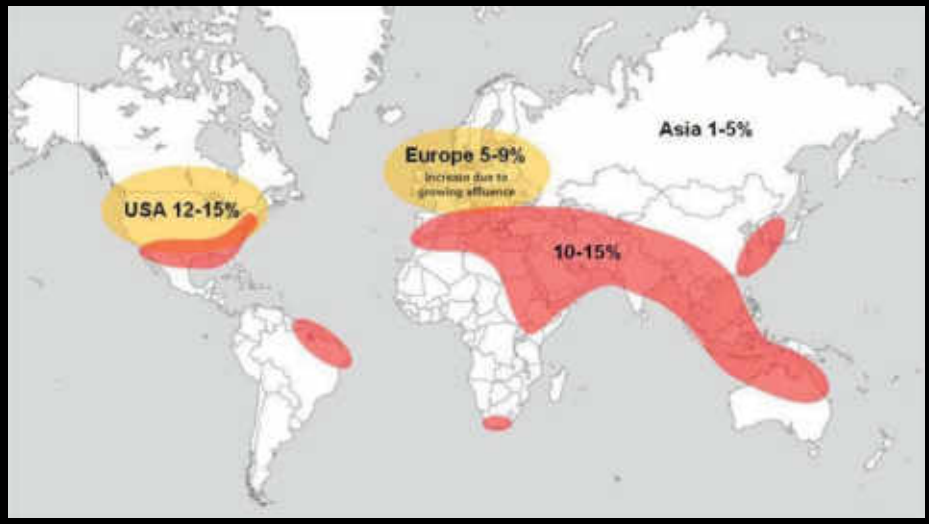
URINARY STONES

Kinga Villanyi MD PhD

Dept. of Urology, University Medical School of Pecs

Prehistoric bladder stone

Epidemiology



- Prevalence: 2-4 %
- Incidence: 0,1-0,5%
- Recidive rate: 10 % per year
  50% per 10 year
- ♂: ♀ = 3:1
- Differences: geography, climate, feeding, life stile, feedings, gender, age, occlusion, infectio, metabolic disorders, familiar factors
  - Germany P:4% - 4,7 % I: 0,54% – 1,47%
  - ↑white, asian people
  - ↓black, middle-south american people

Stone forming components

- Matrix: 2-10 %
- Stone forming crystals

  Ca oxalate, phosphate salts, uric acid, brushit, apatit, cystin
- Organic globulins, mucoprotein, hexosamin, water etc.

  matrix stone contains 65 %
- Rare components

  xantin, silicate, medicine induced stones: triamteren, indinavir
- Inhibitors: magnesium, citrate etc.

Inhibitors & promoters

INHIBITORS

Inhibits uptake – Oxalobact. formigenes

Inhibits crystal growth

- Citrate – complexes with Ca
- Magnesium – complexes with oxalates
- Pyrphosphate - complexes with Ca
- Zinc

