PETROGRAPHIC ANALYSIS OF URINARY CALCULI

Thesis

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INTRODUCTION

Stone formation represents a problem that should be dealt with in our area . The research work in Egypt should be directed to lithiasis as one of its objectives.

Therefore this work aims at determining the constituents of urinary calculi by both chemical and petrographic analysis, with a great concern to the advantages and disadvantages of each.

Also an attempt is made to find a correlation between metabolic disorders and stone formation.

On the other hand another trial is made to explain the different mechanisms which help growth and shaping of urinary calculi . Knowing such processes may assist the clinicians to find preventive measures that can minimize the incidence of stone formation .

Review of Literature

Therefore when the amount of a substance in urine can be increased to a point at which urine will no longer hold it in solution spontaneous nucleation of crystals then begins.

2- Matrix Nucleation Theory.

Boyce & Sulkin (1956) stressed matrix formation as the original event in calculogenesis. They regarded all urinary calculi as comprising an organic matrix, forming 2.5% of the weight of calcium containing stones, with various amounts of crystalloids deposited within the matrix. They postulated that the mucoprotien matrix of calcium stones might be responsible for stone formation by causing nucleation and facilitating crystal growth. Furthermore they pointed out that no concretion is ever formed as a sedimentary mass of crystals, since the architectural features opf calculi can only result from deposition of crystals upon or within a preformed matrix.

3- CRYSTALLIZATION - INHIBITOR THEORY:

An alternative theory of stone formation assumes that urine is always supersaturated with respect to the stone forming salts and postulates that subjects are only protected from stone formation by the passage in thier urine of certain crystallization inhibitor.

It is suggested that stone forming patients have a reduced protection from crystalluria because of decreased excretion of these inhibitors.

4- EPITAXY:

One other aspect of crystallization that has received considrable attention is epitaxy.If a crystal has a pattern or organization of ions that is reguler and predictable,this structure is called a lattice.this surface lattice may resemble very closely that of a second but different type of crystal depending on the closeness of resemblance,the second type of crystal may actually be able to grow on the surface of the first, calcium oxalate and uric acid do have crystal lattices that are similar enough to permit this process of epitaxy, i.e.the deposit of one type of crystal upon the surface of another.

Drach (1978) attempted to combine all the elements discussed previously to explain stone formation. Therefore he pointed out four requirements.

1- Renal function must be adequate for the excretion of excess amount of crystallizable substances.

2 The kidney must be able to adjust its ph excretion to conform to that required to crystallize the substances.

3- The urine must have a complete or relative absance of a number of inhibitors of crystallization of the crystallizable components.

4- The crystal mass must reside in the urinary system for a time sufficient to allow growth or aggregation of the crystal mass to a size large enough to obstruct the urinary passage through which it is proceeding.

Structure and Composition of Urinary Calculi

Urinary calculi are studied and analysed by many techniques such as chemical analysis, and/or physical methods as petrographic microscopy,x-ray diffraction,infrared spectroscopy and electron microscopy.
aiming at a better understanding of stone formation and prevention.

Crystalline Constituent

Stones vary widely in thier composition.many components may combine in a single stone while other stones may contain just one component.

1- Calcium Oxalate.

Is the most common stone forming compound, which usually occurs as one or both of its hydrates. Calcium oxalate can occur either in the nucleus, intermediate zone or the surface of the stones, and it is frequently a major constituent of all layers (Lonsdale et al,1968).

Four types of oxalate stones are described (Prien and Frondel, 1947). The smooth suraface hempseed stone, the mammillated mulberry stone, the spiculated jack-stone and the coarsely crystallized stone. They found that calcium oxalate monohydrate which is the most common single crystalline compound forming urinary stones they found it to be the major constituent of the first three types while the fourth is composed of dihydrate form that usually occurs as an external coat.

2- Phosphates.

Five distinct phosphatic compounds were demonstrated by Prien (1963). These compounds are, magnesium ammonium phosphate hexahydrate, hydroxyl apatite carbonate apatite, ca hydrogen phosphate dihydrate and tricalcium phosphate.

