ECRONICON OPEN ACCESS

EC CLINICAL AND EXPERIMENTAL ANATOMY

Research Article

Does Kidney Size Depend on the Number of Renal Arteries?

Katarzyna Sośnik and Henryk Sośnik*

Department of Pathomorphology Regional Specialistic Hospital, Wrocław, Poland

***Corresponding Author**: Henryk Sośnik, Department of Pathomorphology Regional Specialistic Hospital, Wrocław, Poland.

Received: March 25, 2019; **Published:** April 30, 2019

Abstract

Background: No satisfactory data of the kidney size and number of the kidney arteries exist in the literature.

Objectives: The aim of the study was to determine the correlation between the kidney projection area and number of renal arteries.

Material and Methods: Using planimetric measurements we evaluated the size of the kidney projection area of 465 kidneys, including 247 (53%) male and 218 (47%) female, aged between 4 and 91 years (mean age: 58 ± 18 years).

Results: The above-mentioned size ranged between 21.4 and 104.4 cm^2 (mean: 60.10 ± 11.20 cm^2). It significantly decreased with the age of deceased patients (p = 0.001). It was significantly higher in the male, as compared to the female population (p = 0.001). The side of the body had no influence on kidney size (p = 0.53) The size of the kidney projection area was significantly dependent on the number of renal arteries (p = 0.0138), but the dependency between the size of the kidney projection area and maximum distance of branching renal arteries correlated on the borderline of significance- r = 0.2 (p = 0.09).

Conclusions: The size of the kidney is significantly associated with the number of accessory renal arteries.

Keywords: *Kidney Projection Area; Multiple Renal Arteries; Polish Population*

Introduction

Dealing with the size of the kidney has certain importance considering clinical practice [1-4]. Casuistic case reports [5-7] and own observations in everyday practice (Figure 3 and 4) proves that the size of the kidney depends on the number of renal arteries.

Glodny., *et al.* [8] evaluated radiologically kidney size in 1040 adult patients, demonstrating that (among others) it also depends on the number of kidney arteries. However, the authors did not enter deeper in the issue.

Determination of the size of the kidneys by means of radiological imaging methods [1,2,7,9-13] is associated with some inconsistencies, arising from the fact that the kidney does not have a clear ellipsoidal shape [14,15]. This can do some trouble in comparative evaluation.

Based on the above - mentioned the most accurate comparison feature (in our opinion) is the projected area of the renal vascular mesh (Figure 1 and 2). This feature was used in our studies.

Materials and Methods

Investigations were performed on 377 deceased aortonephrograms (754 kidneys) (Approval of the Bioethical Committee Nr 2/BOPD/2017 DIL) All kidneys were subject to histopathological examinations. If clinical data mentioned a history of malignant neoplasm or amyloidosis, and the microscopic examinations showed the presence of an inflammatory or neoplastic foci cases were excluded from the study. In the end, the surface of projection area and its arterial vascularization were determined in 465 kidneys.

The vasculorenal sample was excised "en bloc". After ligation of all vessels, a 30% aqueous solution of barium sulfate was introduced under pressure into the aorta, as to fill all afferent arterioles supplying the glomerulus. X-rays were performed on 35.6 x 35.6 cm cassettes, containing reinforcement "Foton" films with a sensitivity of 125 CUK. Exposition was performed by means of a probe with a rated voltage of 65 kV and 10 m A from a distance of 90 cm. After two weeks of fixation in a neutralized 10% solution of formalin, the anatomical sample was subject to thorough investigation. As the value of reliable comparative studies we used the size of the projection area of the kidney (Figure 1 and 2). The above-mentioned was determined on the basis of the planimeter, manufactured by PZO (average of two measurements taken at an interval of one month by one person, H.S). The obtained results in square centimeters were subject to statistical analysis (descriptive statistics, Student's test, analysis of variance, correlation matrix and linear models were performed using Statistica software version 10). P = 0.05 mean differences were considered as statistically significant.

