

Investigations on renal vascularisation pathology in the Polish population.

1. Incidence of multiple kidney arteries

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Background: The aim of the study was to determine the incidence of multiple kidney arteries in the Polish population.

Materials and methods: The study group comprised 924 deceased patients aged between 1 month and 94 years (mean age: 63.4 ± 22.4 years) who were subject to aortonephrography and sample preparation. The ratio of male to female patients was 479:445.

Results: Multiple kidney arteries were observed in 44.8% male and 31.5% female patients ($p = 0.004$). Considering male patients, right multiple kidney arteries were diagnosed in 24.4%, and left multiple kidney arteries in 31.3% of cases ($p = 0.017$). In female patients, right multiple kidney arteries were observed in 17.8% of cases, and left multiple kidney arteries in 19.6% of cases ($p = 0.49$).

Conclusions: The incidence of multiple kidney arteries in the Polish population is a frequent phenomenon, and should be considered in case of urological surgery and kidney transplantation. (Folia Morphol 2017; 76, 2: 226–231)

Key words: multiple kidney arteries, aortonephrography, Polish population

INTRODUCTION

Additional kidney arteries are essentially segmentary renal arteries with direct branching from the aorta or iliac arteries [14]. They occur much more frequently than expected, ranging between 7.8% and 39% [2, 8, 10, 15, 18, 21–24, 34, 36, 38]. They can have adverse implications during urological procedures, treatment of arteriorenal hypertension, and kidney transplantation [32, 33]. Considering one of the studies from 1998, preoperative angiography showed no presence of additional renal arteries in 7% of kidneys collected from living donors [17]. In selected cases of postmortem kidney donors the polar arteries were not recognised, and severed or damaged by the transplantologist [31]. The angiographic find-

ings before surgery were in only 95–97% of cases in accordance with the intraoperative situation [6, 28]. Multiple kidney arteries are one of the most difficult conditions considering laparoscopic renal donors [20]. Therefore, knowledge of the above-mentioned issue seems important for the surgeon, in order to avoid clinical complications [3, 9].

In 1975, Hall et al. [16] suggested that the post-mortem kidney donor should be well-ventilated, being aged between 6 and 50 years, and have only one artery. The aging human population and continuous, increased demand for kidney transplantation have forced the liberalisation of the above-mentioned principles, which is particularly important considering that renal transplantation surgery is the therapeutic

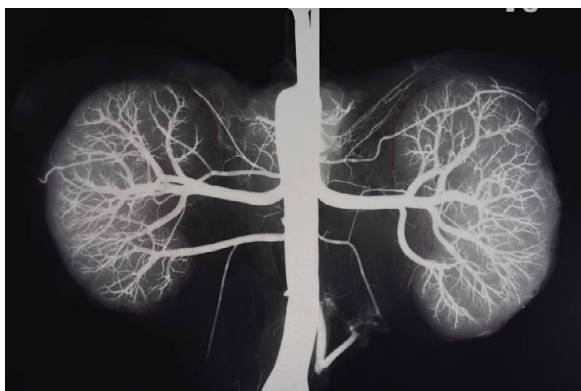


Figure 1. Postmortem aortonephrogram with visualisation of an additional right renal artery.



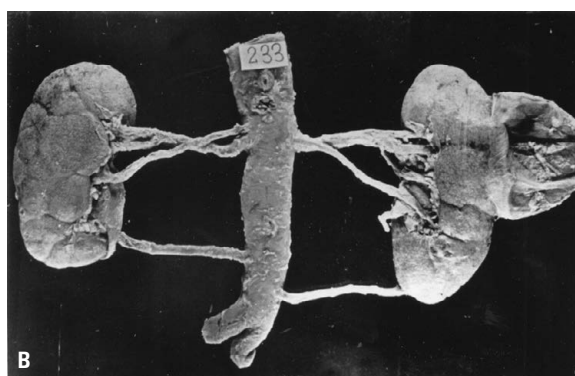
Figure 2. Postmortem aortonephrogram. The left additional renal artery branches of the aorta above the main kidney vessel crossing towards the lower part of the organ.

method of choice in patients with end-stage renal failure [13, 19].

The genesis of multiple kidney artery formation remains unknown. Satyapal et al. [34] suggested the influence of race as one of the possible factors. In the presented study we tried to determine the above-mentioned problem in the Polish population.

