Variants of the Kidney Blood Supply at Trichotomic Division of the Main Renal

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ABSTRACT
The aim of the study was to carry out a three-dimensional quantitative analysis of the variants of blood supply to the segments of the kidneys during dichotomous division of the renal artery. We made 116 corrosive preparations of the human kidney arterial system, followed by 3D scanning to obtain digital models. In three-dimensional projection, we determined types of branching of the main branches of renal artery, number of vessels of the branches of renal artery of different orders depending on the types of branching of each main branch. We determined segmental arteries, their number involved in the nutrition of the renal segments, depending on the types of intraorgan branching in the main and loose types of branching. The morphometric analysis data were processed by the methods of variation statistics. It was found that kidneys with a three-zone (upper pole, lower ventral and lower dorsal) or (lower pole, upper ventral and upper dorsal) blood supply system with a five-segmental structure in the nutrition of pole segments are involved on average: 1 segmental artery (67.1 %), 2 arteries (24.2 %), 1 artery from the main renal artery (7.2 %) and 1 artery from the aorta (1.5 %). In the upper anterior and lower anterior segments, on the average, they branch: 1 segmental artery (86.3 %) or 2 arteries (12.4 %). In the posterior segment, on average, there are branches: 1 segmental artery (82.3 %), 2 arteries (10.3 %) and 3 arteries (6.3 %), which is important to consider when performing segmental resections or organ-preserving kidney operations.

Keywords: *kidney, angioarchitectonics, segments*

1. INTRODUCTION

Knowledge of the segmental structure' anatomy of kidneys is of great importance in clinical practice when performing segmental kidney resections or organ-preserving operations [1–6, 8–17]. According to many researchers, determining factor in the division of all kidneys into segments is its arterial bed, namely the arterial system of kidneys, which determines the segmental arteries and segments of kidneys [1–6, 8–17].

One of the main questions in Olofinsky L.A. (1970) dealt with low-vascular zones [8]. The author revealed a definite relationship between the type of branching of kidney arteries and location of low-vascular zones. Olofinsky L.A. (1970) identified three transverse low-vascular zones, which correspond to the data of Eremeeva S.G. [3].

At the same time, the author notes that in the main type of branching of renal artery, low-vascular zones directed radially are delimited from the medial border of kidneys by intraparenchymal large arteries; in the loose type, radial low-vascular zones are not delimited from the medial border of the kidney.

According to Olofinsky L.A. (1970), longitudinal low-vascular zones are found in the lower pole and along the lateral edge of a middle segment, and they are most pronounced in the main type of arterial branching, corresponding to the Tsondek zone.

Studies on the segmental structure of the kidney Olofinsky L.A. (1970) almost correspond to the data of Rubinov Y L. (1972), which identifies four segments in 18.4 % of cases and five segments in 81.6 % of cases [10].

However, it should be noted that according to Olofinsky L.A. (1970) and Sabirova S. R. (1970), the number of kidney segments can reach up to six ones. Olofinsky L.A. (1970) found six renal segments in 23.9 % of cases, and Sabirov S. R. (1970) in 26.5 % of cases [11].

The issues of the segmental structure of kidneys are also described in detail by foreign authors. Thus, Longia (1982) found five segments of the kidneys in 53 % of cases, four segments in 46 % of cases, and kidneys with three segments in 1 % of cases [15].

Rubinov Y.L. (1972) (cited by Ponukalin A.N. et al., 2013) obtained similar data.

The author also identified kidneys with four segments (18.4 % of cases) and (81.6 % of cases) with five segments [10].

From the studies of the above authors, the observations of Serov V.V. (1959) (cited by Ponukalin A.N. et al., 2013), where the author identified five segments of the kidney: these are the upper pole, the upper anterior lochanochnic, then the lower anterior lochanteric, posterior and lower segments [12].

According to the author, the segment of the upper pole can have several variants of blood supply. Thus, in the first variant, a segment of the upper pole is supplied with blood by one artery (45 % of cases), extending from the anterior

lochial artery. In 32 % of cases, this segment is supplied by two arteries extending from the anterior and posterior branches of the renal artery.

In the blood supply of the segment of the lower pole of the kidney Serov V.V. (1959) also established several options. In the first option, a segment of the lower pole is supplied with blood by one artery, extending from the anterior lobe, which was revealed in 47 % of cases. In the second variant, a segment of the lower pole is supplied with blood by two arteries from the ventral and dorsal branches of the renal artery, which was found in 45 % of cases. In the third variant, feeding of the lower pole segment occurs due to the inferior polar artery, departing from the retilochanteric artery, which was encountered in 8 % of cases [12].