Results

465 kidneys were subject to analysis, aged between 4 and 91 years (mean age: 58.49 ± 18.12 years).

There were 247 (53.11%) male kidneys aged between 13 and 91 years, (mean age: 57.46 ± 16.75 years), and 218 (46.89%) female kidneys, aged between 4 and 87 years (mean age: 59.67 ± 19.54 years) (p = 0.189).

The size of the projection area ranged between 21.36 cm^2 and 104.37cm^2 (mean: 60.12 ± 11.15 cm^2). The mean projection area on the left side amounted to 59.8 ± 11.04 cm^2 and 60.44 ± 11.27 cm^2 on the right side (p = 0.53). Gender significantly differentiated the size of the projection area. The above-mentioned was significantly greater in men, as compared to female kidneys. Considering men the projection area ranged between 39.03 and 104.37cm^2 (mean: 62.87 ± 11.21 cm^2). In case of female kidneys it ranged between 21.36 and 92.23 cm^2 (mean: 57.0 ± 10.24 cm^2) (p = 0.001). In women, both the left and right kidneys were smaller, as compared to male specimens (Table 1). On the other hand, no statistically significant differences were observed considering the side of the body, between both sexes, although the size on the right side exceeded that of the left (p = 0.65).

No	Subject	Men					Women					P
		N	%	Kidney projection area			N	%	Kidney projection area			
				Min	Max	x ± SD			Min	Max	x ± SD	
1	Total	247	53.10	39.03	104.37	62.87 ± 11.21	218	46.9	21.36	92.23	57.00 ± 10.24	0.0001
2.	Left Kidney	123	49.79	39.03	104.37	62.55 ± 11.10	109	50.0	21.36	89.81	56.09 ± 10.16	0.0001
3.	Right Kidney	124	50.20	40.78	90.10	63.20 ± 11.36	109	50.0	22.14	92.23	57.31 ± 10.37	0.0001

Table 1: *Kidney projection area in men and women (cm^2).*

Explanations: N= Number of kidneys, % = Percentage.

The size of the projection area was significantly associated with the number of renal arteries (Table 2 and 3 and diagram 1). The mean projection area with one artery was 59.4 ± 10.9 cm^2, while that with multiple renal arteries- 62.26 ± 11.7 cm^2 (p = 0.0183).

No	Subject	Kidney with only one artery				Kidney with multiple arteries				P
		N	Kidney projection area			N	Kidney projection area			
			Min	Max	x ± SD		Min	Max	x ± SD	
1	Total	351	21.36	92.23	59.40 ± 10.90	114	36.60	104.37	62.26 ± 11.70	0.0183
2.	Left kidney	169	21.36	89.42	58.37 ± 10.43	63	36.60	104.37	63.64 ± 11.76	0.001
3.	Right kidney	182	22.14	92.23	60.41 ± 11.21	51	41.84	89.81	60.56 ± 11.53	0.935

Table 2: *Kidney projection area with only one artery and with multiple arteries (cm^2).*

Explanations: N = Number of kidneys, % = Percentage.

Number of arteries	Number of kidneys	Mean kidney area (cm^2)	Standard deviation	Standard Error
1	351	59.43	10.88	0.58
2	97	61.65	11.95	1.21
3	15	65.06	10.45	2.70
4	2	70.72	5.13	3.63
Overall	465	60.12	11.15	0.52

