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The determination of the changes in the size of kidneys related with gender, age and lateralization with ultrasound

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Abstract
Objective: Morphological development of kidneys according to age and sex was evaluated in this study and data obtained were analyzed statistically.
Material and Method: This study was conducted in Radiology Department of Meram Faculty of Medicine in Necmettin Erbakan University. It was performed on 100 subjects (32 male and 68 female) age of 4-47. 200 kidneys were examined with ultrasound imaging technique. Length, width, thickness values of kidneys were measured and volume and shape indexes were calculated. Data were evaluated in SPSS program (10.0 for windows) and paried sample T test statistically.
Results: Length, width, thickness and RV of right kidney in male was found to be greater than of the female and of left kidney. Length, thickness and RSI values of left kidney in female was found to be greater than of the male and of right kidney. All results have been discussed and compared with the existing results in the literature.
Conclusions: Results attained in the study might be an additional knowledge resource about kidney development and in last years it was decided that they may be useful in sciences such as urology which uses partial nephrectomy and renal transplantation as treatment.

Keywords: Kidney, morphometry, adult

Introduction

Kidneys are located in posterior wall of the abdomen and both sides of columna vertebralis. They are surrounded by loose connective tissue and adipose tissue, and their frontal face is covered with peritonaeum. Their upper part is at the level of 11th thoracic vertebra and lower part is at the level of 3th lumbar vertebra. Since liver is located in the right-upper part of abdominal cavity, right liver is located at a little lower level than left one. Long axis of kidneys is parallel to columna vertebralis. But their upper ends are closer to each other. Each kidney is 11.5 cm in length, 5-7 cm in width and 2,5 cm in thickness. Left kidney is a little longer and tighter than the right kidney. Weight of a kidney is 125 - 170 gr. in adult male and 115 – 155 gr. in adult female. Total weight of two kidneys is approximately 1/240 of the weight of body. This proportion is three times greater in newborn babies [1].

Kidneys are bean shaped and have two faces (facies anterior and Facies posterior), two sides (Margo Medialis and Margo Lateralis), two edges (Extremitas superior and Extremitas inferior) [1].

Most studies demonstrat substantial variability in normal human kidney weight differ markedly. Mean kidney weight have varied from 267 to 432 g and 228 to 312 g in adult men and women, respectively [2, 11]. Many factors have been stated to influence kidney weight. It is well known, for example, that males have greater kidneys than females [3, 5, 6, 8, 11]. Age is associated with decreased kidney dimensions [3, 6, 9, 11] and racial differences in kidney weight have been reported [10]. It is also well known that body size, eg, body surface area, may be used to normalize the kidney weights of children with those of adults [6]. However, the role of body build in determining kidney weight in other circumstances, (eg, obesity and old age), has not been investigated.

Renal length is a single, directly measured. It is the most commonly used quantitative measure of renal dimensions for purposes of comparison with established standards. Renal volume is less frequently used because it requires calculation from multiple measurements. Deviation of renal size from established normal values implies alteration in renal growth and is an important diagnostic criterion for the identification of renal disease.

On Sonography, renal size may be measured in different planes. The various graphically depicted normative standards are based on measurement of renal size obtained from these different imaging planes. It has important that the method of renal length measurement closely replicate that used in creation of the growth chart used as a reference standard [12, 13]. However, a number of factors, including distribution eg. bowel gas, presence of overlying dressings, drainage catheters, and surgical scars, patient cooperation, and patient size may render feasible only certain imaging planes in a given patient. Strict adherence to replication of the imaging method used in growth of the normative reference standards would require using multiple standards within a single imaging center. Kidney size and development is and important parameter in various renal disorders in children [14, 15, 16, 17, 18]. Renal length at urography is a well recognized method for kidney size estimation both in adults and children [19, 20, 15, 21, 16]. Kidney length has also been size by ultrasonography a method of good accuracy [22, 23, 24].

Sonography is a convenient method for examination of the kidneys in children due to the absence of harmful side effects (radiation exposure and allergic contrast reactions) [25, 26].
This study was conducted in consideration of that it would be useful, by the morphometric development of kidneys, to evaluate their differences in regards to sex, age and lateralization (right, left) and comparison of studies conducted on adult.

