

Renal vascularisation anomalies in the Polish population. Coexistence of arterial and venous anomalies in the vascular pedicle of the kidney

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Background: The aim of the study was to determine the coexistence of arterial and venous anomalies in the vascular pedicle of the kidney in the Polish population.

Materials and methods: The study group comprised 550 corpses, including 281 male (mean age 52 ± 22 years), and 269 female corpses (mean age 56.4 ± 23 years) ($p = 0.02$). The vascular bundle was removed together with the kidney, "en bloc"; the vessels were subject to radiological contrasting and preparation. The obtained results were subject to statistical analysis (the exact Fisher test, χ^2 test of independence for cross-tabulation 2×2 tables, and the odds ratio with the confidence interval at a level of 0.95, calculated on the basis of the contingency dependence). Statistica 12 and Microsoft Excel were used for calculations.

Results: Variations in the structure of the renal venous system were observed in 33.8%; insignificantly more often in male (35.9%), as compared to female patients (31.6%). Deviations in the structure of the renal arteries were observed significantly more often in patients with renal venous system developmental disorders ($p = 0.0071$). In patients with a normal renal venous system, arterial kidney structure deviations were observed in 34.9% of cases, significantly more often in male (40%), as compared to female (29.7%) patients ($p = 0.043$). On the other hand, in venous system pathologies, the above-mentioned deviations were observed in 46.8% of cases ($p = 0.002$). Amongst developmental anomalies of the venous system, right-sided venous excess was observed in 20.4% of cases, including 48% of renal artery developmental pathologies, significantly more often in male (61.3%), as compared to female (32%) patients ($p = 0.002$).

Conclusions: Renal artery anomalies of the kidney vascular pedicle are significantly correlated with the coexistence of venous system variations. This is especially true for male patients, which favours female kidneys for transplantation. (Folia Morphol 2019; 78, 2: 290–296)

Key words: renal vascular pedicle, arterial and venous anomalies, correlations

INTRODUCTION

Variations in the structure of the renal vascular pedicle occur relatively frequently [11, 29], which should be considered in surgical treatment of aortic

aneurysms [2, 26], during retroperitoneal procedures [3, 12], in the treatment of renovascular hypertension [5], as well as during kidney transplantation [4, 6, 7, 14, 20].

In studies performed on a large sectional material, excess arteries ranged between 19.1% [23] and 32.3% [21]. In our own material the above-mentioned amounted to 38.3% [27]. The percentage of variations in the structure of the venous system was also high. Pick and Anson [21] observed 14.4% of such cases, while in our previous investigations the above-mentioned amounted to 33.8% [28].

Developmental disorders of the renal arteries are often accompanied by deviations of the venous structure [16, 30]. It is suggested that both anomalies go hand-in-hand [3, 21].

We decided to investigate the problem in the Polish population.

MATERIALS AND METHODS

The study group comprised 550 deceased patients, including 281 men, aged between 0.2 and 91 years (mean age 52 ± 22.6 years), and 269 women, aged between 0.1 and 92 years (mean age 56.4 ± 23 years) ($p = 0.02$) (approval of the Bioethical Committee No. 2/ BOPD/2017 DIL).

The renovascular samples were removed from the deceased bodies, "en bloc". In 377 (68.5%) cases post-mortal aortonephrography was performed, while in 145 (26.4%) — cavonephrography. After 2-week fixation in a 10% formalin solution, each prepared sample was subjected to description (Figs. 1, 2). The methodology was mentioned in our previous studies [27, 28]. The obtained statistical data was subjected to analysis by means of the exact Fisher test, and χ^2 test of independence for cross-tabulation 2×2 tables. The odds ratio (OR) with a confidence interval (CI) at a level of 0.95 was calculated in the case of significant contingency (dependence). The χ^2 test was used to verify the uniform distribution of subgroups of bodies with different renal vessel anomalies. Statistica 12 software and Microsoft Excel were used for calculation.

RESULTS

Results are presented in two stages:

- the occurrence of arterial variations in relation to the number of renal veins (1100 kidneys);
- occurrence of variations in the structure of arterial system in relation to particular types of developmental disorders of the venous system (7 types in our material; 550 cases).

The percentage of excess arteries significantly increased with the number of renal veins (Fig. 3, Table 1). Considering the side of the body, the number of arterial



Figure 1. Vasculorenal sample in the antero-posterior position. Two left renal arteries (arrows) running parallel with left renal vein (arrowhead) to the left kidney hilum. Three renal arteries (arrows) and two renal veins (arrowheads) on the right side. Two accessory renal arteries running precaval and parallel with an accessory renal vein to the inferior pole of right kidney. Right renal artery and vein in normal position.