Table 3: *Parameters of Kidney projection area by number of arteries.*

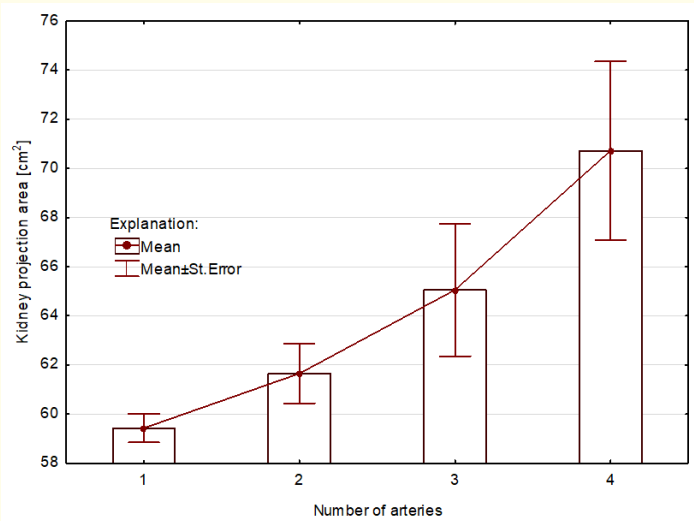

Diagram 1: *Plot of kidney projection area by number of arteries.*

With age the size of the projection area was subject to significant reduction (p = 0.001).

The curve of the above-mentioned in case of one artery and multiple arteries was presented in diagram 2.

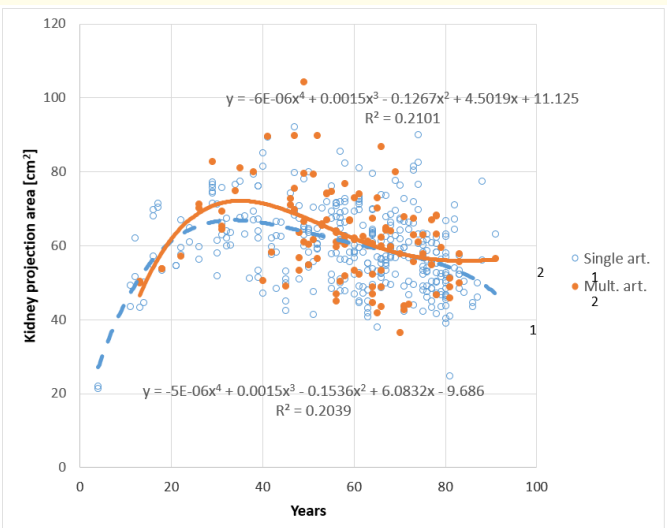

Diagram 2: *Correlation between age and kidney projection area with one and multiple arteries.*

During the following stage, we evaluated the dependency between the size of the projection area, and distance between distal renal arteries, branching of the aorta. The greater the distance between the two, the greater the kidneys (Figure 2-4). Considering the 74 multiple artery kidneys, the minimum projection area was 36.6 cm^2, while the maximum-104.37 cm^2 (mean: 63.76 ± 11.67 cm^2). However, the minimum distance between the distal arteries branching of the aorta amounted to 0.1cm, while the maximum- 9.5 cm (mean: 2.86 ± 2.85 cm). The correlation r factor amounted to 0.2 (p = 0.09). Diagram 3 presented the regression curve.

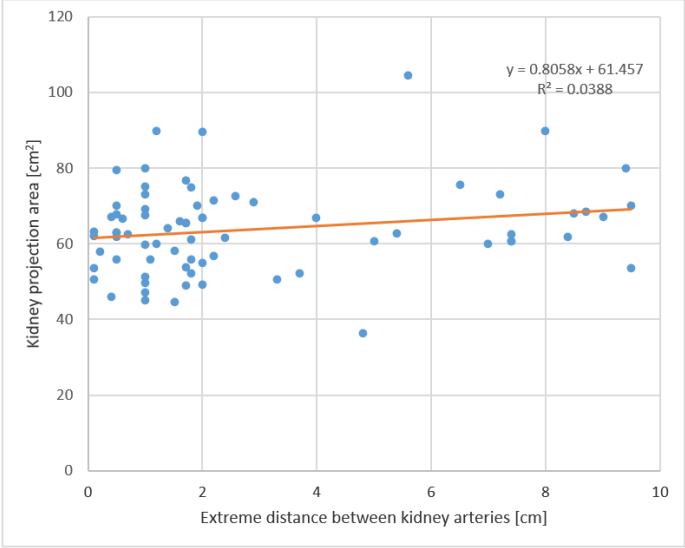

Diagram 3: *Correlation between kidney projection area and renal multiple arteries distance.*

