" OVIDIUS " UNIVERSITY from CONSTAN Ț A

DOCTORAL SCHOOL OF MEDICINE

FIELD: MEDICINE

ABSTRACT OF DOCTORAL THESIS

NORMAL MORPHOMETRY OF THE KIDNEYS AND RENAL PEDICULE ELEMENTS (ARTERY, VEIN, PELVIS)

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THESIS PLAN

Introduction

Purpose of the study

General part - current state of anatomical knowledge on the normal morphology of the kidney and the renal pedicle

Material and working methods

Personal results:

Normal kidney morphometry in children and adolescents on CT images

Normal adult kidney morphometry:

- on formalised kidneys

- on CT images

- on plastic molds

Normal morphometry of renal pedicle elements:

- pelvis morphometry

- morphometry of the renal artery

- morphometry of the renal vein

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INTRODUCTION

As an organ with a vital function in the body, the kidney intervenes together with the hypothalamus, pituitary gland, adrenal glands and the skin in adjusting the elimination of water, catabolism and some dissolved substances, not only as an effector organ, but also as a secretory territory of some local factors, provided with modeling effects of the processes that take place at the level of its various compartments. Many problems related to the external conformation and constitution of the kidney are put in front of the researcher when trying to interpret its variations and explain some renal pathologies. The structural complexity of the kidney and its very complex and varied pathology have led to an impressive development of means of exploration, as well as medicinal and surgical therapeutic means, the latter being based on a good knowledge of its morphology. That is why, as in other regions of the body at the renal level, the needs of modern surgery are those that determine and guide anatomical research, as evidenced by the numerous works published in the specialized literature in connection with the external conformation of the kidney, with the macro and microscopic organization of its structure, of the arterial, venous and lymphatic vasculature and urinary tracts. These do nothing more than complete and sometimes correct the descriptions of the kidney, appearing in classic anatomical works and treaties.

" Evaluation of renal measurements, such as length, width and thickness, is important in the diagnosis and management of many renal conditions (patients with hypertension and renal failure related to renal artery stenosis and patients with recurrent tract infections) as well as in the case of kidney transplantation, because there is a close relationship between kidney size and its function. Currently, apart from the conventional methods of measuring renal dimensions, ultrasound scanning, computed tomography and magnetic resonance imaging have evolved as the three best modalities for this purpose" [[1]].

Many of the standard renal nomograms currently in existence for the comparison of renal dimensions are based on the classic morphometry presented in anatomy treatises and thus explain the many studies that have appeared on the morphometry of the kidneys that have appeared in the different countries of the globe, especially Asian countries.

In conclusion, I want to thank the scientific supervisor, Mr. Bordei Petru, the scientific supervisor of the thesis, who guided me for almost 8 years to complete it. I also thank the team of the anatomy discipline of the Faculty of Medicine in Constanța, for all the help given, especially Mr. Bulbuc Ionuț, for the help given in obtaining the CT images, and Ionescu Constantin who helped me in the technical editing of the thesis.

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[1] Ranjeet S Rathore, Nisarg Mehta, Biju S Pillai, Mohan P Sam, Binu Upendran, Krishnamoorthy H Variations in renal morphometry: A hospitalbased Indian study. Indian Journal of Urology, 32: 61-64, 2016.

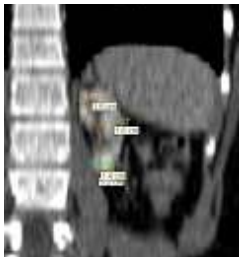
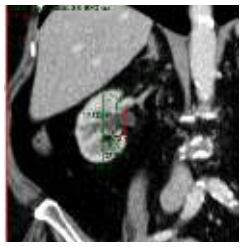
PURPOSE OF THE STUDY

The purpose of this study is to perform a morphometric analysis of both kidneys, right and left, regarding their length (height), width and thickness, measured at three levels: the middle of the kidney, the upper pole and the lower pole. The morphometry of the renal hilum was also determined: the height, the width of the upper and lower edges of the hilum, the distances between the edges of the hilum and the poles, thus establishing the location of the hilum at the level of the medial edge of the kidney. Establishing the morphometry of the renal pelvis (height , width) and the renal vessels (artery and vein) at the level of the hilum and the disposition of the three elements, one in relation to the other. The results obtained on the following morphological landmarks were compared right/ left, in relation to gender (male or female) and with the results presented in the literature that I had the opportunity to consult, resulting in conclusive reports. A separate chapter was devoted to kidney morphometry in young children and adolescents, morphometry being followed only on CT examinations.

MATERIAL AND WORKING METHODS

My study was performed on a number of 280 cases, of which 181 cases on CT examinations (46 cases in children and adolescents and 135 cases in adults), 50 formolised kidneys and 49 plastic casts, obtained by injecting the plastic mass into the renal vascular and urinary systems. Only on the CT cases we analyzed the anatomical landmarks according to gender and age.

TABLE No. 1. Material and working methods

No	METHOD	CASES	PHOTO
1.	Formolised kidneys	50	
2.	CT scans	181	
2a.	Children and adolescents CT images	46	
2b.	Adult CT images	135	
3	Plastic molds	49	
	Total	**280**	

RESULTS AND DISCUSSIONS

MORPHOMETRY OF THE KIDNEYS IN CHILDREN AND ADOLESCENTS

At the age of 1 year, in a number of 4 cases, the height of the kidneys was between 5.3-6.5 cm. The left kidney, in 2 cases, had a height between 5.8-6.5 cm, with a difference between the extreme values of 0.7 cm, and the right kidney, between 5 .3-5.9 cm. The middle width of the kidney was between 1.8-2.0 cm, the left kidney between 1.8-2.0 cm, and the right kidney between 3.1-3.6 cm.

Fig. 1. Morphometry of the kidneys at the age of 1 year. Right kidney: height : 5.9 cm; width at the upper pole: 1.5 cm, width at the middle of the kidney: 2.0 cm; width at lower pole: 2.1 cm. Right kidney: height: 6.5 cm; width at the upper pole: 1.6 cm; width at the middle of the kidney: 2.0 cm; width at lower pole: 1.9 cm (male).

In the age group of 7-8 years, in 7 cases, the height of the kidneys was between 5.9-9.6 cm, the left kidney between 6.6 -9.6 cm, and the right kidney between 5.9-8.6 cm. I found the width between 2.5-4.3 cm, the left kidney between 2.5-4.3 cm, and the right one between 3.1-3.6 cm.

In the 10-12 age group, in a number of 14 cases, the height of the kidneys was between 5.2-11.3 cm, and I found the width between 1.2-4.3 cm. In the male sex, in 8 cases, the height of the kidney was between 5.2-11.3 cm, the left kidney, in 4 cases, with a height between 5.2-7.8 cm, the right kidney between 9.1-11.3 cm. The width was between 1.2-4.3 cm, the left kidney had a width between 1.2-3.4 cm, and the right kidney between 2.3-4,3 cm.

In the female sex, in 6 cases, the height of the kidney was between 6.6-9.4 cm, the left kidney had a height between 6.6-9,1 cm, and the right kidney, between 8.3-9.4 cm. I found the width between 2.3-3.8 cm, the left kidney had a width between 2.6-3.8 cm, and the right kidney between 2.3-3.8 cm.

In the 15-17 age group, on a number of 21 cases, the height of the kidneys was between 5.4-11.8 cm, and the width between 1,7-5.3 cm. In the male sex, in 9 cases the height of the kidney was between 5.4-11.8 cm, the left kidney, in 5 cases with a height between 5,4-11,0 cm, and the right kidney, between 7.3-9.6 cm. The width in the middle of the kidney, I found it between 2.0-4.3 cm, the left kidney, in 5 cases, with a width between 2.0-4.3 cm, and the right kidney between 2.0-3.4 cm. In the female sex, in 12 cases, the height of the kidney was between 8.2-11.8 cm, the left kidney, in 6 cases, with a height between 9.2-11.0 cm, and the right kidney, between 8.2-11.8 cm. The width of the kidney was between 1.7-5.3 cm, the left kidney, between 1.9-5.3 cm, and the right kidney, between 1.7-4.6 cm.

TABLE No. 2 Comparison of personal results with data from the literature regarding the height of the kidney in children and adolescents [[2], [3],[4]]:

Age (years old)	Kadioglu [2]	Chan-Won Park [3]	Ozdikici [4]	***Personal results***
1 y.o	RDr 60,97 RSt 60,92	- -	65 67	***M :53-58*** ***M :59-65***
2 y.o	RDr 69,12 RSt 70,49	M :67,6 ; F :67,8 M :69,8 ; F :7217	67 73	- -
3 y.o	RDr 66,81 RSt 68,73	M :69,1 ; F :72,9 M :71,1 ; F :75,4	73 76	- -
4 y.o	RDr 74,64 RSt 76,00	M :71,9 ; F :73,7 M :74,6 ; F :75,8	-- --	- -
5 y.o	RDr 77,81 RSt 78,18	M :79,3 ; F :73,8 M :79,4 ; F :79,6	81 86	- -
6 y.o	RDr 74,61 RSt 81,37	M :74,9 ; F :- M :78,2 ; F :77,8	- -	- -

[2] Alev Kadioglu Renal Measurements, Including Length, Parenchymal Thickness, and Medullary Pyramid Thickness, in Healthy Children: What Are the Normative Ultrasound Values? AJR, 194: 509 – 515, 2010

[3] Chan Won Park, Nali Yu, Sin Weon Yun, Soo Ahn Chae, Na Mi Lee, Dae Yong Yi, Young Bae Choi, In Seok Lim Measurement and Estimation of Renal Size by Computed Tomography in Korean Children. J Korean Med Sci, 32(3): 448-456, 2017

[4] Özdikici M Ultrasonographic assessment of renal length in 310 Turkish children in the Eastern Anatolia region. SAJCH, 12 (1): 34-37, 2018.

Age	Kadioglu [1]	Chan-Won Park [2]	Ozdikici [3]	***Personal results***
7 y.o	RDr 79,94 RSt 82,76	M :84,6 ; F :79,8 M :88,4 ; F :81,5	91 93	***M:M: 78-96***
8 y.o	RDr 84,02 RSt 86,15	M :83,9 ; F :83,3 M :86,8 ; F :87,3	- -	***M :59-78*** ***-***
9 y.o	RDr 85,48 RSt 88,21	M :86,9 ; F :85,1 M :89,2 ; F :90,4	94 97	***-*** ***-***
10 y.o	RDr 89,79 RSt 91,32	M :87,7 ; F :88,2 M :88,9 ; F :91,0	- -	***M :95 ; F :89*** ***M :65 ; F :90***
11 y.o	RDr 94,99 RSt 97,72	M :85,5 ; F :89,8 M :88,8 ; F :93,1	99 100	***M :-; F :89*** ***M :-; F :90***
12 y.o	RDr 93,88 RSt 95,42	M :92,0 ; F :96,8 M :96,1 ; F :104,2	- -	***M :113 ; F :83*** ***M :52 ; F :38***
13 y.o	RDr 94,84 RSt 95,75	M :102,5 ; F :99,6 M :106,0 ; F :104,9	101 107	***:-*** ***- :-***
14 y.o	RDr 100,07 RSt 101,34	- -	- -	***: :-*** ***-***
15 y.o	RDr 92,58 RSt 94,91	- -	106 113	***M :96 ; F :82*** ***M :110 ; F :99***
16 y.o	RDr 95,84 RSt 96,94	- -	- -	***M :-; F :118*** ***M :-; F :110***
17 y.o	RDr 98,13 RSt 98,84	- -	- -	***M :85 ; F :118*** ***M :10,5 ; F :110***
18 y.o	RDr 99,37 RSt 101,64	- -	- -	***-*** ***-***

ADULT MORPHOMETRY ON FORMOLIZED HUMAN KIDNEYS

It was performed on a number of 50 formalized kidneys, 14 right kidneys and 36 left kidneys, whose gender could not be specified. The kidneys came from cadavers in the anatomy labs and from eviscerated kidneys.

Height of the kidneys was between 5.7-13.7 cm, on the 14 right kidneys it was between 7.5-10.1 cm, and on the right kidneys. Length was between 5.7-13.7 cm.

