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Quantitative Anatomy of the Intrainganic Arterial Kidney

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***Abstract* – Currently, there is no uniform approach to the organization of the kidney bloodstream. Data about kidney bloodstream links are controversial. Digital methods of intravital visualization of the intraorgan arterial bed of the kidney provide new opportunities for early diagnostics of kidney pathologies. The lack of a morphometric standard of the norm of the intraorgan arterial bed limits applicability of these methods. The purpose of the study is to determine quantitative indicators of the intraorgan arterial bed of the human kidney which can be used as a morphometric standard. The morphometric characteristics of corrosive casts of the intraorgan arterial bed of 32 kidneys of humans of two age groups who died from diseases that did not change the angioarchitecture of the kidney were studied (16 men and 16 women). A tree-like form and a loose type of bed are characteristic of the intraorgan arterial bed of the kidney. The intraorgan arterial bed of a human kidney belongs to the euryareal type. The traditional descriptive anatomy of the intraorgan arterial bed of the kidney does not allow for establishing the morphometric standard of its norm, since it is almost impossible to identify links of the channel according to the classical canons. New approaches to the morphometric description of the intraorgan arterial bed of the kidney have to be applied. It is better to use relative indicators rather than absolute ones as a morphometric standard of the intraorgan arterial bed of the kidney. It is better to use values of relative indicators that characterize conceptual models of the intraorgan arterial bed of the kidney.**

Keywords – morphometry, arterial bed, kidney

I. Introduction

Diagnosis and treatment of renal pathology remains an urgent medical problem [9, 10, 15, 17–19]. Severity of these diseases and their high frequency require new diagnosis and treatment methods, and morphological studies [6, 11].

As a rule, pathological changes in the structure of the intraorgan arterial bed of the kidney are caused by kidney diseases [12]. However, there is no uniform approach to the organization of the kidney bloodstream [1, 2, 4, 12]. Information on its main links is controversial. Digital methods of intravital visualization of the intraorgan arterial bed of the kidney open up new opportunities for early diagnostics of kidney pathologies [3, 14–21].

The lack of a morphometric standard of the norm of the intraorgan arterial bed limits applicability of these methods.

II. Methods and materials

The morphometric characteristics of the corrosive casts of the intraorgan arterial bed of 32 kidneys of people of two age groups who died from diseases that did not alter the angioarchitecture of the kidney were studied (Materials of the 7th All-Union Conference on morphology, physiology and biochemistry of the Academy of Medical Sciences of the USSR, Moscow, 1965). Corrosion preparations were made by the standard method [10]. 32 corrosive preparations of the intraorgan arterial bed of the kidney were produced and studied. The minimum diameter of casts of vascular segments was 0.1 mm with an accuracy of 0.05 mm. Measurement and recording of arterial segments was carried out in accordance with the known method [8]. Statistical processing included calculations of the main indicators of distribution of random variables. To obtain a representative sample, we used the method for determining limits of the median [13]. If the distribution of the parameter values differed from the norm, non-parametric criteria were used. The analysis was performed using the licensed package of applied statistical programs - MedStat, as recommended in [13]. Reproduction of the visual image of the intraorgan arterial bed of the kidney was performed using the original computer program "Vasculograph". Vasculograpx.exe models the intraorgan channels of different internal organs [7].

III. Results

32 corrosive preparations of the intraorgan arterial bed of the kidney of people aged 36–74 who died from asphyxia (16 females, 16 males) were studied. The visual assessment of the channel suggests that the intraorganic arterial bed of the kidney is characterized by a tree-like, loose and evririal type of the vascular tree. The latter can be confirmed by quantitative data. It is known that the leptoareal or narrow type branches off in a small narrow area. It is characterized by acute angles of division of the vascular trunks. The euryareal or broad type branches off in a wide area with a division of trunks characterized by angles approaching the straight line. Channels are assigned to a particular type based on the calculation of the index (h/l) which is a ratio of the width of the vessel branching area to its length expressed as a percentage – ((h/l) × 100, where the width of the branching area is length). When the indicator is equal to or less than 60 %, the channel belongs to the leptoareal type; if the index exceeds this figure – to the euryareal type [6]. In our study, 31 corrosive preparations of the intraorgan arterial bed of the kidney (h/l index> 60 %) were of the euryaleal type (97 %), and only 1 organ belonging to the man of mature age was of the first type (3 %).

