"OVIDIUS" UNIVERSITY OF CONSTANŢA
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MORPHOLOGICAL FINDINGS ON RENAL VEINS

PhD THESIS

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INTRODUCTION

As retroperitoneal organs, the kidney with the corresponding suprarenal gland, are the organs on which most frequent surgical intervention occur. As organ with vital function, the kidney intervenes along with the hypothalamus, pituitary gland, suprarenal gland and tegument in adjusting the elimination of water, catabolites and some solvite substances, not only as effector organ, but also as secretory territory of local factors, provided with modelling effects over processes which take place at the level of its different compartments. In respect to the surgical therapy of the kidney, its purpose is to preserve the organ, totally or only partially, taking into account its major role for the good functioning of the entire organism. The importance of the kidney in the organism results also from the fact that it is the most richly vascularized organ, the renal arteries being the longest branches of the aorta in relation to the volume of the organ that it irrigates. In order to intervene surgically and successfully on the kidney, firstly one must know in detail its arteriovenous circulation, arterial circulation standing at the basis of the renal segmentation. V. Delmas used to say that "*in order to clarify as best as possible the problem of renal segmentation, examining the variations which may occur in relation to it, it is best to first study the vascular changes*". As in other regions of the organism, also at renal level, the needs of modern surgery are those which determine and guide the anatomical research. Indeed, the systemic study of renal vessels knows an unmatched momentum once with the introduction of conservative surgery at kidney level (adjusted segmentectomies).

According to Chakravarthi, anatomical variations of renal structures (urinary and vascular) are essential to urological surgery for renal transplant, but also for urological examinations and for the treatment necessary to the preservation or restoring to normal of the renal functions. Vascular variations need to be known in order to determine the diagnosis and for the success of the endovascular proceedings at the level of the abdomen and pelvis.

Variants and renal vascular abnormalities result from some "errors" in their embryogenesis during the weeks 6-10 of gestation (Gotta). Venous vascular variants are frequently associated with variants of renal arteries, of pielocalyceal system and are present in abnormalities of the kidney (horseshoe kidney, sigmoid kidney). They are important to be known in renal surgery: total or segmentary nephrectomy, transplant, especially for the donator. Hence the importance of preoperative diagnosis by angioCT.

The level of the renal veins represents the limit of the direct action of breath on venous return: during a profound breath, the blood is totally aspired until it reaches the level of these veins. Besides its hemodynamic particularities, renal blood presents a characteristic composition, being the best treated blood in the body. It is rich in oxygen, red colour, saturated in percent of 95% in relation to arterial blood (Gillot).

The more complex development of left renal vein in comparison to the right one, explains the most common variants of this vein: renal collar; retroaortic vein, an additional renal vein, a posterior primary division. Their incidence varies considerably, but when present, they have important surgical and therapeutic consequences. This also explains the fact that the study of left renal vein malpositions has been frequently approached by many authors.

With all the interest given to the study of renal veins, the volume of papers dedicated to them is much more reduced compared to that given to renal arteries. All this has determined me to begin this anatomic study on renal veins, where I tried to bring completions and details to the facts described in the specialty literature, explanations that have emerged following the results obtained on local human kidneys.

Renal veins have been described in terms of: origin, way of formation, trajectory, morphometry, relations, related divisions (suprarenal and gonadal veins). Also there has been described: capsulo-adipose venous system and its anastomoses, anomalies and renal venous variants, as well as renal vein anastomoses and its branches of origin.

In the general part, in the actual stage of knowledge existing on renal veins I have described relatively in short the notions that i found in classic treaties of anatomy (Poirier, Papin, Grégoire, Testut, Rouvière, Paturet, Gray), but also in more recent treaties, as well systematized: Chevrel, Kamina, Bouchet etc. Also, I must mention the anatomy atlases, with very suggestive images and schemes: Netter, Moore, Sobotta. The articles which appeared in well-rated international magazines, bring details, following personal studies performed, which proove that aspects that have not been the object of study until now or that have been omitted by forerunners, can still be described: Satyapal, Gotta, Delmas, Prigent, Stolic.

The personal part begins with the methods and working material, presenting also the number of cases which I have worked and the goals pursued.

Afterwards I have presented the personal results obtained for each aspect pursued, describing in detail morphological characteristics of the renal vein and its collaterals, presenting also their anatomic variants which I have found in the performed study. The results exposed are sustained by personal figures, tables and conclusive graphics. These are compared to the results of other consulted authors, commenting the similarities or differences existing between them, which are frequently expressed in percentage. In the conclusions chapter, I have stated the particular and most outstanding results obtained, in comparison to those from the specialty literature, seeking to be found and an explanation of their existence. I also present a series of recommendations deriving from the results obtained on the venous vasculature of the kidney, absolutely mandatory to be known by the urologist surgeon, in the treatment of retroperitoneal formations.

In the end of each chapter I have presented the selective bibliography, in the order of the citation in the text of the authors from the literature which I have had the possibility to consult, and finally I have presented the general bibliography, in the alphabetical order of the authors.

I have had the possibility to periodically communicate the results obtained, in different symposiums and congresses, nationally and internationally, abstracts published in volumes edited on those occasions or in well-rated magazines. (“Surgical and Radiologic Anatomy” - Springer-Verlag editure or “Morphology” in Elsevier editure) and also I have published 3 articles “in extenso” in the magazines rated BDI.

I bring thanks to the colleagues within the discipline, doctors Ionescu Constantin, Bulbuc Ionuţ, whose help I have received in solving some problems for the making of this paper. I thank Mrs. dr. Bărdaş Mariana and Mr. conf. univ. dr. Baz Radu, in the service of whom the CT examination have been performed.

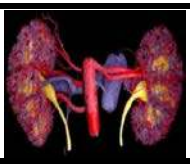
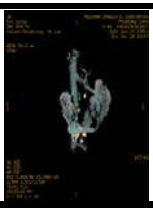
Finally, I thank Mr. prof. univ. dr. Bordei Petru, the scientific coordinator of the PhD thesis, of whose guidance I benefitted from along the four years of accomplishing this thesis.