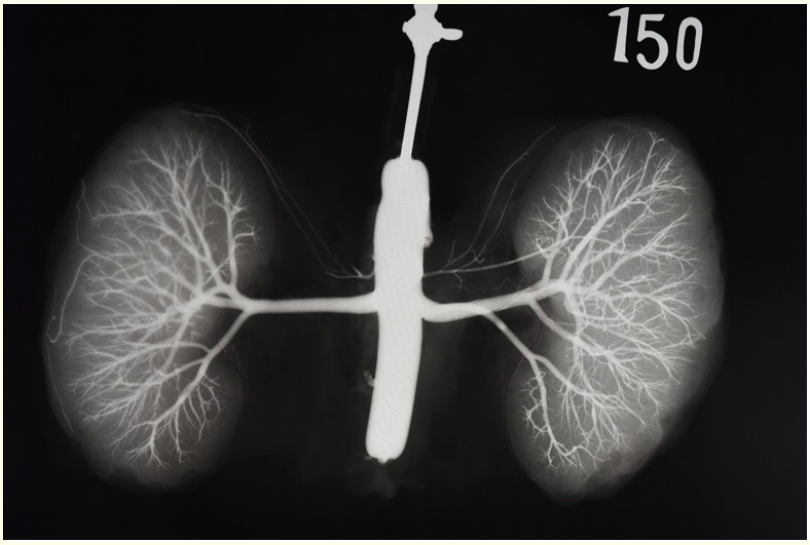

Figure 1: *Aorto-nephrogram with bilateral single artery.*

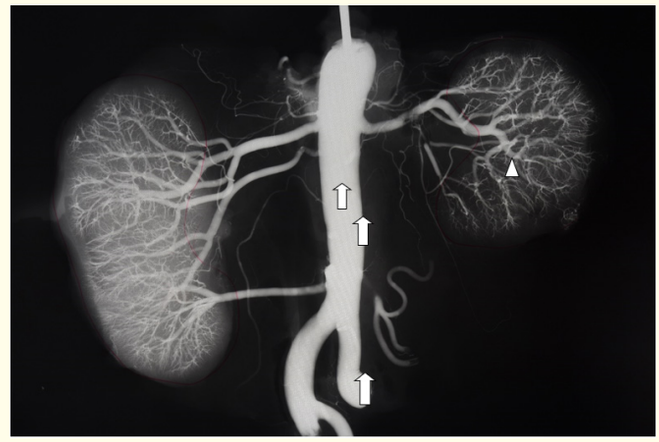

Figure 2: *Aorto-nephrogram with three arteries on the right(arrow) and one on the left side(arrowhead). The right kidney projection area greater than the left one.*

Figure 3: *Vasculorenal sample (posterior-anterior view) with two left renal arteries (arrow)). Left kidney greater than the right one.*

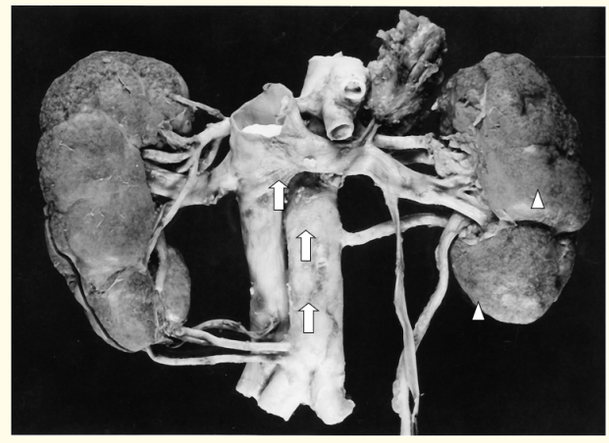

Figure 4: *Vasculorenal sample (anterior-posterior view). Three arteries on the right (arrow) and two on the left side (arrowhead). Right kidney greater than the left one.*

Discussion

Kasiske and Umen showed that the human physique is the most important determinant, considering the size of the kidneys and its glomerulus [16].