Materials and Methods
Our study was conducted on 100 patients scanned with ultrasonography (USG) at our hospital in between 2016-2017. Study was approved by Necmettin Erbakan University Faculty of Medicine Ethical Committee according to Copenhagen criteria by (2008/210). As a beginning study forms have been prepared. Personal data including age, sex and habits information were written down. It was suggested to eat a light meal before 2 or 3 hours to patients for an accurate measurement. And it was said to them empty bladder was a necessity. Afterwards it was time for ultrasound scan. Measeurements were performed in supine position. Renal dimensions (length, width, thickness) were measured (Fig 1). Length in cranio-caudal plane, width in medio-lateral plane and thickness in upper pole, mid pole, lower pole were measured in each kidney (Fig 1).

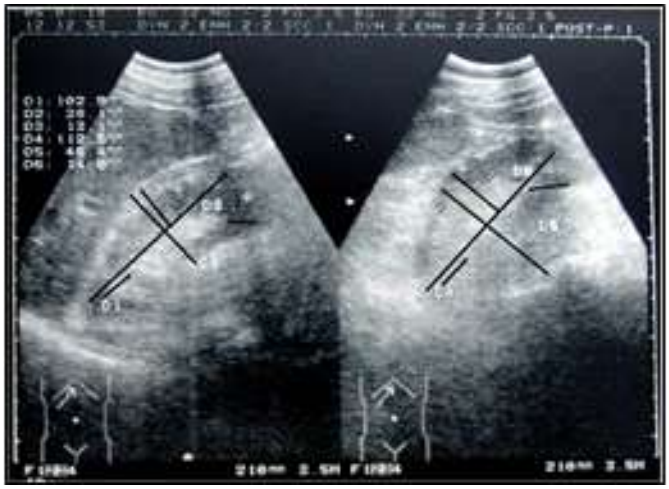

Fig 1: Kidney USG of a 38 year old male

For calculation

Renal shape index (RSI): Renal length/ Renal width + Renal thickness

Renal volume (RV): length x width x thickness x 0.5

Data obtained have been transferred into computer and statistical analysis has been done with SPSS program (10.0 for windows). Data were shown as mean ± SD. T test which shows the difference between groups, if there is any, was performed. $p < 0.05$ value was regarded as significant statistically.

Results
Data obtained from length, width and thickness measurements on kidneys were evaluated statistically. Mean ± SD and P values of these parameters were calculated according to sex (male - female) and lateralization (right - left) and organized in tables. Significant difference was found in length, width and thickness values of each kidney between genders ($p<0.05$) (Table 1). Excluding length and thickness of left kidney and RSI values of right and left kidneys all values were found to be greater in male and in right kidney. Comparison results of right and left kidney measurements were shown. Statistical correlations were evaluated and a significant correlation was not seen between parameters ($p>0.05$).
No significant correlation was seen between age and all parameters ($p>0.05$) (Table 3). Kidney sizes according to various researchers have been shown in Table 4.

Discussion
Kidneys are located in retroperitoneal area in sides of columna vertebralis; right kidney is between Th12-L3 and left kidney is in Th11-L2 vertebral levels [1]. It is known that left kidney is located 8-12 mm higher and closer to medial line compared to right kidney; and extremitas superior and extremitas inferior of kidneys extend vertically, approximately 1 cm closer to medial line in upper part [1].
Length of right kidney is 10.97 cm and length of left kidney is 11.21 cm and thickness of right kidney in hilus renalis averagely 3.21 cm and of left kidney 3.37 cm, width of extremitas superior of right kidney is 6.40 cm and of left kidney 6.48, width of extremitas inferior of right kidney 5.59 and of left kidney 5.39 in an adult.
In references Hoffman [27] stated that there was a difference between right and left kidneys: Right Length: 11.2 cm, Width: 5.6 cm, Thickness: 3.8 cm. Left Length: 11.8 cm, Width: 5.45 cm, Thickness: 3.5 cm. Values belonging to right and left kidneys were shown in Table 4 to compare with Hoffman's data. As analysis on this table implies left kidney is longer than right kidney, and width, thickness values are greater in left kidneys, coherent to data of said researcher. Researchers who support this idea report that kidneys are not equal in size and generally left kidney is a little bigger [28, 29, 30]. All values are greater in left kidney excluding RSI ($p<0.05$) (RSI right 1.90 ± 0.26, left 1.77 ± 0.27). And they had accepted the reason as liver's forcing effect for this asymmetric growth of kidneys.
Autopsy data had shown that weight of kidney differed among normal adults; also male kidney was wider than female kidney [31]. In the study of Gourtsoyannis *et al.* [31] there was not seen difference in the volume of renal parenchyma between two genders. Their findings were coherent with Kasiske and Umen's anatomic findings who studied about kidney size depending on body structure without gender difference [2].
Chiara *et al.* [32] evaluated kidney length with ultrasonography in 132 infants normal and premature born. Average length values were determined as 39 5±7mm for right kidney and 40 1±6 9 mm for left kidney. They had determined a correlation between gestational age and kidney length and reported that there were no significant difference between genders. De Vries *et al.* [33] have reported that there was a significant correlation between gestational age and kidney length, and to determine the anomalies normal kidney parameters should be known.