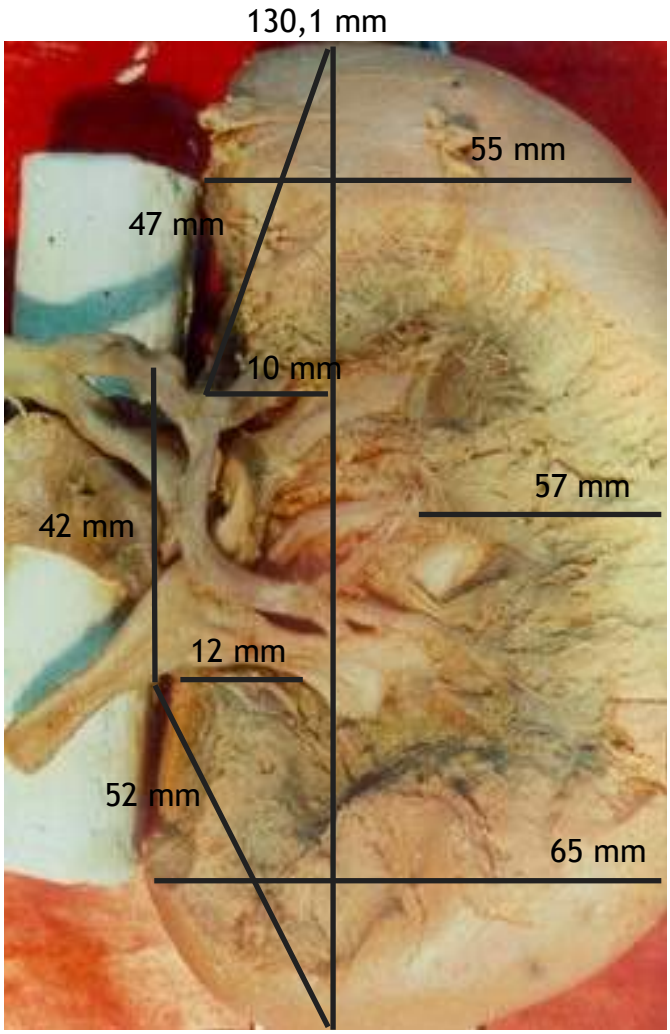


Fig. 2. Left kidney: in the middle kidney = 130. 1 mm; hilum - upper pole distance = 47 mm; lower hill- pole distance = 52 mm; width at the middle of the kidney= 57 mm; width of the upper pole= 55 mm; width of the lower pole = 65 mm; in the middle of the hill = 42 mm; width of the upper edge of the hilus = 10 mm ; width of the lower edge of the hilus = 12 mm .

Distance between the upper edge of the hilum and the upper edge of the upper pole of the kidney, I found it to be between 1.0-4.7 cm *and* the distance between the lower edge of the hilum and the edge lower pole of the kidney, followed on 52 cases, I found it between 2.0-5.2 cm, 5.0-5.2 cm: 4 cases (10.53% of cases).

On a number of 50 kidneys, we followed the *differences between the* edges *of the hilum* and the *upper and lower edges of the renal poles*, finding that in 38 cases the distance between the lower edge of the hilum and the lower edge of the lower pole of the kidney was larger, with differences between 0.3-3.2 cm. In the right kidney, on 14 cases, we found that in 6 cases the distance between the lower edge of the hilum and the lower edge of the lower pole of the kidney was greater, with differences between 0,5-1.9.2 cm, in a number of 4 cases the distance between the upper edge of the hilum and the upper edge of the upper pole of the

kidney was greater with differences between 0.7- 0-0.9 cm, and also in 4 cases, the distance between the edges of the hilus and the edges of the renal poles had an equal value. In the left kidney, out of 36 cases, we found that in 32 cases the distance between the lower edge of the hilum and the lower edge of the lower pole of the kidney was greater, and the distance between the upper part of the hilum and the upper edge of the upper pole of the kidney was larger with differences between 0.7-0.0.2 cm. In a number of 4 cases, the distance between the edges of the hilus and the edges of the renal poles had an equal value.

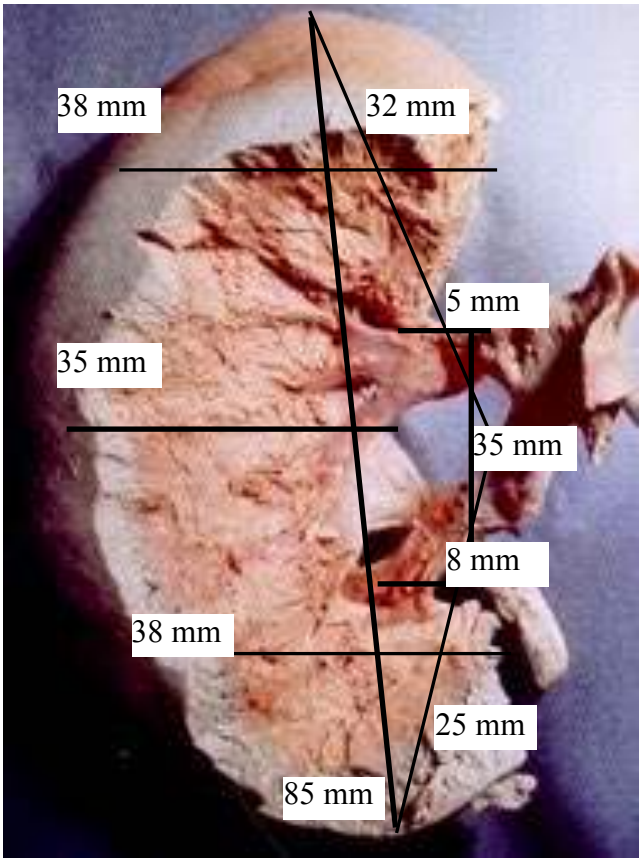


Fig. 3. Right kidney: kidney length = 85 mm; distance from hill to upper pole = 32 mm; distance from hill to lower pole = 25 mm; width at the middle of the kidney = 35 mm; width of the upper pole: 38 mm; width of the lower pole = 38 mm; height of the hilum = 35 mm; width of the upper edge of the hilus = 5 mm; width of the lower edge of the hilus = 8 mm .

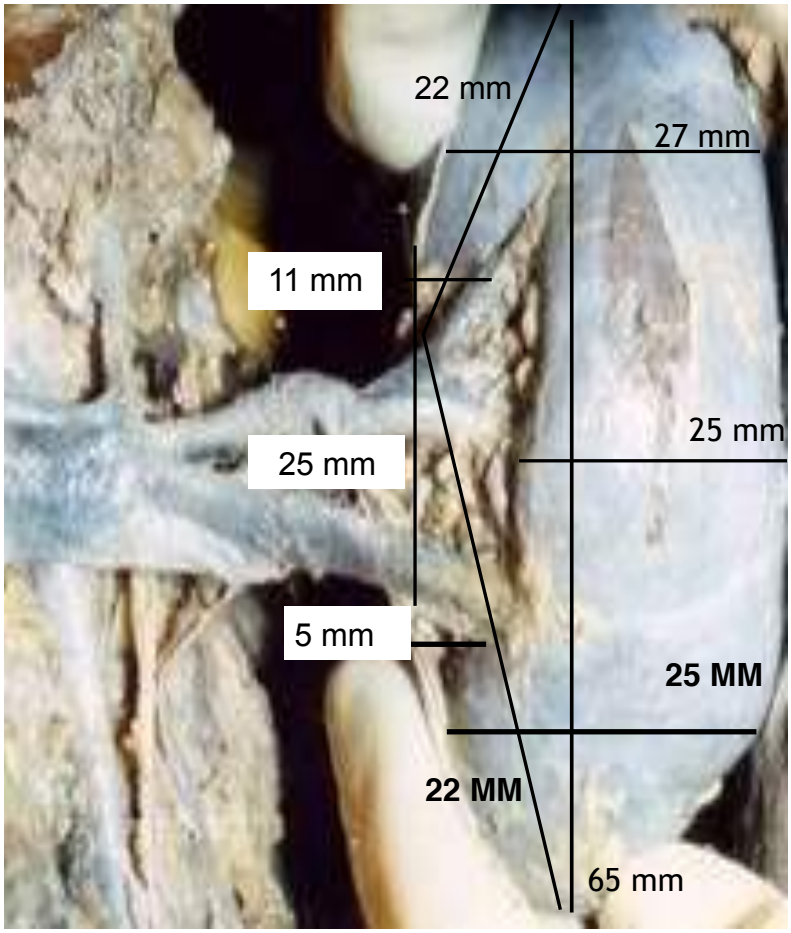


Fig. 4. Right kidney: kidney height = 65 mm; distance of hill-upper pole = 22 mm; distance of lower pole-hil = 22 mm; width at the middle of the kidney= 25 mm; width of the upper pole= 27 cm; lower pole width= 25 mm; hilum height = 25 mm; the width of the upper edge of the hilus = 11 mm; the width of the lower edge of the hilum= 5 mm.

Width at the level of the middle of the formolized kidneys, I found it included between 1.8-7.0 cm, 5.0-5.7 cm, at the level of the right kidney I found it included between 3.2-5.0 cm, and at the level of the kidney it is between 1.8-7.0 cm.

Width at the level of the upper pole of the formolized kidneys was between 1.5-6.2 ***cm***, at the level of the right kidney it was between 2.8-4,6 cm, and the level of the upper pole of the left kidney is between 1.5-6.2 cm.

On the 50 cases studied, we compared the width in the middle of the kidney with the width of the upper pole, finding that in 22 cases (44% of the cases) the width at the level of the upper pole was greater with differences between 0.2-1.1 cm. In 24 cases the width at the middle of the kidney was greater than the width of the upper pole, with differences between 0.2-2.8 cm, and in 4 cases the two widths were equal an equal value.

Width at the level of the lower pole of the formolized kidneys I found it between 2.0-6.5 cm, at the level of the right kidney I found it between 3.4-4.4 cm , and at the level of the left kidney at the level of the lower pole of the formolized kidneys, I found it between 2.0-6.5 cm.

On the 50 cases studied, ***we compared the width in the middle of the kidney with the width of*** the lower ***pole,*** finding that in 32 cases the width at the level of the lower pole was greater with differences between 0 ,1-1.2 cm, in 16 cases the width at the middle of the kidney was greater than the width of the lower pole, with differences between 0.2-0.8 cm, difference between the extreme values being 0.6 cm, and in 2 cases the two widths had an equal value.

We also ***compared the width at the level of the upper pole with the width of the lower pole,*** finding that in 32 cases the width at the level of the lower pole was greater with differences between 0.1- 2.2 cm, in 14 cases the width of the upper pole was greater than the width of the lower pole, with differences between 0.2-0.9 cm, and in 4 cases, the two they were of equal value.

In the height of the hilum of the formolized kidneys on a total of 50 kidneys, I found it between 1.4-5.2 cm, at the level of the right kidney in 14 cases, being between 1.7-3.5 cm, and at the level of the left kidney in 36 cases, between 1.4-5.2 cm.

Width of the upper edge of the hilum on the formolized kidneys was between 0.2-1.7 cm, and the width of the lower edge of the hilum was between 0.2-2.2 cm.

On a number of 49 kidneys, we compared the differences in the width between the upper and lower edges of the hilum on the formolized kidneys. In 21 cases, the lower edge of the hilum was larger, with differences between 0.1-1.0 cm. In 18 cases, the upper edge of the hilum was larger, with differences between 0.1-1.5 cm, and in 10 cases (20.41 % of cases) the two edges of the hilum were equals.

KIDNEY MORPHOMETRY IN ADULTS ON CT SCANS

Kidney height was monitored on a number of 135 cases, of which 54 cases were male (27 right kidneys and 27 left kidneys) and 81 cases were female (42 right kidneys and 39 left kidneys). I found it between 55.5-125.0 mm, in the height of the left kidney between 56.98-122.90 mm, and in the height of the right kidney between 55.50-125.0 mm.

Fig. 5. RD height = 62.04 mm; upper pole width = 17.79 mm; lower pole width = 22.31 mm ; hilum height = 32.15mm (male).

On a number of 66 cases we studied the height differences between the right and left kidneys, finding that in 36 cases, the left kidney was taller by 0.56-27.61 mm, and in 30 cases, the left kidney was taller by 0.22-25.95 mm.

Width of the upper pole of the kidney was measured in 88 cases, in the male sex and 52 cases in the female sex, finding it to be between 11.26-44.30 mm. In the male sex, on 36 cases, the width was between 13.67-44.30 mm, and in the female sex, on 52 cases, the width was between 11.26-30,26 mm.

