SCIENTIFIC RESEARCH GROUP:

Barannyk Kostyantyn
candidate of medical sciences, assistant of the Department of Surgery No. 1
"Dnipro State Medical University" Ukraine

Ishkov Valeriy
candidate of geological and mineralogical sciences, associate professor
National Technical University "Dnipro Polytechnic", Ukraine

Molchanov Robert
doctor of medical sciences, professor,
Professor of the Department of Surgery No. 1,
"Dnipro State Medical University", Ukraine

Barannyk Serhiy
doctor of medical sciences, professor,
professor of the department of general surgery,
surgery No. 3, orthopedics and traumatology of the FPO
"Dnipro State Medical University", Dnipro, Ukraine

FEATURES OF THE STRUCTURE OF URATE UROLITHIASIS IN INHABITANTS OF AN INDUSTRIALLY DEVELOPED REGION

Introduction. According to the World Health Organization, the incidence of this disease has increased 1.5 times over the past 12 years. It affects one person in a hundred in the world. For many centuries, information about the symptoms of the disease and methods of its treatment has been accumulated, many issues of mineralogy, in particular, the ontogeny of uroliths, remain insufficiently studied. Minerals of biogenic origin are integral elements of the structure of many living organisms. Along with genetically physiogenic minerals, pathogenic biominerals are also common. These include, in particular, urinary stones — uroliths, which are formed as a result of the development of urolithiasis. Urolithiasis is called the "disease of civilization" for a reason. Today, the ontogeny of minerals is a developed branch of genetic mineralogy. The available information makes it possible to reconstruct the conditions of their genesis and growth based on the external shape and features of the internal structure of minerals and mineral aggregates. The rich experience of researching inorganic compounds can and should be effectively used in biology and medicine to highlight possible mechanisms of biomineralization in processes of pathogenic origin based on their geological analogues.

The aim of the study. To determine the peculiarities of the structure of urinary stones in residents of an industrially developed region suffering from urate urolithiasis.

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 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.

Research results and their discussion. It is common in the structure of any urinary stones of residents of the Dnipropetrovsk region to have a core ("pocket") around which a urolith shell (body) of varying thickness was located. As a rule, regardless of the mineral composition of the urinary stone itself, the nuclei consist of an accumulation of organic matter (a kind of "matrix") impregnated with finely dispersed.

During the study of kidney stones of residents of the Dnipropetrovsk region using optical petrography methods, we identified the following oxalates: juvelite, uedelite; urates: uricite, pseudomalachite, ammonourate, natrourate monohydrate; phosphates: struvite, hydroxylapatite, brushite, vitlokite, as well as xanthite, cystine, quartz, gypsum and goethite. Monomineral formations occurred very rarely (<1%). Among them, uric acid stones (urates) accounted for 14.23% (35 cases).

The color of urates ranged from yellowish-white to orange shades. The surface was mostly uneven with hills, cavernous, and sometimes thinly drusy. The luster of the main amount of urates was matte, rarely glassy. The macrostructure is fine-grained and fine-grained.

The microstructure is mainly fine-crystalline, hypidiomorphic. The urate stone represented an aggregate of small crystals, which consisted mainly of individual small grains of uric acid monohydrate. Developed crystals of uric acid dihydrate were often found on the surface in the form of a fine powder. In the central part of the urates, calcium oxalate crystals (wavellite) were encountered, which were mainly in the form of inclusions ("prison minerals") in relatively large crystals of uric acid monohydrate and few accumulations of collophane. Organic matter was unevenly distributed. Its main part was concentrated in the form of highly dispersed inclusions between individual microblocks of mineral grains, in cracks and microcavities, at the same time, a certain amount of organic matter was localized in the form of an "organic core" of an irregular shape due to several phases of one generation. The analysis of the relationship between mineral phases indicated the sequential substitution of mineral formation: collophan (phosphate) → wavellite (oxalate) → uric acid monohydrate (urate).