Unlike the renal measurements that had been performed on children, renal measurements that performed on adult were only a few [32, 34, 35]. In many studies differences between genders have not been observed in the measurements that were performed on children and infants [2, 36, 37]. But in the study of Emamian *et al*. significant differences have been observed which were coherent with the post-mortem [38] and radiologic studies [39]. Significant difference were observed between genders, in our study ($p<0.05$) (Table 2). Excluding length and thickness of left kidney, all values were found to be greater in male (Male left length: 10.18 ± 81 cm, left thickness: 14.3 ± 3.13 cm; female left length: 10.21 ± 9.10 cm, left thickness: 14.91 ± 2.74 cm).

Kidney was being wider and thicker with the age according to renal shape index.

This small but significant difference in renal shape index seemed interesting but was not practical. Decrease in kidney dimensions are known as anatomic findings of various researcher. According to an explanation, it is said that abdominal wall is becoming loose and thus kidneys are compressed lower in elders; in another explanation it is also said that liver is compressing right kidney and right kidney is becoming explicit.

Loss of renal mass reaches to 40 % in patients primarily cortical [40] and in octogenarian decade [21]. Accordingly glomerulus are covered with hyalinization 30 %. Between quadragenarian and nonagenarian decades renal blood current decreases by 50 % [25] Gourtsoyiannis' [35] findings show that renal parenchymal thickness decreases with the age. Proportion of thickness of the renal parenchyma to transverse diameter of vertebral body decreases by 10 % in every decade [31]. In our study, renal measurements were observed less in age of 19, increased in age of 20-39 and decreased a little in age of 60 and above. And these were found to be coherent with the other researchers' measurements. In the findings of Goutsoyiannis *et al*. [31] mass of renal parenchyma was expressed ideally as a+b+c+d / vertebral diameter (Renal parenchymal thickness: anterior (a), posterior (b), posterior (c), external (d). But we may explain it with the loose on abdominal wall with the age and low compression of kidneys in elder people. Also low compression on the right kidney by liver is also a subject.

In this study and in former radiological studies a small amount of change in central echogenic area with the age has been observed. On the contrary, recent studies show that adipose takes place in renal parenchyma with the age [41]. Our study shows that renal volume is enough to measure renal parenchymal mass and represent renal mass.

Volume of renal parenchyma right kidney is significantly lesser than of left kidney's in all age groups ($p<0.001$ between ages of 30 - 60, $p=0.13$ in age of 70). This may be explained as spleen is being smaller than liver and that left kidney is having more space to grow and by the relative increase in volume resulting more blood to flow in left artery, left artery being shorter than right artery, left kidney being straighter [36]. Renal thickness showed a little change with age and gender [36]. Measurements of parenchymal thickness of kidneys may be useful in pathological cases [36].

In this study, a significant difference was observed in length, width and thickness values of each kidney between genders; excluding length of left kidney and thickness, parameters have been found greater in female. According to lateralization, excluding RSI value of left kidney, a significant difference was not observed between right and left kidneys. In all data obtained significant correlations were not determined between age and length, width and thickness values of kidneys; and between parameters of right kidney and parameters of left kidney. Results acquired in this study were coherent with the results in literature and with the results acquired in the studies referred above.

