THE COMPOSITION OF KIDNEY STONES AND THE GEO-ENVIRONMENTAL INFLUENCE ON THEIR GEOGRAPHICAL DISTRIBUTION

Maria Luigia GIANNOSI & Vito SUMMA

Laboratory of Environmental and Medical Geology, IMAA-CNR, Tito Scalò (PZ), 85050, Italy
giannossi@imaa.cnr.it

Objective

The main goals of this study are:

1. to characterize the kidney stones from the Basilicata (southern Italy) inhabitants mineralogically and morphologically;
2. to identify the main types of kidney stones found in Basilicata;
3. to determine the presence of trace elements in the stone structure;
4. to analyze the geo-environmental factors which can influence their formation.

Methodology

STONE ANALYSIS on 80 kidney stones

Optical microscopy Scanning electron microscopy X-ray powder microdiffraction

Optical and atomic absorption spectrometry

Mineral names Formula N. samples (%)

Weddellite CaC₂O₄ * H₂O 49 (38%)
Whewellite CaC₂O₄ * 2H₂O 30 (23%)
Calcium oxalate CaC₂O₄ 26 (21%)
Hydroxyapatite Ca₁₀(OH)₆(PO₄)₄ 6 (5%)
Struvite MgNH₄PO₄ * 6H₂O 5 (4%)
Silvite Mg₂(NH₄)PO₄ * 5H₂O 3 (2%)
Cystine C₆H₁₂N₂O₂ 3 (2%)
Uric Acid C₅H₄N₄O₃ 19 (15%)

The composition of kidney stones can be classified into two groups, an organic matrix mainly containing proteins (solids, carbohydrates and cellular components, and biomolecules).

Trace elements

This study confirms the presence of some foreign elements in the kidney stone structure. Three main findings emerge from the results:

1) Most kidney stones collected have high concentrations of elements such as K, Cu and Mg and a low content of Fe when compared to the results obtained from other research activities;
2) appreciable amounts are found in inorganic phases (calcium oxalate + phosphates), whereas only 26% content is in organic phases (uric acid and cystine);
3) among calcium-based stones (more abundant), the calcium-phosphate ones contain greater amounts of trace elements than the calcium-oxalate ones, and among the calcium-oxalate ones whewellite relates more trace elements than whewellite.

Kidney stones classification and geographical distribution

Kidney stones with similar compositions may have a compact, disordered or layered internal structure, with a different reaction to the Extracorporeal Shock Wave Lithotripsy treatment.

Core

There are usually more cones within whewellite kidney stones. Cones appear as spheroidal aggregates, that is the form which best adapt to non-equilibrium conditions. Simultaneous crystallization and oscillation between growth and dissolution events contribute to stone formation. The chromatic differences observed correspond to the microcrystallites of growth where small whewellite crystals and organic matter become the core of new growth.

Internal structure

Kidney stones composed of whewellite appear like small spheroids that develop in kidney cavities with poor urinodynamic efficacy. The interior appears homogenous and consists of closely packed fine whewellite crystals that form concentric laminae grown on central core.

Kidney stones composed of uric acid are typically more disorganized and compact. They can be related to a higher calcium absorption.

A comparison between the regional and international prevalence rates (in the absence of national data) leads to interesting observations:

1) In the Basilicata community there is a larger number of uric acid kidney stones (18%) and a lower quantity of those composed of calcium phosphate, which may be related to some specific risk factors mainly referable to dietary habits such as an excessive consumption of proteins and a consumption of soft water with a low bicarbonate content, which does not facilitate urine alkalinisation.
2) This could justify the geographical distribution of uric acid kidney stones found exclusively in the northern region, an area with a predominant soft water and characterized by a low solar radiation and average temperatures lower than in the rest of the region. All these factors do not facilitate either fluid intake or a higher calcium absorption.

Conclusion

This scientific activity is a first example of Italian study of kidney stones carried out at regional level with a multidisciplinary approach which enabled significant achievements in the field of human health protection.

The chemical-mineralogical and petro-morphological analysis performed with integrated techniques on a large number of kidney stones made it possible to gather useful information for the identification of the prevalent stone types and the definition of some geo-environmental risk factors. This morpho-compositional data are useful for classifying each type of kidney stone, and, therefore, each patient in more than 30 different subgroups characterized by specific etiologic factors necessary to determine the treatment and disease prevention, especially in the presence of mixed stones requiring proper intervention for each mineral phase present. Several kinds of kidney stones with a new mineral assemblage have been found, which is a further step forward in the understanding of this widespread disease as well as an encouragement to carry out additional research activities.

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