SPECIAL PART

METHODS AND WORKING MATERIAL

My study on renal veins has been performed on a number of 192 cases, 93 cases on the right side (48,44% of the cases) and 99 cases on the left side (51,56% of the cases). The work has been performed on human kidneys, gutted (fresh and in formaldehyde), be it in situ, on the dead bodies from the dissection rooms of the anatomy lab or from the necropsy rooms of the forensic laboratory. For injection with plastics I have also used fresh renal organic blocks: kidneys with perirenal fat and corresponding segments of abdominal aorta and of the inferior vena cava. Also, to this statistics 23 angioCT has been added. I couldn't study all the anatomic marks tracked on all studied cases, each anatomic mark being pursued on a characteristic number of cases.

TABLE NO. 1 – METHODS OF WORK USED FOR THE STUDY OF RENAL VEINES

No.	METHOD	NO. CASES	PHOTO
1.	Dissection	64	
2.	Plastic injection /corrosion	93	
3.	CT Exam	23	
4.	Injection of $BaSO_4$/radiography	12	

	Total	193	

Intrarenal I have researched the venous branches up to the level of renal pyramids Malpighi, interpyramidal branches being called secondary branches, and the branches which contribute to the formation of renal venous trunk being called primary branches. There have been registered the relations existing between the intrarenal venous branches, as well as the relations between them and the corresponding arterial branches.

I have looked at: the place and level of formation of renal veins in relation to the kidney, aorta and inferior vena cava; the number of venous branches that form the renal vein and renal territory served by them; the relations existing intrarenal between the venous and arterial branches; the distribution of venous branches in relation to the arterial segmentation of the kidney; the trajectory of the renal vein in relation to the homonymous renal artery and with the aorta; the level of termination of renal veins into the inferior vena cava and in relation to the origin from the aorta of the renal arteries; the number of renal veins; the morphometry of renal veins (caliber, length); I followed the trajectory of suprarenal and gonadal veins, the termination in the renal vein and the relations existing between them; the relations of the renal veins with the pielo-calyceal system; there have been described the characteristics of renal veins for the horseshoe kidney. All these characteristics examined, they could be studied and comparatively right-left on a number of 32 cases.

The dissection has been performed on a number of 64 cases, on fresh kidneys and also on formalinized kidneys (gutted or on dead bodies), most of the pieces studiedcoming from adult human dead bodies. The dissection has been performed also on plastic injected products being executed very carefully, as venous branches could break very easily. The existence of nerve fibers in the vicinity of veins and their branches and the close relations with arterial branches, make the dissection very difficult, conducing to damage of vascular branches, especially in the case of non-formalinized products.

I have frequently practiced the injection with plastic on a number of 93 cases. The injection with plastic was made at the level of the aorta, in case of organic blocks or in the renal vein, in case of separate pieces. For the injection I have used Technovit 7143, as solvent using NN dimethyltoluidine 3%. I have tried the injections only on renal veins (9 cases), on the renal vein and artery (8 cases), and in 10 cases most injections were made on the vein and the pielo-calyceal system. In most cases (66 cases) there were injected the renal vein, renal artery and pielo-calyceal system.

Technovit is a self polymerizable resin on the basis of methyl methacrylate under the form of powder and liquid, the powder being of five colors: red, yellow, blue, green and orange. Its fluidity and mixture depend on the proportions of the mixture of the two components. Technovit is soluble in chlorinated hydrocarbons, esters and ketones. In order to keep the substance for injection, one uses two parts of powder and a part of liquid, but the proportions of the mixture vary depending on the consistency we want to achieve. In order to preserve the mixture it is recommended to use containers of glass, porcelain, polyethylene or metallic containers. In the container we put the liquid first and afterwards the powder is added, in the proportions wanted. For the mixture one can use spatulae made of wood, metal (preferably stainless metal), porcelain or polyethylene. Heat accelerates solidification, and low temperature slows it down. The mixture preparation must be executed continuously, without interruption. During the preparation of the mixture there mustn't be any source of fire, as the liquid is flammable.

The corrosion was performed with sodium hydroxide, which I accelerated by heating until the boiling of the solution. The use of sodium hydroxide for the corrosion presents multiple advantages in comparison to the use of acids, hydrochloric or sulfuric: much more reduced toxicity, no influence on color mold, much lower cost price and time saving. Immediately after the corrosion, the mold obtained is rinsed in running water for the removal of organic waste from the vascular branches. Sometimes, it was necessary to

interrupt the operation of corrosion with a few rinses in running water, after which the corrosion was resumed until the removal of all organic waste.

The CT exams which I had the possibility to study (a number of 23 cases) came from the Center of Explorations Medimar within the Emergency Hospital of Constanţa and from the Center of Imagistic Diagnosis Euromedic Constanța, being executed on a computer scanner GE LightSpeed 16 Slice CT. Also, I had available angiographies executed in the Center of Diagnosis Pozimed, being executed on a computer scanner GE LightSpeed VCT64 Slice CT. The angiographies bring information especially about the origin of veins in relation to the spine, about the length and caliber, trajectory and direction of veins, but also about the origin branches and collateral branches of renal veins, as well as about their level of termination.

On a number of 12 cases I have used the injection of renal vein with barium sulfate followed by the radiography of the injected piece.

The images of the cases studied have been processed and stored on a Pentium computer, which enables us to have now a data base with almost all the cases studied.

RESULTS AND DISCUTIONS

RENAL VEINS FORMATION

Regarding the formation of renal veins, I have studied it from the point of view of the number of primary branches (of order I) which contributes to the formation of the venous trunk and the place of their confluence in relation to the renal sinus and to the distance to the kidney and aorta for the left kidney and the distance to the kidney and inferior cava for the right kidney.

The number of branches contributing to the formation of the renal venous trunk has been studied on 122 cases, of which 50 cases on the right side (40,98% of cases) and 72 cases on the left side (59,02% of cases).

Of these, in 76 cases (62,29% of the total number of cases), renal vein was formed of two primary branches. In 70 cases (57,38% of the total number of cases) the trunk of the renal vein was formed from a superior primary division branch and the other inferior.

