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THE PRACTICAL SIGNIFICANCE OF PRELIMINARY STUDY OF THE CHEMICAL SCALE, STRUCTURE AND STRENGTH OF URINARY STONES FOR CHOOSING A RATIONAL METHOD OF THEIR DESTRUCTION

Introduction. Urolithiasis is one of the oldest diseases known to medicine; however, the mechanisms of stone formation and development remain largely unclear. Physico-chemical, biological and biochemical processes that take place during the formation of urinary stones determine the peculiarities of their composition and structure, which is confirmed by modern methods of analysis: spectral, X-ray, polarization optical, immersion, infrared spectrometry, etc [1,2]. But it was determined that knowledge of the chemical composition and structure of urinary stones does not allow to improve their destruction. Urolithiasis, a complex multifactorial disease, results from an interaction between environmental and genetic factors. Epidemiological studies have shown that urolithiasis is associated with a number of lifestyle-related diseases, including cardiovascular disease, hypertension, chronic kidney disease, diabetes, and metabolic disorders. syndrome. Elucidation of the mechanisms underlying the formation of urinary stones will allow the development of new prophylactic agents [3,4]. For the development of new modern methods of mechanical destruction of urinary stones, data on the structure of urinary stones, which primarily determines their physical properties, are of particular importance. An example can be the fact that graphite and diamond have the same mineral composition (carbon), but the strength of each of them cannot be compared: one is fragile, the other is the hardest.

The goal of the work — to improve the quality of destruction of uroliths from the kidneys of residents of the Dnipropetrovsk region, primarily related to the preliminary study of the structure, morphology and strength of these formations.

Research methods. To carry out the work, a comparative analysis of the morphology of more than 246 renal uroliths of residents of the Dnipropetrovsk region was carried out and their petrographic study was performed. The sizes of the studied stones were from 5 mm to 67 mm in length, from 4 mm to 54 mm in width, from 3 mm to 31 mm in thickness. Some stones were larger. The shape of the stones was varied. The morphology of uroliths was studied using a stereoscopic binocular microscope MBS-9. Microscopic examination of sections of uroliths was performed using an optical polarizing microscope MIN-8. Density characteristics were determined using computed tomography on a Siemens SOMATOM device.

Discussion of results. It is known that solid bodies differ from each other not only in mineral composition, but also in structure and texture. The construction of a solid body, which is a urinary stone, is characterized by structural and textural features due to its origin and subsequent transformation (genesis). Structure and texture determine the structure of matter at different levels. Texture is the composition of a sedimentary rock, determined by the orientation, relative arrangement of constituent parts, as well as the way of filling the space. Texture is mainly a macroscopic feature, the study of which is carried out on rock samples (on dissections of stones, on the surface of anschliffe). Structure - the structure of the rock, which is determined by the size, shape, orientation of the particles and the degree of preservation of the organic residue (microscopic feature). The structure of rocks of chemical origin, including urinary stones, is characterized by the degree of crystallinity and size (sizes) of grains.

The structure is of great importance in the strength of the urinary stone. The most durable and resistant to destruction are stones that have a fully crystalline equally medium-grained or fine-grained structure. Large-grained, coarse-grained, giant-grained formations are more prone to destruction, both under conditions of mechanical impact and under conditions of significant temperature changes, because large crystals with significantly pronounced adhesion in large-grained formations are easily split and destroyed. Vitreous stones quickly split under conditions of sudden temperature changes. Stones are characterized by the presence of cavities, such as cracks and caverns. Cavities are different in shape - bubbly, channel-like, fissure-like, branch-like, etc. The shape and degree of hollowness of the stone determine its properties such as density, strength, and susceptibility to destruction.

In previous works, the most complete attention was paid to the structure and composition of urinary stones, including single kidney stones, using petrography, infrared spectrography, laser and electron probe microanalysis. During the X-ray structural analysis of urinary stones, the predominant amount of calcium oxalate was found - 59%, followed by calcium urate - 36%, and the least amount of calcium hydrogen phosphate - 2%. It has been established that oxalate stones are characterized by a fine-grained and fine-grained structure. The main types of texture of these stones were concentric, zonal and radial-radial. A characteristic structural feature of urate stones is a microcrystalline structure, and the predominant textures are spherulite, sector-spherulite, and chaotic. Amorphous minerals in the vast majority are provided in the form of cementing, binding individual crystals of the mass. Recrystallization processes with the formation of hollowness were more often observed in these stones. Coral-like stones are characterized by a mixed composition. They were formed in the presence of amorphous minerals with the addition of salts of different composition. The structural feature of coral-like stones was their chaotic construction.

