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Original article

Analysis of supernumerary renal arteries by CT and MR method

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Abstract

Introduction: The importance of studying anatomical variation is also indicated by the fact that more than 10% of clinical vices occur as a result of ignoring and neglecting the existence of these. The study of anatomical variation therefore has a significant place in medical education, both due to the way in which they occur and the incidence of occurrence, and the practical application of acquired knowledge in clinical practice.
Aim: The aim of the paper is to determine the frequency of occurrence of supernumerary renal arteries as well as their position in relation to the kidney.
Material and Methods: The analysis covered 209 patients who for any therapeutic reasons were operated at the Urology Clinic of the Clinical Center of the University of Sarajevo. In the preoperative period, within the diagnostic procedure, all patients were analyzed using three-dimensional radiological methods (CT and MR).
Results: Of the total number of supernumerary renal arteries found, the most commonly registered lower polar arteries, followed by hilar arteries, and the rarest upper polar arteries. A larger number of supernumerary renal arteries were registered with the CT method (35 versus 29). Correlation test found that the location of supernumerary renal arteries, with the use of both diagnostic methods, does not depend on gender of the subjects because it is $p > 0.05$.
Conclusion: Thorough knowledge of the renal artery structure is essential to ensure that all surgical procedures are performed safely and efficiently, providing us with modern radiological techniques.The greatest contribution to morphological and topographic research of the living organism is the use of modern three-dimensional radiological methods, such as computerized tomography (CT) and magnetic resonance imaging (MR).

Keywords: Supernumerary renal arteries, CT, MR

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Introduction

The most important question posed by the anatomy of the modern age is: „Is there also a need in the 21st century for further study of human body variations or is this area of anatomical interest long exhaustion?“ (1). The answer to this question is easy and it reads: the advancement of medical science increases the need for an even more accurate and more systematic introduction to anatomical variations in the human body, all with the aim of improving the diagnostic and therapeutic methods that are used daily in clinical practice.

It has long been considered a kidney vascularized one renal artery. However, studies have shown that variations in the number of arteries that vascularize the kidney are frequent and occur in the range of 9 to 76% (2).

Variations in renal vascular anatomy have been important with increasing the frequency of renal transplants, vascular reconstructions, various surgical procedures on the kidney, and the development of radiological and surgical disciplines (3,4).

The longer the waiting list of patients for the donation of the renal organ, forced the transplant teams to think about the use of the so-called " inadequate kidneys" as donor organs, which could not be imagined a few years ago.

It's about the so-called " marginal donors ". This group also includes kidneys with multiple renal arteries. Transplantation teams have long considered them contraindicative, however with the lack of cadaveric transplants and the difficult living donor network there was a need for using and providing other donor resources, and kidneys with anatomically acceptable variations. Pre-transplantation evaluation of live donor kidney is necessary in determining potential donors. Preference is given to new digital diagnostic non-invasive methods such as CT and MR.

CT angiography has the capacity and precision in the representation of kidney vascular morphology almost identical to conventional angiography (5). It is the least

invasive method and provides detailed information on position, size and anatomical relationships useful in diagnosis and treatment, and also allows identification of anatomical variations (101). Allows short exposure time, stronger temporal and spatial resolution. Its precision is 80-100%, and with more detectors the precision is elevated to 93-97% in the blood vessels display.

Magnetic resonance (MR) is used as an alternative method and has precision in the presentation of the renal artery anatomy similar to the CT method (39).

Material and methods

In this anatomical-radiological study, 209 patients were processed, who for any therapeutic reasons were subjected to surgery at the Urology Clinic of the Clinical Center of the University of Sarajevo. Before the operation, all patients were diagnosed using the three-dimensional radiological methods (CT and MR) in the diagnostic procedure.

Of the total, 104 patients (49 male and 58 female), of the average age of 43.7 ± 10.3 years, (ranging from 25 to 69 years) were analyzed with a CT method at the Institute of Radiology of the Clinical Center of the University of Sarajevo. In all patients, the area from the diaphragm to bifurcation of the ilic artery was scanned.

The MR method analyzed 102 patients, 49 male and 53 female, aged 28 to 67 years, with an average of 45 ± 9.7 years at the Institute of Radiology at the University of Sarajevo Clinical Center.

The number of supernumerary renal arteries and their type (upper and lower polar and hilar renal arteries) were analyzed on CT and MR images.

The results are presented as mean ± standard deviation (SD). The average difference between groups with and without supernumerary renal arteries was calculated with the student t-test.

All statistical analyses were performed using the SPSS program (Version 1.5 Windows), and the statistical significance was set to $p > 0.05$.

