Chapter 22
Stone Analysis

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Abstract Stone analysis remains as an essential part of both initial evaluation and follow-up of patients with urolithiasis. For the most detailed analysis, the entire stone should be used. There is currently no standard method accepted for stone analysis. There are concerns about the accuracy of commercial laboratory results due to considerable variability in mixed calculi analysis reports. Besides the techniques described here, there are promising new technologies being developed.

Keywords Stone analysis

Introduction

The formation of a stone within the kidney occurs as a result of pathologies in various steps of ion metabolism. Despite advances in our understanding of the underlying pathophysiology

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Table 22.1 The chemical name and mineral name of the most common type of kidney stones are listed

Chemical name	**Mineral name**
Calcium oxalate monohydrate	Whewellite
Calcium oxalate dehydrate	Weddellite
Calcium hydrogen phosphate dehydrate	Brushite
Tricalcium phosphate	Whitlockite
Basic calcium phosphate	Apatite
Carbonate-apatite	Carbonate-apatite
Magnesium ammonium phosphate	Struvite
Cystine	
Uric acid	

of stone formation, the exact mechanism is still unclear. Therefore, determination of stone composition plays a key role in understanding abnormalities leading to the stone development process.

Stones are mainly composed of inorganic crystalline stone (95 %) and organic-matrix cellular components (5 %) [7]. Varying amounts of crystalline materials may be detected in multicomponent kidney stones. By contrast, the stone type known as a “matrix stone” consists entirely of an organic matrix. Determination of the types and amounts of each component helps to identify the condition and, consequently, the proper medical treatment. Despite advances in minimally invasive treatment methods, medical treatment is essential in preventing stone recurrence. Table 22.1 lists the most common components of human kidney stones.

Why Stone Analysis?

Stone analysis is used to evaluate and identify the specific conditions that led to formation of the stone. For example, stones containing calcium likely result from a condition related to calcium metabolism, while a stone containing cystine could suggest cystinuria. The presence of different types of components may be associated with multiple pathogenesis mechanisms. For this reason, stone analysis could be thought of as a "biochemical biopsy" of the urinary tract [3]. Stone analysis may also provide information about the urinary tract environment. A stone containing magnesium ammonium phosphate, for example, points to the presence of a urease-producing bacterial infection of the urinary tract. A new stone occurring in a treated patient can be analyzed to determine the treatment efficacy. A case in which a newly formed calcium phosphate stone is detected in a patient who formerly had a cystine/uric acid stone likely indicates an overdosage of alkali therapy.

Identification of stone composition may help in choosing future management options. A stone analysis that detected cystine and calcium oxalate monohydrate would contraindicate shockwave lithotripsy (SWL) for the treatment of residual fragments [4]. Detection of drug metabolites such as triamterene, indinavir, and some antacids that lead to stone formation can all lead to treatment modifications to prevent stone recurrence [4]. In addition to other benefits, stone analysis can be used to show epidemiological trends [9].

Techniques of Stone Analysis

There are two main types of analysis methods: (1) simple wet chemical analysis and (2) more complicated techniques, such as polarized microscopy, X-ray diffraction crystallography, infrared spectroscopy, scanning electron microscopy, and thermogravimetry.

Wet Chemical Analysis

This technique subjects the stone solution to quantitative analysis via the same standard biochemical methods used for analysis of blood and urine. Although it is the most widely used method in routine laboratories, it has several limitations, including the requirement for at least 15 mg of stone material and its tendency to miss rare or unidentified substances. It also has generally poor performance. The efficacy of this method can be improved by using a quantitative wet chemical approach [1, 3].

Optic Polarizing Microscopy

This method uses a polarizing microscope to assess crystals removed from different locations on the stone according to their characteristics (e.g., color and refraction of light) [10]. This method is cost-effective and allows for rapid analysis of small, simple particles. Limitations of the technique include the difficulty of identifying some special cases (e.g., stones containing uric acid, purine derivatives, or calcium phosphate), difficulty in identifying stones with mixed compositions, and the need for specialized training on the part of the analyst [1, 10].

X-ray Diffraction

In this procedure, the analyst determines the composition of the stone by observing diffraction patterns made when the crystalline material is exposed to X-ray bombardment. The main advantages include ease of preparation, automated measurement, quantitative analysis, and exact identification of all components. Limitations include high cost and the inability to detect non-crystalline or amorphous substances [1, 4, 9, 10].

Infrared Spectroscopy

In this technique, components are identified according to their interactions with infrared radiation. Benefits include moderate cost, fast sample turnaround, and the ability to identify the constituents of small pieces of sample and of organic samples. Limitations include difficulty in identifying uric acid, purine and calcium phosphate stones, as well as any components that are present in small quantities [1, 4, 9, 10].

Scanning Electron Microscopy

This non-destructive method is based on the evaluation of the specific morphology of calculi, but limitations include high cost and the need for a dedicated staff.

Thermogravimetry

In this technique, the stone material is determined from both weight and from the change in enthalpy while increasing the temperature up to 1000 °C. It is a fast and simple method, but is destructive and requires a large amount of material.

Conclusions

Stone analysis remains as an essential part of both initial evaluation and follow-up of patients with urolithiasis. For the most detailed analysis, the entire stone should be used. There is currently no standard method accepted for stone analysis [5]. There are concerns about the accuracy of commercial laboratory results due to considerable variability in mixed calculi analysis reports [5,6]. Besides the techniques described, there are promising new technologies being developed [2, 8].

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