Special attention was drawn to various options for the construction of the urat stones themselves. At the same time, the main part of the examined section was composed of the mineral substance of heterogeneous crystals of uric acid monohydrate. However, inclusions of wavellite (calcium oxalate monohydrate) were detected in large crystals of uric acid monohydrate. Sometimes, in addition to this inclusion, a second inclusion in uric acid phosphate monohydrate was observed - collophan in the "shirt" of wavellite. In addition, a fragment of the "organic core" with a thin border of colophan was repeatedly observed. The analysis of these observations also confirms the successive replacement of mineralization phases. Organic matter (matrix) was mainly concentrated in the form of extremely thin films ("organic shirt") along the surface of the crystals and their microblocks, as well as in the form of numerous finely dispersed inclusions in the microblocks of individual crystals. Sometimes, during observation, cells with polygonal microblock crystals of uric acid monohydrate, as well as cells of collophan accumulation, were found.

Peculiarities of the structure of the peripheral part of urates, which had mainly a homogeneous component of their own structure, consisted in the fact that it is possible to observe a concentric-zonal structure of a spherulite of mainly urate composition. At the same time, the presence of 5 zones, which corresponded to successive stages of mineral formation, was clearly recorded. The zones were separated from each other by layer-by-layer accumulations of organic matter inclusions. A characteristic feature of the construction of zone 1 (the central or "core" of the spherulite) is the presence of polygonal crystals of uric acid monohydrate and a relatively large, solitary accumulation of collophane. The second zone was composed of radially elongated tabloid crystals of uric acid monohydrate. The third zone was formed by the largest tabloid crystals of uric acid monohydrate and also located radially. Analysis of the elongation of the crystals of the second and third zones (by 34 measurements) indicates their equivalence within the margin of error. In contrast to the other zones, the fourth zone was distributed intermittently and appeared as several thin lenses of rosin grains. The fifth zone was composed of combined polygonal and radially elongated tabloid grains of uric acid monohydrate. In addition, it was possible to note the presence of individual small crystals of wavellite and uric acid dihydrate in the composition of the third and fifth zones.

It should be noted that in conditions of high saturation of urine with components in the kidney bowl, the mechanism of layer-by-layer growth of crystals should dominate. At the same time, the morphology of the future individual will be determined mainly by the point at which the growth of the next growth layer will begin.

In the formation of urinary stones, not only thermodynamic, but also kinetic factors play an important role. This greatly complicates the physicochemical analysis of potential crystallization phenomena and forces us to take into account the degree of supersaturation of the solution, the presence of inhibitors that prevent the formation of microcrystallites and their aggregation, the nature of the organic matrix, the phenomenon of epitaxy, as well as the position in which the nucleation and growth of urolith occurred.

In the case of crystallization of minerals from environments with high supersaturation, which we are interested in, the crystal can grow not only due to the incorporation of individual atoms, but also by the deposition of mostly associates — so-called two-dimensional nuclei — on the growth edge. Their joining also takes place mainly near the tops and edges of the crystal. Layer-by-layer growth according to this mechanism proceeds from the edges to the centers of the faces, causing specific morphological manifestations of layer-by-layer growth. As a result of high saturation and high speed of two-dimensional nucleation, the growth layers break off before reaching the center of the growth face. They are overlapped by successive layers, the result of which is the edge growth of crystals. This leads to the destruction of flat faces and the appearance of dendrite-like skeletal forms and the splitting of crystals. In conditions of very high supersaturation, the presence of both chemical and mechanical impurities (primarily organic matter), low temperature of the environment, the crystallized face will lose its stability and break up into a series of differently oriented microblocks.

Urinary stone spherulites, as a rule, are heterogeneous. Several zones are usually distinguished in their structure. The zonal structure is formed by the alternation of essentially mineral and mainly organic layers, as well as mineral layers of different composition. Layering can be observed at different levels of research — during the visual study of samples of large stones, and in the process of studying some areas of the samples. The layered structure in urinary stones of the spherulite type is recorded most clearly, somewhat worse - in granular aggregates. The central ("nuclear") part of such uroliths is most often represented by an accumulation of organic matter, which plays the role of a kind of "seed". In this case, the spherulite first forms as a polycrystalline aggregate of several split individuals. The sub-individuals that make up the spherulite have a conical shape, but in the process of increasing the splitting intensity, they interact with each other, obeying the law of geometric selection. Optimally oriented individuals, the elongation of which coincides with the radius of the future spherulite, will later transform into the thinnest fibers.

