ADVANCES OF SCIENCE

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MORPHOMETRIC FEATURES OF THE STRUCTURE OF THE KIDNEY CALYCESS OF CHILDREN, ADOLESCENTS AND YOUNG PEOPLE

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Introduction. In recent years, various aspects of the anatomy of the renal pyelocalyceal complex and renal calyces of mature and elderly people have been intensively studied in connection with the production of organ-preserving surgeries [1-3]. The morphometric characteristics of the linear and volumetric parameters of the renal calyces of children, adolescents and young people, as well as the dynamics of their morphofunctional development, are insufficiently studied [4, 5].

Aim. To study the morphometric characteristics of the renal calyces of children, adolescents and young people.

Materials and methods. The material of this study was 152 isolated kidneys of children, adolescents and young people studied by corrosion methods, pyelography with subsequent morphometry, statistical processing and mathematical analysis. Morphometric characteristics of the renal calyces of children, adolescents and young people are given in one-dimensional [diameter of the vault of the renal calyx (d_{rc}, mm), height of the renal calyx (h_{rc}, mm), diameter of the cervix - (c_{rc}, mm)] and three-dimensional [volume of renal calyces - (V_{rc}, mm^3)] parameters.

Results and discussion. Peculiarities of the evolution of linear morphometric parameters of renal calyces in childhood and adolescence are presented using the method of variational statistics with the calculation of the reliability of quantitative differences, as well as methods for qualitative analysis of morphometric features with the construction of hysteresisograms and morphochronography of the parameters of the renal calyces. For the morphometric modeling of linear, planar and volumetric parameters of the renal calyces, the method of least squares is applied with obtaining polynomial equations (second degree) reflecting the regularity of the morphometric characteristics change from the moment of birth to reaching the young age.

The morphogenesis of the superior renal calyx (S) is characterized by the presence of statistically significant quantitative "transitions" of linear dimensions and the volume index, while we also noted the stability of the dimensions along the height coordinate at a statistically unreliable ($p > 0.05$) increase from 1hS=8.6±2.1 mm (at birth) to 6hS=12.1±3.6 mm (in adolescence). Thus, the dynamics of the parameters of the superior renal calyx is characterized by the presence of significant ($p<0.05$) unidirectional quantitative transitions in the fifth (10.3±1.5 years) and in the sixth (14.2±2.3 years) age groups - the volume of the renal calyx increases significantly ($p <0.05$). We found a twofold increase in volume: in young people ($p <0.05$) due to increase in the diameter of the vault of the renal calyx, and in adolescents - increase ($p <0.05$) in the diameter of the renal calyx anastomosis.

Table 1. Characteristics of quantitative and qualitative relationships of parameters of renal calyces of children, adolescents and young people