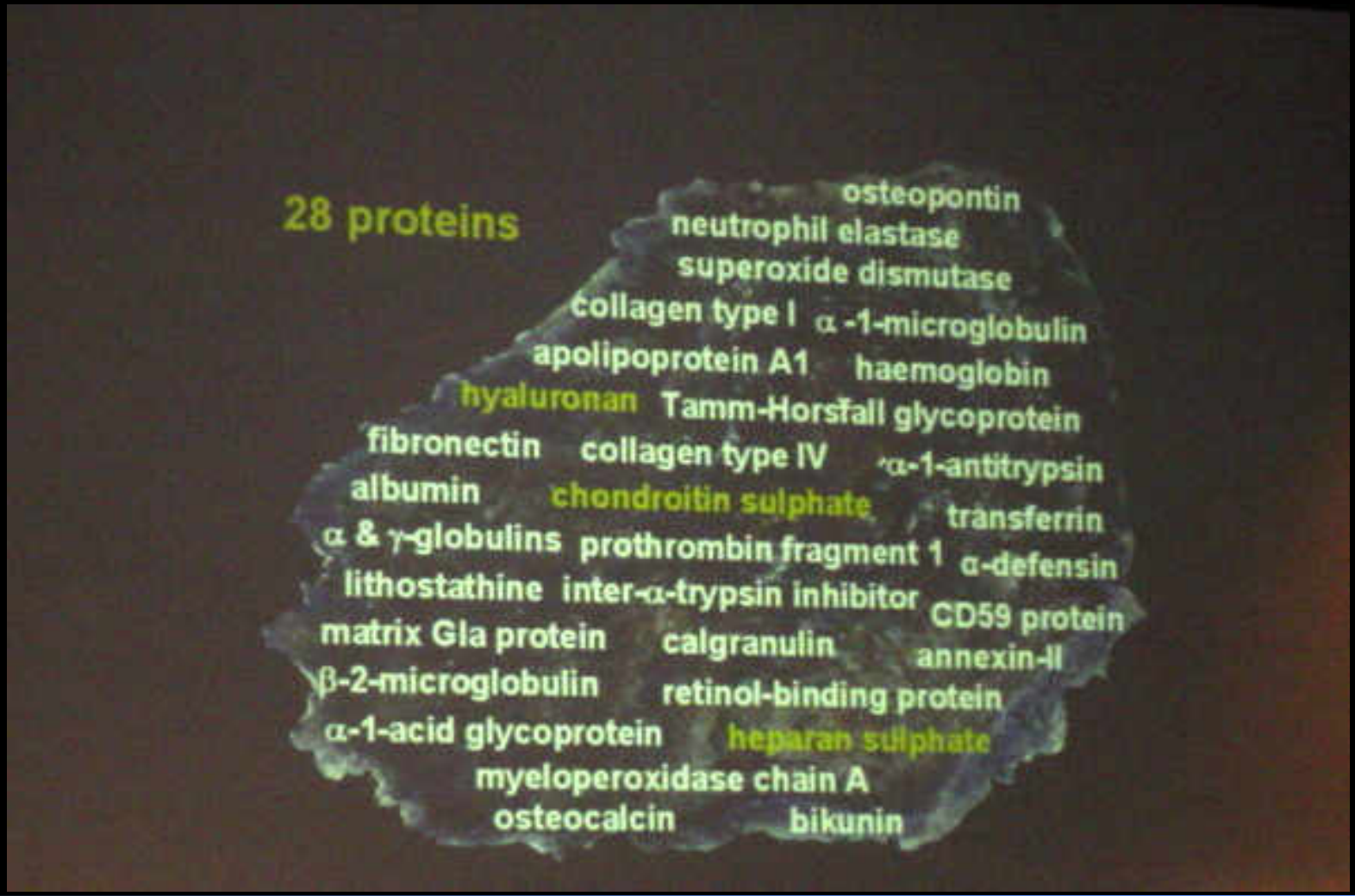
Inhibits crystal aggregation

- Glycosaminoglycans
- Tamm- Horsfall protein etc.
- other proteins

PROMOTERS

- Bacterial infection
- Matrix
- Anatomic abnormalities – PUJ obst., MSK
- Prolonged immobilisation
- ↑ uric acid level - crystallisation promoter
- ?? Nanobacteria – seen in 97% of renal stones

Inhibitor proteins



Stone formation

CONC.

GROWING PHASE

Precipitation, aggregation

STONE FORMATION

Formation product

- salt can no longer be held in solution
- homogenous nucleation will occur

METASTABLE PHASE

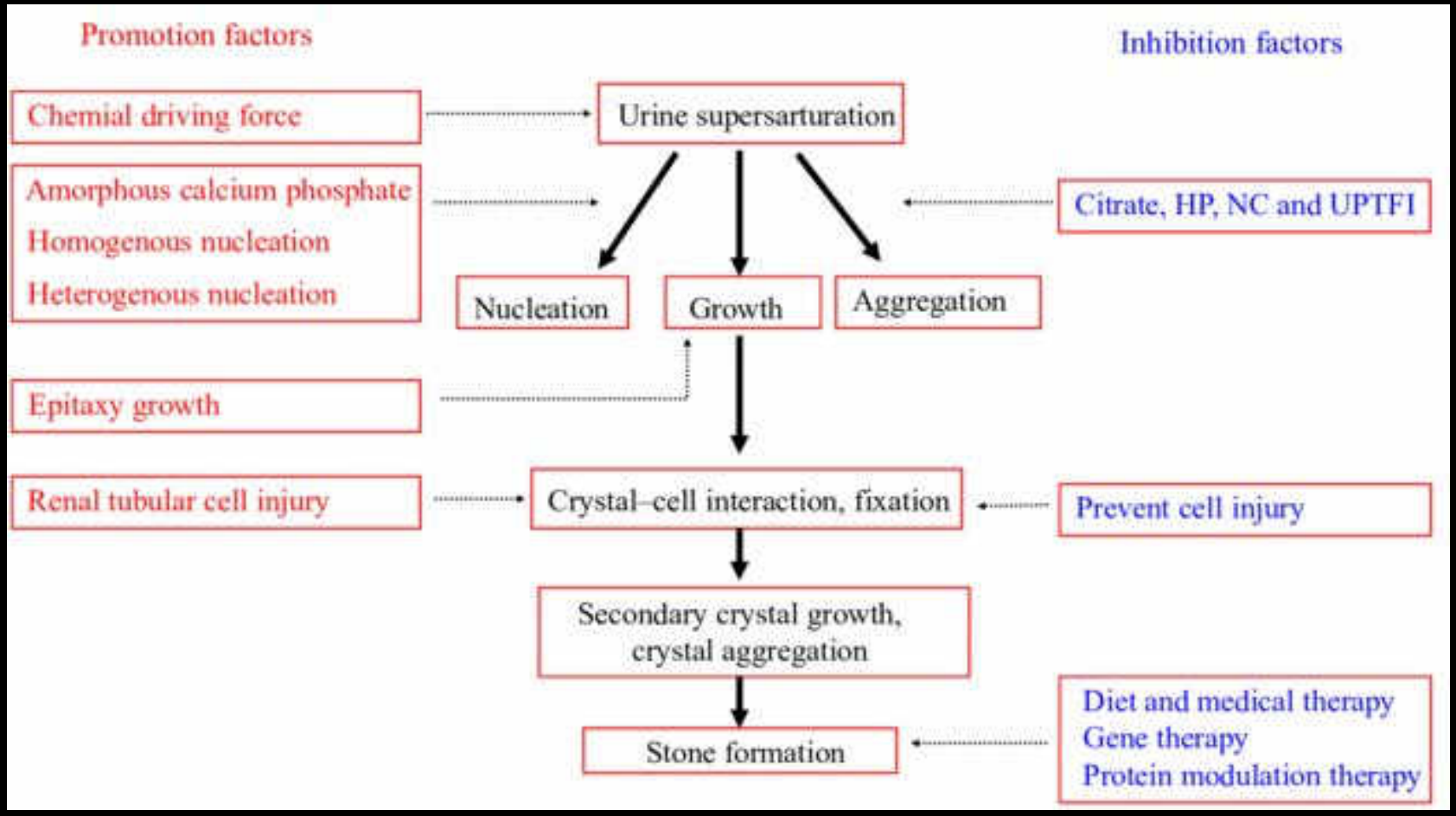
Metastable urin – supersaturated, inhibitors prevent crystallization

