

Renal vascularization anomalies in the Polish population. Congenital anomalies of the renal veins

Authors' Contribution:

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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ABSTRACT:

Summary: The aim of the study was to determine the incidence of renal venous system congenital anomalies in the Polish population.

Material and method: Vascular kidney samples were investigated by means of preparations and X-ray contrasting. The study group comprised 281 male and 269 female specimens.

Results: Congenital anomalies were diagnosed in 186 patients (33.8% of all cases), and they were more frequent in men than in women, albeit that difference was non-significant. The following anomalies were most commonly observed: multiple venous variations on the right side (20.4%), retroaortic course of the left renal vein (4.2%), and circumaortic venous ring of the left renal vein (3.8%). Other anomalies were diagnosed in 1%–2% of cases.

Conclusions: Awareness and preoperative assessment of the venous system before abdominal aortic surgery, isolated collection of renal venous blood samples, and urological or kidney transplantation procedures is essential.

KEYWORDS:

kidney, venous anomalies, Polish population

INTRODUCTION

Presence of renal venous anomalies can cause difficulties during abdominal aortic aneurysm surgery, kidney transplantation, laparoscopic kidney tumor excision, and renal venous blood sampling [1–7]. Although the transplanted kidney has the so-called “renal collar”, which mimics normal renal venous system with one vein on each side [8], surgical success varies in different transplant units [6]. The significant variations of selected renal venous system anomalies presented by Beckmann and Abrams [9] and Satyapal et al. [10] encouraged us to analyze renal venous anomalies in our samples.

MATERIAL AND METHODS

This study was approved by a local Bioethics Commission (approval No2/BOPD/2017 DIL). We analyzed data from 550 fresh autopsy specimens (281 male, 51.0%; 269 female, 48.9%). The causes of death were as follows: cardiovascular diseases (most common), cerebral hemorrhage, and cancer; surgical cases were excluded. The dissection technique was similar to the techniques used for renal artery investigations [11], and it involved preparation of vessels from previously collected renovascular samples (Fig. 4–6, 8, 9). Prior to preparation, 74 male (26.33%) and 71 female (26.39%) specimens underwent cavo-nephrography (Fig. 1–3, 7). The chi-squared test and the Student's t-test were used for comparisons. $P \leq 0.05$ indicated statistical significance.

RESULTS

Normal renal venous systems, i.e. those with one vein on each side, were found in 364 cases (66.2%), including 180 men (64.1%) and 186 women (68.4%) ($p=0.4$).

Men with normal venous systems were aged 0.1–84 years (mean

age, 55.4 ± 21.3 years). Men with congenital anomalies were aged 0.1–91 years (mean age, 48.8 ± 23.9 years) ($p=0.02$). Women with normal venous systems were aged 0.2–92 years (mean age, 56.3 ± 22.3 years). Women with congenital anomalies were aged 3–92 years (mean age, 56.83 ± 21.41 years).

In the analyzed samples, multiple right renal veins were the most common venous anomaly (20.4%; men, 22.1%; women, 18.6%). A retroaortic course of the left renal vein was found in 4.2% of samples, and 3.8% of samples had circumaortic venous rings. Left-sided and bilateral multiple kidney veins were found in 2.2% of specimens (Fig.3). The incidence of other venous anomalies was 1%–2%. Abnormal development of the inferior vena cava was observed two times as often in women than in men.

Right-sided multiple venous variations typically presented as double renal veins. Two specimens (1.8%) had triple renal veins, and one (0.9%), quadruple renal veins. The above-mentioned additional veins coursed parallel to the proper renal veins, whereas the course of double renal veins differed. Of 112 cases with double renal veins, 88 (78.6%) had parallel renal veins, in 21 cases (18.8%, 11 men, 10 women), the veins crossed each other and connected to the inferior vena cava, and in 4 cases (3.6%, 2 men, 2 women), the right additional vein connected directly to the right sex vein. The additional right renal veins had diameters that were equal to or smaller than the diameters of the normal renal veins (Fig. 1, 2).

Twelve patients had left-sided additional vessels (2.2% of entire sample, 6.5% of patients with congenial renal venous anomalies), and the incidence of left-sided additional vessels was 1.5 times greater in men than in women. Of 12 patients with left-sided additional vessels, in 9 (75%), the left additional renal vein connected to the left sex vein and not the inferior vena cava, and in 3 cases (25%), the additional renal vein was as wide as the proper renal vein, and it connected retroaortically to the inferior vena cava.

Tab. I. Renal venous pattern in 550 bodies.