Thus, the analysis of our own data shows that urinary stones have a different composition and, depending on the type, mainly consist of crystals of uric acid, sodium or ammonium uric acid, calcium oxalate or ammonia, calcium phosphate, magnesium phosphate or ammonia. All stones consist of organic and mineral parts. Many of them are mixed in their composition. Mineral slkad contains from 6 to 17 or more trace elements. As for the structure of stones, the studies devoted to this issue concern the study of the microstructure as a consequence of stone formation. It was established that the microstructure of stones, as well as their composition, depends on the type of urinary stones. The study of the structure and composition of urinary stones in order to detail the mechanism of their destruction is an important task, because the principle of mechanical destruction is the basis of remote and contact methods of stone disintegration.

According to external features, the studied stones were divided into groups of known types: urates, oxalates, phosphates and mixed composition.

Urate had a solid consistency, color from yellow to dark brown. Their surface was often smooth. Individual stones were covered with small grains that were tightly connected to the surface or (less often) easily separated from the surface of the stone after a slight pressure. Oxalates were solid formations from yellow to dark brown (more often). Their surface was also smooth, sometimes warty or rough, covered with dull sharp spines. Phosphate stones were of different consistency: some of them were easily crushed, others had a solid consistency. They had a mostly white or yellowish-white color, a smooth or slightly rough surface. The stones of mixed composition had various colors and surfaces. Depending on the predominant ratio of constituent parts and internal connections, some of them were solid, others were easily crushed. Some of them were easily crushed only after the destruction of the hard surface layer. Others, on the contrary, were solid even after the destruction of the surface layer [5].

Depending on the component, we divided the studied stones into three groups: 1) crystalline, among which we additionally identified two groups: a) monomineral and b) polymineral; 2) amorphous; 3) mixed in composition - complex salts of various acids. Depending on the location of the crystals, radial-radiant, spherulite, globular, and chaotic structures were distinguished.

It was established that urates are characterized by a concentric structure. In 90% of stones, a well-formed core is visible, the diameter of which (measured on the samples) ranges from 0.1 to 0.5 mm. The core is surrounded by dense layers with loose layers 0.1-0.5 mm wide. Often, "holes" are formed around the core, which leads to the separation of layers and further destruction of the stone. The obtained data make it possible to determine the structure of urates as pelitomorphic-hidden crystalline, equivalently fine-grained (crystal size 0.01 mm).

Research results showed that phosphates, like urates, have a concentric structure around a nucleus, often have 2 or more nuclei and a coral-like shape. The diameter of the nuclei is from 0.1 to 0.5 mm. Phosphates have multi-step cleavages and loose layers. The width of the layers is 0.1 mm and less. The structure of the stones is cryptic, equally fine-grained [6].

Unlike urates and phosphates, oxalates do not have a clear concentric structure. These are monolithic stones. Only 20% of samples have a well-formed core. Oxalates consist of dense layers that do not have loose layers. When studying them under a microscope, it can be seen that pronounced crystals are not defined, but microcracks have a very fine structure, which is filled with an organic part. That is, according to the degree of crystallization, the structure of oxalates is vitreous, fine-grained, stones do not have clearly marked crystals.

Computed tomography (CT) is the gold standard in the diagnosis of kidney stones; its sensitivity and specificity are high (~94% and ~97%, respectively), and small structures around 1 mm can be identified. In addition, CT determines the number, shape, location and attenuation coefficients of stones [7].

Hounsfield units (HU) are related to the density of the tissue or stone. HU is the result of a linear X-ray attenuation scale, and the HU value is related to distilled water at normal pressure and temperature. In addition, the relationship between stone radiodensity, expressed in HU, and stone size can be considered a predictor of kidney stone composition. This measure is called the Hounsfield density. Several studies have linked HU to the composition of kidney stones. However, there is little evidence of a relationship between Hounsfield density and kidney stone composition [7,8].

A preliminary study of the density of the stone structure of various types using CT in the experiment showed the following results (Table 1).

Table 1

Indicators of density, of heterogeneity, of the structure of uroliths

Parameters of uroliths	Sample 1	Sample 2	Sample 3	Sample 4
Form	wrong	wrong	wrong	wrong
Dimensions (mm)	15x9x17	14x11x17	14x9x16	11x9x13
Medium density	1329	1584	1516	570
Minimum density	639	503	108	436
Maximum density	1765	1910	1855	623
Heterogeneity index (standard deviation of density)	263	278	379	38

Indicators of heterogeneity of the structure of urinary stones were compared with the data of their further petrographic study. As a result of the comparative analysis, it was proved that in the vast majority of stones there is a coincidence of structural features with indicators of structural heterogeneity. The latter may indicate the nature of the strength of the stone. Especially the mismatch of indicators was determined in samples 3 and 4, which indicates significant changes in the structure and chemical composition of these stones (Fig. 1-4).