- heterogenous nucleation may occur
- de novo crystall formation very slow
- crystal growth or aggregation will occur

SOLUTION

Solubility product - depends on T, pH

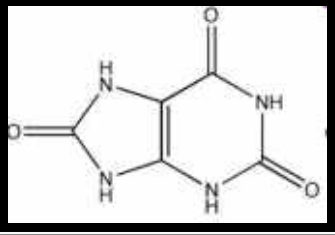
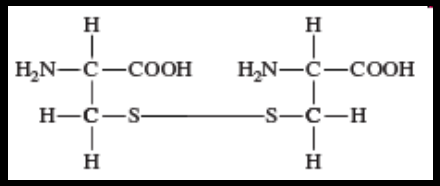
- solid and solvent stages in equilibrium
- no crystal formation, or may dissolve


Promotion factors
Inhibition factors
Chemial driving force
Urine supersarturation
Amorphous calcium phosphate
Homogenous nucleation
Heterogenous nucleation
Citrate, HP, NC and UPTFI
Nucleation
Growth
Aggregation
Epitaxy growth
Renal tubular cell injury
Crystal–cell interaction, fixation
Prevent cell injury
Secondary crystal growth,
crystal aggregation
Stone formation
Diet and medical therapy
Gene therapy
Protein modulation therapy

