TOPOGRAPHIC AND ANATOMICAL PECULIARITIES OF THE PYELOCALICEAL SYSTEM OF THE KIDNEY IN THE FETAL PERIOD OF HUMAN ONTOGENESIS

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Abstract

TOPOGRAPHIC AND ANATOMICAL FEATURES OF THE PYELOCALICEAL SYSTEM OF THE KIDNEY IN THE FETAL PERIOD OF HUMAN ONTOGENESIS

Background: The study of the features of the topographic anatomy and individual anatomical variability of the renal pyelocaliceal system (RPCS) during the fetal period of human intrauterine development (IUD) is important for elucidating and understanding the complex transformations of their structure, syntopy and skeletotopy, in particular, to explain the causes and time of appearance of the structural variants and congenital malformations of the organ.

Material and methods: A total of 102 human fetal biomanikins of 160.0-480.0 mm parietal-coccygeal length (PCL) (4-10 months of IUD) were studied. A complex of methods of morphological research was applied.

Results: It was found a lobar structure of the kidneys of human fetuses on all specimens. Two main variants of their external structure were revealed – bean-shaped and oval-shaped. Two variants of the structure of the renal hilum were observed – their open and compact forms. Among the variants of the structure of the RPCS, we observed ampullary and branched types. Syntopy of the renal pelvis and pyelo-ureteral segment with renal vessels on the right and on the left is almost the same, and in the dynamics of the fetal period of IUD does not change significantly.

Conclusions: 1. The topography of the renal calyx-pelvic system is largely determined by the peculiarities of the spatial structure of the kidney – its external shape, size, skeletotopy, individual features of the hilum of the organ, their syntopy with the renal vessels.

2. Close syntopy of the renal pelvis and pyelo-ureteral segment with renal vessels with a compact form of the renal hilum may be an anatomical prerequisite for impaired urodynamics, provided there are variants of renal vessels branching or the existence of an abnormal vessel in the renal hilum region.

3. Variants of the structure of the kidneys and their structures are clearly observed from the beginning of the fetal period of human IUD, significantly affect the topography of the calyces and pelvis, and in some cases can cause impairment of urodynamics.

Key words: prenatal development, kidney, renal pyelocaliceal system, fetus, human.

Actuality

The study of the features of the topographic anatomy and individual anatomical variability of the renal pyelocaliceal system (RPCS) during the fetal period of human intrauterine development (IUD) is important for elucidating and understanding the complex transformations of their structure, syntopy and skeletotopy, in particular, to explain the causes and time of appearance of the structural variants, the possible occurrence of congenital malformations of the organ [1-4].

Renal development is a very complex and multi-stage process that can be disrupted by genetic mutations, especially due to a defect in transcription factors or prenatal exposure of teratogenic factors, maternal malnutrition can impair prenatal kidney development [5, 6].

The frequency of congenital urological pathology of newborns increases annually [7].

The increase in this group of patients is due to both an increase in the frequency of congenital malformations of the urinary system and the improvement of antenatal diagnostics. Understanding the complex mechanisms of pathogenesis of diseases of RPCS is necessary for effective prenatal diagnosis of renal abnormalities and their timely surgical correction [8-12].

Materials and methods

A total of 102 human fetal biomanikins of 160.0-480.0 mm parietal-coccygeal length (PCL) (4-10 months of IUD) were studied. A complex of methods of morphological research was applied, which included anthropometry, morphometry, injections of blood vessels with X-ray contrast mixtures, X-ray techniques, dissection, microscopy, three-dimensional reconstruction and statistical analysis.

Results and discussion

It was found a lobar structure of the kidneys of human fetuses on all specimens (Fig. 1).