Fig. 10 – The mold of a renal vein formed of two venous anterior trunks, superior and inferior, the posterior branch ending in the antero-inferior branch.

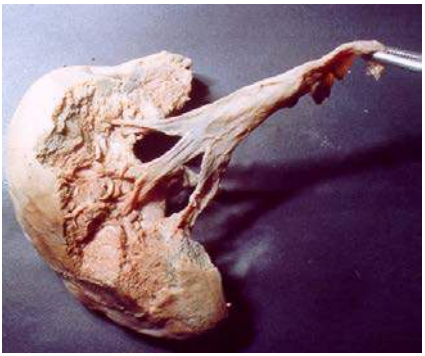


Fig. 12 - Right renal vein formed juxtahilar of three primary branches, antero-superior, antero-middle and antero-inferior.

In 34 cases (27,87% of the total number of cases) the trunk of the renal vein was formed of three primary branches. Of these cases, in 28 cases (22,95% of the total number of cases) the renal vein was formed of a antero-superior branch, an antero-middle one and the other antero-inferior.

In only three cases (2,46% of the total number of cases), the venous trunk was formed of three primary branches positioned antero-superior, antero-inferior and posterior, all cases being left renal veins (4,17% of the left renale veins).

In 12 cases (9,84% of the total number of cases), trunk of the renal vein was formed of four primary branches, in 10 cases (8,20% of the total number of cases), the four branches being oriented antero-superior, antero-middle, antero-inferior and posterior, and in only 2 cases (1,64% of the total number of cases) the primary branches were represented only by anterior braches: superior, mezorenal superior, mezorenal inferior and inferior, both cases being on the left side (2,78% of the left renal veins).

Fig. 14 – Mold of a right renal vein (anterior sight) formed of four primary branches: 3 anterior (superior, middle and inferior) and a posterior branch.

TABLE NO. 5 - COMPARATIVE STATISTICS BETWEEN PERSONAL CASES AND THE RESULTS OF LACERDA AND SATYAPAL.

NO. BRANCHES	AUTHOR				
	LACERDA	SATYAPAL	PERSONAL CASES		
2 branches	32%	38,6%	62,29%	right.: 56%	left.: 66,67%
3 branches	36%	37%	27,87%	dr.:32;	st.: 25%
4 branches	32%	10,1%	9,84%	dr.:12%	st.: 8,33%

The place of renal vein formation in relation to the facts mentioned, has been studied on 110 cases, 32 cases being right renal veins (29,10% of the cases) and 78 cases of left renal veins (70,90% of the cases). I found that in 40 cases (36,36% of the total number of cases), the renal venous trunk was formed intrasinisian.

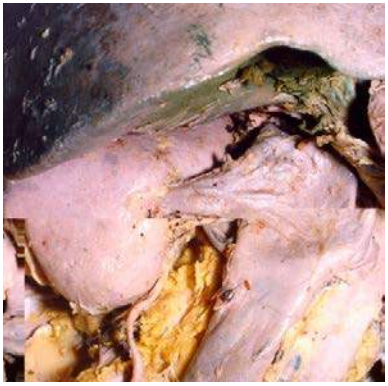


Fig. 16 – Right renal venous trunk is formed intrasinusian.

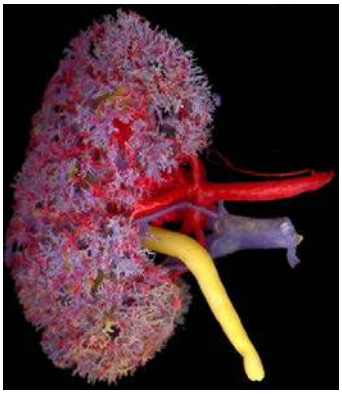


Fig. 17 - Right renal vein (posterior sight) which is formed juxtahilar.

In 34 cases (30,91% of the total number of cases) the venous trunk was formed juxtahilar.

In 36 cases (32,73% of the total number of cases), the renal vein trunk was formed extrarenal (extrahilar), of the cases, in 14 cases (12,73) of the total number of cases, the veins were formed closer to the kidney and for the left renal vein, in 8 cases (10,26% of the left veins), the venous trunk was formed halfway between the kidney and the aorta, respectively closer to the aorta.

Fig. 18 – Left renal vein formed extrarenal, closer to the kidney.

Fig. 19 - Left renal vein formed extrahilar, halfway the distance kidney-aorta, from two venous trunks. Renal artery is situated postero-superior to renal vein. Inferior suprarenal vein is ended into the renal vein at the same level with the left gonadal vein, both being perpendicular to the renal vein.

At the level of right renal vein I was confronted with 4 cases (12,5% of the right renal veins) in which the renal vein was formed halfway the distance between the kidney and the inferior vena cava, in other 2 cases (6,25% of the right renal veins) the renal vein being formed closer to the inferior vena cava.

Fig 21 - Anterior sight. Right renal vein is formed extrahilar, halfway between the inferior cava and the kidney, from two branches, superior and inferior, both formed of 2 collectors. Right renal vein ends into the inferior vena cava at the same level with the left renal vein and is situated anterior to the right renal artery.

From my statistics it results that intrahilar, the renal vein is formed in percentage more frequently on the right side only with 2,4%, and juxtahilar also more frequently on the right side, more with 9,30 percent. Renal vein is formed extrahilar more frequently on the left side, with 10,90%, which favors the interventions at the level of left kidney.

POSTERIOR PRIMARY RENAL VENOUS BRANCH

Posterior primary venous branch has a very variable morphology and its presence as a well individualized branch was found by me in 56 cases (45,90% of the cases) out of 122 cases. Most frequently, in 32 cases, the posterior branch was ended in the renal venous trunk (57,14% of the total number of cases).

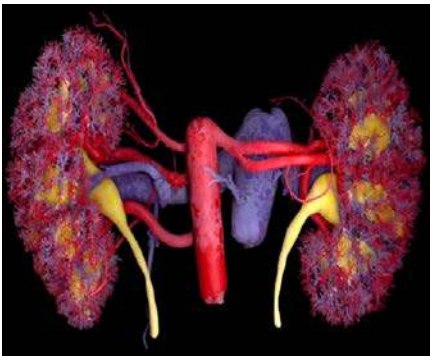


Fig. 23 – Posterior sight. Left posterior venous branch which ends in the trunk of the renal vein, closer to aorta, vascularizing the posterior mezorenal area. Left renal vein is situated between the middle and inferior renal arteries.