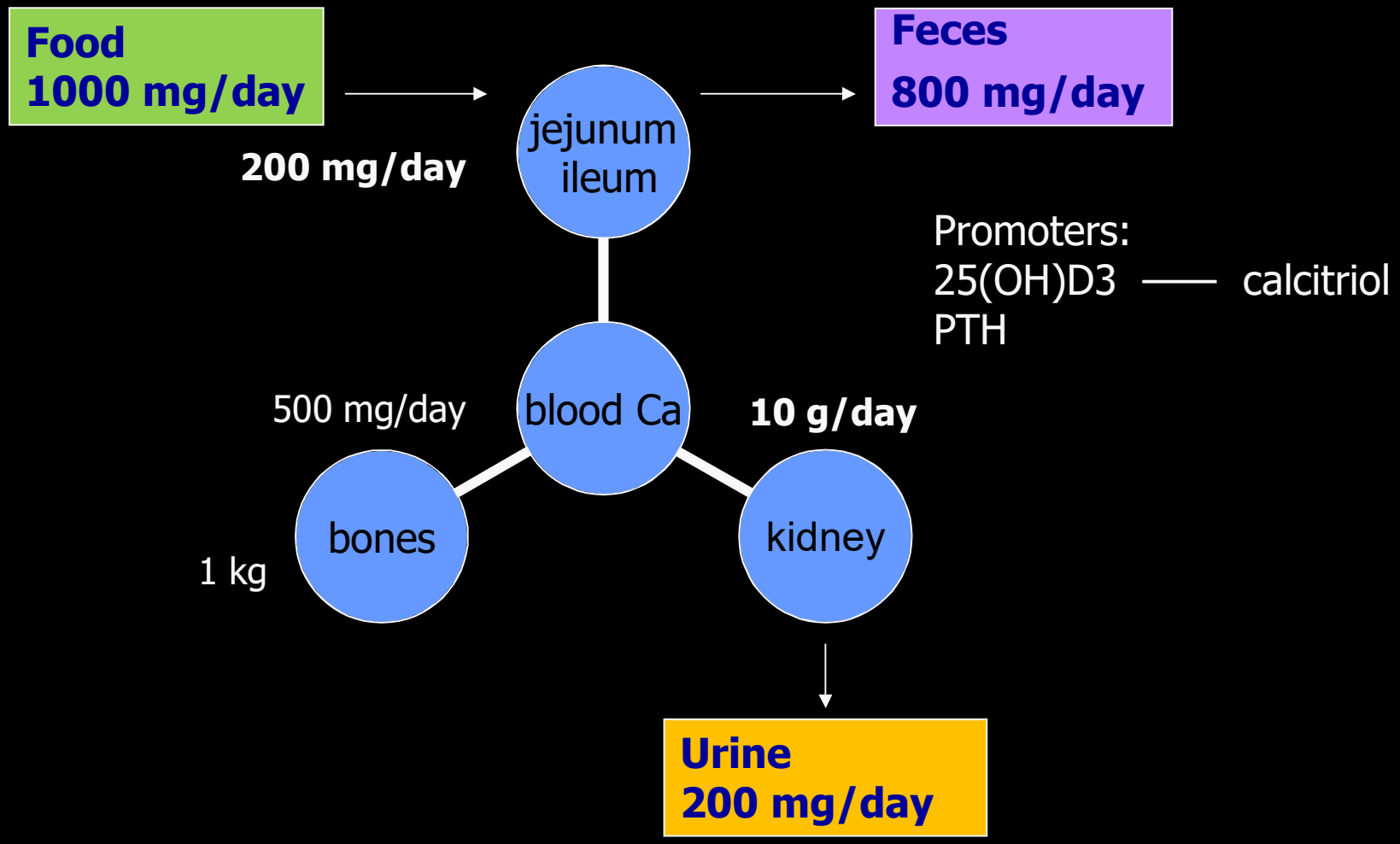
Stone types I. – Ca containing

STONE TYPE	%	RADIOPACITY	CHARACTER
Ca oxalate monohydrate dihydrate	75-80	opaque $CaC_2O_4 \times H_2O$ $CaC_2O_4 \times 2H_2O$	hard brown /pale yellow mulberry surface
Ca phosphate apatite brushite		very opaque $Ca_{10}(PO_4)_6(OH)_2$ $CaHPO_4\ 2H_2O$	dark brown hard
Mg ammoniun phosphate Carbonate apatite	10	moderately op. $MgNH_4PO_4\ 6H_2O$ $Ca_{19}(PO_4)_6\ CO_3$	chalky white often large strong alkaline pH

Stone types II.

STONE TYPE	%	RADIOPACITY	CHARACTER
Uric acid	8-10	non-opaque 	faceted multiple light brown acidic pH
Cystine	2	slightly opaque 	compact, yellowish metabolic acidic pH
Xanthin			rare
Indinavir (protease inhibitor for HIV)		non-opaque can not seen on CT!	rare acidify urine

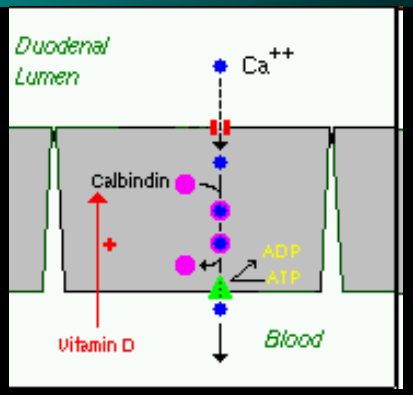
Calcium metabolism



Hypercalcaemia

- Se Ca ↑, U Ca ↑
- Causes:
  malignancy associated
  sarcoidosis and other granulomatous diseases,
  glucocortoikoid induced,
  pheochromocytoma,
  AIDS,
  immobilization,
  familial,
  iatrogenic – thiazid, lithium, Vitamin A and D etc.)