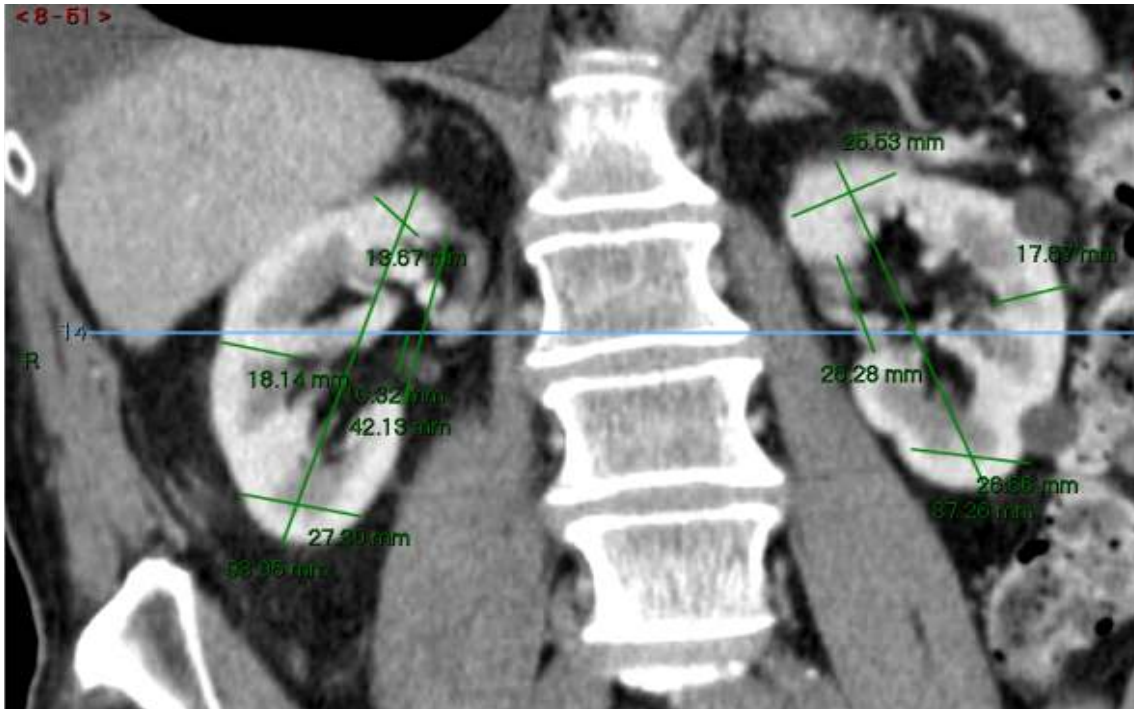


Fig. 6. RD : height = 93.05 mm; upper pole width = 13.67 mm; lower pole width = 27.30 mm; width RD in hill = 18.14 mm; height of the hilum = 42.13 mm; RD thickness at hilum level = 46.51mm; hilum width = 24.30 mm; thickness RD at hilum level = 49.38 mm; hilum width = 23.21 mm; RS : height = 87.26 mm; upper pole width = 25.53 mm; lower pole width = 26.66 mm; RS width at the level of the hilum = 17.67 mm; hilum height = 25.28 mm. The right kidney is higher than the left one by 5.79 mm; the width at the upper pole is greater in the left kidney than in the right one by 11.86 mm; the width at the lower pole is greater in the right kidney than in the left one by 0.67 mm; the width at the level of the hilum is greater in the right kidney than in the left one by 0.57 mm; The height of the hilum is greater in the right kidney than in the left one by 11.85 mm (male).

On a number of 44 cases we compared the width of the upper pole of of the left kidney with the width of the upper pole of the right kidney. We found that in 28 cases the upper pole of the left kidney was larger by 1.0-15.63 mm, and in 16 cases the upper pole of the right kidney was larger by 0.1-11.86 mm.

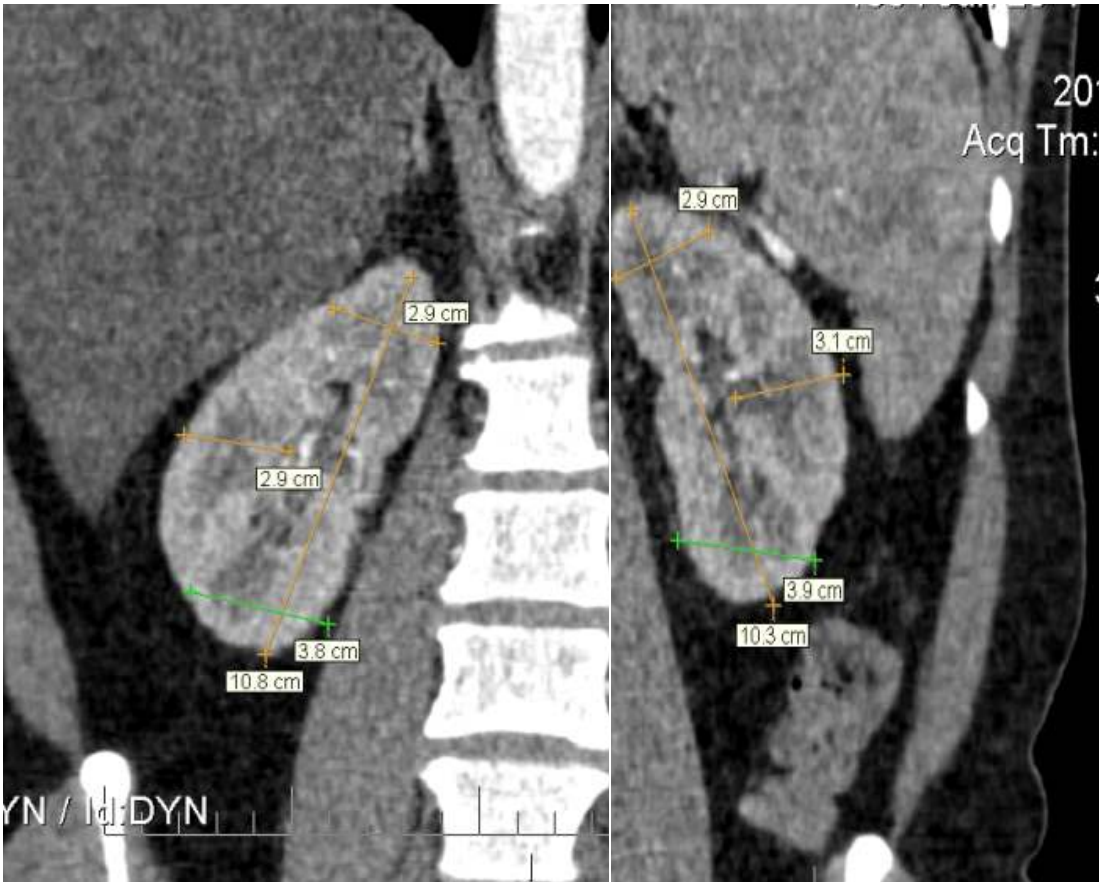


Fig. 7. RS: height= 103mm, upper pole width= 29mm; lower pole width= 39mm; RS width in hilum = 31mm; RD: height= 108 mm; upper pole width= 29 mm; lower pole width= 38 mm; width RD in hilum= 29 mm; the width of the upper poles is the same; the width of the lower left pole is 1 mm greater than the lower right pole; the middle width of the right kidney is 2 mm greater than the left kidney (female).

Width of the kidney at the middle level was found to be between 12.72-41.10 mm, for males, being between 14.37-41.10 mm, and for females female between 12.72-20.0 mm. At the level of the right kidney it was between 14.37-27.36 mm, and at the level of the left kidney between 15.54-31.0 mm.

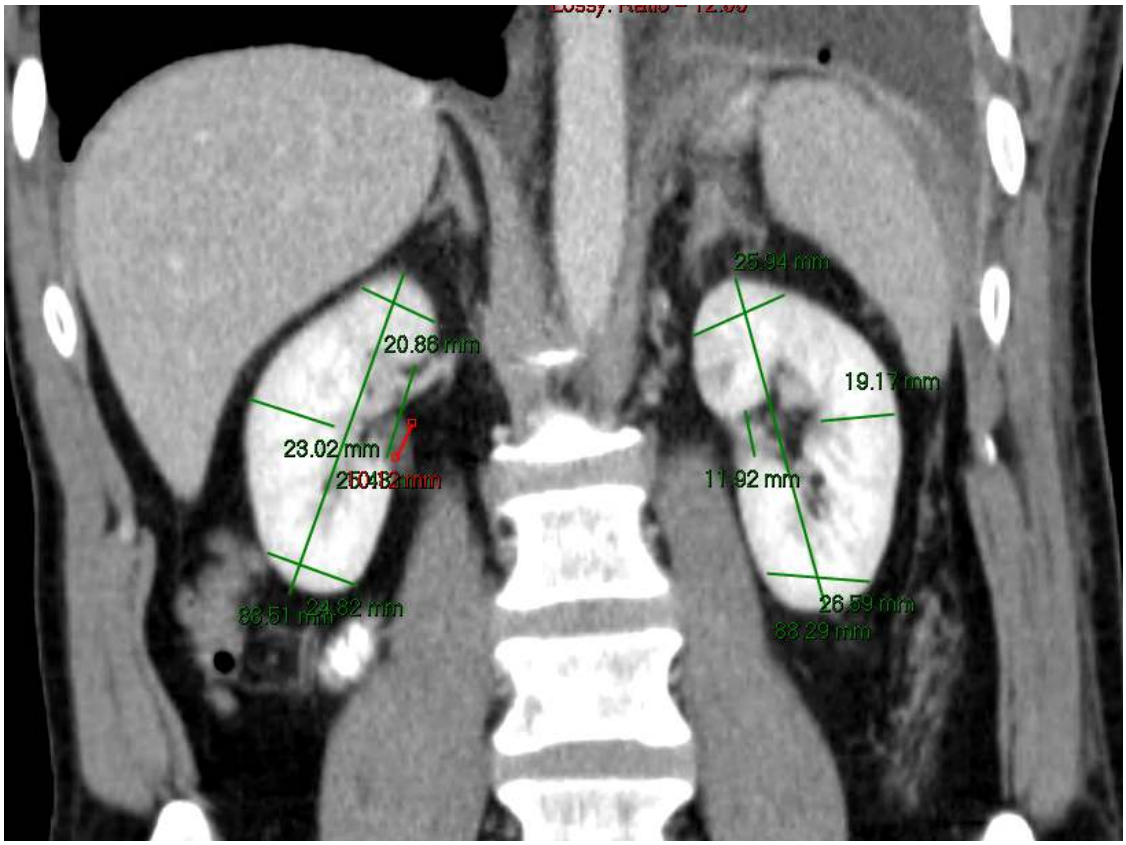


Fig. 8. RD: length = 88.51 mm; upper pole width = 20.86 mm ; lower pole width = 24.82 mm ; width at hilum level = 23.02 mm; Height of hilum = 25.48 mm, height of pelvis = 10.12 mm ; RS : length = 88.29 mm; upper pole width = 25.94 mm; lower pole width = 26.59 mm, hilum height= 11.92 mm; RS hilum width = 19.17 mm. The height of the right kidney is greater by 0.22 mm; the width of the upper left pole is larger by 4.92 mm; the width of the lower left pole is larger by 1.77 mm. The width at the middle of the right kidney is greater by 3.85 mm (male).

On a number of 66 cases, we compared the width at the middle of the left kidney with the width at the middle of the right kidney. We found that in 39 cases the width of the left kidney was greater by 0.30-10.62 mm, and in 27 cases the width of the right kidney was greater by 0.47- 3.66 mm.