In 14 cases (25% of the total number of cases) the posterior venous branch was one of the primary branches which contributed to the formation of the venous trunk, and in 6 cases (16,22% of the total number of cases), the posterior primary venous branch ended in the antero-superior branch, all cases being on the left side (16,22% of the left renal veins).

Fig. 25 - Posterior sight. Posterior primary venous branch ending in the antero-superior primary branch. Vascularizes the posterior mezorenal area. Renal vein is situated between the two left renal arteries, closer to the superior one.

Fig. 26 – Posterior sight. Mold of a renal vein formed of two venous trunks, the posterior primary branch ending in the antero-inferior vein.

In 2 cases (3,57% of the total number of cases) the posterior branch is ended in the primary antero-inferior branch.

In only one case (1,79% of the total number of cases), on the right side (5,26% of the right renal veins), the posterior venous branch was ended in the inferior vena cava, as additional renal vein. Also, in only one case (1,79% of the total number of cases), but

on the left side (2,70% of the left renal veins), the posterior venous branch ended in the primary mezorenal anterior branch.

It is found that for the cases in which the posterior primary branch ends in the trunk of the renal vein after its formation, in which usually ends extrahilar, the percentage are similar for the two sides of the organism, on the right side the percentage being bigger only with 1,13 percents. The posterior primary venous branch contributes to the formation of the renal vein trunk more frequently on the right side, with a percentage higher with 10,63 percents, probably due to the fact that the right renal venous trunk is much shorter than the left one. The termination of the primary posterior branch into the primary antero-superior branch, respectively mezorenal anterior, was found only on the left side, while the termination of the posterior nbranch into the inferior vena cava was found only on the right side.

Fig. 28 – Anterior sight. Renal vein which is formed by confluence of three branches: superior, mezorenal and inferior. The posterior venous branch is ended in the mezorenal branch.

TABLE NO. 8 – PRESENCE OF VENOUS PRIMARY POSTERIOR BRANCH

AUTHOR	PRESENCE OF POSTERIOR BRANCH (%)
Merklin&Mitchels	30
Satyapa	35,3
Personal cases	***45,90***

In 22 cases of the venous primary posterior branches (39,29% of the cases), I found the aspect in arcade with medial concavity.

Fig. 30 – Posterior sight, right kidney. Venous posterior primary branch in arcade.

RELATIONS OF RENAL VEINS WITH THE CORRESPONDING ARTERIAL BRANCHES.

- Referring to the vascular trunks, anterior to terminal ramification (in the case of arteries) or thier formation (in case of veins), on a number of 150 cases I found the following situation: 1. the vein was situated anterior to corresponding artery, aspect found in 70 cases (46,67% of the total number of cases); 2. in 18 cases (12% of the total number of cases) the vein was situated posterior to artery; 3. in 60 cases (40% of the total number of cases), the arterial trunk was situated cranial to the venous one; it is noted that the vein was situated inferior to artery, but on a plan anterior to it; 4. only in 2 cases (1,33% of the total number of cases), both on the right side (2,86% of the right veins) I found that the renal vein was situated antero-superior to its homonymous artery.

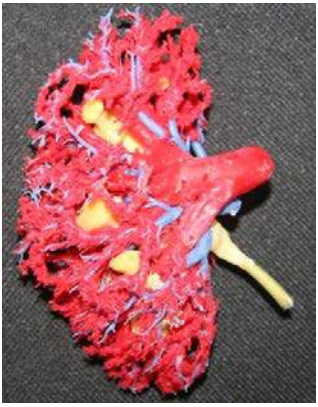


Fig. 32 - Right kidney – anterior sight. Renal arterial body and its intrarenal branches are positioned anterior their venous counterparts.

ANASTOMOSIS OF RENAL VEINS

I have traced the existence of anastomosis veins in a number of 77 cases, 31 cases of the right side (40,26% of cases) and 46 cases on the left side (59,74% of cases).

I have encountered 12 cases (15,58% of cases) where anastomosis were present, anastomosis between the venous branches, either intrarenal or outside the kidney . In 6 cases (7,7% of all cases), anastomosis were situated in extrahilar position, and only 2 cases (2,60% of all cases), anastomosis were situated in juxtahilar position, both cases being on the right side (6,45% of the right renal veins).

In 4 cases (5,19% of all cases), anastomosis were situated in intrahilar position, all the 4 cases being situated on the right (12,90% of the right renal veins). These anastomosis were located between the primary venous branches which contributed to the formation of the renal vein trunk, between the primary venous branches and the secondary ones, or between the secondary venous veins.

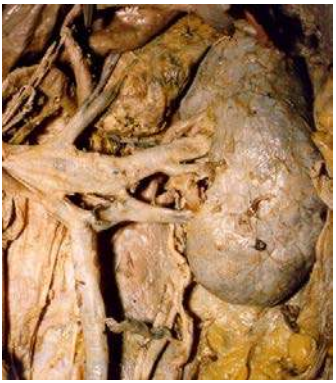


Fig. 37 – Strong anastomosis situated at ½ distance kidney-aorta, slightly orientated oblique super medial, between the two primary venous branches of the left renal vein, which unite on the left flank of the aorta. In the inferior venous trunk is less bulky than the superior one, the left gonadal vein ends.

Fig. 39 – Anterior view. 2 posterior right side renal veins, anastomosis between them juxtahilar, through an oblique super medial anastomosis.

In 4 cases (5,19% of all cases) I have met these anastomosis between the trunks of the double veins, all the 4 cases being on the right side (12,90% all of the renal veins).

Only in two cases on the right side, anastomosis between the primary venous branches were situated on the posterior side.

A much higher frequency of the existence of intravenous anastomosis on the right side can be observed, more than 27,91 percentages compared to the left side, on this side only extrahilar anastomosis can be observed between the primary veins of renal veins, but also left side extrahilar being less frequent than 8,55 percentages than the right side.