Quantitative characteristic: linear dimensions (mm) and volumes (mm^3) of renal calyces						Qualitative characteristic: a hysteresisogram of the renal calyces ($p < 0.05$)
Age						
14,0±4,5 days	6,5±1,5 monts	2,1±0,5 years	5,3±0,5 years	10,3±1,5 years	14,8±2,3 years	
S – superior renal calyx						$S \equiv \{{}^5d_S\uparrow, {}^6c_S\uparrow, {}^{5,6}V_S\uparrow\}$
10,3±1,7	9,4±1,0	10,4±1,7	9,7±1,3	14,5±1,9	16,2±1,1	${}^1d_S = {}^2d_S = {}^3d_S = {}^4d_S < {}^5d_S = {}^6d_S$
8,6±2,1	7,4±1,0	8,5±2,0	9,8±1,6	12,1±3,7	11,6±1,3	${}^1h_S = {}^2h_S = {}^3h_S = {}^4h_S = {}^5h_S = {}^6h_S$
5,4±0,4	5,0±0,7	5,8±0,8	5,5±0,9	6,9±0,8	8,5±0,9	${}^1c_S = {}^2c_S = {}^3c_S = {}^4c_S = {}^5c_S < {}^6c_S$
1300 ±400	940 ±200	1270 ±200	1500 ±400	2300 ±600	3900 ±500	${}^1V_S = {}^2V_S = {}^3V_S = {}^4V_S < {}^5V_S < {}^6V_S$
I – inferior renal calyx						$I \equiv \{{}^5h_I\uparrow, {}^6V_I\uparrow\}$
8,0±1,0	6,6±0,8	8,1±1,0	6,2±0,8	9,9±1,4	10,9±1,2	${}^1d_I = {}^2d_I = {}^3d_I = {}^4d_I = {}^5d_I = {}^6d_I$
5,9±1,0	5,6±1,0	5,9±0,7	8,2±0,9	9,8±1,4	9,4±1,0	${}^1h_I = {}^2h_I = {}^3h_I = {}^4h_I < {}^5h_I = {}^6d_I$
5,5±0,7	4,4±0,6	5,5±0,7	4,8±0,9	5,9±1,1	6,5±0,7	${}^1c_I = {}^2c_I = {}^3c_I = {}^4c_I = {}^5c_I = {}^6c_I$
800 ±200	560 ±100	980 ±200	1040 ±200	1700 ±500	1900 ±400	${}^1V_I = {}^2V_I = {}^3V_I = {}^4V_I = {}^5V_I < {}^6V_I$

Morphogenesis of the inferior renal calyx (I) is characterized by the presence of statistically significant quantitative "transitions" of its volume and height, while we also noted the stability of the diameter of the arch and the diameter of the anastomosis. The volume of the inferior renal calyx, starting from the neonatal period (1VI=800±200 mm3), gradually increases, reaching statistically significant differences only in adolescence (6VI=1900±400 mm3). Thus, the morphogenesis of the lower renal calyx is characterized by the presence of significant ($p < 0.05$) unidirectional quantitative transitions in the fifth (10.3±1.5 years) and in the sixth (14.2±2.3 years) age groups. It was found that the increase in volume in adolescence ($p<0.05$) is due to increase in the height of the renal calyx.

The general for the morphogenesis of the superior and inferior renal calyces is an increase in their volume (mostly of the superior calyx), but if the increase in VS occurs due to the advancing increase in diameters, then VI - due to the increase in height. These are peculiarities of the morphogenesis of the largest renal calyces of children, adolescents and young people.

Morphogenetic analysis of linear and volume characteristics of anterior renal calyces allowed to reveal the presence of statistically significant quantitative "transitions" of linear dimensions and indices of their volume.

Thus, the age dynamics of the parameters of the anterior middle renal calyx (A2) is characterized by reliable quantitative "transitions" of the volume index in adolescents and young people; if in adolescents the increase in volume A2 is associated with a simultaneous increase ($p<0.05$) of the diameter of the arch, then in young people, the increase in A2 in the volume is due to an increase ($p<0.05$) in the height of this renal calyx. A stable morphometric parameter is the diameter of its anastomosis. Thus, the dynamics of parameters of A2 is characterized by the presence of significant ($p<0.05$) unidirectional quantitative transitions in the fifth (10.3±1.5 years) and in the sixth (14.2±2.3 years) age groups.

The anterior superior and anterior inferior renal calyces are 1.5 to 2 times smaller than the volume of the anterior middle renal calyx, the dynamics of these calyces' changes during morphogenesis is monotonous and is characterized by a significant increase in volume to adolescence due to an increase in the diameter of the arch and height; in these calyces the diameter of the anastomosis is stable and does not reach statistically significant differences from the moment of birth (1cA3=3.8±0.4 mm, 1cA1=4.1 ± 0.5 mm) and until reaching adolescence (6cA3=4.4±0.5, 6cA1=5.0±0.4 mm). It should be separately noted that in the age dynamics of A1 we found that a significant increase in 5VA1 chronologically "outstrips" the increase in some linear parameters (6dA1 and 6hA1).