In the gate of the kidney, the artery can be divided into 2 or 3 branches. The obtained facts are consistent with the classical canons of descriptive anatomy of the intraorgan arterial bed of the kidney. In the first case, blood enters the kidney through the renal artery which is divided into anterior and posterior branches in the gate of the kidney. In the second case, the renal artery is divided into three branches: to the upper and lower poles and to the central part of the organ – the trichotomic variant of the arterial bed of the kidney. The analysis of corrosion preparations showed that in most cases (90 ± 5 %), the renal artery is divided into two branches, and only in 10 ± 5 % of cases, three branches were observed. In male, the renal artery is divided into the ventral and dorsal branches (dichotomous version of the arterial bed of the kidney) (88 ± 8 %), and only in 12 ± 8 % of men, it is divided into pole and central branches (trichotomous version of the arterial kidney). In 94 ± 6 % of women the renal artery is divided into two branches, in 6 ± 6 % of women, it is divided into three branches.

In representatives of mature age, in 88 ± 8 % of cases, the renal artery is divided into ventral and dorsal branches and in 12 ± 8 % – into three branches. In 94 ± 6 % of the elderly, there are two branches. It can be assumed that individuals whose renal artery is divided into two branches are long-livers. The renal artery is divided into three branches on the right in 18 ± 9 % of cases; trichotomic variants of the arterial kidney were not found on the left. There are two branches I n 82 ± 9 % of right kidneys and in 100 % of left ones. After visual examination, measurement of the diameter of the initial segment of the renal artery, length, width and blood supply area, calculation of h/l, distribution of values of the variables under study were tested. It was established that distributions of diameter values of the initial segment of the renal artery, the length of the blood supply area and the h / l index do not differ from the normal ones at the significance level p> 0.05.

Distribution of the width and area of the blood supply is different from the normal distribution law. Therefore, it is necessary to use parametric and non-parametric criteria. The hypothesis about the belonging of independent samples to one general population was tested. The Mann – Whitney U Test and Student-test criteria were used. It was established that the values of the diameter of the initial segment of the renal artery, length, width and area of the blood supply, as well as h/l do not depend on gender, age, kidney side, and kidney arterial division option parameters. The surface area of the intraorgan arterial bed of the kidney divided into 2 branches (dichotomous variant) is slightly larger (7004 ± 2196 mm^2) than when divided into 3 branches (trichotomic variant) (5928 ± 305 mm^2).

However, the differences are not statistically significant, p = 0.54. It was established that the average diameter of the renal artery is 5.45 ± 0.17 mm. When the renal artery was divided into two branches, the internal diameter was 5.42 ± 0.18 mm, into three branches – 5.8 ± 0.76 mm; the difference in averages is not statistically significant, p = 0.53. The average renal artery diameter in men is 5.1 ± 0.38 mm; when divided into 2 branches, it is 5.44 ± 0.32 mm; when divided into three branches, it is 5.55 ± 1.25 mm. In women, the diameter is 5.45 ± 0.17 mm; when divided into 2 branches, it is 5.39 ± 0.17 mm; when divided into three branches, it is 6.3 mm. In men and women, the values of the internal diameter of the renal arteries do not differ statistically, p = 0.55. In representatives of mature age, the diameter of the renal artery is 5.7 ± 0.3 mml; for the two-branch artery, it is 5.57 ± 0.32 mm; for the three-branch artery, it is 6.55 ± 0.31 mm. In old age, it is 5.2 ± 0.2 mm; when divided into 2 branches, it is 5.27 ± 0.16 mm; when divided into three branches, it is 4.3 mm. In different age groups, the difference in the internal diameters of the renal arteries is not statistically significant, p = 0.17.