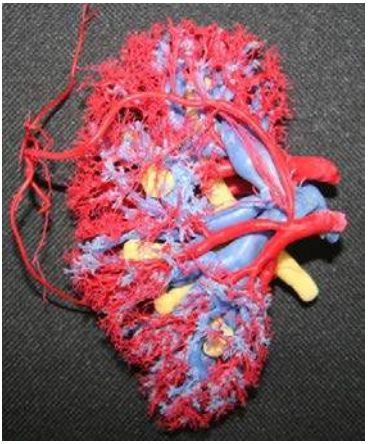


Fig. 40 – Anterior right kidney view. Intrarenal anastomosis between the primary branch and the secondary superior branch of the inferior primary one.

TRAJECTORY (DIRECTION) OF RENAL VEINS

I have studied the direction of renal veins on 62 cases and most frequently, renal veins had an ascending oblique trajectory, aspect in 28 cases (45,16% of all cases). The trajectory of the veins was strait, except for 2 cases (3,23% of all cases) situated on the left, where the veins were slightly curved, with superior concavity.

Fig. 42 – Anterior view. Left side renal vein formed with ascending trajectory, upper side concave arcuate , passing in pre-aortic position, being formed of 2 primary branches, inferior and superior.

In 18 cases (29,03% of all cases) renal veins had a transversal trajectory (horizontal), in 8 cases (12,90% of all cases), the renal veins initially had an oblique ascending trajectory, but approximately on their middle they became oblique ascending, describing a curve with the concavity facing higher, aspect met only for the left side (20% of the left side renal veins), in 6 cases (9,68% of the cases), renal veins initially had an oblique ascending trajectory, for later to become horizontal towards the inferior cava vein, and in only 2 cases (3,23% of all cases) we have met, only on the left side the italic lying "S" aspect of the renal vein.

Having the same trajectory on both sides, I have encountered only 8 cases of renal veins (12,90% of all cases), in 6 cases the two cases, right and left, having an oblique ascending

trajectory (9,68% of all cases) and in 2 cases initially having an oblique ascending trajectory and subsequently a horizontal trajectory (3,23% of the cases).

LEFT RENAL VEINS WITH RETRO-AORTIC TRAJECTORY

I have followed left renal veins with retro-aortic trajectory on a number of 42 cases, finding only two cases where the left renal vein had a retro-aortic trajectory (4,76% of cases). One of the cases is the one with Para-aortic ring, the left renal vein ending below the right renal vein termination, the latter being formed of 2 primary branches close to the inferior cava vein and ending in the cava one on its anterior lateral side.

The second case presents the left renal vein ending in the inferior cava vein on its lateral side, at the corresponding level for the space between the 2 right renal veins, closer to the right superior renal vein.

TERMINATION LEVEL OF RENAL VEINS

I had the opportunity to pursue a number of 32 cases at termination level of renal veins in the inferior cava vein compared to the right-left and I have found 16 cases (50% of all cases) the two renal veins ended at the same level.

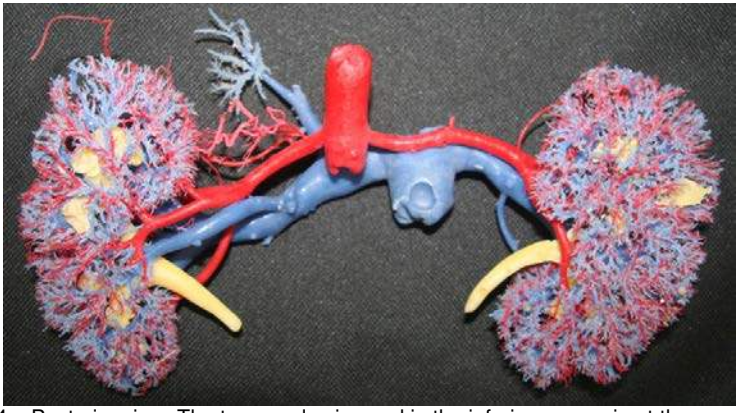


Fig. 44 – Posterior view. The two renal veins end in the inferior cava vein at the same level. The left posterior venous branch ends in the trunk of the renal vein on its posterior side, halfway of the aorta-kidney branch. The left renal vein is located below the homonymous vein.

In 12 cases (37,5% of all cases) the right renal vein ends in the cava vein at a superior level of left renal vein termination.

Fig. 45 – Anterior view. Right renal vein ends in the inferior cava vein at a superior level compared to the left renal vein.

In 4 cases (12,5% of all cases), left renal vein ends in the inferior cava vein at a superior level compared to the right renal vein.

Fig. 46 – Posterior view. Left renal vein ends into the inferior cava vein at a superior situated level compared to the right renal vein.

On the postero-lateral face of the inferior cava vein ended 26 renal veins (29,55% of all cases).

Fig. 48- Right renal vein juxtahilar composed of the two venous trunks. The vein ends on the postero-lateral face of the inferior cava vein.

On the antero-lateral face of the inferior cava vein 24 renal veins ended (27% of all cases) and only in 2 cases (2,27% of all cases), both cases on the right side (3,70% of right renal veins), renal veins ended on the anterior side of the inferior cava vein.

On the lateral side of the inferior cava vein, the right renal vein most commonly ends than the left renal vein by 18,74 percentages, on the poster lateral left renal vein ending more frequently the right one by 9,36 percentages, and on the anter lateral side of the inferior cava vein the left renal vein ending most frequently by 23,07 percentages.

I have found that in 14 cases (15,91% of the cases) the two renal veins form on the same side of the inferior cava vein: in 4 cases (4,55% of the cases) ending on the lateral side of the inferior cava vein, in 6 cases (6,82% of the cases) on the anter lateral side, and in 4 cases on the poster lateral side (4,55% of cases).

MORPHOMETRY OF RENAL VEINS

The length of the left venous trunk I found it ranging between 7-12, 5 cm, while the ***length of the right venous trunk*** I found it ranging between 1,5-5,5 cm.