MATERIALS AND METHODS

The study group comprised 924 arteriorenal preparations collected from fresh deceased patients, including 479 male and 445 female subjects. Male patient age ranged between 1 month and 91 years (mean age: 51.2 ± 22.2 years), while female patient age between 1 month and 94 years (mean age: 55.8 ± 22.5 years) ($p = 0.002$). In 377 cases, aortonephrographic examinations were performed as follows: the kidneys with their arteries and aorta were excised "en bloc". After vascular ligation a 30% solution of barium sulphate was introduced into the aorta. The solution was placed on the X-ray tape, 35.6×35.6 cm in size possessing X-ray membranes manufactured by FOTON with a sensitivity of 125 CUK. The images (pictures) were performed using an X-ray with the following parameters: 65 kV and 10 mA. The exposition distance was 90 cm. After taking the pictures (Fig. 1–3A) the anatomical specimen was placed into a 10% formalin solution for a period of 2 weeks. Afterwards, it was subject to preparation (Fig. 3B) with results presented on paper. Interesting cases were photographed. The study protocol considered the following features: examination



Figures 3. A, B. Postmortem aortonephrogram and its anatomical preparation. Bilaterally, the superior additional arteries cross the main vessels running towards the renal hilus, while the inferior additional arteries run towards the lower kidney poles beyond the renal pelvis.

number, age of the deceased, measurements of selected arteries, distances between them, and localisation of its branching from the aorta. The obtained data were subject to statistical analysis by means of STATISTICA10.

Table 1. Multiple renal arteries in Polish population

Number of right renal arteries	Number of left renal arteries	Males		Renal arteries' patterns	Females		Total number	Total percentage
		Number	Percentage		Number	Percentage		
1	1	265	55.32%		305	68.54%	570	61.69%
	2	88	18.37%		58	13.03%	146	15.80%
	3	9	1.88%		3	0.67%	12	1.30%
2	1	56	11.69%		50	11.24%	106	11.47%
	2	38	7.93%		20	4.49%	58	6.28%
	3	1	0.21%		1	0.22%	2	0.22%
	4	1	0.21%		1	0.22%	2	0.22%
3	1	7	1.46%		3	0.67%	10	1.08%
	2	5	1.04%		3	0.67%	8	0.87%
	3	5	1.04%		0	0.00%	5	0.54%
	4	1	0.21%		0	0.00%	1	0.11%
4	1	1	0.21%		0	0.00%	1	0.11%
	2	2	0.42%		1	0.22%	3	0.32%
Column sum		479	100.00%		445	100.00%	924	100.00%

RESULTS

Based on the results presented in Table 1, only 61.7% of patients presented with the so-called "normal" renal vascular system, while 38.3% were diagnosed with multiple renal arteries. Amongst the above-mentioned patients, most frequently observed pattern was: 1 right renal artery and 2 left renal arteries (15.8%). 11.5% of patients presented 2 right renal arteries and 1 on the left side. Bilateral 2 renal arteries were found in 6.3%. Other variants in less than 1% of cases, apart from 1.08% with 3 right renal arteries and 1 on the left side.

Gender had significant influence on the occurrence of renal artery anomalies. Amongst 479 male patients, 214 (44.8%) were diagnosed with multiple renal arteries, while amongst 445 female patients, only 140 (31.5%) presented with multiple renal arteries ($p = 0.0004$).

In male patients, right-sided anomalies were observed in 117 (24.4%) cases, while left-sided anomalies in 150 (31.3%) cases ($p = 0.017$). Considering female patients, right-sided anomalies were observed in 79 (17.8%) cases, while left-sided anomalies in 87 (19.6%) cases ($p = 0.49$).

Gender differences in terms of the side of the body were as follows: right-sided anomalies were observed in 117 (24.4%) in male patients and in 79 (17.8%) females ($p = 0.013$). Left-sided anomalies were observed in 150 (31.3%) in male patients and in 87 (19.6%) females ($p = 0.0004$).

The course of additional renal arteries and their relationship to the renal pelvis have clinical significance. Thorough analysis was undertaken regardless the course and calibre of the artery. However, the obtained results exceeded the volume content of the study, and therefore only selected percentages were presented. Among the 164 investigated additional arteries in male patients, 65.9% on the left side and 61.8% on the right side presented with a prepelvic course. On the other hand, 23.9% on the left and 32.9% on the right side exhibited a retropelvic course. The remaining arteries are the so-called polar vessels (arteriae polares renum). Among the 102 additional arteries in female patients, 67.3% on the left and 76.6% on the right side presented with a prepelvic course. On the other hand, 25.5% on the left and 14.9% on the right side exhibited a retropelvic course. The remaining were considered as polar arteries.