Magnesium ammonium phosphate hexahydrate is found to be either associated with carbonate apatite or rarley present in pure calculi.
One of the well knwon stones containing such a combination is the staghorn stone, that usually develops in infected , alkaline urine.

Hydroxyl and carbonate apatite are the urinary members related to the apatite family, and they are the most frequent stone forming phosphates.

Hydroxyl apatite is found to be a frequent associate of compounds that precipitate in acid urine, especially calcium oxalate(Prien and Frondel, 1947), being secondarly deposited on the surface or incorporated within the interior of the calculus.

On the other hand ,carbonate apatite shows a particular affinity to be associated with struvite which occurs in infected alkaline urine.

Ca hydrogen phosphate dihydrate is considerd to be an acid phosphate, which explains its tendancy to co-exist with ca oxalate, hydroxyl apatite, uric acid and cystine, which precipitate in acid urine.

Tricalcium phosphate is a relatively uncommon constituent of phosphatic stones.

3- Uric Acid.

Uric acid stones are more commonly present in a pure form rather than being mixed with other constituents as ca oxalate monohydrate, and hydroxyl apatite which are the most common associates of uric acid in calculi of mixed composition.

In these mixed stones uric acid may either form the nucleus while the other constituents form the main bulk or it may appear as featurless patches throughout the stone.

4- Urates.

The acid salts of sodium and ammonium urates share in the formation of urinary calculi (Prien and Frondel , 1947), both of them are uncommon constituents. Generally urates are intimately mixed with other stone constituents especially the calcium oxalate.

5- Cystine.

Cystine usually forms pure urinary calculi, but sometimes it is found mixed with apatite, and rarely calcium oxalate monohydrate(Prien,1949).

6-Xanthine.

They are extremely rare and usually found in admixture with uric acid to which it bears an apparent similarity, that makes them indistinguishable.

The Matrix of Renal Calculi

In every humen urinary concretion the matrix is present from center to surface(Boyce,1969).

1- BIOCHEMICAL COMPOSITION.

According to Boyce & Garvey (1956) matrix is composed nearly of two thirds mucoprotien and one third sulfated mucopolysaccharide. The protien content is 64%, non amino sugars 9.6%, amino sugars 5% and bound water 10%, the remainder is organic ash as calcium and phosphate.

2- MOLECULAR COMPOSITION OF MATRIX.

a- MATRIX SUBSTANCE A.

It is an immunologically distinct component of the organic matrix of human renal calculi.

Boyce (1969) postulated that it is apparently of renal origin as it is immunologically detected in renal tissue from patients with renal calculi.

b- ALBUMIN.

It is a constant component of calculus matrix and it is a relatively minor component as judged by immunological assay and biochemical analysis of matrix.

c- ALPHA GLOBULINS.

Patients with urinary calculi exhibit an absolute and relative increase in the alpha globulins.

d- GAMMA GLOBULINS.

These relatively large molecules are found to increase five fold in strile urine in patients with calculi and a fifteen fold increase from the normal in calcular disease patients with bacterial infection.

e- UROMUCOID & TAMN HORSFALL MUCOPROTIEN.

This mucoprotien is increased as much as ten fold in the urine of stone formers .(Boyce,1969) .

Growth of Renal Calculi

Growth of renal calculi is related to the fact that once nucleation has occurred in a complex solution such as urine, certain nuclei may continue to grow if the urine remains supersaturated.

The process of stone growth is usually either by epitaxy or cohesion.

Epitaxy:

If a crystal has a pattern or organisation of ions that is regular and predictable, this structure is called a lattice. this surface lattice may resemble very closely that of a second but different type of crystal. Depending upon the closeness of resemblance the second type of crystal may be able to grow upon the surface of the first (Lonsdale,1968;Sutor & Wooly,1972).

In the presence of a potential nucleus, precipitation of a stone forming compound from saturated or supersaturated urine will readily follow, provided that there is an epitaxial relationship. This epitactic deposition explains the textural features that might be visualized on dissection of calculi.