During fetal evolution, kidneys grow symmetrically from each trimester, regardless gender [17]. However, in children [18,19], as well as adults, the left kidney was significantly larger than the right one [9,10]. According to Tarzamni., *et al.* [13], the left kidney was slightly longer than the right one. Our own observations and others [1,20] were of different opinion. In trisomy 13 there was a tendency for the left kidney to be lighter, and the right heavier, but in case of other trisomy disorders this was not observed [21].

However, when comparing the size of the projection area of the kidney angiogram, considering one and multiple arteries, the left kidney proved to be significantly greater. In our previous studies, we showed that the presence of multiple arteries was observed more often on the left side of the body [22]. This might be responsible for the observations deduced by the above-mentioned authors, who demonstrated greater left kidney size.

According to Emamiam., *et al.* [10], the left kidney is greater, because the spleen is smaller than the liver, which creates more space for its development, as well as because the left renal artery is shorter and more straight, as opposed to the right artery. The latter favors greater blood inflow and kidney growth.

Interesting studies concern research on the size of the kidney and patient age.

Our studies showed that the projection area was significantly decreased in older patients. Akpinar., *et al.* [9] also demonstrated that the length of the kidney significantly decreased with age, as well as the kidney shape changed with age. It became wider and thicker [10]. There is a possibility that atherosclerosis plays an important role in the pathogenesis of age-associated changes, considering renal structure and function [23].

On the other hand, considering large correlation studies, age had no impact on kidney weight if BSA was taken into account. Increases in BSA are accompanied by a proportional increase in renal size and function [16].

In children up to 15 years of age no kidney size differences were observed, in relation to gender (sex) [19], but in 665 healthy adult volunteers, the mean kidney volume was greater in men, as compared to female patients [10]. Our own studies showed that the kidney projection area was significantly greater in the male population. It is hard to tell where these differences come from. Perhaps the more frequent incidence of multiple arteries in men might be responsible for the above-mentioned [22].

Finally, clinical aspects should be taken into account. It is worth to remember that Raman., *et al.* [3] observed no relationship between arterial pressure and kidney size in 188 healthy volunteers.

The kidney volume derived from CT scans can help predict the GFR value in kidney donors with normal renal function [1].

Considering 156 patients the left kidney was collected for transplantation in 94% of cases [12]. However, anatomical variations in renal arteries dictate the choice of the right kidney instead, and in 24% of cases, it was procured [24]. In the presence of two equivalent kidneys the right was generally preferred, because it was smaller, more accessible then the left kidney, lower in the abdomen, and during pregnancy, more prone to hydronephrosis and pyelonephritis [25]. Thus, authors leave the better with the donor, and the smaller of the two kidneys is used for donation [2].

Conclusions

The size of the kidney projection area was influenced by kidney gender and age of deceased patients. A significant relationship between the projection area and number of renal arteries was observed, especially, on the left side. The kidneys with multiple arteries also showed a certain relationship, although insignificant considering the distance of renal arteries branching from the aorta.

Bibliography

1. Adibi A., *et al*. "Relationship between renal volume calculated by using multislice computed tomography and glomerular filtration rate calculated by using the Cockcroft-Gault and modification of diet in renal disease equations in living kidney donors". *Saudi Journal of Kidney Diseases and Transplantation* 27.4 (2016): 671-676.

2. Janoff DM., *et al*. "Computerized tomography with 3 -dimensional reconstruction for the evaluation of renal size and arterial anatomy in the living kidney donor". *Journal of Urology* 171.1 (2004): 27-30.

3. Raman GV., *et al*. "Is blood pressure related to kidney size and shape?" *Nephrology Dialysis Transplantation* 13.3 (1998): 728-730.