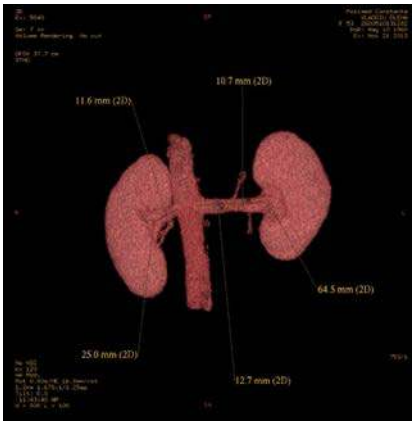


Fig. 51 – Left renal vein has a length of 6,45 cm, its caliber being of 1,07 cm at origins and 1,27 cm at termination. Right renal vein has a length of 2,50 cm a caliber of 1,16 cm.

TABLE NR. 14 – LENGTH OF RENAL VEINS

AUTHOR	DRIGHT / CM	LEFT / CM
Gray	2,5	7,5
Gillot	3-7 (4,73)	7,5-14 (10,04)
Williams	2,5	7,5
Juskiewenski	2-4	5-9
Delmas	1-3,5	3,5-9
Prigent	3-7	7,5-14
Gotta	1-1,5	5,9
Satyapal	2,4+/-0,78	5,9+/-1,5
Chiriac	3-4	8-9
Personal cases	***1,5-5,5***	***7-12,5***

The caliber of the left renal vein I found it ranging between 0,8-1,8 cm, while ***the caliber of the right renal vein*** I found it ranging between 0,7-1,5 cm.

TABLE NO. 15 – CALIBER PF RENAL VEINS.

AUTHOR	RIGHT / CM	LEFT / CM
Gillot	1,14	1,4
Delmas	0,81-1,71	0,8-1,83
Prigent	0,6-2,5	0,9-2,6
Satyapal	1,2+/-0,2	1,2+/-0,2
Personal Cases	***0,7-1,5***	***0,8-1,8***

INFERIOR ADRENAL VEIN AND LEFT GONADAL

I have traced the trajectory of the adrenal vein in a number of 44 cases, finding that the adrenal vein has always a straight trajectory, presenting two aspects: 1. in 24 cases (54,55% of all cases) it presents an oblique inferior medial trajectory; 2. in 20 cases (45,45% of all cases) the trajectory of the venous trunk after its formation was in vertical position. The trajectory of the left gonadal vein has been traced on a number of 36 cases, being found in 20 cases (55,56% of cases) in oblique upper-medial position, and in 16 cases (44,44% of cases) it was vertical. Unlike the appropriate adrenal vein, the left gonadal vein is present in 7 cases (19,44% of cases) corrugated path.

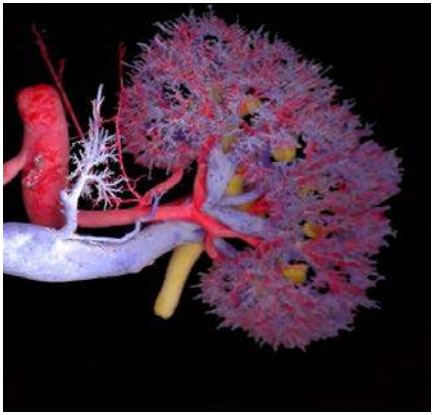


Fig. 52 – The adrenal vein which flows perpendicular into the renal vein onto the antero-lateral side of the aorta.

As far as the termination location of the left adrenal vein is concerned, aspect which I have traced on a number of 48 cases, I considered that in 24 case (50% of cases), the termination of the adrenal vein into the left renal vein was made laterally to the aorta, in 20 cases (41,67% of cases) being closer to the aorta and in 4 cases (8,33% of cases) halfway of the aorta-left kidney distance. In the other 24 cases, the left adrenal vein terminates into the left renal vein on the anterior side of the aorta, in 8 cases (25% cases) the termination being on the anter lateral side of the aorta and in 16 cases (33,33% of cases), strictly on the anterior side of the aorta, closer to the midline, in one case of these (2,78% of cases) the termination of the vein exceeding to the right the middle of the anterior side of the aorta. The termination location of the left gonadal vein, has been traced in 32 cases, finding that in 24 cases (75% of cases) it ended laterally from the aorta, in 12 cases (37,5% of cases) being closer to the aorta, and 12 cases also (37,5% of cases) being halfway of the aorta – left kidney distance. In 8 cases (25% of cases) the left gonadal vein ends in the renal vein on its anter lateral side. Comparing the termination location of the adrenal vein in the left renal vein to the one of the gonadal vein (on a number of 41 cases), I have found out that in 12 cases (29,27% of cases) they ended on the same level, but only in 3 cases both veins had a vertical trajectory (7,32% of cases). In 25 cases (60,97% of cases) the gonadal vein ended laterally from the adrenal vein, and only in 4 cases (9,76% of cases) the gonadal vein ended medial from the adrenal vein, in only one of these cases the gonadal vein ending on the anter lateral side of the aorta.

Fig. 53 – Adrenal vein with an oblique lower-medial trajectory ending in the renal vein on the anterior side of the aorta, and the left gonadal vein, slightly oblique upper-medial, ending on the antero-lateral side of the aorta.

Fig. 54 – Adrenal vein, slightly oblique lower-medial, it ends on the postero-upper side of the renal vein, the left gonadal vein, oblique postero-upper, the left gonadal vein, oblique upper-medial, between the two veins an obtuse laterally opened angle being.

Between the inferior suprarenal vein and the left gonadal vein, at termination level into the renal vein, an obtuse laterally opened angle is most commonly being formed.

ADDITIONAL RENAL VEINS

I have traced the presence of additional renal veins on a number of 116 kidneys (I have found a number of 6 cases of additional renal veins).

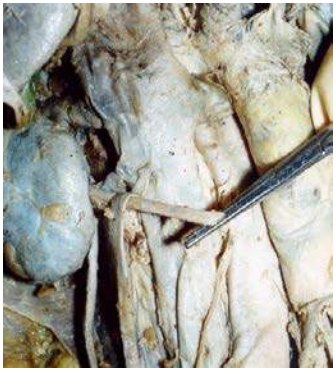


Fig. 56 – Two right renal veins, the inferior one less voluminous being polar inferior. The superior renal vein is ascending oblique and it terminates on the poster lateral side of the cava vein, inferior renal vein which is ascending oblique, ending on the anterior side of the cava vein.

