

THE STRUCTURE OF LARGE LAMELLAR URINARY STONES

A quantitative chemical analytic study applying a new classification scheme

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Abstract. To study the structural composition of 61 renal and 9 vesical large lamellated non-infection urinary tract stones, samples from successive layers were quantitatively analyzed with standard chemical techniques, but with a new classification based on percentage composition of ions rather than compounds. The commonest pattern of composition ($n=41$) was that of the lamellar stones of one stone type (uric acid, oxalate, or phosphate) and group (according to % of indicating ion), followed by bilamellar stones of different stone types (17) or of one stone type but different groups (8). The other stones were trilamellar (3) or quadrilamellar (1) of different stone types. In the 29 stones with lamellae of different type and/or group, the chemical composition of successive layers seemed to confirm the correlation between uric acid and oxalate, rather than phosphate, ions and between oxalate and both uric acid and phosphate ions. An influence on these correlations either positive or negative, may be the responsible factor for specifying the type and group of a forming stone or layer of a stone. The observed ionic correlations within the stones seem to support the choice of the oxalate ion, in the uric acid or phosphate stones, and both of the uric acid and phosphate ions, in the oxalate stones, as indicating ions for grouping in our proposed classification of urinary stones.

Key words: non-infection urinary stones, percentage ionic composition, stone classification, lamellar chemical structure.

In studying the relationship between adjacent constituents of urinary stones, stages of stone formation and the changes occurring during growth of stone, many authors, using various analytical methods, stressed the importance of examining different parts of the stone separately (4–7, 10, 11, 13, 14, 17–19).

Such structural analysis would, it was hoped, increase understanding of the physico-chemical events necessary for stone formation and development. Interpretation of results and comparison between studies were hampered, however,

by differences in criteria for classifying stones (13) and because the minor components tended not to be taken in consideration (4, 13, 15).

Use of quantitative chemical methods necessitates considerable calculations based on certain assumptions in order to arrive at estimates of compound composition. Several classification schemes have been suggested (9, 12, 21), but comparison between results are impeded by differences in the manner of presenting the findings from chemical analysis (13).

We have proposed a different scheme for classifying urinary stones, based only on the percentage composition of the detected ions, without need for such cumbersome calculations which introduce an element of uncertainty (13). Contrary to the common practice of disregarding minor components, with limit set at 10% or 25% in all other classifications, we specified and considered the trace and minimum amounts of the present ions.

This paper reports the application of our classification scheme in studying the structure of 61 renal and 9 vesical large lamellar stones.

MATERIAL AND METHODS

Analytical methods

The stones were washed with distilled water (to remove blood or attached tissues) and dried—unlike earlier practice (7, 11)—in an oven to 60°C for 5 hours or overnight, so as to avoid the probable water loss at higher temperature (10, 16) or in longer heating at lower temperature (20).

All the stones weighed more than 200 mg and showed variations in density on plain radiographs. Each stone was split into two parts using a chisel and scalpel as personal experience showed that sawing whether electrical (17) or manual (10, 11) led to mixing of the different layers. Then using a scraper and small blunt curette, samples were taken from a central

Table I. Identification of urinary stones types by % of characterizing ions and further grouping by % of indicating ions

Stone type	Characterizing ion (%)		Stone groups ^a	Indicating ion (%)	
1. Uric acid (Ur)	Uric acid	≥20	UrI1	Oxalate	<40–>33
			UrI2	Oxalate	33–>21
			UrI3	Oxalate	21–10
			UrI4	Oxalate	<10
2. Oxalate (Ox)	Oxalate	≥40	OxI1	Uric acid	<20
			OxI2	Phosphate	<20
			OxI3	Uric acid & phosphate, each	<20
3. Phosphate (Ph)	Phosphate	≥10 & Uric acid <20 & Oxalate <40	PhI1	Oxalate	<40–10
			PhI2	Oxalate	<10

^a I denotes category I (non-infection) stones, distinguished from category II (infection) stones.

and a peripheral lamella in 66 stones, while from the other four stones one or two additional samples were taken from an intermediate layer.

All the samples were subjected to wet chemical analysis for the determination of oxalate (22) and phosphate (3) in sulphuric acid digest. Urates and xanthine were measured in a lithium carbonate digest (8). Calcium and magnesium were determined by the inductively coupled plasma atomic-emission spectrometry.