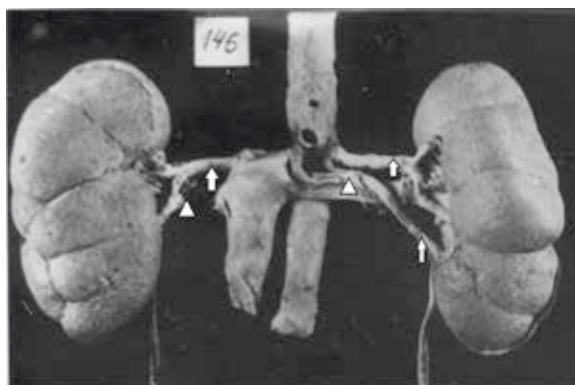


Figure 2. Vasculorenal sample in the antero-posterior position. On the left side two renal arteries (arrows). One of them wrapping around the left renal vein (arrowhead), running to the left kidney hilum. Normal arterio-venous position on the right side.

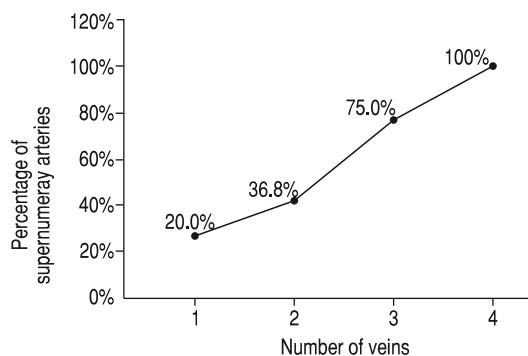


Figure 3. Percentage of supernumerary arteries depending on number of veins.

Table 1. Arterial-venous coincidence in the vascular bundle of kidney (1100 kidneys)

Number of veins	Number of arteries				Total	Supernumerary arteries	
	1	2	3	4		Sum	Percentage
1	738	172	9	4	923	185	20.0%
2	103	48	10	2	163	60	36.8%
3	3	4	4	1	12	9	75.0%
4	0	0	1	1	2	2	100.0%
Total	844	224	24	8	1100	256	23.3%

P-values: 1–2: 0.0000, 1–3: 0.0000, 1–4: 0.005, 2–3: 0.009, 2–4: 0.067, 3–4: 0.42

Table 2. Arterial-venous coincidence in the vascular bundle of kidney depending on the side of body (n = 550)

Number of veins	Right kidney				P	Left kidney				
	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries		Number of veins	Number of arteries	Number of kidney	Per cent	Per cent of super-numerary arteries
1	1	341	82.8%	17.2%	0.056	1	1	397	77.7%	22.3%
	2	66	16.0%			2	106	20.7%		
	3	4	1.0%			3	5	1.0%		
	4	1	0.2%			4	3	0.6%		
2	1	85	67.5%	32.5%	0.055	2	1	18	50.0%	50.0%
	2	34	27.0%			2	14	38.9%		
	3	6	4.8%			3	4	11.1%		
	4	1	0.8%			4	0	0.0%		
3	1	3	30.0%	70.0%	0.71	3	1	1	33.3%	66.7%
	2	3	30.0%			2	1	33.3%		
	3	3	30.0%			3	1	33.3%		
	4	1	10.0%			4	0	0.0%		
4	1	0	0.0%	100.0%	–	4	1	0	–	–
	2	0	0.0%			2	0	–		
	3	1	50.0%			3	0	–		
	4	1	50.0%			4	0	–		

variations was significantly greater on the left side, especially in kidneys with one or two renal veins (Table 2).

Gender also had significantly influence on the occurrence of arterial system deviations, in relation to the number of renal veins, although only in kidneys with a single renal vein. The above-mentioned ratio was lower in female (14.8%), as compared to male patients (25.3%) ($p = 0.0001$) (Table 3).

In male patients the percentage of excess arteries was significantly greater on the left side in the case of kidneys with one or two renal veins (Table 4). Such differences were not seen in women (Table 5).

Amongst the 7 types of venous renal system structure variations, considering 550 bodies, 214 were diagnosed with arterial kidneys structure variations (38.9%), significantly more often in men (46.6%), as compared to women (30.9%; $p = 0.0002$).

In patients with "normal" venous system structure (both-sided, single vein), 34.9% of arterial kidney structure variations were observed, significantly more often in male (40%), as compared to female patients (29.89%; $p = 0.043$).

Rows 2–7 of Table 6, present the particular types of venous system structure abnormalities. Amongst the above-mentioned, isolated right-sided venous excess (112/550; 20.4%) was observed significantly more often ($p = 0.005$), including 48.2% of arterial system variation, significantly more often in men (38/62; 61.3%), as compared to women (16/50; 32%; $p = 0.002$). Amongst the remaining 74 venous system, structure variations (13.5%), the retroaortic course of the left kidney vein accounted for 31.1%, while the periaortic venous ring — 28.4%.