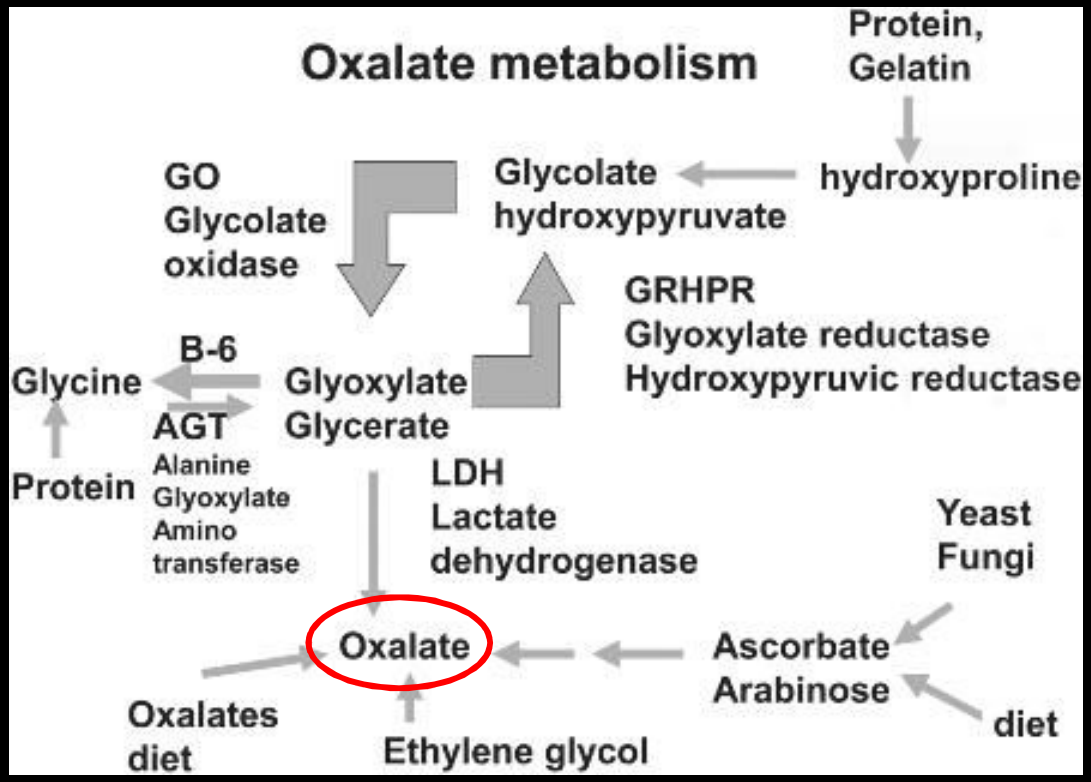
Hypercalciuria



- U Ca ↑
- Active and passive uptake
- **Absorptive**: increased intestinal absorption
- **Renal:** primary renal leak of calcium (50-60%)
- **Resorptive** (hyperparathyreoidism): ↑SeCa, ↑ PTH, increased bone demineralisation
- Idiopathic (5-10%) - familial