As a result of this study morphometric evaluation of kidney has been done and data obtained were compared with the results of studies conducted both on children and on adult. It was concluded that the knowledge of kidney morphometry and its morphometric variations may be useful for treatment of internal diseases, urological surgery interventions and uroradiology for purposes of diagnosis, medical monitoring and treatment.

Table 1: Comparison of parameters measured in kidney belonging to right and left parts (male - female) (mm) (Mean±SD) (n=32 male, n=68 female)

	Right			Left		
Parameters	**Male Mean±SD**	**Female Mean±SD**	**P**	**Male Mean±SD**	**Female Mean±SD**	**P**
Length	102,20± 10,29	99,14 ± 9,62	0,150	101,81 ± 9,99	102,15 ± 9,10	0,866
Width	42,12 ± 6,40	37,86 ± 6,16	0,002	45,63 ± 8,15	43,15 ± 7,48	0,135
Thickness	15,05 ± 3,03	14,03 ± 4,03	0,208	14,32 ± 3,13	14,91 ± 2,74	0,342
RV	33178,3 ± 12597,1	27078,8 ± 11345,9	0,017	34736,9 ± 15703,7	33840,9 ± 12099,4	0,755
RSI	1,81 ± 0,28	1,94 ± 0,25	0,031	1,73 ± 0,25	1,79 ± 0,27	0,272

Table 2: Comparison of parameters measured in kidneys according to lateralization (right-left) (Mean ± SD) (n=100 right, n=100 left)

	Right	Left	
Parameters	**Mean±SD**	**Mean±SD**	**P**
Length	100,04 ± 9,87	101,85 ± 9,50	0,186
Width	39,16 ± 6,52	43,95 ± 7,71	0,000
Thickness	14,33 ± 3,74	14,69 ± 2,87	0,454
RV	28923,8 ± 12028,7	34000,9 ± 13278,9	0,005
RSI	1,90 ± 0,26	1,77 ± 0,27	0,001

Table 3: Comparison of right and left parameters measured in kidney (mm) (Mean± SD)

Parameters	Age	n	Mean±SD	P
Right length	19 and below	28	95,07 ±11,01	0,008
	20–39	22	103,46 ±9,87	
	40–59	42	101,23 ±7,63	
	60 and above	8	101,37 ±11,44	
	Total	100	100,04 ±9,87	
Right width	19 and below	28	35,88 ± 6,09	0,007
	20–39	22	38,78 ± 5,90	
	40–59	42	41,16 ± 6,66	
	60 and above	8	41,28 ± 4,74	
	Total	100	39,16 ± 6,52	
Right Thickness	19 and below	28	14,33 ± 3,74	0,693
	20–39	22	13,95 ± 3,91	
	40–59	42	14,37 ± 2,43	
	60 and above	8	15,06 ± 6,04	
	Total	100	13,79 ± 2,88	
Left Length	19 and below	28	101,85 ± 9,50	0,000
	20–39	22	92,80 ± 12,30	
	40–59	42	104,68 ± 7,92	
	60 and above	8	104,44 ± 8,05	
	Total	100	98,06 ± 9,46	
Left Width	19 and below	28	43,95 ± 7,71	0,007
	20–39	22	43,47 ± 10,38	
	40–59	42	45,71 ± 7,34	
	60 and above	8	45,58 ± 7,33	
	Total	100	40,12 ± 6,65	
Left Thickness	19 and below	28	1,77 ± 0,27	0,303
	20–39	22	1,66 ± 0,28	
	40–59	42	1,75 ± 0,28	
	60 and above	8	1,76 ± 0,21	
	Total	100	1,84 ± 0,27	

Table 4: Kidney sizes according to various researchers (mm)

Length	Width	Thickness	Researcher
115	56	37	Rauber-Kopsch FR (27)
112 right	56 right	38 right	Hoffman (27)
118 left	54,5 left	35 left	Hoffman (27)
-----	50–60	30–40	Rouviere (42)
120	70	---	Callenders (43)
110–120	50–50	30–40	Morris (44)
110	50	40	Cunnigham (45)
130	---	---	Gardner (46)
110	60	30	Warwick (1)
120	60	---	Testut (47)
120	70	---	Anson (43)
100 right	39 right	14 right	Tuncer
101 left	43 left	14 left	Tuncer

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