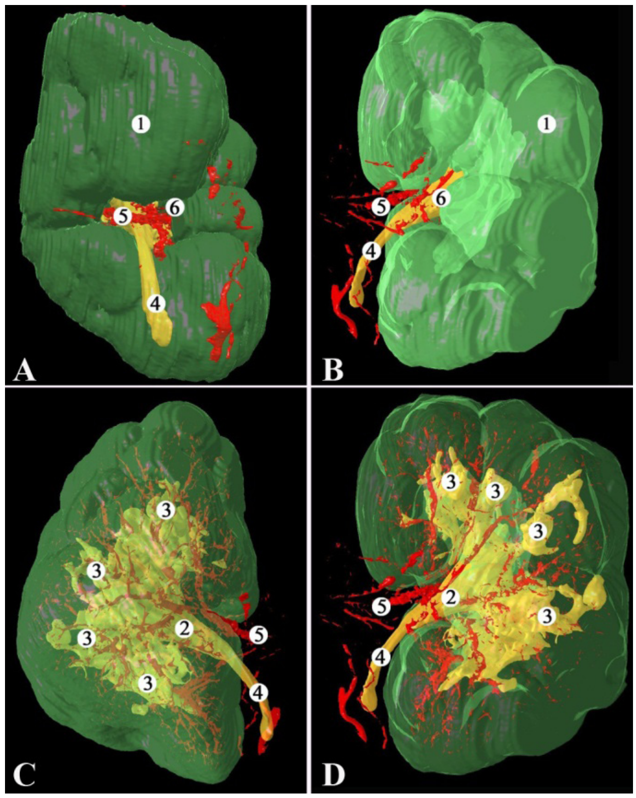

Fig. 1. 3D reconstruction of the left kidney of the human fetus 250.0 mm PCL. *A – median projection; B – anterior-medial projection; B – posterior-medial projection; D – anterior-medial projection. Magn.: x3: 1 – renal perenchyma; 2 – renal pelvis; 3 – renal calyces; 4 – ureter; 5 – renal artery; 6 – renal hilum.*

The shape, skeletotopy and holotopy of the kidneys can significantly affect the structure and topography of RPCS. Two main variants of their external structure were revealed – bean-shaped and oval-shaped.

At the beginning of the fetal period of IUD, the oval shape is most often observed, but from the 6th month of the IUD, the bean-shaped form begins to prevail, and from the 8th month it is determined almost twice as often (fig. 2).

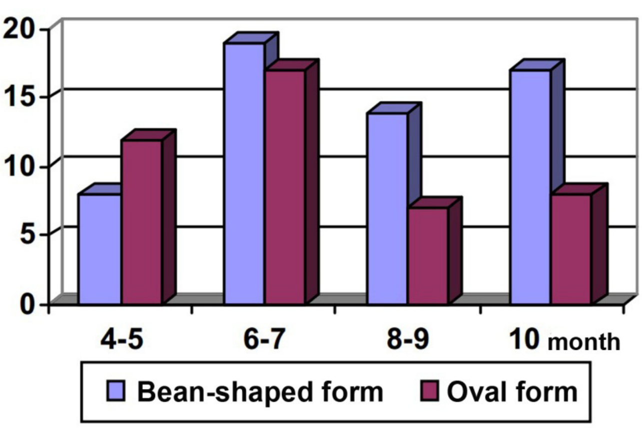

Fig. 2. Temporal dynamics of changes in the ratio between bean- and oval shapes of human fetal kidneys.

It is this form of the external structure of the kidneys should be considered ontogenetically more mature.

The peculiarities of the temporal dynamics of the shape of the kidneys revealed during the research are inextricably linked with the changes in the spatial structure of the renal hilum, and, consequently, with the syntopy of the renal vessels with the renal pelvis. Two variants of the structure of the renal hilum were observed – their open and compact forms.

Until the 6th month of IUD, the open form of the renal hilum prevails (see Fig. 1), and from the end of the 7th month and at the beginning of the 8th months of IUD, a compact form of the organ hilum was revealed on most preparations. In 10-month-old human fetuses, the compact form occurs almost three times more often than the open one (Fig. 3).

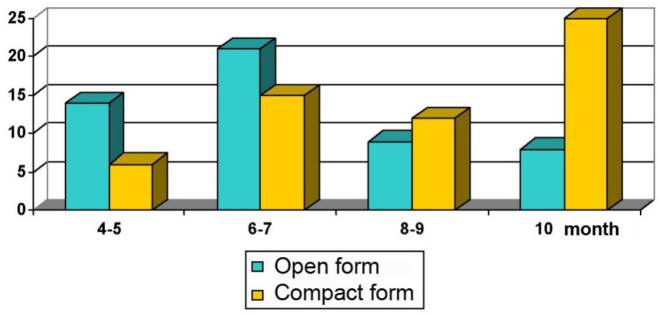

Fig. 3. The ratio of open and compact forms of the renal hilum.