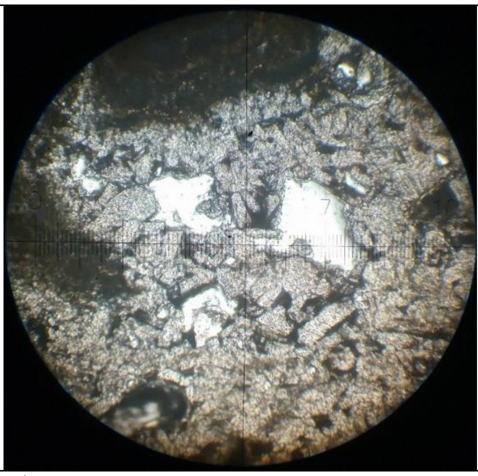

Fig. 1. **Features of the structure of the central part of sample No. 3**. Micrograph of the area immediately adjacent to the "organic core". A layer consisting mainly of flaky aggregates of large crystals of vevellite with separate accumulations of phosphate - collophane. Near the cross hairs there are 3 large inclusions of collophane. simple transmitted light. Magnification x90.

Fig. 2. **Features of the structure of the central part of sample No. 4.** On the crosshairs of the threads, the differences in the shades of the color of the organics of the “organic core” are clearly visible. Slightly below the crosshairs of the filaments, there is a polymineral aggregate mainly consisting of cystine grains with a slight admixture of veddyllite. To the left of the vertical thread are located (above and below the horizontal thread) isometric aggregates. They are surrounded by organics from the outside, and in their central part there are intergrowths of cystine grains. Polarized transmitted light. Magnification x90.

Stones of mixed composition are characterized by features of both phosphates and oxalates. They have a concentric structure, often 2 or more nuclei with a diameter of 0.01-0.1 mm. Stones of the mixed type combine the elements of oxalates and phosphates, the structure is concentric in the form of a core, which is surrounded by layers of different width (0.1-0.2 mm) and hardness. Often, similarly to phosphates, layers of loose material with a width of 0.001 mm are formed. The stone structure is pelitomorphic-fine-grained.

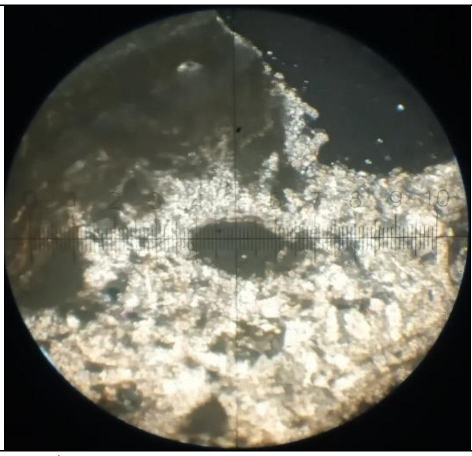

Fig. 3. **Structural features of the peripheral part of sample No. 3.** At the cross hairs there is a rather large lenticular inclusion of organic matter. The mineral component is predominantly represented by flaky accumulations of wewellite with an insignificant admixture of grains of uric acid dihydrate. Polarized transmitted light. Magnification x90.

Fig. 4. **Structural features of the peripheral part of sample No. 4.** In the field of view, there is a coarse and thin-layered aggregate intersected along a thin layer of organic matter by a rather thick and consistent interlayer of wevellite. In general, weddellite dominates in the field of view, and wevellite is in a sharply subordinate amount. Single highly dispersed crystals of uric acid dihydrate were found at the very edge of the sample. Polarized transmitted light. Magnification x90.

It can be seen from the above that the three types of stones, except oxalates, have the same structure. The texture of all is layered or irregular. Chips are especially important in the construction of stone. Cleavage failure is the most brittle form of failure that can occur in a crystalline material when crystallographic surfaces separate. Due to the fact that neighboring crystal grains have different orientations, the brittle fracture at the crystal grain boundary changes its direction and continues to propagate in the most favorable direction of the fracture surface. It was noted that the cracks have a step that is parallel to the crack propagation direction and perpendicular to the crack plane. In all types of such stones, cavities, cracks and splits around the cores were identified, along which the separation of layers and subsequent destruction of the stone occurs. But it should be noted that these formations are most pronounced and often occur in phosphates and urates. In phosphates, cracks are more often multi-step. There are almost no cracks in oxalate stones, cavities and cracks are occasionally found.

Conclusions. Thus, urinary stones, as biological objects, in contrast to hard bodies of mineral origin, have characteristic diagnostic signs and stable types of structures and textures for each type. It is known that the nature of destruction is significantly influenced by the structure of urinary stones. In turn, the features of the chemical composition and distribution of elements of zonal structures are reflected in the structure. However, in order to be able to improve the methods of their litholysis, destruction and, especially, metaphylaxis of recurrent stone formation, in-depth knowledge about the peculiarities of the physical and technical properties of urinary stones is required.

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