Therefore, literature review contains various information regarding variants of the segmental structure of kidneys and characteristics of the blood supply to its segments. There are various data on the blood supply to the renal poles. They can have great variability depending on the number of arteries in the renal hilus, their topography and division options that require their analysis.

2. METHODS AND MATERIALS

116 corrosive preparations of human renal arterial vessels were manufactured. The corrosive specimens were 3D scanned to produce digital models.

1) the computer program “Mimics-8” determined: – projection of the main arteries in the hilum of the kidneys in relation to the planes; – projection of extraorgan branches of the renal artery; – number of main branches of the renal arteries at the hilum of the kidney;

2) determined: – types of intraorgan branching of the main branches of the renal artery inside a kidney, depending on the division options at the gate of each of its branches: – with the main type: – with loose type;

3) determined: – number of vessels of the main branches of the renal artery of different orders: – with the main type; – with loose type;

4), segmental arteries were determined, their number involved in the nutrition of the renal segments, depending on the types of intraorgan branching with the main and loose types of branching.

Statistical processing included the calculation of the main indicators of the distribution of random variables: median, mean, quartiles, confidence interval, minimum and maximum values, variance, standard deviation, mean error, median error. We used a licensed package of applied statistical programs MedStat in accordance with the recommendations [7].

3. RESULTS

Of the total number of investigated corrosive preparations of the arterial system of the kidneys, we found that in 12.9 % of cases there is a trichotomous variant of the division of the main renal artery. It was divided into the ventral, dorsal and upper pole branches relative to the frontal and horizontal planes. It is noted that in the first type of branching of intraorgan arterial vessels of the kidney of the entire renal artery system, the ventral branch is “A. ventralis ”(zonal) (2), was divided according to the loose type, the dorsal – according to the main type and the upper pole – according to the loose, which was revealed in 43.4 % of cases.

With this variant and the type of branching of the arterial vessels of kidneys, the number of “segmental” arteries averaged (X ± m) 9 ± 1.

With the five-segmental structure of kidneys, one segmental artery, “A. interlobares” (3), extending from the upper pole branch (72.3 % of cases), distributed mostly in the ventral parts of the upper pole of the kidney.

In the second variant, two segmental arteries participated in the blood supply, which were evenly distributed in ventral and dorsal parts of the upper pole of kidneys, extending from the upper pole artery – “A. superius polus” (zonal) (2), which accounted for 21.4 % of cases. In the third variant, the segment was supplied with one segmental artery extending from the most important renal artery – “A. renalis” (1), which accounted for 6.3 % of cases.

Blood supply to the upper anterior segment in the first variant was due to one segmental artery – “A. interlobares” (3), extending from the upper pole branch – “A. superius polus” (zonal) (2), (83.5 % of cases), and in the second variant, two segmental arteries, extending from the upper pole branch, were involved in the blood supply – “A. superius polus” (zonal) (2), which was found in 16.5 % of cases.

As for the lower anterior segment, in the first variant it was supplied with blood by one segmental artery – “A. interlobares” (3), extending from the ventral branch; – “A. ventralis” (zonal) (2), (71.5 % of cases). In the second variant, two segmental arteries were distributed in it, extending from the ventral branch – “A. ventralis” (zonal), which was found in 28.5 % of cases.

In the first variant, the lower pole segment was supplied with one segmental artery – “A. interlobares” (3), extending from the ventral branch (62.3 % of cases), distributed mostly in ventral parts of the lower pole of the kidney.

In the second variant, the blood supply involved two segmental arteries extending from the ventral branch – “A. ventralis” (zonal), (22.4 % of cases). In the third variant, the segment was also fed by two segmental arteries extending from the ventral and dorsal arteries (11.3 % of cases), evenly distributed by its branches in ventral and dorsal parts of the kidney parenchyma. In the fourth variant, the segment was supplied with one segmental artery extending from the main renal artery – “A. renalis” (1), which accounted for 4.0 % of cases.