NO.	RENAL VENOUS PATTERN	MALE		FEMALE		TOTAL	
		N	%	N	%	NR	%
1		180	64,05	184	68,40	364	66,18
2		62	22,06	50	18,58	112	20,36
3		7	2,49	5	1,85	12	2,18
4		6	2,13	6	2,23	12	2,18
5		13	4,62	10	3,71	23	4,18
6		2	0,71	4	1,48	6	1,09
7		11	3,91	10	3,71	21	3,81
SUM		281	100,0	269	100,0	550	100,0

N – number of cases
% – percentage

Bilateral multiple veins were observed in 12 cases (2.2% of entire-sample, 6.5% of patients with congenital renal venous anomalies, Fig. 3); the frequencies were similar in men and women.

Retroaortic course of the left renal vein was observed in 23 cases (12.4% of patients with congenital renal venous anomalies; 4.2% of entire sample). That anomaly occurred more often in men than in women, with the opening located slightly below the ostium of the right renal vein (6, 26%) or significantly below it (17, 73.9%). In 20 cases, the left suprarenal vein connected to the retroaortic left renal vein (87%), and in 3 cases (13%), its ostium was located in the inferior vena cava (Fig.4). In 3 patients with a retroaortic course of the left renal vein, one had right-sided multiple veins (13%), comprising 2 double veins and 1 triple anomaly.

In our study, congenital venous anomalies affected the inferior vena cava least frequently (6 cases, 1.09% of entire sample, 3.2% of patients with congenital venous anomalies). These anomalies occurred more often in women than in men. Similar to McClure and Butler [12], we referred to a double inferior vena cava as type BC, and to a left-sided vena cava, as type C (mirroring the normal condition). Of six inferior vena cava anomalies, two were type C (Fig.6), and four, type BC (Fig.5). The left-sided venae cavae crossed the aorta below the superior mesentery artery, moved to the right, and connected to the liver. Single renal veins on both sides connected to the left venae cavae. The right sex vein connected to the right kidney vein, and the left sex vein and adrenal vein, directly to the vena cava. In one case (9-year old boy), the B branch was poorly developed, and it accepted one of the two branches of the bifurcated right sex vein, whereas the second branch connected to the right renal vein. In the remaining 3 cases, the B branch was significantly thicker than the C branch. In patients with type BC venae cavae, two right-sided renal veins and two cases of bilateral double renal veins were observed. Moreover, one patient had triple left-sided veins.

There were 21 renal venous collar cases (3.8% of entire sample, 11.3% of patients with congenital renal venous anomalies), with similar frequencies in men and women. The cases of venous collars were very different from one another (Fig.7-9). In 11 cases, the preaortic branch was the main branch (52.4%, Fig.8). In one case, both branches had the same width (4.8%, Fig.7). In 9 cases (42.9%), the retroaortic branch dominated (Fig.9). The circum-aortic venous ring was accompanied on the right side by two veins (5, 23.8%) or three veins (1, 4.76%). On the left side, two veins (5,



Fig. 1. Extracorporeal cavo-nephrogram with visualization of two veins, similar in width, on the right side.



Fig. 2. Extracorporeal cavo-nephrogram with visualization of two right-sided veins. One has an early bifurcation.



Fig. 3. Extracorporeal cavo-nephrogram with bilateral visualization of double veins of similar width.

23.8%) or three veins (1, 4.76%) were observed. One of these veins connected to the left sex vein.

DISCUSSION

In this study, we did not differentiate between basic and additional veins, as suggested by Satyapal [13], and we were only in-



Fig. 4. Vasorenal sample in the A-P position presents a retroaortic course of the left renal vein. The left renal vein connects directly to the inferior vena cava and the left sex vein that connects to the retroaortic left renal vein (excised fragment).



Fig. 7. Extracorporeal cavo-nephrogram presents the venous renal collar. Both the pre- and retroaortic branches are similar in width.

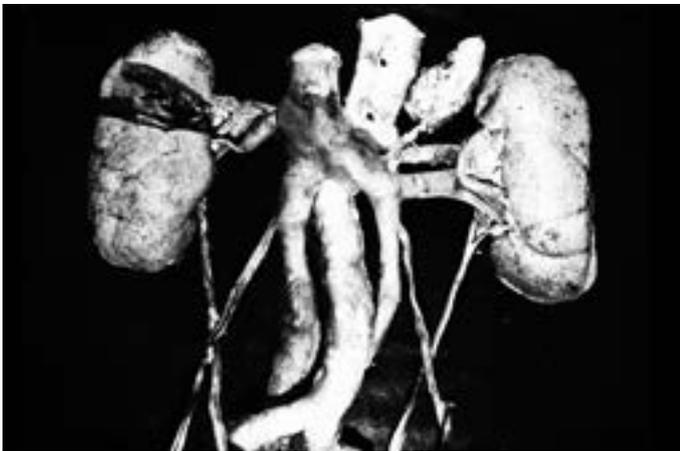


Fig. 5. Vasorenal sample in the A-P position presents double inferior vena cava. Bilaterally, the sex vein connects to the main vena cava and to the left adrenal vein from the left branch, above the left renal vein ostium.



