Introduction

Urinary stones

- belong to the group of biominerals
- are the final product of a multifactorial process
- the stone is the symptom, not the disease itself

Symptoms of different abnormalities

- occur today with a prevalence of 4–10%, which is steadily increasing
- regional differences are important to acknowledge

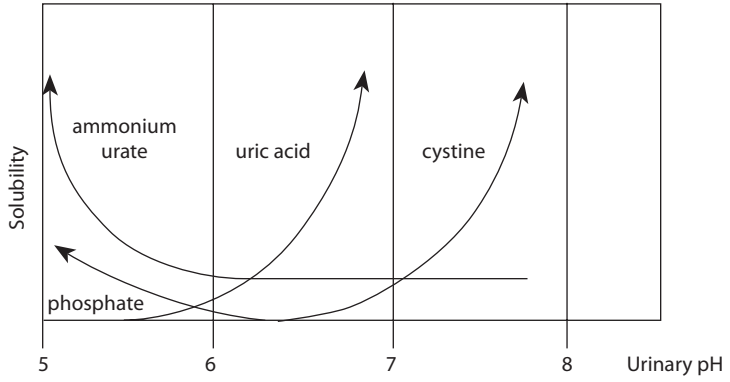
Widespread disease

- the recurrence rate which depends on the stone composition is 50–100% in untreated patients and 10–15% in treated patients