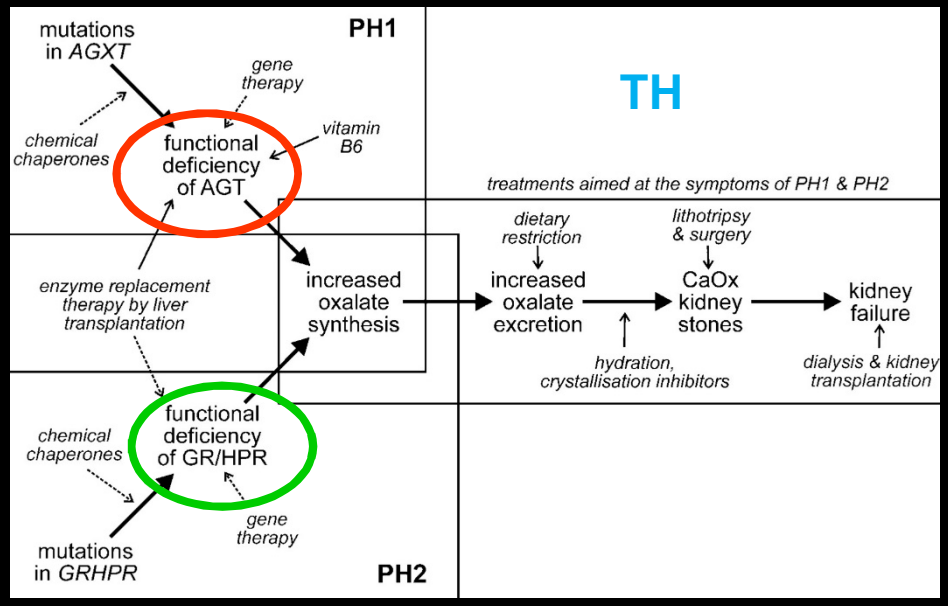
Oxalate metabolism

Hyperoxaluria: primary – liver deficiency
secundary - dietary, intestinal damage



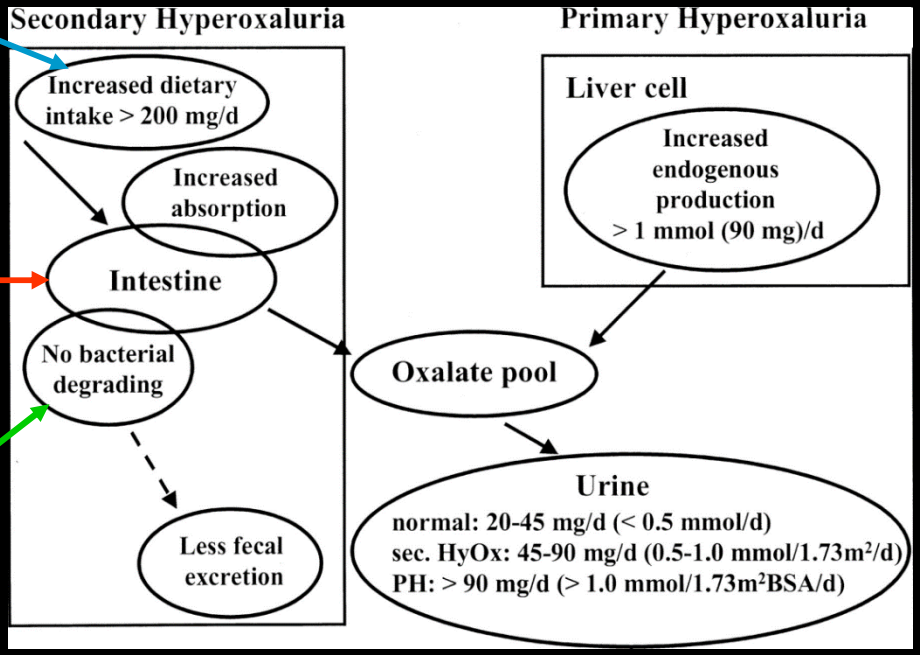
Primary hyperoxaluria

- **Toxic:** ethylen glykol, methoxyfluran, piridoxin deficiency
- **Enzyme deficiency 1. type:**
  alanin-glyoxilate amino - transferase (AGT) defect
  1/120000, AR, progressive, nephrocalcinosis, oxalosis,
  renal failure
- **Enzyme deficiency 2. type:** glycolate and hydroxypiruvate reductase defect or L-glyceric aciduria (GR/HRP)
  much less, mild, ↑U glycerate

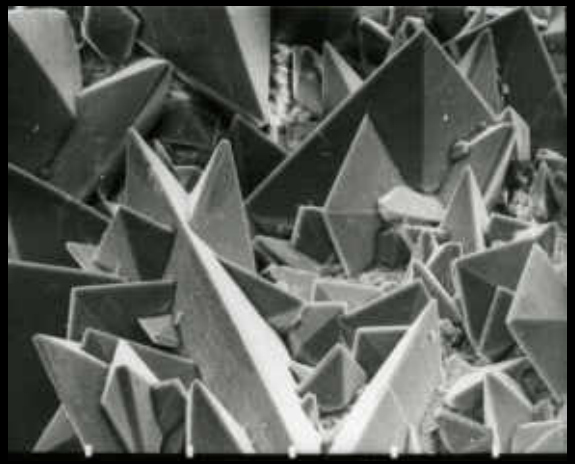


Secondary HO

- 10-50% comes from food, exchanger protein
- Dietary imbalance
- Enteral: bypass surgery, infl. bowel disease, pancreatic insuff. , ileal resection, fat malabasorption - fatty acids bind Ca
- Oxalobacter formigenes – oxalate decarboxylase
- TH: low fat, low oxalate diet; and calcium