Fig. 8. Vasorenal sample presents the circumaortic venous ring in the A-P position. The left sex and adrenal veins connected to the preaortic vessel. The right sex vein connected to the right renal vein.



Fig. 6. Vasorenal sample in the A-P position presents a left-sided inferior vena cava. Left-sided sex veins and adrenal veins connect directly to the vena cava, whereas the right sex vein originates from the right renal vein.



Fig. 9. Vasorenal sample in the A-P position presents the circumaortic venous ring. The retroaortic branch is significantly wider than the preaortic segment, which connected to the left sex vein. In contrast, the left adrenal vein connected to the preaortic vessel. The right sex vein communicated with the inferior vena cava.

terested in their numbers. Anson and Kurth [14] showed that right-sided multiple veins had parallel courses, while the left-sided multiple veins had different cross-connections. In general, our study agrees with those observations, but in our study, the double right renal veins crossed one another in 18.8% of cases. The frequency of right-sided venous variations was similar to that observed

by Beckmann and Abrams (23%) [9]. Although Dhar noted lower frequencies (4.2%), that analysis involved only 24 specimens [15]. A retroaortic course of the left renal vein was the second most frequent anomaly in our study, which is in line with the observation of Trigaux et al. (3.7%) [16], but disagrees with the study by Satyapal et al. (0.5%) [10]. The circumaortic venous ring was the third

most common anomaly in our study, and it was more common in our study than in the study by Satyapal et al. (0.3%) [10] but less common than in the studies by Trigaux et al. (6.3%) [16] or Beckmann and Abrams (11%) [17]. Congenital anomalies of the inferior vena cava were observed in only 1.1% of 550 patients, and left-sided vena cava, in only 0.36%. Such variations were not observed by Beckmann and Abrams [9] or Trigaux et al. [16] among 1,614 spiral CT examinations.

In our study, the percentage of renal venous anomalies was high (33.8%) and similar to the figures reported by Chuang et al. [18] and Beckmann and Abrams [17].

We found 7 venous variations, which could be explained by the complex development of the abdominal venous system. McClure and Butler [12] also found these types of anomalies, and they also published interesting animal data on that issue [18-23]. The development of renal veins commences in the 6-8-th embryonic week, and it follows a complex process of "development and regression" of three pairs of vertical cardinal veins. The lateral and dorsal postcardinal veins direct blood to the ductus Cuvieri and the venous sinus. Next, two subcardinal veins develop ventrally and medially to the aorta with transverse connections in-between. During involution of the postcardinal veins, supracardinal veins appear dorsally and medially to the aorta. Between the sub- and supracardinal veins, antero-dorsal communicating vessels exist. The aorta is located in the venous communicating system. Blood flow, thus far, bilateral, moves to the right side of the body, with left supracardinal vein degeneration, and the left subcardinal vein transforms into the left sex and adrenal veins. Complex renal venous changes were also observed on the right side of the body. The final inferior vena cava is created from 4 different segments: the subcardinal vein connected to the hepatic venous plexus (hepatic fragment); the growing right supracardinal vein that forms the infrarenal segment; the upper part of the subcardinal vein that forms the suprarenal segment; and the supracardinal – subcardinal and

post-subcardinal anastomoses, considered as the renal segment of the inferior vena cava. Bilateral venous plexuses at the kidney level form a pair of renal veins from the anastomoses between the supra- and subcardinal veins, from which the more dorsal vein undergoes atrophy. If both branches remain, the venous renal collar is created. The left-sided inferior vena cava originates from the persistent left supracardinal vein due to simultaneous involution of the right supracardinal vein. In case of two left renal veins, or even more so, three or four right renal veins, their genesis might be difficult to decipher. These vessels have to develop from non-atrophied, embryonic intersubcardinal veins, as supported by our observations of the communicating sex veins with separate branches. All these vessels are part the subcardinal venous system. A very low occurrence of the retroaortic left renal veins might be due to survival of one of the intersupracardinal communicating systems. Some additional renal veins connected to the sex vein, which supports a claim that the caval fragment of the additional renal vein undergoes degeneration. Malcic-Gurbuz et al. [24] presented similar observations. In their case, the left sex and adrenal veins had a common trunk of a non-atrophied left subcardinal vein, a separate connection ran above the aorta to the proper inferior vena cava, and the renal segment of the kidney vein had undergone degeneration. Moreover, in that case, there was also a retroaortic left kidney vein, and on the right side, two additional renal veins. Based on the above-mentioned observations, the accepted model of venous system development should be improved, which was also put forward by Friedland et al. [22] Based on the presented cases and a high rate of venous system congenital anomalies, during early embryogenesis, the development of complicated venous systems might be disturbed; however, the underlying mechanisms remain unknown.

From a clinical point of view, knowledge of the common renal venous anomalies is important. It is also essential for adequate angiographic assessments during surgery, and magnetic resonance imaging may be used to visualize aberrant vessels [13,18, 19, 23].

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