Table 3. Arterial-venous coincidence in the vascular bundle of kidney depending on the sex of body (n = 550)

Male (n = 281)					P	Female (n = 269)				
Number of veins	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries		Number of veins	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries
1	1	345	74.7%	25.3%	0.0001	1	1	393	85.2%	14.8%
	2	107	23.2%			2	65	14.1%		
	3	6	1.3%			3	3	0.7%		
	4	4	0.9%			4	0	0.0%		
2	1	54	59.3%	40.7%	0.163	2	1	49	68.1%	31.9%
	2	30	33.0%			2	18	25.0%		
	3	7	7.7%			3	3	4.2%		
	4	0	0.0%			4	2	2.8%		
3	1	2	28.6%	71.4%	0.64	3	1	1	20.0%	80.0%
	2	2	28.6%			2	2	40.0%		
	3	2	28.6%			3	2	40.0%		
	4	1	14.3%			4	0	0.0%		
4	1	0	0.0%	100.0%	-	4	1	0	-	-
	2	0	0.0%			2	0	-		
	3	1	50.0%			3	0	-		
	4	1	50.0%			4	0	-		

Table 4. Arterial-venous coincidence in the vascular bundle of kidney depending on the side of male body (n = 281)

Right kidney					P	Left kidney				
Number of veins	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries		Number of veins	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries
1	1	162	79.0%	21.0%	0.035	1	1	183	71.2%	28.8%
	2	40	19.5%			2	67	26.1%		
	3	2	1.0%			3	4	1.6%		
	4	1	0.5%			4	3	1.2%		
2	1	45	65.2%	34.8%	0.039	2	1	9	40.9%	59.1%
	2	20	29.0%			2	10	45.5%		
	3	4	5.8%			3	3	13.6%		
	4	0	0.0%			4	0	0.0%		
3	1	2	40.0%	60.0%	0.67	3	1	0	0.0%	100.0%
	2	1	20.0%			2	1	50.0%		
	3	1	20.0%			3	1	50.0%		
	4	1	20.0%			4	0	0.0%		
4	1	0	0.0%	100.0%	-	4	1	0	-	-
	2	0	0.0%			2	0	-		
	3	1	50.0%			3	0	-		
	4	1	50.0%			4	0	-		








Generalising our results, in the case of both-sided single venous system presence, arterial variations were observed in 34.9% of cases, while in the case of venous system developmental disorders — in 46.8%

(OR: 1.6399, 95% CI :1.1444–2.500, $p = 0.007$). The above mentioned occurred more often in men, as compared to women (OR: 1.566, 95% CI: 1.0129–2.413, $p = 0.0436$).

Table 5. Arterial-venous coincidence in the vascular bundle of kidney depending on the side of female body (n = 269)

Right kidney					P	Left kidney				
Number of veins	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries		Number of veins	Number of arteries	Number of kidneys	Per cent	Per cent of super-numerary arteries
1	1	179	86.5%	13.5%	0.297	1	1	214	84.3%	15.7%
	2	26	12.6%			2	39	15.4%		
	3	2	1.0%			3	1	0.4%		
	4	0	0.0%			4	0	0.0%		
2	1	40	70.2%	29.8%	0.45	2	1	9	64.3%	35.7%
	2	14	24.6%			2	4	28.6%		
	3	2	3.5%			3	1	7.1%		
	4	1	1.8%			4	0	0.0%		
3	1	1	20.0%	80.0%	0.333	3	1	1	100.0%	0.0%
	2	2	40.0%			2	0	0.0%		
	3	2	40.0%			3	0	0.0%		
	4	0	0.0%			4	0	0.0%		
4	1	0	–	–	–	4	1	0	–	–
	2	0	–			2	0	–		
	3	0	–			3	0	–		
	4	0	–			4	0	–		

Table 6. Correlation of kidney venous anomalies with other kidney arterial anomalies in 550 cadaver bodies with p-value of chi-square test between men and women

No.	Type of venous anomalies	Venous/other kidney arterial anomalies						P
		Men		Women		Total		
		N	%	N	%	N	%	
1		180/72	40.00%	184/55	29.89%	364/127	34.89%	0.043*
2		62/38	61.29%	50/16	32.00%	112/54	48.21%	0.002**
3		7/3	42.85%	5/1	20.00%	12/4	33.33%	0.408
4		6/6	100.00%	6/4	66.66%	12/10	83.33%	0.121
5		13/4	30.76%	10/1	23.50%	23/5	21.73%	0.699
6		2/1	50.00%	4/2	50.00%	6/3	50.00%	1.000
7		11/7	63.63%	10/4	40.00%	21/11	52.38%	0.279
Total		281/131	46.61%	269/83	30.85%	550/214	38.90%	0.0002***

*p < 0.05, **p < 0.01, ***p < 0.001

Considering the clinical aspect, we presented the percentage of additional renal artery topographic variations, in relation to the veins. Considering male patients, 4.3% of right-sided additional arteries

presented with a precaval course, while in female patients — 3% (Fig. 1). Apart from the above-mentioned, in 3.2% of male, and in 0.7% of female, the right additional artery wrapped around the renal vein.