Results

By analyzing the supernumerary renal arteries found and their relationship to the kidney, it was found that the lower polar arteries most commonly occur. In the examined material, they were found in 36 (8.6%) cases.

In second place, the frequency of reporting were hilar supernumerary arteries, recorded in 20 (4.8%) cases, and the rarest recorded upper polar arteries were found in 8 (1.9%) cases (Figure 1).

Of the total of 35 registered CT arteries, the lower polar arteries were found in 23 (10.7%) cases, in 10 (4.8%) hilar arteries, while upper polar arteries were recorded in 2 cases or 0.9%, (Figure 1).

Supernumerary renal arteries were found in 29 cases by MR method. Out of that number 13 (6.4%) were lower polar arteries, 10 (4.9%) hilar arteries, and in 6 (2.9%) cases upper polar arteries were found (Figure 1).

By analyzing the percentage representation of supernumerary renal arteries in relation to the kidney, and according to the polar representation using both methods the following results were obtained .

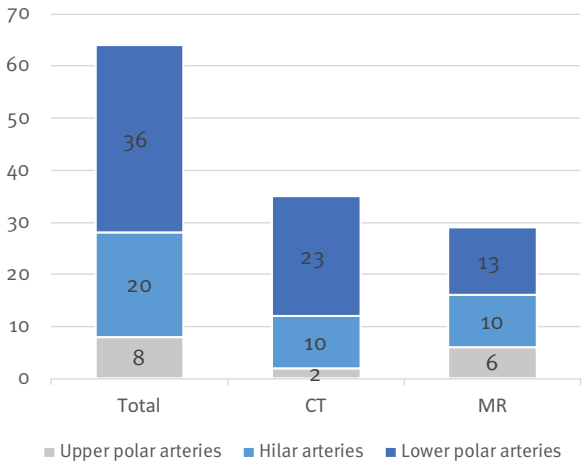

Figure 1. Location of supernumerary renal arteries in relation to the kidney

The CT method among the female group of subjects found 2 hilar supernumerary arteries or 15.4% and 11 (84.6%) lower polar arteries, while the upper polar arteries were not found (0%). In male respondents, the CT method recorded upper supernumerary renal arteries in 2 (9.9%) cases, hilar arteries in 8 (36.4%) cases, and lower polar in 12 cases or 54.6%.

The MR method among female subjects found 1 (10%) upper polar artery, 3 (30%) hilar arteries and 6 (60%) lower polar arteries. Among the male respondents, the MR method recorded 5 (26.3%) upper polar arteries and 7 (36.8%) hilar and 7 lower polar arteries.

Correlation tests found that the location of supernumerary arteries in both diagnostic methods did not depend on the sex of the subject since $p > 0.05$.

The following angiogram shows supernumerary renal arteries, different locations in relation to the kidney, identified by CT and MR method (Figures 2, 3).

Discussion

One of the most common and clinically significant anatomical variations is the occurrence of supernumerary renal arteries.

Embryologists believe that the overlapping renal arter-

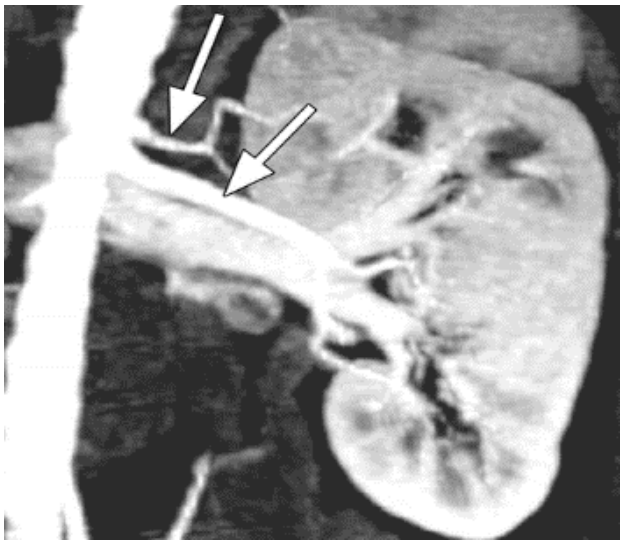

Figure 2. CT angiogram of a 40-year-old male with a single supernumerary of the upper polar artery