Table 2. Characteristics of quantitative and qualitative relationships of the parameters of the anterior renal calyces of children, adolescents and young people

Quantitative characteristic: linear dimensions (mm) and volumes (mm^3) of renal calyces						Qualitative characteristic: a hysteresisogram of the renal calyces ($p < 0.05$)
Age						
14,0±4,5 days	6,5±1,5 months	2,1±0,5 years	5,3±0,5 years	10,3±1,5 years	14,8±2,3 years	
A_2 – anterior middle renal calyx						$A_2 \equiv \{{}^6d_{A2}\uparrow, {}^5h_{A2}\uparrow, {}^{5,6}V_I\uparrow\}$
5,8±0,6	5,5±0,6	5,8±0,6	5,9±0,7	7,0±0,5	8,3±0,6	${}^1d_{A2}={}^2d_{A2}={}^3d_{A2}={}^4d_{A2}={}^5d_{A2}<{}^6d_{A2}$
5,1±1,3	5,4±1,3	5,1±0,9	6,8±1,1	8,0±1,2	10,3±1,3	${}^1h_{A2}={}^2h_{A2}={}^3h_{A2}={}^4h_{A2}<{}^5h_{A2}={}^6h_{A2}$
4,6±0,7	3,5±0,5	4,6±0,6	4,4±0,7	4,8±0,6	5,4±0,7	${}^1c_{A2}={}^2c_{A2}={}^3c_{A2}={}^4c_{A2}={}^5c_{A2}={}^6c_{A2}$
450 ±100	350 ±100	450 ±100	530 ±100	900 ±100	1500 ±200	${}^1V_{A2}={}^2V_{A2}={}^3V_{A2}={}^4V_{A2}={}^5V_{A2}<{}^6V_{A2}$
A_3 – anterior superior renal calyx						$A_3 \equiv \{{}^6d_{A3}\uparrow, {}^6h_{A3}\uparrow, {}^5V_{A3}\uparrow\}$
5,1±0,4	5,9±1,1	5,1±0,7	5,4±0,7	6,0±0,6	6,5±0,5	${}^1d_{A3}={}^2d_{A3}={}^3d_{A3}={}^4d_{A3}={}^5d_{A3}<{}^6d_{A3}$
4,1±0,5	3,0±0,4	4,2±0,8	4,7±0,8	4,2±0,6	6,5±1,0	${}^1h_{A3}={}^2h_{A3}={}^3h_{A3}={}^4h_{A3}={}^5h_{A3}<{}^6h_{A3}$
3,8±0,4	5,2±1,0	3,7±0,6	3,9±0,6	5,1±1,0	4,4±0,5	${}^1c_{A3}={}^2c_{A3}={}^3c_{A3}={}^4c_{A3}={}^5c_{A3}={}^6c_{A3}$
270±60	300±70	280±60	350±100	900±140	620±130	${}^1V_{A3}={}^2V_{A3}={}^3V_{A3}={}^4V_{A3}<{}^5V_{A3}={}^6V_{A3}$
A_1 – anterior inferior renal calyx						$A_1 \equiv \{{}^6d_{A1}\uparrow, {}^6h_{A1}\uparrow, {}^{5,6}V_{A1}\uparrow\}$
5,2±0,5	4,9±0,4	5,0±0,5	5,4±0,8	6,1±0,7	7,7±0,6	${}^1d_{A1}={}^2d_{A1}={}^3d_{A1}={}^4d_{A1}={}^5d_{A1}<{}^6d_{A1}$
3,2±0,4	3,9±0,8	3,2±0,5	4,4±0,9	4,0±0,9	6,6±0,8	${}^1h_{A1}={}^2h_{A1}={}^3h_{A1}={}^4h_{A1}={}^5h_{A1}<{}^6h_{A1}$
4,1±0,5	3,5±0,5	4,1±0,6	4,4±0,5	5,7±0,9	5,0±0,4	${}^1c_{A1}={}^2c_{A1}={}^3c_{A1}={}^4c_{A1}={}^5c_{A1}={}^6c_{A1}$
200±50	200±60	200±60	300±100	450±100	850±100	${}^1V_{A1}={}^2V_{A1}={}^3V_{A1}={}^4V_{A1}<{}^5V_{A1}<{}^6V_{A1}$

Thus, the group of anterior renal calyces is characterized by a third variant of the dynamics of morphogenetic parameters, the most significant age periods are adolescent and (to a greater extent) youthful age, in which we recorded statistically significant changes in both linear parameters and volumes of the renal calyces in the examined group .