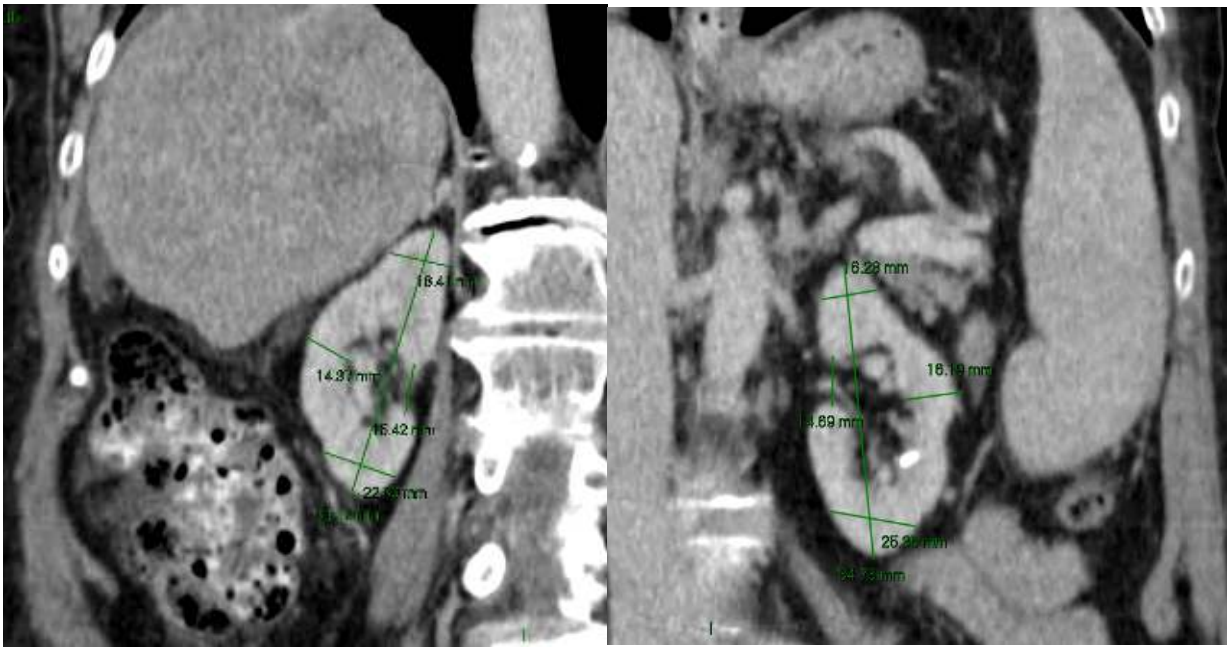


Fig. 9. RD: length = 84.12 mm; upper pole width = 18.41 mm; lower pole width = 22.80 mm; width of hilum = 14.37 mm; hilum height= 15.42 mm; RS : length = 84.73 mm; upper pole width = 16.28 mm; lower pole width = 25.35 mm; width at hilum = 16.19 mm; hilum height= 14.69 mm; the height of the left kidney is greater by 0.61 mm; the width of the upper right pole is larger by 2.13 mm; width of lower left pole, it is larger by 2.55 mm. The height of the right hilum is larger by 0.73 mm (male).

On a number of 135 cases, we compared the width of the kidneys at the level of their middle with the height of the corresponding kidney, finding that this represented between 15.07-48.28 % of in time.

The width of the lower pole of the kidney was measured in 90 cases, 36 cases in males and 54 cases in females. I found it between 9.93-40.30 mm, at the level of the left kidney, on 18 cases, the width of the lower pole of the kidney being between 18.36-40.30 mm, and at the level of the right kidney between 14.37-35.30 mm.

On a number of 44 cases we compared the width of the lower pole of the left kidney with the width of the lower pole of the right kidney. We found that in 28 cases (63.64 % of cases) the width of the lower pole of the left kidney was greater by 0.64-19.76 mm.

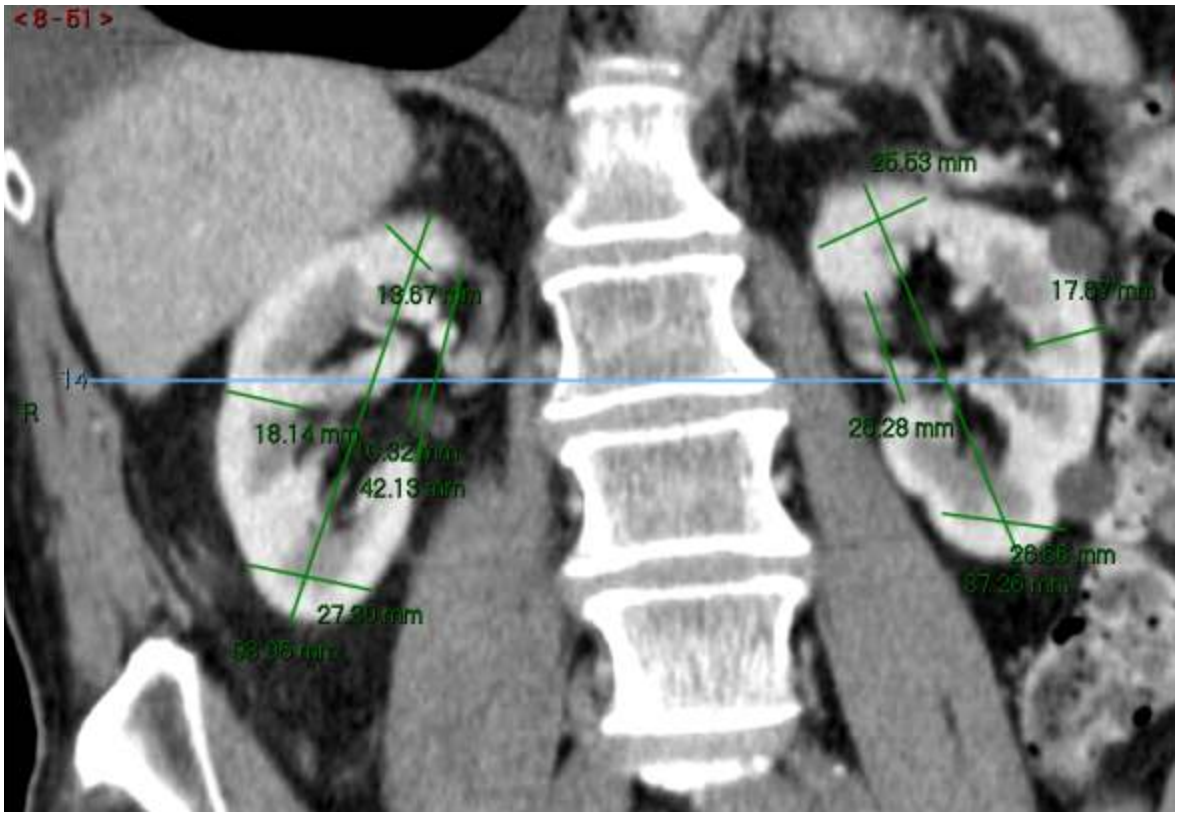


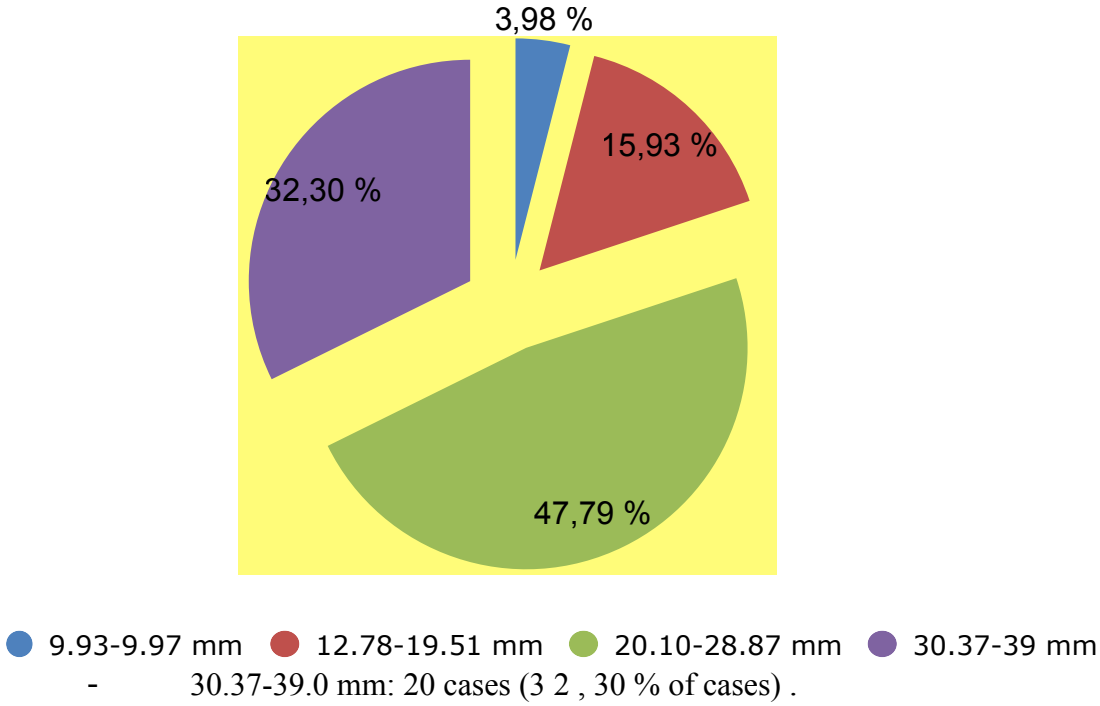
Fig. 10. RD : height = 93.05 mm; upper pole width= 13.67 mm; lower pole width= 27.30 mm; width at hilum= 18.14 mm; hilum height = 42.13 mm; pelvis length = 10.32mm. RS : length = 87.26 mm; upper pole width= 25.53 mm; lower pole width= 26.66 mm; width at hilum = 17.67 mm, length = 25.28 mm. The width of the lower right pole is greater by 0.66 mm than the left one .

At the level of the right kidney, also in 18 cases, the width was between 14.37-35.30 mm, the difference between the extreme values being 20.93 mm, in the increasing order of the values times , describing the following situation:

- 14.37-15.22 mm: 2 cases (11.11% of cases);
- 20.70-29.44 mm: 11 cases (61.11% of cases);
- 32.21-35.30 mm: 5 cases (27.78% of cases).

In the female sex, in 54 cases (60% of cases) the width was between 9.93-39.0 mm, the difference between the extreme values being 29.07 mm , in increasing order of width values , describing the following situation :

- 9,93-9.97 mm: 2 cases (3.98 % of cases);
- 12.78-19.51 mm: 8 cases (1 5.93 % of cases);
- 20.10-28.87 mm: 24 cases (4 7 , 79 % of cases);



- 30.37-39.0 mm: 20 cases (3 2 , 30 % of cases) .

Chart no. 1 . The width of the kidneys at the level of their lower pole in the female sex

At the level of the left kidney, in 28 cases (51.85% of female cases), the width of the lower pole of the kidney was found to be between 9.93-39.0 mm, the difference between the extreme values being 9.93-39 mm, in increasing order of width values, describing the following situation :

- 9.93-9.97 mm: 2 cases (7.14% of cases);
- 17.21-19.51 mm: 4 cases (14.29% of cases);
- 20.10-28.87 mm: 12 cases (42.86% of cases);
- 30.37-39.0 mm: 10 cases (35.71% of cases).

At the level of the right kidney, in 24 cases (48.15% of female cases) the width was between 12.78-38.0 mm, the difference between the extreme values being 25.22 mm. in ascending order of width values , describing the following situation :

- 12.78-13.51 mm: 4 cases (15.38% of cases);
- 21.14-27.97 mm: 12 cases (46.15% of cases);

- 32.33-38.0 mm: 10 cases (38.46% of cases).

On a number of 44 cases we compared the width of the lower pole of the left kidney with the width of the lower pole of the right kidney. We found that in 28 cases (63.64 % of cases) the width of the lower pole of the left kidney was greater by 0.64-19.76 mm, and in 16 cases the width of the lower pole of the right kidney was larger by 2.60-8.46 mm.