Conclusions. The size, shape, mineral composition and structure of the uroliths of residents of the Dnipropetrovsk region are quite diverse. Most often, spherulites and drusen-like aggregates, as well as their combinations, occur. Areas of attachment to renal papillae are usually observed on the surface of spherulite formations of urinary stones. As a rule, drusen aggregates are formed in the free space of the renal pelvis. The presence of 15 mineral species was established in the composition of kidney stones using optical petrography methods, among which oxalate and urate compounds predominate. Monomineral formations occur very rarely — less than 1%. The central part of uroliths is usually represented by accumulations of organic matter containing finely dispersed mineral components. A characteristic feature of all mineral individuals without exception is their multi-scale microblocking and the presence of inclusions of organic matter.

Oje, a complex of various-scale studies, combining the morphological analysis of the sample and its petrographic study, aimed at identifying the structural features and mineral composition of the urolith, makes it possible to confidently establish the main regularities of its ontogenesis and to determine an adequate and unambiguous decision in the choice of methods and methods of prevention of this disease and metaphylaxis relapses of stone formation.

References:

1. Ішков В.В., Козій Є.С., Труфанова М.О. Особливості онтогенезу уролітів жителів Дніпропетровської області. *Мінералогічний журнал Mineralogical journal (Ukraine). 2020. 42, № 4.* С. 50-59.
2. Barannik C., Ichkov V., Molchanov R., Barannik S. Signification pratique des caractéristiques de la composition et de la structure des pierres d'urée chez les résidents de la région industrielle développée. *The XXI International Scientific and Practical Conference «Actual priorities of modern science, education and practice», May 31 – 03 June, 2022, Paris, France. 873 p.* P. 410-414.
3. Barannik K., Molchanov R., Barannik S. Practical significance of the features of lithogenesis of ureatic stones in residents of the developed industrial region, patients with urial stone disease. *II International Scientific and Theoretical Conference (Vol. 3), June 24, 2022. Helsinki, Republic of Finland: European Scientific Platform. 110 p.* P. 40-44.
4. Barannik K., Molchanov R., Barannik S., Kasparova M. The practical significance of preliminary study of the chemical scale, structure and strength of urinary stones for choosing a rational method of their destruction. *The current state of development of world science: characteristics and features: collection of scientific papers «SCIENTIA» with Proceedings of the III International Scientific and Theoretical Conference, August 5, 2022. Lisbon, Portuguese Republic: European Scientific Platform. 200 p.* P. 153-157.
5. Barannik C., Molchanov R., Barannik S., Kasparova M. Practical significance of chemical composition, structure and strength of urinary stones for choosing a rational method of their destruction. *International scientific journal «Grail of Science» | № 20 (September, 2022)*. P. 170-177.
6. Barannyk K., Balalaev O., Ishkov V., Molchanov R., Barannyk S. Complex determination of the identification of urinary stones in patients residents ofthe industrial region. *International scientific journal «Grail of Science» | № 24 (February, 2023).* P. 669-676.
7. Barannyk K., Ishkov V., Molchanov R., Barannyk S. Features of the structure of urinary stones in residents of industrially developed regions suffering from oxalate urolithiasis. *Theoretical and practical aspects of modern scientific research:II International Scientific and Practical Conference, Seoul, April 28, 2023. Seoul-Vinnytsia: Case Co., Ltd. & European Scientific Platform*, 2023. P. 229-232.
8. Irwin Tadeo Rodriguez-Plata, Marta Medina-Escobedo, Mario Basulto-Martinez, Azalia Avila-Nava, Ana Ligia Gutierrez-Solis, Nina Mendez-Dominguez, Roberto Lugo. Implementation of a technique based on Hounsfield units and Hounsfield density to determine the composition of kidney stones. *Tomography*. 2021. *7* (4). 606-613.
9. Zhu Wang, Ying Zhang, Jianwen Zhang, Qiong Deng, Hui Liang. Recent advances on the mechanisms of kidney stone formation (Review). *International journal of molecular medicine 48: 149, 2021*. P. 2-10.