Fig. 57 – Posterior view. Three right renal veins. The superior one, ascending oblique ends on the lateral side of the cava, being formed extrahilar, closer to the kidney, of 2 primary branches. The middle one (posterior) ends on the poster lateral side, anterior to the inferior renal vein, which ends on the anter lateral side of the cava.

From the 16 cases with additional renal veins, in 14 cases there were double renal veins (12,07% of cases) and in 2 cases triple renal veins (1,72% of cases).

Depending on their externalization from the kidney, I have classified renal veins into ***real, hilar*** *or* ***main vein***, which leave the kidney through the renal hilum (and which I have always found more voluminous) and ***polar veins***, which leave the kidney outside the renal hilum. All superior veins leave the kidney through the renal hilum, therefore they were all real or proper renal veins, not finding additional polar renal veins. For the inferior renal vein, in 6 cases the veins were leaving the kidney through the renal hilum, being hilar or real veins (42,86% of cases), and in 8 cases (57,14% of cases) they were leaving the inferior kidney of the renal hilum, naming them inferior polar veins, although they vascularized the inferior 1/3 of the kidney.

I have encountered no case of double bilateral renal veins, and the unique renal vein of the opposite side can terminate as follows: a. above the superior renal artery; b. on the same level as the superior renal vein; c. between the two veins, sometimes even at midway between them. I encountered no case where the unique renal vein terminates in the cava vein below the inferior renal vein termination.

Fig. 58 – Two right renal veins, the inferior one, less voluminous, being formed in intra renal position. The superior renal vein is formed extrahilar, at the midway between the kidney – inferior cava vein, from two venous trunks, being a hilar renal vein. Inferior renal vein, formed intrahilar, passes above the ureter.

Fig. 61 – Right double renal veins, the superior one with ascending oblique trajectory, being a hilar vein, ending on the postero-lateral side of the inferior cava vein, and the inferior one, with horizontal trajectory, being an inferior polar vein, ending on the lateral side of the inferior cava vein.

Additional left renal veins rarely meet compared to the right ones, I personally have met only 2 cases of left double renal veins (3,12% of left veins), therefore by 22,96 percentages less than at the level of the right veins.

TABLE NO. 16 – INCIDENCE OF ADDITIONAL RENAL VEINS

AUTHOR	NUMBER OF CASES	LEFT ADDITIONAL RENAL VEINS (%)
Rupert (1915)	115	1,0
Anson et al. (1936)	200	3,0
Pick&Anson (1940)	194	1,0
Weinstein et al. (1940)	203	6,0
Merklin&Michels (1958)	185	3,1
Reis&Esenther (1959)	500	0,8
Ross et al. (1961)	34	3,0
Beckmann&Abrams (1980)	56	1,0
Pollak et al. (1986)	400	2,0
Satyapal et al. (1995)	153	2,6
Satyapal et al. (1997)	1008	0,4
Range	-	0,8-6
Median	-	2,3
Personal cases	***116***	***3,12***

Comparing the personal results to those of scientific literature, the percentage I have found for double renal veins for the left side can be observed.

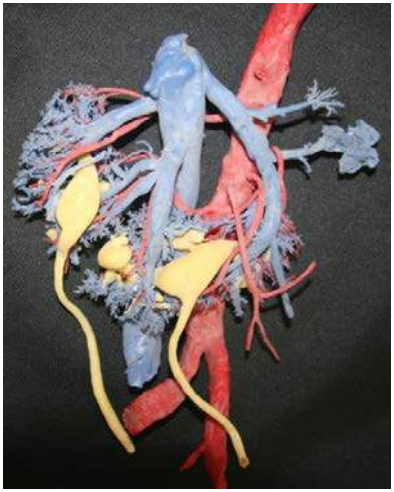


Fig. 62 – Horseshoe shape kidney which presents 3 right renal veins.

PERIAORTIC VENOUS RING

In the study conducted on a total of 32 cases of kidneys-arteries organic blocks and renal veins – aorta – inferior cava vein, I have found a case of periaortic venous ring or renal venous collar (3,12% of cases). From the level of the left renal vein, on the retro aortic left side, it was branched off an ascending venous branch which described a curve with a left side convexity towards the aorta, under the left renal artery, passing then on the anterior side of the aorta, at superior level of the retro aortic venous trunk, to end on the left flank of the inferior cava vein, on its antero-lateral side, at the same level with the superior right renal vein termination.

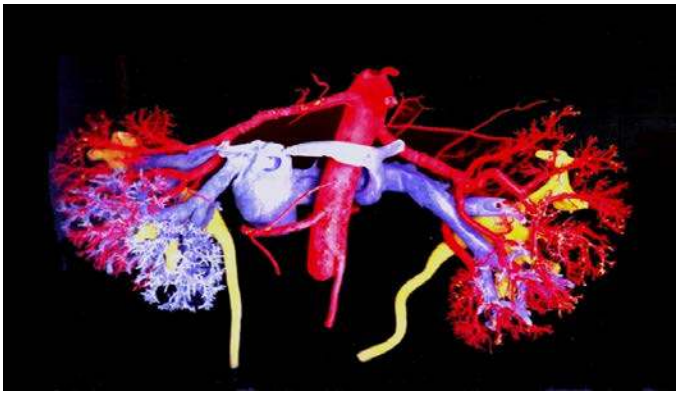


Fig. 63 – Periaortic venous ring, with retroactive left renal vein, 2 arteries and 2 right renal veins. The inferior renal artery, polar inferior, has a precav and retrouretral route. The adrenal artery ends in the convexity of the periaortic ring.