Ca-oxalate stones

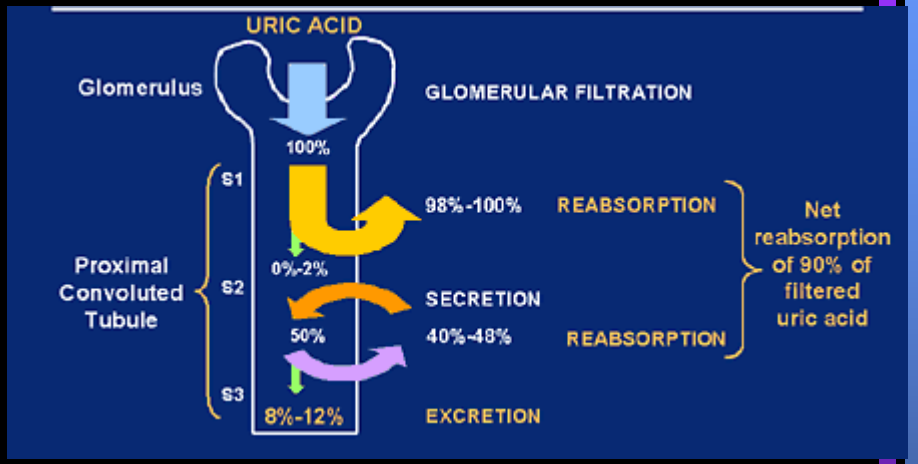


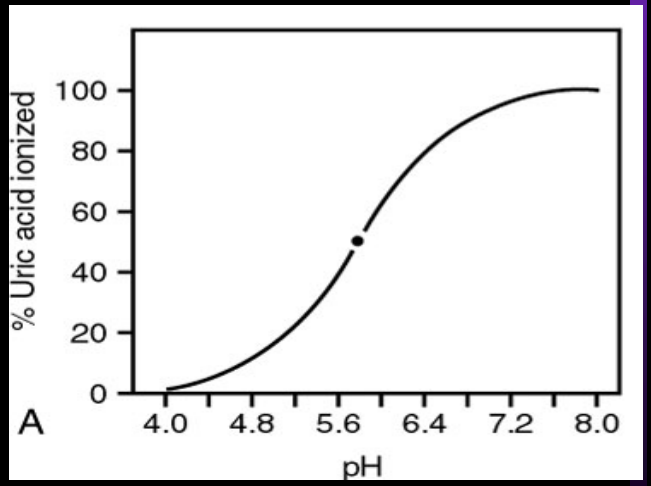
Uric acid stones

- **Origin**
  endogenous - end product of purin metabolism
  exogenous – red meet, alcohol anchovy

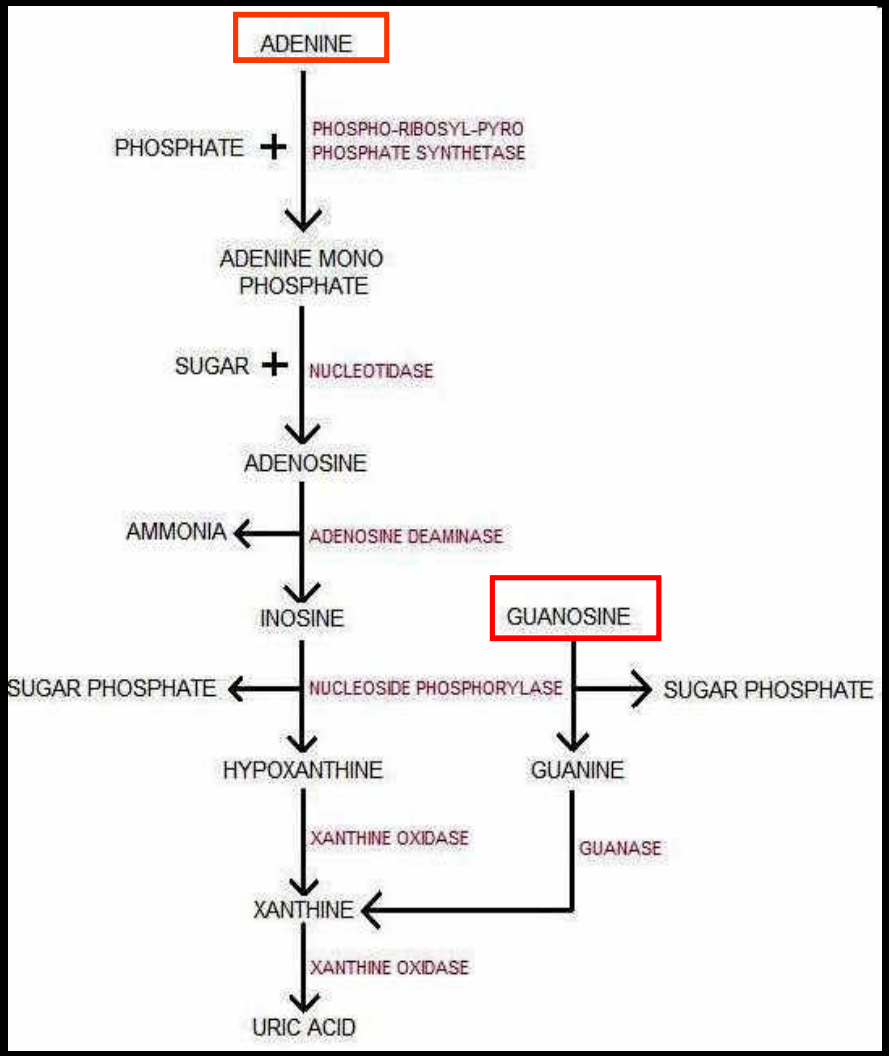
- **Kidney**
  pK: 5,3
  solubility: depends on the pH
  no inhibitor