Classification of stones

As shown in Table I, the identification of the three types of urinary calculi was based on the percentage composition of their characterizing ions. Thus, stones were classified as uric acid when the uric acid radicle was ≥20%, as oxalate when oxalate radicle was ≥40%, and phosphate when the phosphate content was ≥10% with uric acid <20% and oxalate <40%.

Furthermore, the stones were defined as category I in our classification, viz non-infection stones (I) being distinguished from infection stones (category II) by

their content of magnesium. Unlike category I stones, category II contain ≥3% magnesium.

In these category I stones, the characterizing ion of one type, at a different percentage of composition, was the indicating ion for grouping in another type (Table I). Accordingly the category I uric acid stones, which constantly contained trace amounts (<2%) of phosphate radicle and variable amounts of oxalate (up to <40%) were subdivided into the four groups UrI1, UrI2, UrI3, UrI4 depending on the percentage content of the oxalate radicle (Table I).

The identified category I oxalate stones constantly contained radicles other than the oxalate viz. uric acid and/or phosphate. In the present classification, therefore, stones of the oxalate type were grouped (Table I) according to whether they contained uric acid (OxI1) or phosphate (OxI2), or both (OxI3). In all these stones, the uric acid or phosphate was <20%.

The identified phosphate samples contained minimal amounts (2–10%) of uric acid and variable amounts of oxalate radicle. In our classification, therefore, the non-infection phosphate stones were

Table II. Structural patterns of chemical composition in 70 lamellar urinary stones^a

No. of lamellae	Stone types	Stone groups	No. of stones		
			Renal	Vesical	Total
2	Alike	Alike	34	7	41
2	Alike	Unlike	7	1	8
2	Unlike	...	16	1	17
3	2 types	...	3	0	3
4	2 types	...	1	0	1

^a Definitions of stone types and groups in Table I.

Table III. Lamellar stones of one type and group^a

Chemical analysis		No. of stones		No. of samples from stones	
Nucleus	Shell	Renal	Vesical	Renal	Vesical
UrI3	UrI3	2	–	4	–
UrI4	UrI4	5	1	12	2
OxI1	OxI1	1	–	4	–
OxI3	OxI3	20	6	43	14
PhI1	PhI1	3	–	7	–
PhI2	PhI2	3	–	6	–

^a Stone types and groups defined in Table I.

grouped as PhI1 or PhI2, according to the percentage composition of the observed oxalate radicle (Table I).

Stone samples were labelled in accordance with this classification, using an abbreviation Ur (uric acid), Ox (oxalate) or Ph (phosphate), followed by I to denote non infection stone (II would have denoted infection stone), and then an Arabic numeral to indicate the stone group as shown in Table I.

RESULTS

As shown in Table II, the commonest pattern of stone composition, was bilamellar stones of one stone type and group ($n=41$) followed by bilamellar of different stone types ($n=17$). The least common (1 stone) was the quadrilamellar stone of mixed type.

The varieties of the structural patterns of chemical composition in these large lamellated urinary stones are detailed in Table III–VI. All the stones were of the non-infection type (category I). No more than two stone types were involved in the composition of any of the lamellar stones of different stone types (Tables V–VI). Therefore, in the three-lamellae and four-lamellae stones of different stone types

(Table VI) more than one group of any of the stone types involved were present.

According to the patterns of chemical composition shown in the lamellar stones of single stone type but different groups (Table IV) and in all the varieties of the different-type lamellar stones (Tables V–VI) it seemed that UrI1 or UrI2 uric acid layers were usually succeeded by a layer of oxalate stone type (especially group OxI3, less commonly OxI1). Succession by a phosphate layer (PhI2) was rare and occurred when the uric acid lamella contained 2–10% phosphate rather than the usual trace (<2%). The layer adjoining UrI3 or UrI4 layers, on the other hand, usually was of uric acid UrI2 or UrI3 (containing a higher percentage of oxalate) or oxalate (OxI3) type and rarely a phosphate (PhI1) layer when the uric acid lamella contained somewhat more than the usual trace of phosphate.