Cross-supply of the posterior segment in the first variant involved one segmental artery – “A. interlobares” (3), extending from the upper pole artery – “A. superius polus” (zonal) (2), (73.3 % of cases). In the second variant, it was supplied with blood by two segmental arteries

extending from the upper polar and dorsal arteries (13.5 % of cases), in the third variant, one segmental artery extending from the dorsal artery – "A. dorsalis" (zonal) (2), which accounted for 11.2 % of cases. In the fourth variant, the segment was supplied with three segmental arteries extending from the superior polar and dorsal arteries, which accounted for 2.0 % of cases.

In 21.4 % of cases, we reveales the third type of branching of arterial vessels, where all branches of the renal artery system were of loose type. With this variant and the type of branching of the arterial vessels of the kidney, the number of "segmental" arteries averaged (X ± m) 9 ± 1.

In the first variant, one segmental artery participated in the blood supply of the upper pole segment – "A. interlobares – 1" (3), extending from the upper pole branch (54.5 % of cases), distributing its branches mostly in ventral parts of the upper pole of the kidney.

In the second variant, the segment was supplied with two segmental arteries extending from the superior polar artery – "A. superius polus" (zonal) (2), (43.3 % of cases), evenly distributed in the ventral and dorsal parts of the kidney parenchyma. And in the third variant, he fed on one segmental artery – "A. interlobares – 1" (3), extending from the main renal artery – "A. renalis" (1), which was detected in 2.2 % of cases.

In the first variant, one segmental artery participated in blood supply to the upper anterior segment – "A. interlobares – 1" (3), extending from the upper pole branch – "A. superius polus "(zonal) (2), which accounted for 85.5 % of cases, and in the second variant, two segmental arteries were involved, also extending from the superior polar artery, which was revealed in 14.5 % of cases.

In the first variant, the lower anterior segment was supplied with one segmental artery – "A. interlobares – 1" (3), extending from the ventral branch (68.5 % of cases). In the second variant, two segmental arteries extending from the ventral branch – "A. ventralis" (zonal) (2), which was revealed in 31.5 % of cases.

In the first variant, one segmental artery, "A. interlobares – 1" (3), extending from the ventral branch – "A. ventralis" (zonal) (2), (61.4 % of cases), distributed mostly in the ventral parts of the lower pole of the kidney.

In the second variant, the blood supply involved two segmental arteries extending from the ventral branch (22.3 % of cases). In the third variant, the blood supply also involved two segmental arteries extending from the ventral and dorsal arteries (16.3 % of cases), evenly distributed in ventral and dorsal parts of the lower pole of the kidney. In the fourth variant, one segmental artery, extending from the main renal artery "A. renalis" (I), which was detected in 4.0 % of cases.

In the first variant, one segmental artery, "A. interlobares – 1" (3), extending from the upper pole branch – "A. superius polus" (zonal) (2), (66.2 % of cases). In the second variant, the posterior segment was fed by two segmental arteries, departing from the upper polar and dorsal arteries (17.3 % of cases), in the third variant, one segmental artery – "A. interlobares – 1" (3), extending from the dorsal branch – "A. dorsalis" (zonal) (2), (13.1 % of cases). Lastly, in the fourth variant, three segmental arteries were distributed in the posterior segment, extending from the superior polar and dorsal arteries, which was revealed in 3.4 % of cases.

4. CONCLUSION

Thus, our three-dimensional (3D) stereoanatomical analysis showed that in a five-segment kidney, in a three-zone (lower polar, upper ventral and upper dorsal) blood supply system, the upper polar segment is supplied by one artery extending from the ventral (54.7 %); by two arteries extending from the ventral branch (18.1 %); by two arteries extending from the ventral and dorsal branches (23.2 %); by one artery extending from the main renal artery (3.9 %).

The upper anterior segment is supplied by one artery extending from the ventral branch (91.4 %); by 2 arteries extending from the ventral branch (8.6 %). The lower anterior segment is supplied with blood on average by one artery extending from the lower pole branch 75.9 %; by 2 arteries extending from the lower pole branch (4.1 %). The lower pole segment was supplied with blood by one artery extending from the lower pole branch (66.3 %); by 2 arteries extending from the lower pole branch (27.8 %); one artery extending from the main renal artery (5.9 %). The posterior segment is supplied with blood by one artery extending from the inferior pole (39.6 %); by two arteries extending from the inferior pole and dorsal branches (20.2 %); three arteries extending from the inferior pole and dorsal branches (4.2 %); by one artery extending from the dorsal branch (35.8 %), which is important to consider when performing segmental resections or organ-preserving operations.

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