We consider that close syntopy of the renal pelvis and pyelo-ureteral segment (PUS) with renal vessels in the compact shape of the renal hilum may be an anatomical prerequisite for urodynamic disorders under the conditions of renal branching or the existence of an abnormal vessel in the renal hilum.

In the case of a compact shape of the renal hilum, there is a higher probability of compression of the PUS by the accessory inferior renal artery (Fig. 4).

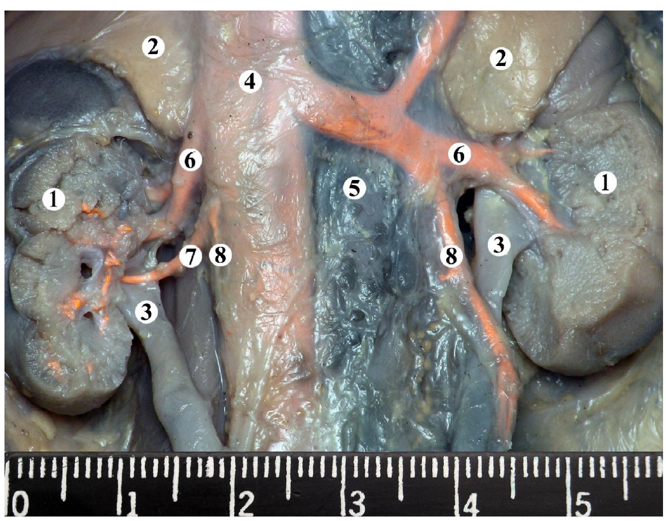

Fig. 4. Organs of the retroperitoneal space of the male fetus 350.0 mm PCL. The veins are filled with a mixture based on red lead. Macrospecimen. Magn.: x2: *1 – kidneys; 2 – adrenal glands; 3 – pyeloureteral segments; 4 – inferior vena cava; 5 – aorta; 6 – renal veins; 7 – accessory right inferior renal vein; 8 – testicular veins.*

Such cases are often described as one of the morphological causes of hydronephrosis, megacolyx, pyeloectasis, vasorenal hypertension, pyelonephritis, nephrolithiasis or bedsores of the anterior wall of the renal pelvis and PUS.

Simultaneously with changes in the shape of the renal hilum, changes in their holotopy occur: in 4-7-month-old fetuses, the hilum is directed forward and medially, and from the 8th month of IUD they are reoriented and placed already on the medial surface of the kidney.

The renal pelvis also has structural variants.

On macrospecimens and 3D reconstructions of fetal kidneys, the renal pelvis is somewhat compressed in the anteroposterior direction (see Fig. 1), due to which the shape of its cross section approaches the oval.

Among the variants of the structure of the RPCS, we observed ampullary Fig. 5 and branched (see Fig. 1) types.