Metaphylactic treatment is undoubtedly necessary

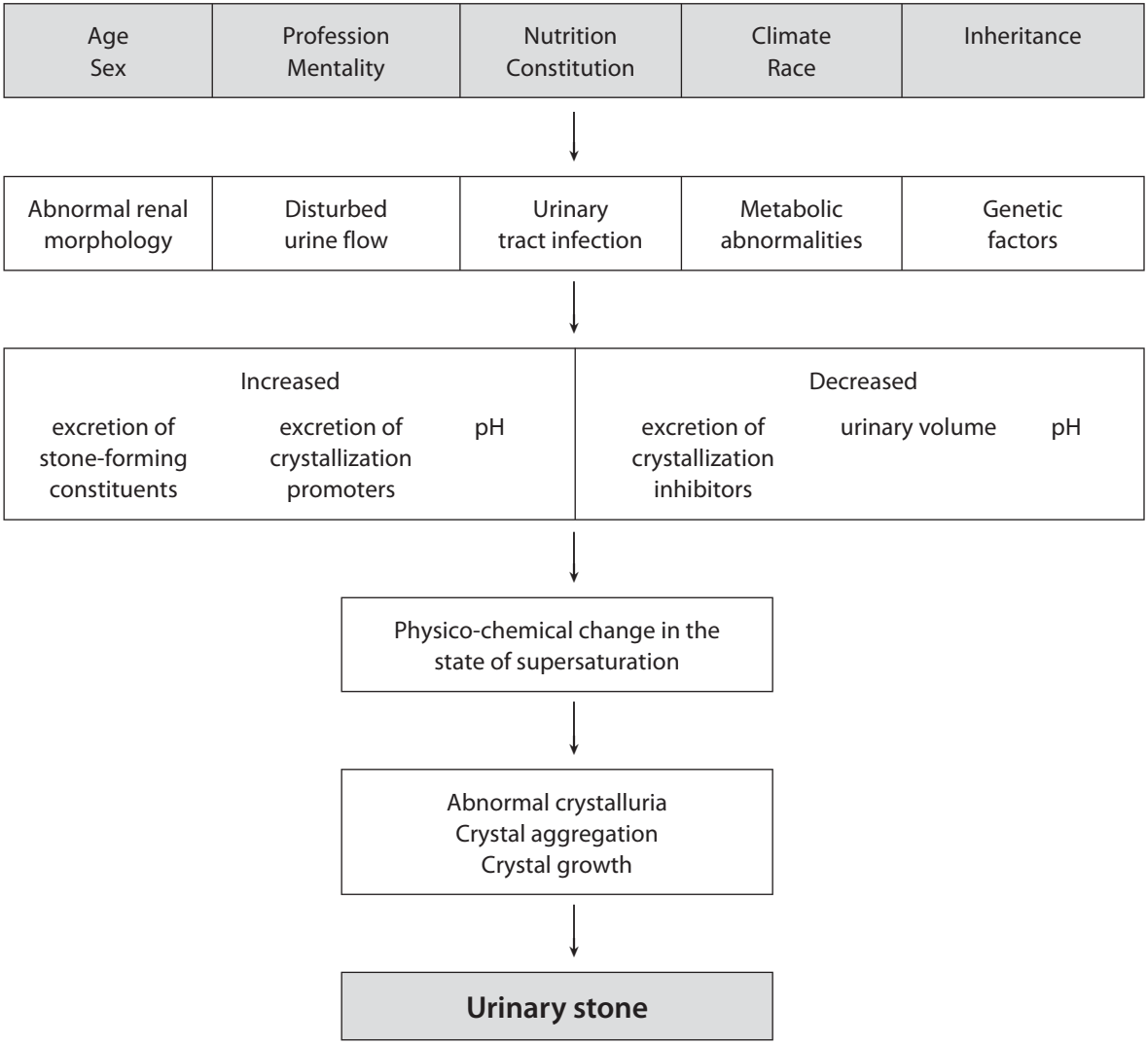
Formation of urinary stones

The biomineralization resulting in a urinary stone has a multifactorial origin in which socio-economic, genetic and constitutional factors as well as diet, pharmacologic treatment and metabolic abnormalities might act in concert.
A supersaturation of urine with the stone-forming salt(s) is of fundamental importance and a prerequisite for the necessary precipitation. The solubility of the different stone components depends on the urinary pH and the excretion of other urine constituents. Accordingly, a saturation of urine above the solubility product (SP) and the associated risk of crystallization are determined by the urinary concentration (mmol/l) of the solutes taking part in the crystal formation and the pH. When the SP has been exceeded, the supersaturation is metastable. At this level of supersaturation the crystals can grow and aggregate (agglomerate) but new crystal formation is not possible unless promoted in some way. In order to start the formation of new crystals, the supersaturation has to be further increased to a level termed the formation product (FP). The isolated findings of increased concentrations are not diagnostic for stone disease but might reflect only the concentration capacity of the kidney. Normal values of urine constituents are usually expressed as the total excretion during a 24h period or a fraction of a 24h period. In children the excretion values are normally expressed in mmol and mg/1.73 m^2 body surface area/day, or in mmol and mg/kg body weight/day, respectively. In infants and small children spot urines are analyzed and the substance concentration in urine is related to creatinine. Normal values are age-related and additionally given in mmol/24h and in mmol/kg body weight/24h (Appendix, tables 4–6).
There is often an overlap in terms of urine supersaturation between stone formers and normal subjects indicating that factors other than the supersaturation have to be considered in the process of stone formation. It is of note, however, that the urine composition obtained from 24h or similar collections might obscure term from peaks of supersaturation. Substances which inhibit the nucleation, growth and aggregation of crystals are thought to play an important role. Furthermore, anatomical and functional abnormalities might contribute either by fixation of crystals or by reducing their excretion. Such a retention of crystals is necessary for the development of a clinically significant crystalline deposit.



pH dependence of the urinary solubility of lithogenic substances

Formation of urinary stones



Location and form of urinary stones

Urinary stones occur in all parts of the renal collecting system. The sites of occurrence and formation are not necessarily identical. In the industrialized part of the world,

- *97% of all urinary stones are localized in the:*

parenchyma (collecting ducts)
papilla
calices
pelvis
pelvis + calices
ureter

- *only 3% are found in the bladder and the urethra.*

The anatomy of the collecting system at the site of stone development is an important determinant for the shape of the stone inasmuch as there frequently is an adaptation to the surrounding structures.

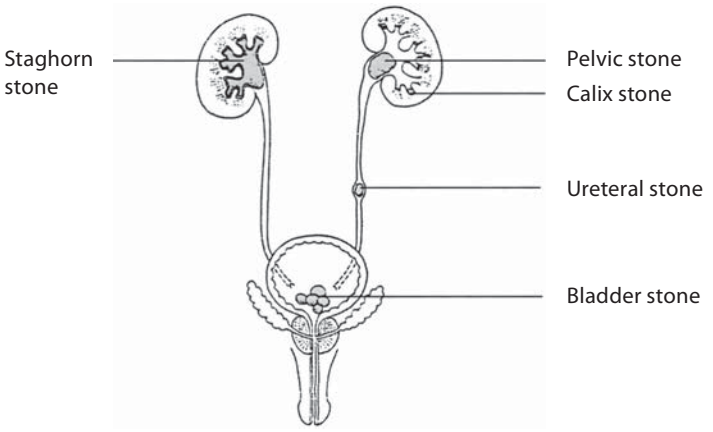
Composition and occurrence of the different crystal phases in urinary stones

Urinary stones belong to the group of biominerals. Different inorganic or organic substances with a crystalline or amorphous structure are the major constituents of the stones. Only about 1/3 of all urinary stones has a monomineral composition. There is frequently a structure with layers of varied composition or a homogeneous mixture of different crystal phases. Calcium oxalate is by far the most common stone constituent, and is considered to be the major mineral in at least 70% of all stones.

Stone type	Chemical composition	Mineral	Major constituent, % of cases
Oxalates	Calcium oxalate monohydrate Calcium oxalate dihydrate	Whewellite Weddellite	74.0
Uric acid and urates	Uric acid Uric acid dihydrate Ammonium urate (mono ammonium urate)	Uricite	11.0 1.0 0.5
Phosphates	Magnesium ammonium phosphate hexahydrate Carbonate apatite Calcium hydrogenphosphate dihydrate	Struvite Dahllite Brushite	5.8 5.0 1.5
Protein	Protein		0.5
Genetically determined stones	Cystine		0.5
	Xanthine 2,8-Dihydroxyadenine		rare
Drug stones	Indinavir Silicates Sulfonamides		

It is important to consider that the relative distribution of various stone constituents is subject to pronounced geographical variations.

Location and shape of urinary stones



Composition of the most important stone constituents

	Chemical name	Mineral name
Oxalate	Calcium oxalate monohydrate Calcium oxalate dihydrate	Whewellite Weddellite
Phosphate	Carbonate apatite Calcium hydrogenphosphate dihydrate Tricalcium phosphate Calcium hydroxyl phosphate Magnesium ammonium phosphate hexahydrate	Dahllite Brushite Whitlockite Hydroxyapatite Struvite
Uric acid, *Urate*	Uric acid Uric acid dihydrate Ammonium urate (mono ammonium urate) Mono sodium urate monohydrate	Uricite – – –
Stones associated with inborn errors of metabolism	L-Cystine Xanthine 2,8 -Dihydroxyadenine	– – –