On the left side, the above-mentioned phenomenon was observed in 2.13% of male and 0.36% of female (Fig. 2).

DISCUSSION

Our investigations showed significant coexistence of venous and arterial developmental anomalies, considering the renal vascular bundle. Based on the performed angiographies, Baptista-Silva et al. [3] observed more than one renal artery, being convinced of finding two or more additional renal veins. The existence of such anatomical variants should be taken under consideration, in the prevention of bleeding during retroperitoneal space and abdominal aortic surgery [2, 3]. The mentioned anomalies result from the complicated development of the vasculorenal system, which was thoroughly described in our previous studies [27, 28]. Generally speaking, an embryo 14–16 mm in length (6–8 weeks of development), is subjected to mesonephros ascend from the pelvis to the lumbar area with simultaneous atrophy of lower arteries and the development of novel abdominal aortic vessels [21, 29]. At the same time, the venous system develops from three successive and degenerative, cardinal veins. One may observe many transverse and anterodorsal connections between them. Thus, the aorta and renal artery branches are connected in the network of numerous venous vessels, and blood initially flowing to the heart symmetrically, is shifted to the right side. At the same time, the inferior caval vein develops from four separate fragments. These complicated processes favour the development of the mentioned anomalies. We do not know the final cause of their development. In our research, considering a normal venous structure (both-sided, single vein), arterial variants were observed in 34.9%, while in the case of developmental disorders — in 46.8%. Pick and Anson [21] showed the existence of a single artery and vein on both sides in only 38.5%.

For transplantation purposes, cases with one renal artery are desired [6]. However, due to the increased demand for transplantation material and ageing population, no material is discarded. Thus, knowledge of the described anomalies, as well as introduction of different surgical techniques seems especially important [7]. Transplantations with the presence of the above-mentioned anomalies are safe, if performed by an experienced team. Fast diagnosis and proper treatment protect both the transplanted organ and the patient. However, vascular complications are observed in 2.55%

to 13.5% [1, 2, 4, 8, 25]. Amongst them, the most important include rupture of arterial anastomoses, which might lead to transplant rejection, and even lower leg loss [18]. Bleeding was observed in 2.8% and stenotic vascular complications in 0.9% [19], 1.5% [5], and 3.17%, [6], respectively. Vascular complications occurred significantly more often in the case of a transplant with many vessels, as compared to a single renal artery transplant. The above-mentioned was associated with prolonged surgery and transplant ischaemia [14, 15, 19, 24, 25], which had, however, no negative influence on its future functioning. The described complications were reduced with the development of operative techniques and acquired surgical knowledge of the operating team [4, 9, 18].

The mentioned problems concerning arterial complications may also apply to venous damage complications. Variants in their structure were observed in 33.8%, mainly on the right side (20.4%) [28]. Pick and Anson [21] noted such complications in 27.8% of cases. Bleeding was observed in 25.4%, and venous anastomoses stenosis in 8.2% [19]. Veins do not pulsate, are subject to rupture, and are difficult to distinguish from adhesions [21].

Considering patients operated for abdominal aortic aneurysms, knowledge of venous anomalies, especially on the left side, seems very important. The above-mentioned veins are often hidden in the adhesions, and overlooked [2, 26]. Understanding the possible existence of particular venous anomalies, and especially precise computed tomography image analysis before surgery, as well as effective surgical technique are conditions, which minimalise the occurrence of these complications [13].

The retroaortic course of the left renal vein was observed in only 1.4% of cases [3]. Considering our material, these figures amounted to 12.4%. The compression of the vein by the aorta led to the clinical diagnosis of haematuria in a 13-year-old boy [10].

Considering the presented material, 4.3% male and 3% female cases showed a precaval course of right-sided additional renal arteries. These cases do not exclude kidney transplantation [22].

Compression of renal veins by surrounding additional renal arteries was observed in 3.2% of male and 0.74% female cases, on the right side. On the other hand, 2.13% of male and 0.36% of female cases on the left side. Nathan came to similar conclusions, considering a study material of 200 analysed corpses; but he observed 6% of such cases on the left side,

and only 1% on the right one [17]. It is generally accepted that increased kidney venous system pressure might lead to orthostatic proteinuria. In search of the cause of proteinuria one should not forget about the mentioned possibility.

CONCLUSIONS

The coexistence of renal, venous and arterial, developmental anomalies in the vascular bundle is significantly correlated. It occurs especially often in men; therefore, the female kidney is preferred for transplantation.

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