The average right renal artery was 5.3 ± 0.2 mm; with the dichotomous variant of the intraorgan arterial bed of the kidney, it was 5.17 ± 0.22 mm; with the trichotomic version, it was 5.8 ± 0.76 mm. On the left, its diameter was 5.6 ± 0.3 mm. Division of the renal artery into three branches with a left-sided arrangement of the organ was not found. Statistically significant (p = 0.37) differences of internal diameters of the left and right renal arteries were not established. With the dichotomous variant of the arterial bed of the kidney, the average value of the diameter of the anterior and posterior branches was 4.035 ± 0.12 mm: 4.02 ± 0.17 mm in men, and 4.04 ± 0.18 mm in women; the difference in averages is not statistically significant, p = 0.94. In persons of the second mature age, the diameter was equal to 4,14 ± 0,19 mm, in old age – 3,92 ± 0,16 mm; the difference of averages is not statistically significant, p = 0,39. On the right, it was 3.93 ± 0.22 mm, on the left – 4.1 ± 0.15 mm; the difference in averages is not statistically significant, p = 0.51.

IV. Conclusion

In accordance with the classical ideas about the structure of the intraorgan arterial bed of the kidney in the kidney sinus, the anterior and posterior branches of the renal artery are located in front of and behind the renal pelvis and are divided into segmental arteries. The front branch is divided into four segmental arteries: upper, upper anterior, lower anterior and lower ones. The posterior branch goes into the posterior segmental artery. Unfortunately, we did not observe this "idyllic" picture. When analyzing the corrosive preparations and graphic images of the intraorgan arterial bed of the kidney, the question arises what should be taken as the anterior and posterior branches and segmental arteries. In some cases, it can be assumed that the beginning of the posterior branch of the renal artery is a segment (section of the arterial kidney between the closest branches) which has a greater length and a smaller internal diameter. The renal artery enters the organ between the vein and the ureter. The anterior branch should form 4 segmental arteries, and the posterior one should be larger than the posterior one. One more problem was impossibility of finding the anterior branch divided into four arterial segments. The branches form two segments, i.e. they are divided dichotomously, and then each of these segments is also divided into two ones. This complicates identification of the branches of the intraorgan arterial bed of the kidney in accordance with classical concepts. It is not possible to determine which of the arterial segments is part of the interlobar, arcuate or interlobular arteries. It is impossible to link the established dimensions to different parts of the intraorgan arterial bed of the kidney (segmental, interlobar, arcuate and interlobular arteries). Moreover, classical anatomy indicates the presence of 5 renal segments and 5 segmental arteries. But in reality, the anterior and posterior branches are divided dichotomously and give rise to four arterial segments.

In the case of the trichotomic variant of the arterial bed of the kidney, according to descriptive anatomy, the renal artery is divided into three two pole and one central branches. It is impossible to distinguish the initial segments of these branches from each other. The average diameter of the artery segments is 3.5 ± 0.28 mm. In men, it is 3.4 ± 0.2 mm, in women, it is 3.7 ± 0.7 mm, the difference is not statistically significant, p = 0.65. In the second period of mature age, the diameter is 3.55 ± 0.4 mm, in old age – 3.4 ± 0.2 mm, the difference is not statistically significant, p = 0.82. The description concerns only the bed of the right kidney, since we did not find the division of the left renal artery into three branches. As in the case with the dichotomous variant of the arterial bed of the kidney, it is not possible to identify interlobar, arcuate and interlobular arteries. Qualitative visual assessment of the intraorganic arterial bed of a human kidney established that it is characterized by a tree-type form and a loose type of bed.

Thus, the quantitative analysis established that the intraorgan arterial bed of a human kidney is euryareal. This is confirmed by a larger number of correlations between morphometric parameter values and the level of division as well as the fact that the h/l index value exceeds 60 %.

The traditional descriptive anatomy of the intraorgan arterial bed of the kidney does not establish a morphometric standard of the norm of the intraorgan arterial bed of the kidney, it is almost impossible to identify links of the channel according to the classical canons. This is aimed at finding new approaches to the morphometric description of the intraorgan arterial bed of the kidney.

It is better to use relative rather than absolute indicators as a morphometric standard of the intraorgan arterial bed of the kidney. It is better to use the values of relative indicators that quantitatively characterize conceptual models of the intraorgan arterial bed of the kidney [5].

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