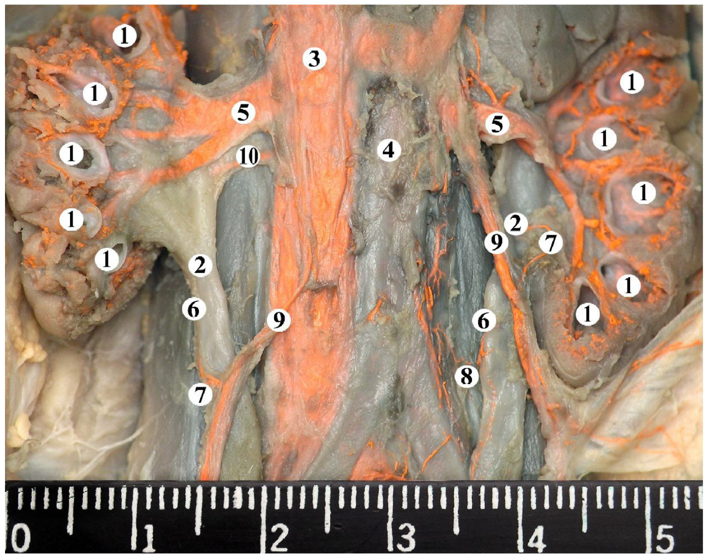

Fig. 5. Organs of the retroperitoneal space of the male fetus 360.0 mm PCL. The veins are filled with a mixture based on red lead. Macrospecimen. Magn.: x1,8:
1 – renal calyces; 2 – pyeloureteral segments; 3 – inferior vena cava; 4 – aorta; 5 – renal veins; 6 – ureteral vein; 7 – junction of ureteral and testicular veins; 8 – junction of the left ureteral and ascending lumbar veins; 9 – testicular veins; 10 – accessory right inferior renal vein.

During the study of renal pelvis skeletotopy, it was found that at the beginning of the fetal period (4-5-months-old fetuses), the right and left renal pelvis are located almost at the same level in relation to the spine – approximately at the level of the interval between the II and III lumbar vertebrae (Fig. 6), but starting from the 6th month, they „ascend" on the left to the level of the middle third of the II lumbar vertebra, and on the right, on the contrary, „descend" to the middle third of the III lumbar vertebra. Syntopy of the renal pelvis and PUS with renal vessels on the right and on the left is almost the same, and in the dynamics of the fetal period of IUD does not change significantly.

The syntopy of the renal pelvis and PUS with renal vessels on the right and left is almost the same, and in the dynamics of the fetal period IUD does not change significantly.

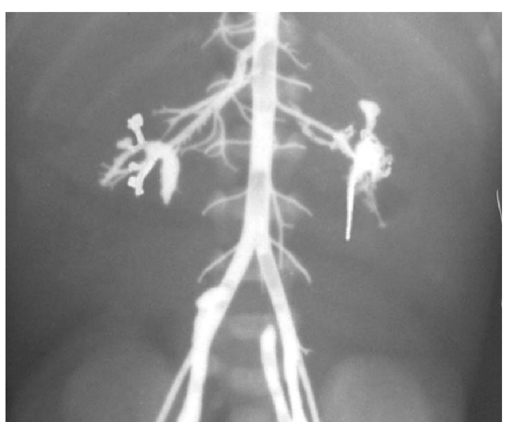

Fig. 6. Radiograph of the female fetus 210.0 mm PCL. Injection of arteries, pelvic system of the kidney with red lead. Magn.: x2.

The renal artery, divided into 2-4 branches, and then the renal vein, represented by 2-3 vessels, are determined ventrally of the narrowed part of the renal pelvis in the anterior direction. The renal vein is located in front of the PUS and below the branches of the renal artery.

The relationship of the elements of the renal pedicle outside the renal hilum is as follows: above is the renal artery, in front of it and slightly below – the vein and behind – the renal pelvis and PUS.

In the renal hilum, around the renal pelvis, such a syntopy is not observed: the venous vessels after leaving its parenchyma surround the corresponding artery on all sides. The vessels pass both in front and behind the renal pelvis, covering it. Variants of the topography of the renal vessels and their abnormal placement in relation to the renal pelvis and PUS can cause functional disorders of the upper urinary tract. Thus, accessory renal arteries were detected on 4 specimens of female fetuses, multiple renal veins were observed on specimens of 4 male fetuses. In two cases, signs of hydronephrosis were observed in these fetuses.

The causes for its occurrence were nephroptosis, compression of PUS by vessels, flexures of the proximal part of the ureter. Macroscopically, a significant dilatation of the RPCS, thinning of the renal parenchyma was detected.

Conclusions

1. The topography of the renal calyx-pelvic system is largely determined by the peculiarities of the spatial structure of the kidney – its external shape, size, skeletotopy, individual features of the hilum of the organ, their syntopy with the renal vessels.

2. Close syntopy of the renal pelvis and pyelo-ureteral segment with renal vessels with a compact form of the renal hilum may be an anatomical prerequisite for impaired urodynamics, provided there are variants of renal vessels branching or the existence of an abnormal vessel in the renal hilum region.

3. Variants of the structure of the kidneys and their structures are clearly observed from the beginning of the fetal period of human intrauterine development, significantly affect the topography of the calyces and pelvis, and in some cases can cause impairment of urodynamics.

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