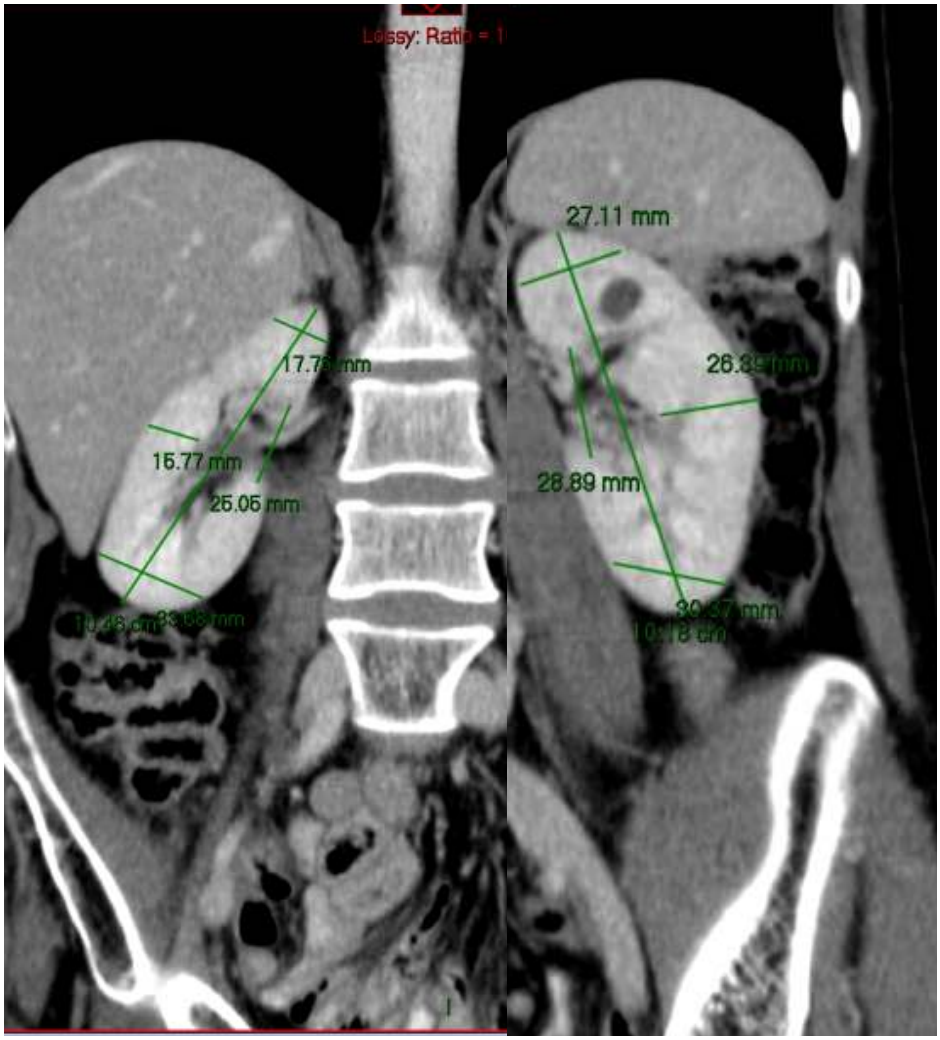


Fig . no 11. RD : length = 104.8 mm; upper pole width= 17.76 mm; lower pole width= 33.68 mm; RD width = 15.77 mm ; hilum height = 25.05 mm. RS: length = 101.8 mm; upper pole width= 27.11 mm; lower pole width= 30.37 mm; RS width at hilum = 26.39 mm; hilum height = 28.89 mm; the width of the lower right pole is greater than that of the upper pole by 16.08 mm, and at the left by 3.26 mm.The width of the lower right pole is greater than the left one by 3.31 mm (female).

KIDNEY MORPHOMETRY ON PLASTIC MOLDS

The height of the kidneys was determined on a number of 49 cases, 20 on the left side and 29 on the right side, finding it covered between 7.9-13.15 cm, the left kidney, in a number of 20 cases, had a height between 7.9-13.15 cm, and the right kidney, in a number of 29 of cases, had a height between 8.1-12.20 cm.

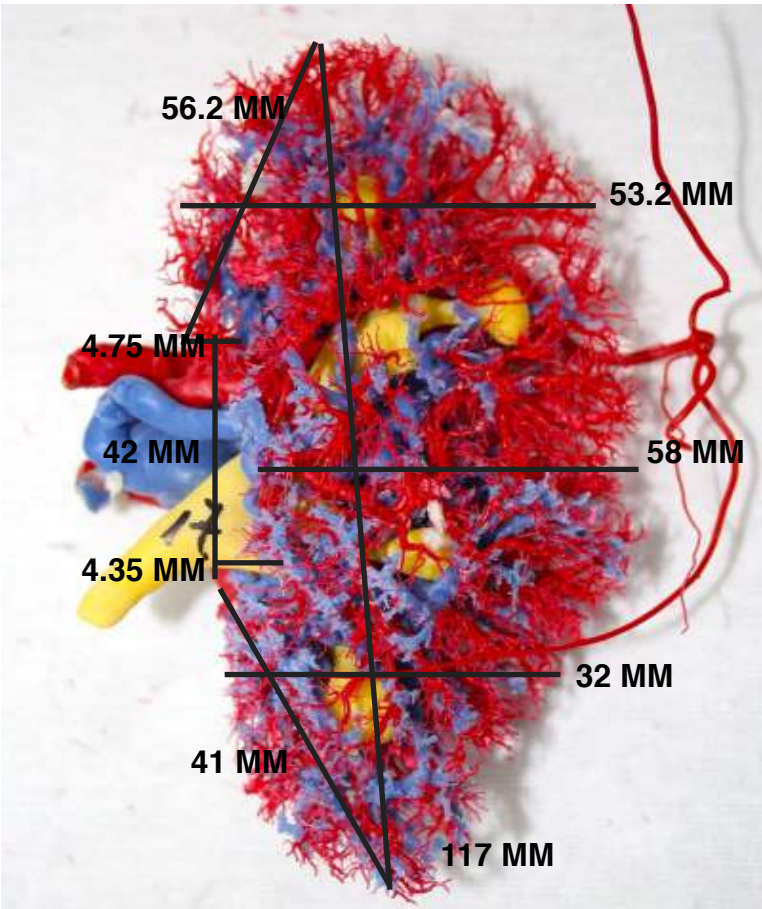


Fig. 12. Right kidney: length = 117 mm, width = 58 mm; renal hilum: height = 42 mm, width = 19 mm; upper pole width= 53.2 mm; lower pole width= 32 mm, upper pole - hilum distance= 56.2 mm; lower hilum-pole distance = 41 mm, upper edge width = 4.75 mm; bottom edge width = 4.35 mm.

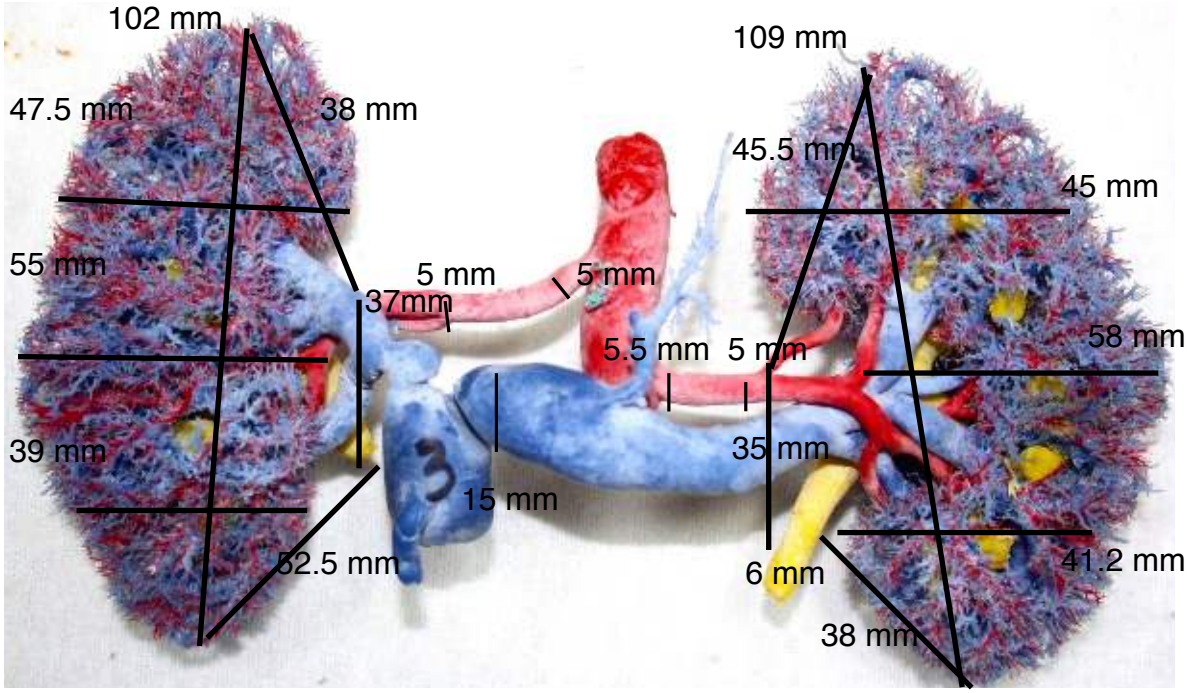


Fig. 13. RD: length= 102 mm; width at the middle of the kidney = 55 mm; renal hilum: height = 37 mm, width = 13 mm; upper edge = 4.75 mm; lower edge = 3.90 mm, distance from hilum -upper pole =38 mm; hilum-lower pole distance= 52.5 mm . RS : length= 109 mm, width at the middle of the kidney= 58 mm, renal hilum: height = 35 mm, width = 23 mm; upper edge = 4.50 mm; lower edge = 4.12 mm; distance from hilum to upper pole = 4.55 cm; distance from lower pole to hilum = 38 mm; the width at the middle of the left kidney is greater by 3.0 mm.

Pe un număr de 12 cazuri, am comparat dreapta/stânga înălţimea rinichilor, găsind că în 7 cazuri înălţimea rinichiului stâng era mai mare cu diferenţe cuprinse între 0,4-1,5 cm, iar în 5 cazuri înălţimea rinichiului drept era mai mare cu diferenţe cuprinse între 0,3-2,2 cm. cazuri.

Width of the kidneys was determined on a number of 33 cases, 15 on the left side and 18 on the right side, finding it covered between 3.6-5.8 cm, the right kidney, in a number of 18 cases, it had a diameter in the middle between 4.1-5.8 cm, and the left kidney, in a number of 29 cases, had a length between 3.6-5.8 cm.

The width at the level of the upper pole of the kidneys was determined on a number of 41 cases, 21 on the right side and 20 on the left side, finding it between 2.90-6.20 cm, the right kidney, it had a thickness at the level of the upper pole between 2.90-5.12 cm, and the left kidney had a thickness between 2.90-6.10 cm.

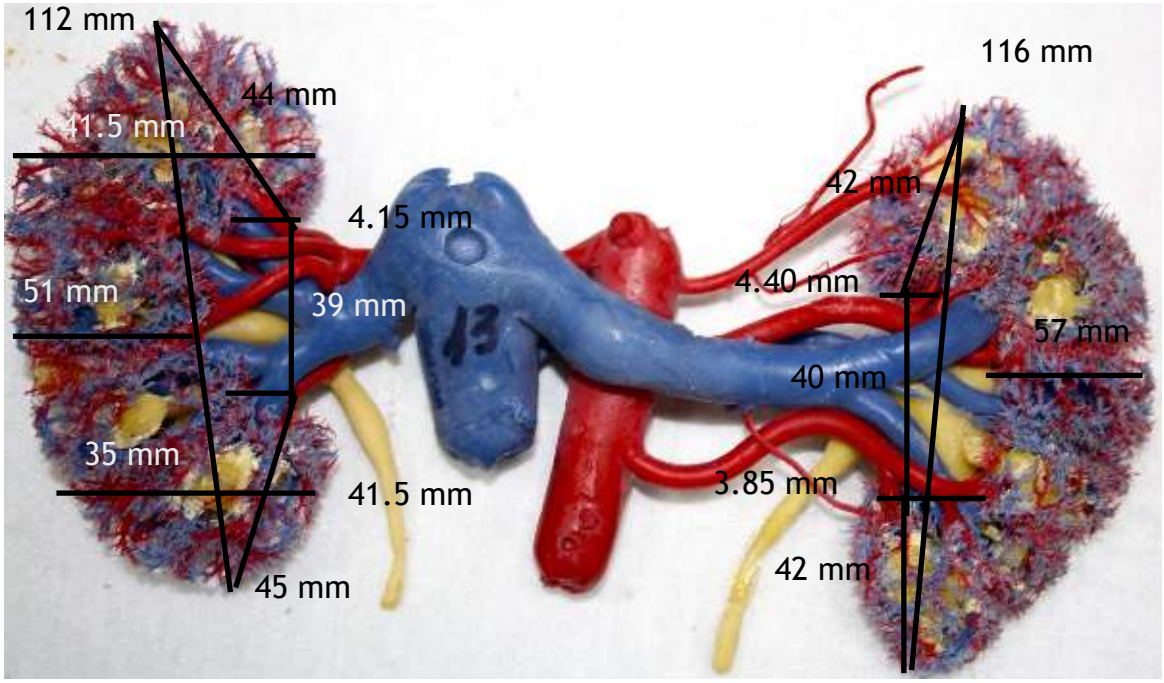


Fig. 14. RD: length= 112 mm, width at the middle of the kidney= 51 mm, width of the upper pole= 41.5 mm; lower pole width= 35.0 mm; renal hilum height= 39 mm, width= 16 mm; upper edge= 4.15 mm; lower edge= 41.5 mm; distance hilum-upper pole= 44 mm; distance hilum-lower pole= 45 mm. RS: length= 116 mm, width= 57 mm, renal hilum: height= 40 mm, width= 22 mm; upper edge= 4.40 mm; bottom edge = 3.85 mm; distance hilum-upper pole= 42 mm; distance hilum-lower pole= 42 mm.