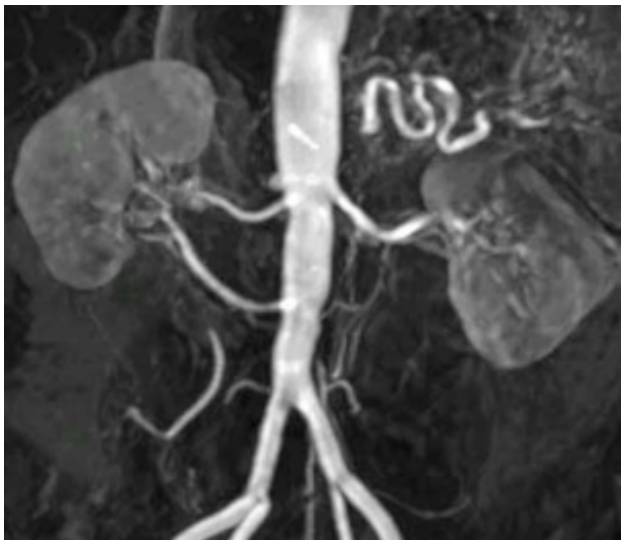

Figure 3. MR angiogram of a 44 year old male with a single hilar supernumerary artery

ies of the lateral branches of mezonephrosis are lagging during the ascension of the kidneys during embryonic development (8). Increased incidence of supernumerary renal artery indicates the need for mandatory preoperative renal angiography during the examination and finding appropriate surgical technique on the kidney for any therapeutic reasons.

As Vilhova points out in his work published in 2001, besides being often described, there are still controversies regarding the appointment of these arteries (9).

Merclin considers the best classification of these arteries to the upper and lower polar arteries of the kidney (these are arteries that enter the kidney parenchyma directly) and hilar arteries (those that enter the kidney hill) (10). We have also applied this division in our work, because we are of the opinion that the classification according to the way the arteries enter the kidney is the most appropriate.

All researchers who have studied the percentage of supernumerary arteries in their studies can be divided into two groups.

The first group consists of those who have proven in their works that supernumerary arteries occur in more than 25% of cases and the second group consists of researchers who recorded the above variation under 25% of cases.

In the first group of researchers, Zhang recorded 27.2% of supernumerary renal arteries, Janoff in 27%, Mishra in 26.67%, and Guntz in 1967 in 26.73% of cases (6,11, 12,13). In the eighties, Sampaio and Passos, using the dissection method, found this variation in 30.4% of cases, without a significant difference in the appearance of these arteries in relation to the side of the report (14). Namasivayam, reports about 35% of cases of supernumerary renal arteries, which approaches the values of the study in Shoja (15,16). Vilhova, in his work, recorded 31.8% of cases of these arteries (9).

The second group of researchers are authors with a lower percentage of registered supernumerary arteries, including: Satyapal with 23.2% and Ramadan with 22.8% cases (17.5).

A somewhat lower percentage, 20% in his work is recorded by Bordeaux and Callas (18,19). Chugh and associates among the 170 examined kidneys find these arteries in 21.2%, and Gosicka in 19.2% of cases (20.21). Khamanarong, on a sample of 534 analyzed kidneys, contains 17.43% of supernumerary kidney arteries (22).

Many authors point out that an increase in the number of identified supernumerary renal arteries is affected by the appearance of numerous, sophisticated, more precise radiological methods to identify these vascular "in vivo" vessels. Thanks to the new methods, it is possible to identify the blood vessels of smaller diameter, which have been confirmed by our research.

Analyzing the percentage of supernumerary arteries in our work, 418 kidneys were subjected to the analysis. Of this number, 64 kidneys or 15.3% were found to be supernumerary arteries, so the percentage representation of supernumerary arteries in our work is similar or approximate to the results presented by Bergman (10%), Benedetti (15-18%), Gossicka (19.2%) and Khamanarong (17.43%) (23, 24, 21, 22).

In our work, we analyzed the appearance of supernumerary renal arteries using two radiological methods of CT and MR angiography. CT was performed by 214 kidneys (107 on the right and 107 on the left) and MR by the 204 kidneys (102 on the left and 102 on the right). The CT method identified 35 kidneys with supernumerary renal arteries or 16.4%, and the MR

method of 29 kidneys had supernumerary renal arteries or 14.2% of the total number of kidneys analyzed.

Advancement in technique and technology has made progress in precision analysis of overdose of renal arteries and numerous papers have been published that deal with types of overgrowth arteries and their prevalence.

Our research has shown that lower polar arteries are most common among supernumerary renal arteries.

These arteries among the 64 identified supernumerary arteries were found in 36 (8.6%) cases. In second place, the percentage of reports is hilar arteries in 20 cases or 4.8%, while the upper polar arteries were recorded in 8 cases or 1.9%.

