0.73	1.45
		19-26	522.94	2.47	2.38	4.85
		27-32	1099.42	7.63	8.65	16.28
		33-40	2474.62	17.02	16.79	33.81

Thakur R et al<sup>14</sup> studied morphometric and histological quantitative analysis of nephron during development of human fetal kidney in the latter half of gestation in 42 kidneys between 16-40 weeks of gestational age in Chhattisgarh, India. They found increase in weight and volume of right and left kidney with increase in the gestational age of the fetus. In the present study also we found increase in weight of right and left kidney with increase in the gestational age of the fetus. Sunitha V et al<sup>15</sup> studied development of human kidney in 50 still born fetuses between 10-40 weeks of gestational age in Vizianagaram, Andhra Pradesh, India. Mean weight of right kidney ranged from 200.8 mg (at 10 weeks) to 5600 mg (at 40 weeks), while mean weight of left kidney ranged from 200 mg (at 10 weeks) to 5500 mg (at 40 weeks). Weight of fetus as well as weight of right and left kidneys is more in the Gujarati population of present study as compared to the findings of the study done by Sunitha V.

Ryan D et al<sup>16</sup> studied development of 71 human fetal kidneys between 20-41 weeks of gestational age in Australia. They measured fetal weight as well as fetal kidney weight immediately after birth in all 71 specimens. In both male as well as female infants from 20 weeks of gestational age until the full term, they found strong positive correlation between gestational age and fetal body weight as well as gestational age and fetal kidney weight. Male infants were significantly heavier than the female infants overall, with significantly heavier kidney. Rate of body and kidney weight gain over the gestational period was not different between male and female infants. Throughout the gestational period, kidney weight was directly proportional to the body weight. The findings in the Gujarati population of present study are also backing up the findings of Ryan D et al. J Man et al<sup>17</sup> studied organ weights and ratios for postmortem identification of fetal growth restriction in 1064 fetuses in London. The majority of fetal organs including kidneys in small for gestational age fetuses were significantly lighter than those in non small for gestational age fetuses. Body organ weight ratios for kidney were significantly greater in macerated fetuses as compared with non-macerated fetuses demonstrating that the macerated fetuses having disproportionately lighter organs compared with body weight. Internal organs lose weight more as compared to musculoskeletal elements of body during period of retention after intrauterine death. In the non-macerated human fetuses used in the present study, we obtained the fetal kidney weight and fetal body weight ratio, which is fluctuating during the whole length of gestational period, suggestive of difference in the rate of increase in the fetal kidney weight and fetal body weight during different gestational ages of developing human fetuses in Gujarati population. Das N et al<sup>18</sup> studied morphometric analysis of human fetal kidney in 60 spontaneously aborted and still born human fetuses between 11-38 weeks of gestational age in Imphal, Manipur, India. They found statistical significant and positive correlation between fetal kidney weight and fetal gestational age. All the parameters show the linear growth from 11-38 weeks of gestational age with growth spurts during 18-22 weeks as well as during 24-26 weeks of gestational age. In the present study, we found growth spurt in fetal weight and fetal kidney weight at 37-39 weeks of gestational age.

#### **Conclusion:**

As the gestational age advances, the fetal body weight, fetal right kidney weight, fetal left kidney weight as well as fetal combined kidney weight increases with only growth spurts

between 37-39 weeks of gestational age. Ratio between fetal kidney weight and fetal body weight is fluctuating during the whole length of gestational period, suggestive of difference in the rate of increase in the fetal kidney weight and fetal body weight during different gestational ages of developing human fetuses in Gujarati population. Observations of the present study pertaining to fetal body weight as well as fetal kidney weight at different gestational ages of developing human fetuses can be used as reference parameters while performing routine perinatal postmortem examination. This population specific data regarding gestational age, fetal body weight and fetal kidney weight can be correlated with one another and if any of these two parameters are known than the third parameter can be obtained for the Gujarati population of present study.

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