Linear and volume characteristics of the posterior renal calyces in the process of age dynamics are less susceptible to quantitative "transitions", in particular, from birth to adolescence, only the posterior inferior renal calyx is significantly different in height and volume in young people.

Significantly larger changes characterize the posterior renal calyces in adolescence. Statistically significant changes were recorded in the posterior middle (two parameters), the posterior lower (two parameters) and a significant increase (in three parameters) of the posterior superior renal calyx with a simultaneous increase in volume more than twofold were found in this age group.

The age dynamics of the parameters of the posterior middle renal calyx (P2) is characterized by reliable quantitative "transitions" of the volume index in adolescence, which is associated with a simultaneous increase ($p<0.05$) in the height of this renal cup. A stable morphometric parameter is the diameter of its anastomosis. Thus, the dynamics of P2 parameters is characterized by the presence of significant ($p<0.05$) unidirectional quantitative transitions in the sixth (14.2±2.3 years) age group.

The dynamics of the parameters of the posterior upper renal calyx (P3) attests to an abrupt increase in all parameters in adolescence and young people.

The posterior inferior renal calyx (P1) is characterized by quantitative "transitions" of the volume index in young people (due to an increase in the diameter of the arch), and in adolescents (due to the simultaneous increase ($p <0.05$) of the height of this renal calyx). A stable morphometric parameter is the diameter of its anastomosis. Thus, the dynamics of P1 parameters is characterized by the presence of quantitative transitions in adolescents and young people.

Table 3. Characteristics of quantitative and qualitative relationships of the parameters of the posterior renal calyces of children, adolescents and young people