CT by the total number of registered 35 sumernumerary renal arteries, 23 (10.7%) were lower polar arteries, 10 (4.7%) hilar arteries and 2 (0.9%) upper polar renal arteries. The MR method of the total 29 identified supernumerary renal arteries identified, the lower polar artery was recorded in 13 cases or 6.4%, hilar arteries in 10 cases or 4.9%, and the upper polar arteries in 6 cases or 2.9%.

Among the researchers, we have different results in this segment of the study. Khamanarong discovered 7.3% of the upper polar arteries and 3.6% of the lower polar arteries (22). Samapio and Passos found 8.7% of the upper polar arteries and 6.8% of the lower polar arteries (14).

Ozkan, in his work, finds the lower polar supernumerary arteries of the kidney on both sides, in 7% of cases on the left and 9% on the right (25). Bordei, an supernumerary renal arteries, is found in 54 cases (20%), of which 28 kidneys were present in the hilar arteries, 16 in the lower polar arteries and 5 in the upper polar arteries (18). Paturet was found in 12% of the upper polar artery, and in 9% of the lower polar artery of the kidney (26). Villhova, also found in 20% of the hilar supernumerary arteries of the kidney, the upper polar to 26%, and the lower polar in only 6% of the cases (9). In the study Pollack on 800 kidneys, the percentage of reports of supernumerary renal arteries was 23%, of that number in 4% of the cases the kidneys were supplied with three, and in 1% with even four renal arteries (27).

According to the division of the supernumerary renal arteries by Merklin, which we accept despite all the disagreements in the literature, the highest prevalence of supernumerary arteries is deposited on the lower polar and hilar renal arteries (10).

On the other hand, according to the results presented in his work by Paturet and Villhov, who point out that the lower polar arteries of the kidney appear to be only 9% and only 4.4% for hilar arteries. This is a much smaller percentage compared to 16.5% of the registered upper polar renal arteries in their work (26, 9).

As many authors point out and the topographic arrangement of supernumerary renal arteries depends on many of the modalities used in their identification and with that fact we also agree. In order to obtain precise data on this problem, the researchers went a step further and joined the analysis of the influence of sexual affiliation on the occurrence of these arteries.

Chai found that supernumerary renal arteries were more common in the male population (28%) than in women(16.44%) (28). In contrast, Chugh in his study recorded a higher percentage of supernumerary arteries in women (57.6%) than in men (42.8%) (20).

Based on the results presented, we can conclude that there is no harmonized attitude among researchers on this issue.

Our work has shown that this anatomical variation is more common in male than in the female population. Of the 64 kidneys with registered supernumerary renal arteries in forty-one cases, the kidneys belonged to male patients, and 23 kidneys with supernumerary arteries were female. So our results are consistent with the Chai results published in 2008 (28).

This is why we in our work have decided on the CT and MR method, because these are modern methods, which replaced the conventional catheter angiography, known as the gold standard, by which it is possible to identify supernumerary renal arteries with a confidence of 91 to 100 % (12).

Previous studies have shown that CT angiography has some disadvantages including exposure to ionizing radiation and the use of nephrotoxic iodine contrast agents, and therefore this method is not applicable for young children, pregnant women and patients with renal insufficiency.

On the other hand, MR angiography has many advantages over other methods in delivering kidney vascularization. First of all, there are diagnostic indicators without the risk of catheterization, no exposure to radiation and iodinated contrast agent. Patients well tolerate the MR angiography procedure, is suitable for outpatient procedures, images are presented in a format similar to that of conventional angiography catheter. Surgeons consider that the anatomical details provided by MR angiography are sufficient in the selection of sites for nephrectomy.

Potential live kidney donors require a comprehensive assessment and analysis prior to surgery and a detailed radiological examination that provides insight into a couple of anatomical information related to the number of renal arteries, their separation and branching site, and the way they enter the kidney.

In the last two to three decades, the constant devel-

opment of modern diagnostic methods has in the first place introduced two less invasive radiological methods, CT and MR angiography in planning surgical operation, the identification of supernumerary renal arteries with which we are in agreement, and further analysis of the occurrence of supernumerary arteries is required.

Conclusion

Based on all presented results in this paper, we have come to the following conclusions:

Supernumerary renal arteries in our investigated material were identified in 64 kidneys or in 15.3% of cases. The most commonly recorded type of supernumerary renal arteries were the upper polar arteries, followed by hilar and at the end of the lower polar artery.

Supernumerary renal arteries are more common in males than in females. MR, along with CT, became the imaging method of choice in detecting these arteries during preoperative preparation of patients for transplantation or some other surgical intervention on the kidneys.

Declaration of interest

Authors declare no conflict of interest.

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