On a number of 12 cases, we compared the right/ left width at the level of the upper pole of the kidneys, finding that in 5 cases, the width of the right upper pole was greater with differences included between 0.01-0.40 cm. In 4 cases the width of the upper left pole was equal to the width of the right upper pole, and in 3 cases the width of the left upper pole was greater with differences between 0.27-1.65 cm .

The width at the level of the lower pole of the kidneys was also determined on a number of 41 cases, 21 on the right side and 20 on the left side, finding it between 3.0-6.20 cm, and the right kidney having a width between between 3.15-6.20 cm.

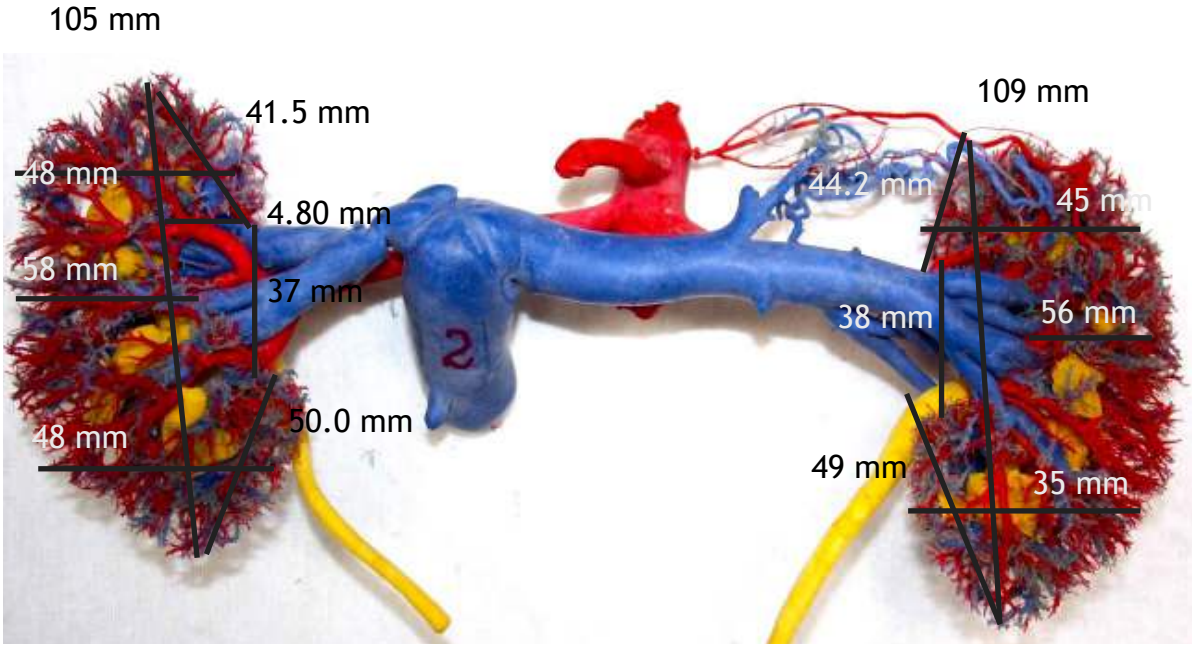


Fig. 15 . RD: length= 105 mm, width at mid-kidney= 58 mm; upper pole width= 48 mm; lower pole width= 48 mm; renal hilum: height= 37 mm; width= 14 mm; upper edge= 4.80 mm, lower edge= 4.80 mm, distance hilum-upper pole= 41.5 mm; distance hilum-lower pole= 50.0 mm. RS: length= 109 mm, width at mid-kidney= 56 mm; upper pole width= 45 mm; lower pole width= 35 mm; renal hilus: height= 38 mm, upper margin= 4.70 mm; lower margin = 4.5 mm, distance hilum-upper pole= 44.2 mm; distance hilum-lower pole=4.9 mm.

On a number of 12 cases, we compared the right/ left width at the level of the lower pole of the kidneys, finding that in 4 cases the width of the right lower pole was greater with differences between between 0.15-1.40 cm; also in 4 cases the width of the lower left pole was equal to the width of the lower right pole; and also in 4 cases the width of the lower left pole was larger with differences between 0.15-0.55 cm.

We followed the comparative width between the middle of the kidney and its upper pole on a number of 27 cases, 15 right kidneys and 12 left kidneys. In 25 cases the width of the kidney at the level of its middle was greater than the width at the level of the upper pole, with differences of 0.20-1.95 cm, only in two cases the width of the kidney at the level of its middle was smaller by 0.11 cm, respectively 0.90 cm, than the width at the level of the upper pole.

We followed the comparative width between the middle of the kidney and its lower pole on a number of 31 cases, 16 right kidneys and 15 left kidneys. In 29 cases, the width of the kidney at the level of the middle was greater than the width at the level of the lower pole, with differences of 0.10-2.20 cm, only in two cases the width of the kidney at the level of its middle was smaller by 0.50 cm, respectively 0.90 cm, than the width at the level of the lower pole.

We followed the comparative width between the upper and lower poles of the kidney on a number of 32 cases, 16 right kidneys and 16 left kidneys. In 19 cases, the width of the

kidney at the level of its upper pole was greater than the width at the level of the lower pole. In 9 cases (28.12 % of cases), the width of the kidney at the level of its lower pole was greater than the width at the level of the upper pole, with differences between 0.25-1,0 cm, and in 4 cases the width of the kidney at the level of its upper pole was equal to the width at the level of the lower pole.

The thickness at the middle of the kidneys was determined on a number of 48 cases, 24 on each side, right and left, finding it between 1.92-3.20 cm, the right kidney having a thickness at its middle between between 1.92-3.20 cm, and the left kidney a thickness between 2.05-3.30 cm.

The thickness at the level of the upper pole of the kidneys was determined on a number of 49 cases, 25 on the right side and 24 on the left side, finding it between 1.65-2 .52 cm, the right kidney having a thickness between 1.65-1.98 cm, and the left kidney, between 1.65-2.32 cm.

The thickness at the level of the lower pole of the kidneys was also determined on a number of 49 cases, 25 on the right side and 24 on the left side, finding it to be between 1.45-2.90 cm, the right kidney has a thickness between 1.55-2.90 cm, and the left kidney has a thickness between 1.45-2.60 cm.

TABLE No. 3

Comparison of the height and width of the kidney with data from the literature

Author	Kidney height	Kidney width	Kidney thickness
Testut	12 cm	6 cm	3 cm
Rouvière	12 cm	6 cm	3 cm
Juskiewski	12 cm	6 cm	3 cm
Kamina	12 cm	6 cm	3 cm
Cordier	12 cm	6 cm	3 cm
Gray	11 cm	6 cm	3 cm
Schünke	12 cm	6 cm	3 cm
Moore	10 cm	5 cm	2,5 cm
Beauthier	11 cm	6 cm	3 cm
Arase	8,0-13,5 cm	4,5-7,0 cm	3,0-4,5 cm
Abdel Jeffri	RD : 10,38 cm RS : 10,32 cm	RD :5,30 cm RS : 5,15 cm	RD : 3,82 cm RS : 4,10 cm

Author	Kidney height	Kidney width	Kidney thickness
Sivanageswara	RD : 8-14 cm RS : 9,5-14,5 cm	RD :2-5 cm RS : 5,9 cm	-- --
Wael El Rashaid	RD:M:10,8cm;F:10,5cm RS:M:10,71cm;F:11,2cm	-- --	-- --
Morthy	M :11,15cm;F:10,98 cm	M :6,33 cm ; F: 6,12cm	M :4,73cm; F:4,61cm
Kalucki	M :12,0 cm; F:11,4 cm	--	--
Cheong	M: 12,4cm; F:11,6cm	--	--
Panichi, Bonechi	8,9-13,5 cm	4,1-6,5 cm	-
Lahlaidi	12 cm	6 cm	3 cm
Iancu	12 cm	6 cm	3 cm
Chiriac	12 cm	6 cm	3 cm
Ulmeanu	12 cm	6 cm	3 cm
Papilian	10 cm	5-6 cm	3 cm
Zăhoi	10-12 cm	5-6 cm	3-4 cm
Rezultate personale	***RD: 7,05-11,92 cm*** ***RSt: 6,47-12,82 cm***	***RD : 2,54-4,63 cm*** ***RSt : 2,31-5,64 cm***	***RD : 2,05-3,30 cm*** ***RSt : 1,92-3,20 cm***

MORPHOLOGY OF THE RENAL HILUM

LOCATION OF THE RENAL HILLUM

Distance between the renal hilum and the upper pole of the kidney was measured on plastic casts, from the level of the upper edge of the hilus to the upper edge of the kidney, in a number of 38 cases, 22 on the right side and and 16 cases on the left side. I found it between 3.35-5.62 cm, at the level of the right kidney it was between 3.35-5.10 cm, and at the level of the left kidney I found it between 3.50-5.62 cm.

Distance between the renal hilum and the lower pole of the kidney was measured on plastic casts, from the level of the lower edge of the hilus to the lower edge of the kidney, in a number of 39 cases, 25 on the right side and and 14 cases on

the left side. I found it between 3.35-5.90 cm, at the level of the right kidney being between 3.35-5.90 cm, and at the level of the left kidney between 3.60- 5.55 cm.

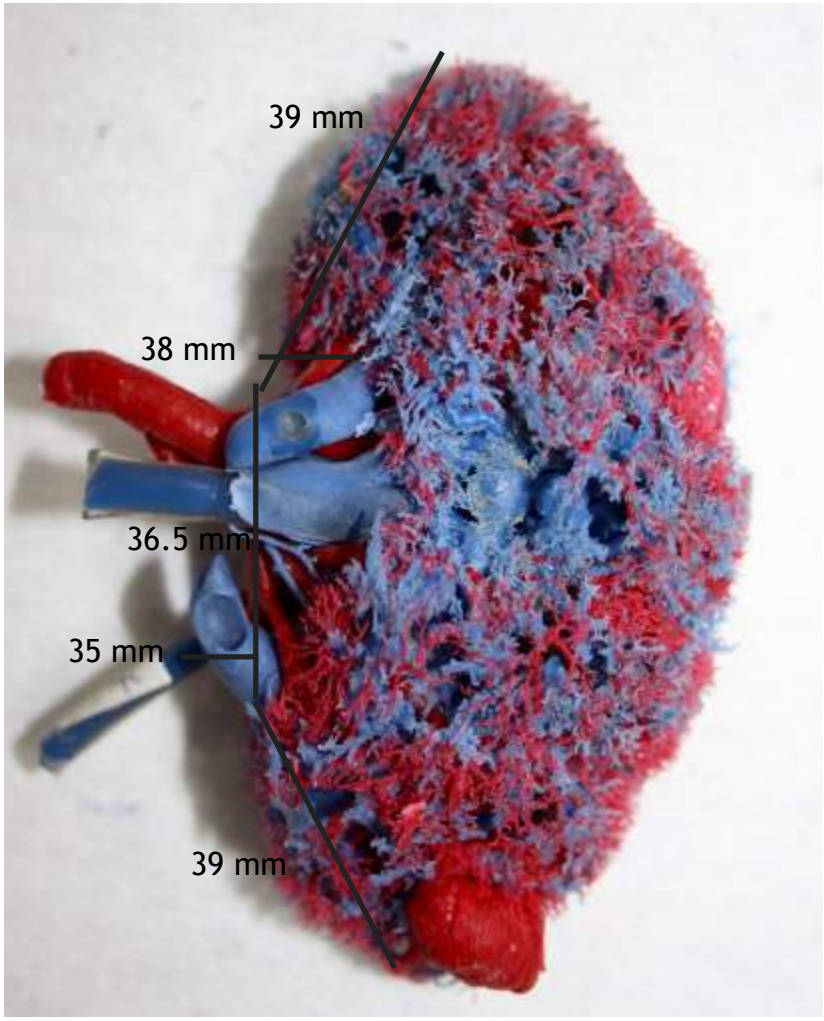


Fig. 16. Left kidney – anterior view. Hilum height = 36.5 mm; distance hilum-upper pole= 39.0 mm; distance hilum-lower pole= 39.0 mm; upper edge = 38 mm; bottom edge = 35 mm.