TABLE No. 17 – INCIDENCE OF PERIAORTIC VENOUS RING

AUTHOR	NO. OF CASES	RENAL RING (%)
Zumstein (1896)	220	8,2
Jeanbrau (1910)	24	4,2
Hovelacque (1914)	20	30,0
Gérard (1920)	225	7,5
Seib (1934)	176	9,1
Făgărășanu (1938)	-	8,5
Pick&Anson (1940)	215	16,8
Anson&Cauldwell (1947)	425	17,0
Davis et al. (1958)	100	6,0
Reis&Esenther (1959)	-	2,4
Anson&Daseler (1961)	100	1
Davis&Lundberg (1968)	270	1,5
Ortmann (1968)	79	11,4
Brener et al. (1974)	-	2 cazuri
Chuang et al. (1974)	3	1 caz
Royster et al. (1974)	387	0,5
Gillot (1978)	322	5,6
Beckmann&Abrams (1979)	127	7,9
Kramer&Grine (1980)	193	5,7
Nishimura et al. (1986)	31	3,2
Hoeltl (1990)	5089	0,2
Satyapal et al. (1997)	1008	0,3
Range	-	0,2-30
Median	-	5,7
Personal cases	***32***	***3,12***

CONCLUSIONS

Renal veins present morphological variants concerning various aspects: formation (original branches and their conflation location), trajectory (especially for the left renal vein), termination, morphometry, but especially the variants concerning their number and the possible existence of a periaortic venous ring.

Among the origin branches of the renal vein, the posterior branch presents variations related to its existence and their termination manner. Satyapal states that it is obvious that dissections may reveal posterior primary branch, while radiological analysis does not allow, due to difficulties to make the distinction between posterior branches on an isolated antero-posterior image. Also, "in vivo" interventions, limited to incision and the mobilization possibilities, exclude the visualizing of certain branches, especially the primary posterior branch. Recent progress, as well as retroperitoneal surgery (achieving a sympathectomy, an adrenalectomy or a nephrectormy), allow a better visualization of posterior veins, which classical retroperitoneal surgery did not allow.

These variations are clinically silent, and they remain unknown until the surgery or necropsy. The cure of abdominal aortic aneurysm during which the aorta is being mobilized, the retro aortic vein is very important. In retroperitoneal surgery, the operator can visualize a pre-aortic vein, but it ignores the primary posterior branch and he can damage it by mobilizing the kidney or clamping the aorta. (Satyapal).

The left retro-aortic renal vein is a vulnerable abnormality which obsesses surgeons and radiologists. According to these authors, this abnormality is important in radiological practice (phlebograhy, scintigraphy, catheterization, scanning and imaging of magnetic resonance) and urology.

Diagnosis of abnormalities of renal veins requires a good knowledge of anatomic variations of renal veins, especially of the left renal vein. The retro aortic positioning has a great importance in vascular and urological pathology in the treatment of abdominal aorta aneurysms, eradication of retroperitoneal nodules of testicular tumors or in renal transplants as well as in port cava derivations. Collateral veins of the left renal vein, just like the ascending lumber vein, it undertakes the vascularization of the kidney in case of thrombosis, compression or aortic aneurysm. According to Arslan the retro aortic renal vein can develop haematuria, left renal vein thrombosis and hypertension.

In relation to the adrenal vein, the existence of a single main venous trunk explains the common use of radiological opacification of adrenals by phlebograhy more than by arteriography, which requires selective catheterization of the three pedicles. (Sénécail).

Regarding the affluents of the renal vein, I have encountered the same left-right asymmetry on the obliquity of the adrenal vein and the asymmetric way and termination position of this vein in the corresponding renal vein.

Contrary to classical anatomy, which states that in most cases the adrenal vein above the lower end of the left gonadal vein termination in the renal vein, I have met this aspect only in a very low percentage, most commonly gonadal vein ending in medial renal vein of superjacent adrenal vein, contrary to the statements made by Satyapal, Chuang. Interesting are also the cases when the left gonadal vein is satellite to a left gonadal artery originating in the renal artery, single or incidental, a less quoted aspect in scientific literature.

Chakravarthi considers the additional renal vein anything that drains the isolated and independent kidney in the inferior cava vein and which must be considered as normal variation. This definition corresponds to the one proposed by Satyapal related to the additional renal vein "***vessel resulted from the convergence and union of a variable***

number of primary branches which leave the kidney and they end separately in the inferior cava vein", it corresponds to type III in his classification.

There are contradictions on multiple renal veins names, being called **accessories** (Sykes) or ***additional*** (Satyapal, Chakravarthi, Ribeiro). The name of accessories is improper, due to the presence of an additional artery at kidney level, it requires the vascularization of a well delimited territory, which can represent up to ½ of its surface, instead of a careless aspect. Therefore I propose that for the cases of additional veins, terms like **multiple renal veins** should be used, making thus reference to **a double or triple vein.** Not always the existence of double renal veins is accompanied by the existence of double renal arteries, double urethra or keeping the fetal lobulation of the kidney.

The existence of e periaortic venous ring may be responsible for the development of collateral network immediately after the surgical interruption of the cava vein if achieved not knowing its existence (Krause, Piccone). Therefore, a careful search of this anatomic abnormality must be practiced by a renal phlebograhy prior to surgery. If a retroactive venous ring is discovered, the cava interruption must be practiced at the inferior level of the retro aortic renal vein hole, in the inferior lumbar region (Ferris, Gurewich). Another consequence of this congenital variant is the restricting usage of the left renal vein in interventions which require its mobilization (for example, the spleen and renal shunt) where the advantage of its length is being cancelled (transplant of the left renal vein) [Davis]. The cure of abdominal aortic aneurysm when the aorta is mobilized, the retro aortic vein is very important. In retroperitoneal surgery, the operator can visualize a pre-aortic vein, but he ignores the primary posterior branch and he can damage it by mobilizing the kidney or clamping the aorta. (Mitty, Waren).

For transplant surgery, morphology of renal veins has a particular significance, since variations and abnormalities can significantly influence the feasibility of the operating technique. Prior knowledge of the prior aortic ring is important when blood samples are taken based on adrenal or renal veins. When venous suprarenal sampling (prelevation) is conducted (for example, for hormonal dosages), in the presence of circum aortic venous ring, only the para aortic segment can be chosen, as adrenal vein ends in this segment.

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