Quantitative characteristic: linear dimensions (mm) and volumes (mm^3) of renal calyces						Qualitative characteristic: a hysteresisogram of the renal calyces ($p < 0.05$)
Age						
14,0±4,5 days	6,5±1,5 months	2,1±0,5 years	5,3±0,5 years	10,3±1,5 years	14,8±2,3 years	
P_2 – posterior middle renal calyx						$P_2 \equiv \{{}^6h_{P2}\uparrow, {}^6V_{P2}\uparrow\}$
6,2±0,6	5,6±0,6	6,2±0,6	6,5±0,5	6,9±0,9	7,9±0,5	${}^1d_{P2}={}^2d_{P2}={}^3d_{P2}={}^4d_{P2}={}^5d_{P2}={}^6d_{P2}$
6,5±1,0	5,9±0,9	6,4±0,9	7,0±0,5	8,6±1,8	10,6±1,8	${}^1h_{P2}={}^2h_{P2}={}^3h_{P2}={}^4h_{P2}={}^5h_{P2}<{}^6h_{P2}$
4,0±0,5	3,6±0,5	4,0±0,6	4,5±0,8	4,7±0,7	6,1±0,9	${}^1c_{P2}={}^2c_{P2}={}^3c_{P2}={}^4c_{P2}={}^5c_{P2}={}^6c_{P2}$
560±100	410±100	570±70	670±100	970±300	1610±200	${}^1V_{P2}={}^2V_{P2}={}^3V_{P2}={}^4V_{P2}={}^5V_{P2}<{}^6V_{P2}$
P_3 – posterior superior renal calyx						$P_3 \equiv \{{}^6d_{P3}\uparrow, {}^6h_{P3}\uparrow, {}^6c_{P3}\uparrow, {}^6V_{P3}\uparrow\}$
5,0±0,3	5,2±0,5	5,2±0,5	6,0±0,4	7,1±1,1	7,5±0,7	${}^1d_{P3}={}^2d_{P3}={}^3d_{P3}={}^4d_{P3}={}^5d_{P3}<{}^6d_{P3}$
3,9±0,5	3,7±0,8	4,1±1,0	4,3±0,5	3,9±1,2	6,5±0,6	${}^1h_{P3}={}^2h_{P3}={}^3h_{P3}={}^4h_{P3}={}^5h_{P3}<{}^6h_{P3}$
4,1±0,3	4,4±0,8	4,1±0,3	5,0±0,6	6,3±1,0	6,0±0,7	${}^1c_{P3}={}^2c_{P3}={}^3c_{P3}={}^4c_{P3}={}^5c_{P3}<{}^6c_{P3}$
300±60	300±100	300±60	400±80	500±140	980±300	${}^1V_{P3}={}^2V_{P3}={}^3V_{P3}={}^4V_{P3}={}^5V_{P3}<{}^6V_{P3}$
P_1 – posterior inferior renal calyx						$P_1 \equiv \{{}^5d_{P1}\uparrow, {}^6h_{P1}\uparrow, {}^{5,6}V_{P1}\uparrow\}$
5,1±0,4	5,4±0,7	5,4±0,6	6,5±0,5	7,0±1,1	7,3±0,5	${}^1d_{P1}={}^2d_{P1}={}^3d_{P1}={}^4d_{P1}<{}^5d_{P1}={}^6d_{P1}$
4,8±0,7	4,2±0,8	4,7±1,0	5,5±0,8	5,2±1,3	8,3±1,6	${}^1h_{P1}={}^2h_{P1}={}^3h_{P1}={}^4h_{P1}={}^5h_{P1}<{}^6h_{P1}$
4,1±0,2	3,9±0,6	4,3±0,3	5,4±0,7	6,1±1,5	5,4±0,9	${}^1c_{P1}={}^2c_{P1}={}^3c_{P1}={}^4c_{P1}<{}^5c_{P1}={}^6c_{P1}$
300±60	30±100	260±60	600±80	790±300	1000±200	${}^1V_{P1}={}^2V_{P1}={}^3V_{P1}={}^4V_{P1}<{}^5V_{P1}<{}^6V_{P1}$

Thus, for the dynamics of the morphometric parameters of the posterior renal calyces, the most significant age periods are the adolescence and (to a greater extent) youthful age, in which we recorded statistically significant dynamic changes of both linear parameters and the volumes of the renal calyces.

Conclusions.

1. The study made it possible to study the anatomy and obtain a quantitative characteristic of the human kidneys in different age groups of children and adolescents according to the standard method, on the basis of which general morphogenetic and age-related anatomical features were revealed.

2. The character of the studied morphometric features of the renal calyces in the age aspect allows us to classify the age groups of children according to the frequency of statistically reliable "morphometric transitions". In general, the age groups of older children and adolescents are the most significant in the differentiation of the renal calyces, since these age groups were characterized the greatest number of changes in the linear and volume parameters of the renal calyces.

3. It has been found that the morphogenesis of linear and volumetric parameters of renal calyces in children and adolescents is unidirectional, but the increase in these parameters is asynchronous and is differentiated by age.

4. Constantly present anatomical formations are the upper and lower renal calyces, which differentiate in linear dimensions and in the classical votive (conical) form in the early stages of morphogenesis.

5. The revealed and studied phenomenon of smaller heterogeneity of renal calyces having a larger volume is confirmed by an inverse, strong correlation dependence (r_{xy}=-0.87±0.11) between the volume of the renal calyces and the corresponding parameters of their heterogeneity, which supports the genetically-evolutionary conditionality and number of renal calyces, and their volume.

The character of the studied morphometric features of the renal calyces in the age aspect allows us to classify the age groups of children according to the frequency of statistically reliable "morphometric transitions". In general, the age groups of older children and adolescents are the most significant in the formation of the renal calyces, since the greatest number of dynamic changes in the linear and volume parameters of the renal calyces are recorded in these age groups.

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