The height of the renal hilum **on plastic casts** was measured on a number of 39 vascular plastic casts, finding **it to** be between **1.70-5.45** cm. The height of the right renal hilum in 22 cases was between 1.70-5.45 cm, and the height of the left renal hilum in 17 cases was between 1.70 -5.45 cm.

Width of the renal hilum on plastic casts was measured on a number of 34 plastic vascular casts, measuring it separately at the level of the two edges (upper and lower) of the renal hilum. At the level of the upper edge of the hilum, I found it between 0.85-2.0 cm, and at the level of the lower edge of the hilum, I found it between 0.70-1.84 cm .

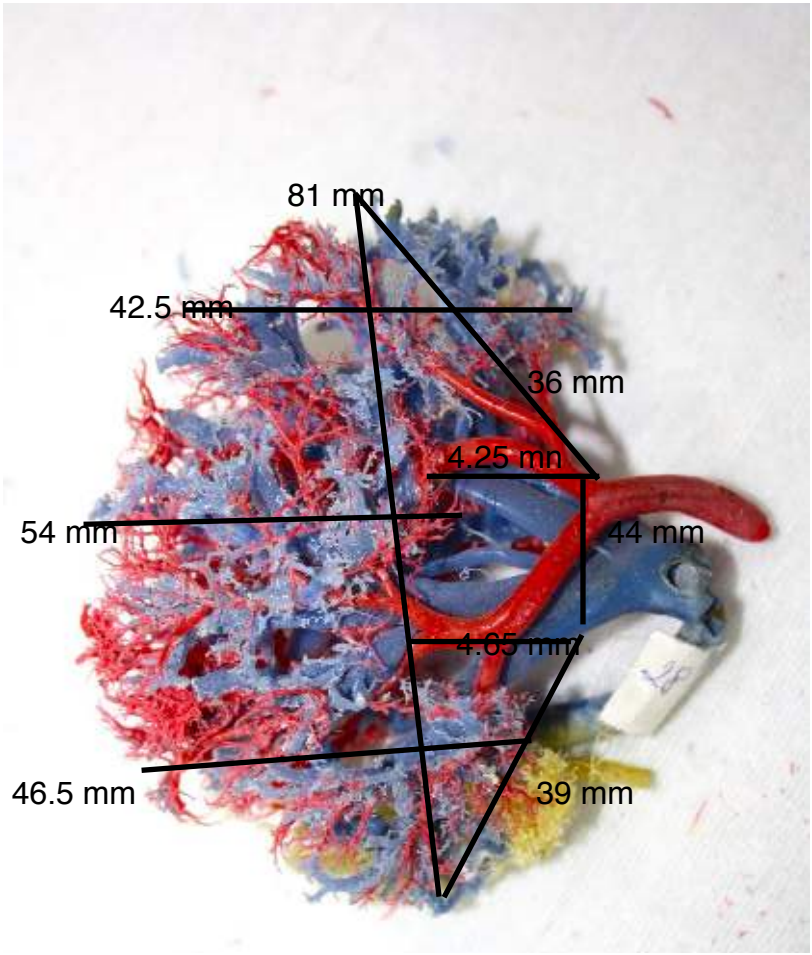


Fig. 17. RS: length= 81 mm; width at the middle of the kidney = 54 mm; renal hilum: height = 44 mm; upper edge = 4.25 mm; lower edge = 4.65 mm; hilum-upper pole distance = 36 mm; distance from hilum to lower pole = 39 mm.

MORPHOMETRY OF THE RENAL PELVIS

Height of the pelvis was measured on 86 CT examinations, finding it to be between ***0.30-6.35*** cm, in males the height of the renal pelvis was determined on a number of 36 cases I found it to be between 0.30-1.56 cm, and in the female gender the height of the renal pelvis determined on a number of 50 of cases, I found it between 0.52-6.35 cm.

On a number of 42 cases, we compared right/ left in the height of the renal pelvis, finding that in 26 cases, the height of the right pelvis was greater by 0.07-5.71 cm, and in 16 cases the height of the left pelvis was greater by 0.018-0.75 cm. Height of the right pelvis is 1.98 mm higher than the height of the left pelvis (male).

The width of the pelvis was measured on 92 CT examinations, finding it to be between 0.26-2.42 cm, and for men, the width of the renal pelvis determined on a number of 36 cases

was between 0.31-1, 47 cm, l a female sex the width of the renal pelvis determined on number of 56 cases was between 0.26-2.42 cm, and in males between 0.53-2.05 cm. 1.21cm: 1 case (5.56% of cases).

TABLE No. 4 Dimensions of the renal pelvis

AUTORUL	Height	Width
Rouvière	-	2-2,5
Juskiewicz	1,5-1,8	2
Papin	1,6-3,5	1,6-4,1
Nedelec	2,36	2,17
Maisonet	1-3	1-2
Cordier	2-2,5	1-2
Papilian	2-3	1-2
Lahlaidi	2-2,5	
Iancu	1	32
Chiriac	1	2
Frasin	1	2
Ulmeanu	1,5-2	2-3
Glodeanu	1,05-2,50	0,8-1,8
Rezultate personale.	***M Dr 0,62-1,56 St 0,30-1,37 F Dr 0,52-2,86 St 0,84-2,44***	***M Dr 0,53-2,86 St 0,31-1,47 F Dr 0,52-2,05 St 0,26-2,42***

MORPHOMETRY OF THE RENAL VESSELS

It was performed on renal casts, both for the arteries and for the renal veins, specifying the vascular diameter at the origin of the arteries, at the level of the formation of the veins and the diameter of their collateral branches. Vascular diameters were compared right- left and related to the dimensions (height) of the pelvis

MORPHOMETRY OF THE RENAL ARTERIES

The diameter at the origin of the renal arteries (right and left) was made on a number of 70 casts obtained by injection of plastic mass, finding a diameter between 3.5-7.3 mm, at the level of the right renal artery, the diameter was measured on 38 cases, finding it between 4.0 -7.30 mm, and at the level of the left renal artery, the diameter was measured on 32 cases, finding it between 3.5 -7.30 mm.

The diameter of the anterior branches of the renal arteries (right and left) are variable in number, being one, two (superior and inferior), three (superior, middle and inferior and less often there can be four anterior branches : superior, two middle and It was measured on 70 molds, finding a diameter between 3.0-7.0 mm.

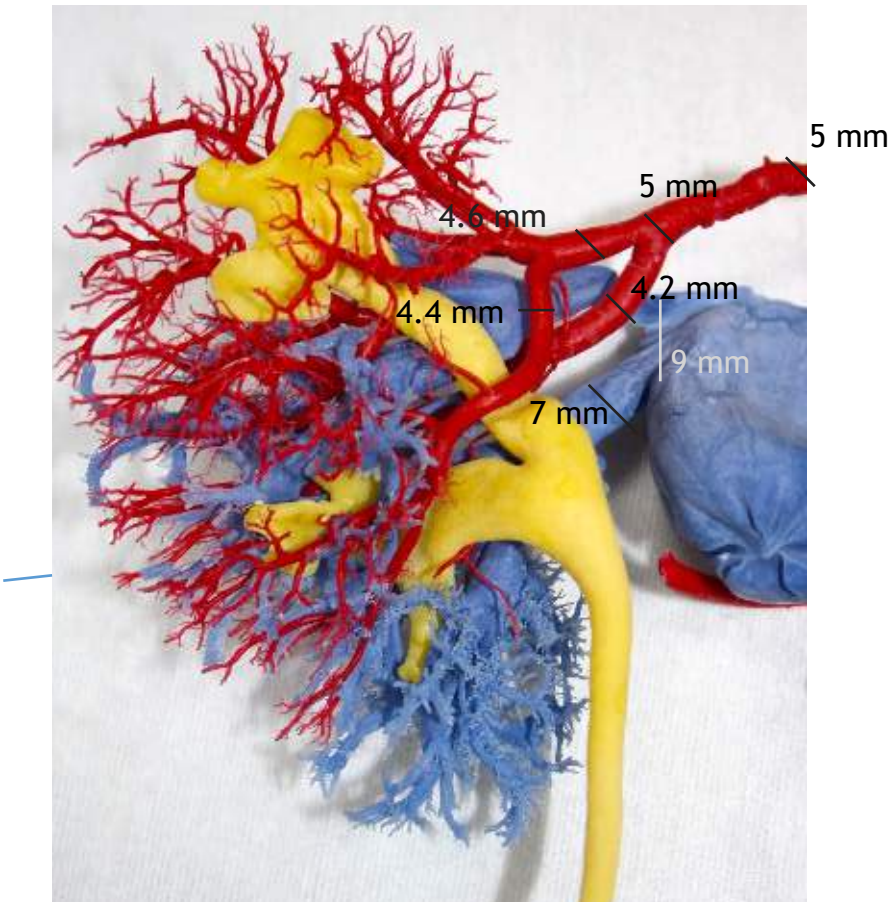


Fig. 18. Right renal artery: diameter at origin= 5 mm, diameter at branching= 5 mm, diameter of the superior anterior ramus= 4.6 mm, lower branch diameter= 4.4 mm, diameter of posterior ramus (inferior)= 4.2 mm. Right renal vein: diameter at formation = 9 mm, diameter of the upper branch= 3.0 mm, lower branch diameter= 7 mm.

At the level of the right renal arteries, the diameter of the anterior branches was between 3.0 -6.2 mm, and at the level of the left renal artery the diameter was between 3.0 -7.0 mm.

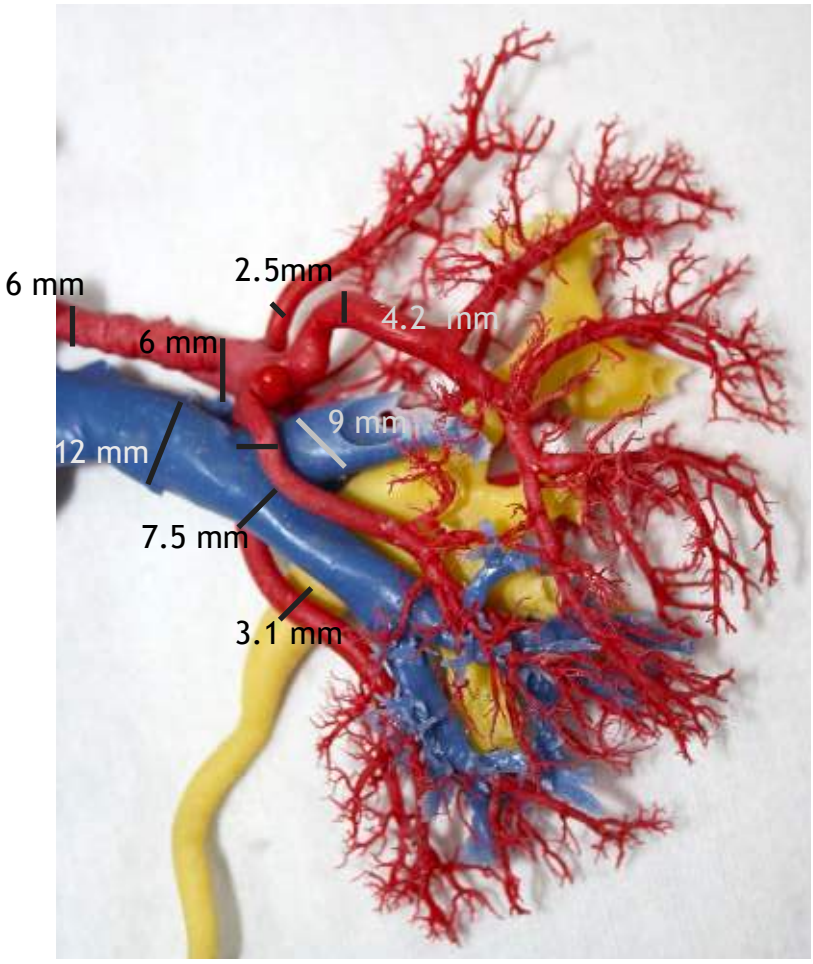


Fig. 19. Left renal artery: diameter at origin= 6 mm, diameter at branch= 6 mm, diameter of the upper branch = 2.5 mm; diameter of the upper middle branch = 4.2 mm; diameter of lower middle branch = 3.1 mm; diameter of the lower branch=3.1 mm. Left renal vein : diameter at formation= 12 mm, diameter of the upper branch= 9 mm, lower branch diameter= 7.5 mm.