4. Roseman DA., *et al*. "Clinical association of total kidney volume: the Framingham Heart Study". *Nephrology Dialysis Transplantation* 32.8 (2016): 1344-1350.

5. Czech B and Weisman Z. "Wielokrotne tętnice nerkowe odchodzące od aorty i tętnicy biodrowej". *Folia Morphologica* 13 (1962): 171-176.

6. Kem DC., *et al*. "Renin-dependent hypertension caused by nonfocal stenotic aberrant renal arteries". *Hypertension* 46.2 (2005): 380-385.

7. Krishnaveni C and Roopa Kulkarni. "A right ectopic kidney with bilateral multiple anomalies of the renal vasculature-a case report". *Journal of Clinical and Diagnostic Research* 7.1 (2013): 150-153.

8. Glodny B., *et al*. "Normal kidney size and its influencing factors-a 64-slice MDCT study asymptomatic patients". *BMC Urology* 9 (2009): 19 pages 1-3.

9. Akpinar IN., *et al*. "Sonographic Measurement of kidney size in geriatric patients". *Journal of Clinical Ultrasound* 31.6 (2003): 315-318.

10. Emamian SA., *et al*. "Kidney dimensions at sonography: Correlation with age, sex, and habitus in 665 adult volunteers". *American Journal of Radiology* 160.1 (1993): 83-86.

11. Guggemos E., *et al*. "A rare case of an arterial connection Between the Left and Right Kidneys". *Annals of Surgery* 156.6 (1962): 940-943.

12. Laugharne M., *et al*. "Multidetector CT angiography in live donor renal transplantation: experience from 156 consecutive cases at a single centre". *Transplant International* 20.2 (2007): 156-166.

13. Tarzamni MK., *et al*. "Anatomical differences in the right and left renal arterial patterns". *Folia Morphologica* 67.2 (2008): 104-110.

14. Jones TB., *et al*. "Ultrasonographic determination of renal mass and renal volume". *Journal of Ultrasound in Medicine* 2.4 (1983): 151-154.

15. Marciniak T. "Nefrometria u człowieka (Human nephrometry)". Prace Wrocławskiego Towarzystwa Naukowego, Wrocław, Seria B, Nr 121 (1964).

16. Kasiske BL and Umen AJ. "The influence of age, sex, race, and body habitus on kidney weight in humans". *Archives of Pathology and Laboratory Medicine* 110.1 (1986): 55-60.

17. Sulak O., *et al*. "Size and location of the kidneys during the fetal period". *Surgical and Radiologic Anatomy* 33.5 (2011): 381-388.

18. Oh M., *et al*. "Sonographic growth charts for kidney length in normal Korean children: a prospective observational study". *Journal of Korean Medical Science* 31.7 (2016): 1089-1093.

19. Thapa NB., *et al*. "Sonographic assessment of the normal dimensions of liver, spleen, and kidney in healthy children at Tertiary Care Hospital". *Kathmandu University Medical Journal* 13.52 (2015): 286-291.

20. Engelhorn ALDV., *et al*. "Ultrasound tissue characterization of the normal kidney". *Ultrasound Quarterly* 28.2 (2012): 275-280.

21. Barr Jr M. "Organ asymmetries as correlates of other anomalies". *American Journal of Medical Genetics* 101.4 (2001): 328-333.

22. Sośnik H and Sośnik K. "Investigations on renal vascularisation pathology in the Polish population. 1. Incidence of multiple kidney arteries". *Folia Morphologica* 76.2 (2016): 226-231.

23. Kasiske BL. "Relationship between vascular disease and age-associated changes in the human kidney". *Kidney International* 31.5 (1987): 1153-1159.

24. Walker TG., *et al*. "Donor renal angiography: its influence on the decision to use the right or left kidney". *American Journal of Radiology* 151.6 (1988): 1148-1151.

25. Berardinelli L. "Technical problems in living donor transplantation". *Transplantation Proceedings* 37.6 (2005): 2449-2450.

Volume 2 Issue 3 May 2019