An oxalate OxI1 layer (contains uric acid radicle) was succeeded by a uric acid (UrI4) layer, and an OxI2 (contains phosphate radicle) by one of OxI3 (Table VII), whereas OxI3 lamellae (containing both uric acid and phos-

Table IV. Lamellar stones of one type but different groups^a

Chemical analysis		No. of stones		No. of samples from stones	
Nucleus	Shell	Renal	Vesical	Renal	Vesical
UrI4	UrI3	1	1	2	2
OxI2	OxI3	1	–	2	–
OxI3	OxI1	3	–	6	–
PhI1	PhI2	2	–	4	–

^a Stone types and groups defined in Table I.

Table V. Bilamellar stones of different types^a

Chemical analysis		No. of stones		No. of samples from stones	
Nucleus	Shell	Renal	Vesical	Renal	Vesical
UrI1	OxI3	1	–	3	–
UrI2	OxI3	1	1	3	2
UrI2	OxI1	1	–	2	–
UrI4	OxI3	2	–	5	–
UrI2	PhI2	2	–	4	–
OxI3	PhI1	1	–	2	–
OxI3	UrI4	2	–	4	–
OxI1	UrI4	1	–	2	–
PhI1	OxI3	3	–	6	–
PhI1	OxI2	1	–	3	–
PhI2	OxI3	1	–	2	–

^a Stone type and groups defined in Table I.

Table VI. Trilamellar or quadrilamellar stones of different stone types^a

Chemical analysis			No. of stones	No. of samples from stones	
Nucleus	Midzone	Shell	Renal	Renal	
<i>Trilamellar</i>					
UrI4	PhI1	PhI2	1	4	
PhI1	OxI3	PhI1	1	3	
OxI3	UrI3	UrI2	1	3	
<i>Quadrilamellar</i>					
OxI3	UrI4	UrI3	OxI3	1	4

^a Stone types and groups defined in Table I.

phate radicles) were succeeded by another oxalate (OxI1), or by uric acid (UrI3 or UrI4) or phosphate (PhI1). Lamellae of phosphate group PhI1 or PhI2 were succeeded mostly by a lamella of oxalate (OxI2 or OxI3), and less commonly by a phosphate layer of a different group.

This chemical composition pattern of successive layers in the lamellar stones was also observed in the successive stones passed by individual recurrent stone-formers. Thus, one patient passed a lamellar stone of uric acid nucleus and oxalate shell, then a one-layer stone of oxalate type. Another patient first passed uric acid stones of group UrI4 (oxalate content <10%) and thereafter uric acid stones of groups with a higher oxalate content. Four

Table VII. Distribution of 29 stones (25 bilamellar, 3 trilamellar, 1 quadrilamellar) by lamellar chemical composition^a

First-formed layer	Adjoining layer								
	UrI1	UrI2	UrI3	UrI4	OxI1	OxI2	OxI3	PhI1	PhI2
UrI1	–	–	–	–	–	–	1	–	–
UrI2	–	–	–	–	1	–	3	–	2
UrI3	–	1	–	–	–	–	–	–	–
UrI4	–	1	2	–	–	–	2	1	–
OxI1	–	–	–	1	–	–	–	–	–
OxI2	–	–	–	–	–	–	1	–	–
OxI3	–	–	1	3	3	–	–	2	–
PhI1	–	–	–	–	–	1	4	–	3
PhI2	–	–	–	–	–	–	1	–	–

^a Stone types and groups defined in Table I.

more recurrent stone formers passed a total of 9 successive stones of the same type and group (OxI3).

DISCUSSION

The chemical composition of the adjoining lamellae, not only in all lamellar stones of one type but different groups and all those of different stone types, but also of the successive stones from recurrent stone formers, seems to confirm our previous suggestion (paper submitted to *Scandinavian Journal of Urology and Nephrology* 1992) of a relationship between the uric acid ions and the oxalate rather than the phosphate ions. An influence on these correlations, either positive or negative, may be the responsible factor for specifying the type and group of a forming stone or layer of a stone.

Furthermore, the mentioned ionic correlations within the stones seem to support our choice of the oxalate ion, in the uric acid or phosphate stones, and both of uric acid and phosphate ions, in the oxalate stones, as indicating ions for grouping in our proposed urinary stone classification (1, 2 and paper submitted 1992).

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