The diameter of the posterior branch of the renal arteries to be between 2.0-6.0 mm, at the level of the right renal artery, being between 2.5-6.0 mm, and at the level of the left renal artery it was between 2.0 -6.0 mm.

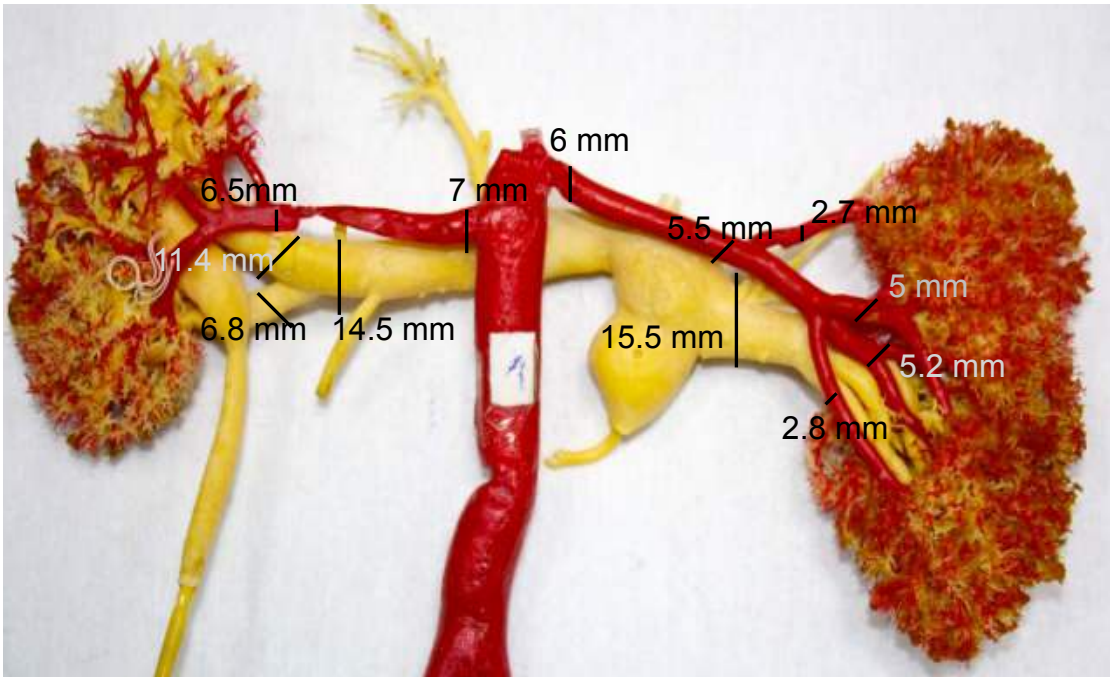


Fig. 20. Posterior view (renal veins in yellow). Left renal artery: diameter at origin= 7 mm, diameter at branch= 6.5 mm, upper ram diameter (upper pole)= 2.2 mm, middle ram diameter= 4.0 mm, lower ram diameter= 4 mm. Right renal artery: diameter at origin= 6 mm, diameter at branch= 5.5 mm, upper ram diameter (upper pole)= 2.7 mm, antero-superior ram diameter= 5 mm, antero-middle diameter= 5.2 mm, antero-inferior diameter= 2.8 mm. The diameter of the left renal artery at the origin and branching is 1.0 mm larger, the anterior-superior branch is smaller by 2.8 mm, the anterior-middle branch is smaller by 1.2 mm and the anterior-inferior branch is larger by 1.2 mm. Right renal vein: diameter at formation= 15.5 mm, upper ram diameter (upper pole)= 2.5 mm, anterior-superior ram diameter= 5 mm, anterior-middle ram diameter= 4mm, anterior-inferior diameter= 3.3 mm. Left renal vein: diameter at formation= 14.5 mm, anterior ram diameter= 11.4 mm, posterior ram diameter= 6.8 mm. The right renal vein has a diameter larger than 1.0 mm when formed .

The ratio between the height of the renal pelvis and the diameter of the anterior (prepelvic) branches of the renal artery, we found to be between 3.0-6.20% on the right side and between 3.0-7.0% on the left side. For the minimum values this ratio showed the same difference on both sides, and for the maximum values the ratio was higher by 0.8 cm on the left side.

The ratio between the height of the renal pelvis and the diameter of the posterior (retropielic) branch of the renal artery, we found to be between 2.50-6.0% on the right side and between 2.0-6.0% on the left side. For the minimum values this ratio showed a greater difference of 0.50% on the right side for the minimum values, and for the maximum values the ratio showed the same difference on both sides.

The relationships of the renal pelvis are varied in the case of multiple arteries (2-3), one of the arteries may be an upper or lower polar artery, cases in which the terminal branches of the arteries may not have a relationship with the renal pelvis [5].

MORPHOMETRY OF THE RENAL VEINS

The diameter at the level of the formation of the renal veins (right and left) was determined on a number of 54 casts with a diameter between 5.0-17.0 mm, at the level of the right renal vein, the diameter was between 5.0 -16.0 mm, and at the level of the left renal vein the diameter was between 8.5 -17.0 mm.

The ratio between the height of the renal pelvis and the diameter of the anterior (prepelvic) branches of the renal vein, we found to be between 5.0-13.0% on the right side and between 5.0-12.5% on the left side. For the minimum values, this ratio presented the same difference on both sides, and for the maximum values, the ratio was higher by 0.5 cm on the right side. The ratio between the height of the renal pelvis and the diameter of the posterior branch (retropielic) of the renal vein, we found it to be between 4.0-11.0% on both the right and left sides.

The ratios of the terminal branches of the renal pelvis arteries and veins depend on the level of the terminal branching of the arteries, respectively on the level of formation of the venous trunk, closer to the kidneys or closer to the aorta or inferior vena cava in the case of veins.

5 Bordei P, Antohe DŞt Ètude anatomique des artères rénale triples. Morphologie, Nantes, 86, 274: 37-42, 2002 .

Conclusions

Many authors, Romanian and foreign, from the specialized literature that I consulted, consider the morphometry of the kidney (length, width and thickness) to be a multiple of three (3, 6, 9), but somatic modification in the human species observed In the last decades, it requires a new assessment of the dimensions of the organs in general and therefore of the dimensions of the kidneys, in order to be able to make an adequate assessment of them. This also explains the existence of scientific papers published in specialized magazines in recent years, dedicated to the morphometry of the kidneys, the results being obtained through various work, a special role returning to imaging. The morphometric variations of the kidneys are based on morphological and clinical findings, this could play an important role in improving the knowledge of anatomists, surgeons and radiologists [6]. Establishing normal parameters is necessary to define pathological changes in any organ. Each parameter was described on a characteristic number of cases, because not all analyzed benchmarks could be followed on the same case.

In the case of the obtained results, frequently, the minimum and maximum values, especially on CT exams, were found in only one case, sometimes between these values and the next or previous being significant differences.

We found differences, sometimes significant, in the morphometry of the kidney related to sex, being sizes as a rule larger in the male sex and less often in some measured landmarks (for example, the dimensions of the hilum), in the female sex. We also found dimensional differences between the two kidneys, right and left, not being respected the statement that, as a rule, the right kidney has larger dimensions, and the cases of equality between the dimensions of the landmarks being less frequent, therefore there is a right/ left asymmetry.

The morphometric differences found by me in comparison with the standard values quoted in the classical literature or those presented in the recent literature, would be due to several factors: the number of cases worked on, the working methods used [7] and the imaging methods, the experience and attention of the radiologist. Also, the results obtained by imaging methods vary greatly, depending on the equipment and methods used to measure and interpret

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6 Sivanageswara Rao Sundara Setty, Raja Sekhar Katikireddi Morphometric study of human adult cadaveric kidneys-research article. Int J Cur Res Rev, 5(20), 109-115, 2013.

7 Christopher J Lisanti, David J Oettel, Michael J Reiter, Ryan B Schwope Multiplanar Reformations in the Measurement of Renal Length on CT: Is It Plain Which Plane to Use? AJR, 205: 797-801, 2015.

renal length [8,9]. These differences are also related to ethnicity, the region where the measurements and diet were performed, and the period when the studies were performed, and may be influenced by environmental conditions.

According to [10], the lack of renal growth can only be stated when the renal length decreases in the growth curve, taking into account the appropriate measurement error limits, when they are found to be greater than 2.5 mm. If the subsequent measurement is within normal limits, lack of adequate renal growth should not be inferred, even if the renal length measurement decreases or remains unchanged for up to 3 years.

Among imaging methods, renal ultrasound is simple, inexpensive, and can be performed at the bedside to provide the clinician with important anatomical details of the kidney with low interobserver variability [11,12,13]. It is also an essential procedure when performing renal biopsy in adults [14].

[15,16] insist on "the need for precise knowledge of the normal anatomy and morphometric variants of the kidney and the vascular pedicle of the kidneys, as well as the normal anatomy and variants of the hilum and renal hilar structures and their clinical significance." Knowledge of these variations is useful for operating surgeons to identify and grasp the hilar structures individually, which is advantageous over grasping them en bloc."

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8 Benjamin Cheong, Raja Muthupillai, Mario F. Rubin, Scott D. Flamm Normal Values for Renal Length and Volume as Measured by Magnetic Resonance Imaging. Clin J Am Soc Nephrol, 2: 38 – 45, 2007 .

9 Tuncay Haz ı rolan, Meryem Ö z, Bar ış T ü rkbey, Ali Devrim Karaosmano ğ lu, Berna Sayan O ğ uz, Murat Canyi ğ it CT angiography of the renal arteries and veins: normal anatomy and variants. Diagn Interv Radiol, 17: 67 – 73, 2011 .

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[17] is of the opinion that "these data will help clinicians to understand the cause of the increase in kidney diseases and surgeons to introduce more conservative methods in kidney operations".

[4, 18] are of the opinion that "to plan the appropriate surgical procedure and to avoid any vascular complication, multiple detector computed tomography (MDCT) should be performed before surgery."

For the study of renal morphometry and for preoperative planning for anatomical evaluation, CT, MR and conventional angiographic anatomy with surgical findings are recommended as non-invasive methods, or a correlation of these methods [4 ,12] .

17 Rashmi Avinash Patil, Parvez Abutaher Chowki Comparison of Human Renal Arteries in Cadavers and in Computed Tomography Scans – A Morphometric Study. J Anat Society of India, 70(4): 233-238, 2021.

18 Poonam Verma, Anterpreet K. Arora, Punita Sharma, Anupama Mahajan Variations in branching pattern of renal artery and arrangement of hilar structures in the left kidney: clinical correlations, a case report. IJAE, 117 (2): 118 -122, 2012.

ORIGINALITY OF THE STUDY

1. Realization of an up-to-date study on renal morphometry, which is rarely done in Romania;
2. The use of several different study methods and working material (formolized kidneys, CT examinations, plastic molds obtained by personal injections) with the correlation of the obtained results;
3. An appropriate number of cases for each monitored parameter, which will allow the preparation of a statistic that can be compared with the results in the literature;
4. Comparison of landmarks determined according to sex, age (a chapter dedicated to renal morphology in children and adolescents) and right/left comparison;
5. Consulting the classic anatomical literature, but also the recent one, some works being published in the period 2020-2022;
6. The multitude of anatomical landmarks;
7. The description of some unique morphological aspects, rarely described, or even not described in the literature: the ratio between the height and width of the kidneys; morphology of the renal hilum (height, width, location of the hilum in relation to the kidney poles): the width of the kidneys at the level of the renal poles; the thickness of the kidneys at the level of its middle and at the level of the renal poles; existing ratios at the level of the renal pelvis, the ratio between the height and the width of the pelvis (important for determining the shape of the pelvis); the ratio between the height of the renal pelvis and the height of the kidney; the morphometric ratios between the height of the pelvis and the diameter of the terminal branches of the renal artery and vein;
8. The importance of the study carried out for the anatomist, radiologist, but especially for the clinician, internist or surgeon.

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