DISCUSSION

In our study, we focused, similarly to Satyapal et al. [34], only on arteries branching of directly from the aorta or iliac arteries. Considering a large material of deceased patients, we observed a significant occurrence of multiple kidney arteries (38.3%). Based on clinical investigations, the distortion of results was probably associated with the selection of the most favourable material for transplantation. Additionally, the authors present their results following analysis of the transplanted kidneys, and not the anthropological units of a given population. The quality of the obtained results might have also been influenced by the methodology and nomenclature used. It seemed that autopsy examinations might provide the most reliable results. We determined the above-mentioned phenomenon by comparing results obtained from 7 clinical investigations with 6 autopsy study results. Clinical investigations [1, 11, 15, 22, 31, 34, 37] that comprised 3059 kidney transplants revealed 523 cases of multiple kidney arteries (17.1%), with the prevalence rate ranging between 7.79% [22] and 31.4% [37]. On the other hand, in the autopsy material [2, 21, 23, 24, 32, 38], 213 (18.7%) multiple renal arteries were diagnosed of the 1141 investigated kidneys, ranging between 2% [23] and 24.8% [38]. Based on the above-mentioned data, the type of sampled material had no influence on the occurrence of multiple kidney arteries. Satyapal et al. [34] demonstrated some differences in the occurrence of multiple kidney arteries, depending on race. There is the question, however, whether in today's globalised world one can speak of race in the anthropological sense of the word, particularly taking into account that the same authors encountered problems, naming one of the subgroups "coloured". The presented material was too scarce to draw significant conclusions. Saldarriaga et al. [32] also analysed the above-mentioned phenomenon on a Colombian mestizo population (it meant Caucasian, Mongoloid, and Negroid racial phenotype mixture). Satyapal et al. [34] showed that 35.3% of white race subjects were diagnosed with renal vascular anomalies, which is similar to the results obtained in the investigations undertaken on Slavic subjects. On the other hand, in "Colombian mestizos", renal vascular anomalies were observed only in 24.8% of the samples [32].

Based on the review, it is impossible to draw clear anthropological conclusions regarding the influence of race on the occurrence of kidney arterial anomalies.

Differences in the occurrence of kidney vascular anomalies might be influenced by many factors, such as the selection of the study material, number of patients, and reliability of the investigations. Reis and Esenther [29] presented results obtained from 500 deceased patients during student training from different American autopsy labs. Multiple renal arteries were diagnosed in 19.1% of cases. At the same time, they mentioned that small arteries might not have been noticed by the students.

Our study results demonstrated that 6.3% of patients were diagnosed with 4 renal arteries. However, patients with 5, 6 or 7 renal arteries were rarely observed, mainly in the male population (0.21–1.0%).

Gender may have an influence on the incidence of the above-mentioned vascular anomalies. It is believed that these kidney anomalies occur more often in males, as compared to female patients [18, 34]. Aragao et al. [2] investigated the human fetuses and showed only slight differences in the incidence of renal artery anomalies, between the male (11.7%) and female (10%) population.

In our investigations the incidence of the above-mentioned kidney anomalies was greater in men, as compared to female patients (44.7% and 31.8%, respectively). These differences were especially visible when the left and right side of the body were compared. Left-sided kidney anomalies were diagnosed in 31.3% of male and 19.6% of female patients ($p = 0.0004$). Right-sided kidney anomalies were observed in 24.4% of male and 17.8% of female patients ($p = 0.013$). Our results are similar to those obtained by other authors [24, 28, 29, 32, 34]. Only Aragao et al. [2] showed right-sided predominance (11.7% vs. 10%).

CONCLUSIONS

In conclusion, it is worth mentioning that the kidney during its early developmental stage ascends from the minor pelvis to the abdominal cavity, being subject to size and artery metamorphosis. Early in the embryogenesis the blood supply to the developing urogenital structures arises from the urogenital "rete arteriosum". Nine pairs of bilateral mesonephric arteries are present. Normally, the caudal branches of renal vessels undergo involution and disappear. Cranial arterial branches from the aorta become the persistent arteries. Finally, 1 artery undergoes bifurcation into 5 branches to particular kidney vascular segments. Aetiologically, multiple kidney arteries rep-

resent mesonephric arteries. Hypothetically, a common embryonic error may underlie the formation of accessory renal arteries [5, 9, 11, 14, 27, 30, 35, 36]. However, for unknown reasons, this process is often incomplete and multiple kidney arteries not so rare [26]. Knowledge of the variety of renal arteries should be a beacon in such vascular procedures as therapeutic embolisation and angioplasty, as well as management of renal ischaemia during transplantation [7, 25]. Although multiple kidney artery transplants are burdened with some dose of risk, there is a consensus that the obtained results tend to be comparable to kidney transplantations with a single renal artery [1, 3, 12, 39]. Singh et al. [37] even performed partial laparoscopic nephrectomy in 333 patients with renal tumours, in which multiple renal arteries was not a particular problem. Definition of renal artery anomalies prior to operation could prevent an unnecessary loss of renal function in the postoperative period, and routine angiography and aortonephrography should be performed prior to every nephrectomy [5, 18, 34].

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