- **Types**
  – **hyperuricaemia: ↑Se UA, ↑U UA**
  – **hyperuricosuria: ↑U UA**
  – **idiopathic: acidic urine pH**





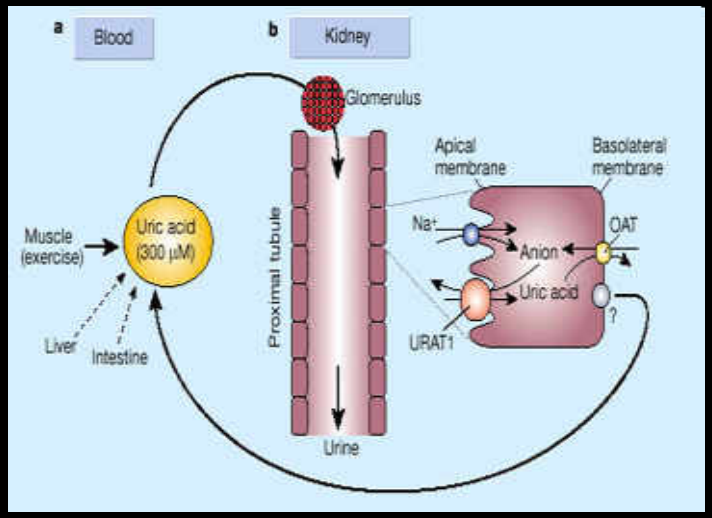
Hyperuricaemia



- gout
- ↑ destruction of cells: cancer, hemolytic anaemia malaria, rhabdomyolysis
- others: psoriasis, pagets disease, alcoholism, obesity, high blood pressure, hypothyroidism, eclampsia, Down syndrome, sarcoidosis, dehydration
- renal failure
- deficiency of enzymes
- drugs: aspirin, cyclosporine, ethambutol, diuretics (increase urine formation)

Hyperuricosuria

- **Reabsorption: exchange for anions,**
  - **–Passively by Na^+-coupled transport**
  - **–Actively by organic anion transport (OAT) and URAT1 proteins**
- **Defects**
  - **–tubular dysfunctions**
  - **–deficiency of transport genes: 9 genes**
  - **–drugs: amlodipine, atorvastatin, losartan, ACTH, cortisone**



- **TH:**
  diet
  alkalization
  allopurinol (analogue to hypoxanthine)

Uric acid stones

Struvite stones

- Conditions: urine pH of 7.2 or above
  ammonia in the urine
- Urea splitting bacteria: Proteus, Klebsiella, Pseudomonas, Serratia, Providentia, Haemophilus, Ureaplasma etc. except E. coli and Gram + species

$$NH_2—CO—NH_2 + H_2O \text{ (urea)} \rightarrow \overset{\text{urease}}{\rightarrow} 2NH_3 + CO_2$$

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow 2H^+ + CO_3^-$$

- Ammonium: epithel destruction, ↑adherence of crystals and matrix
- Alkaline pH: precipitation of Mg, ammonium, carbonate and apatite crystals
- TH: antibiotics
  acidify urine

Struvite stone

Cystin stone

- autosomal-recessive disorder of transmembrane transport of dibasic amino-acids (COLA), manifested in the intestine and in the kidney
- Solubility depends on the pH

  pH5 - 300 mg/l,

  pH7 - 400 mg/l,

  pH9 - 1000mg/l
- TH: ↑ fluid intake

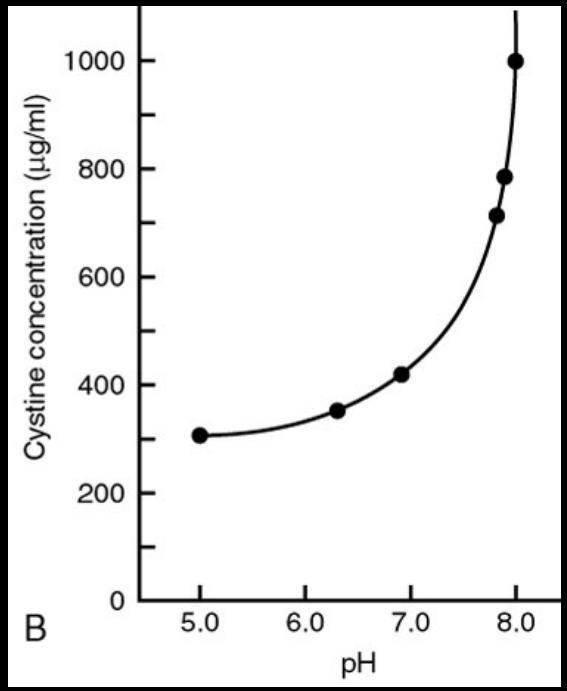
  alkalization - pH 7,5 ↑

  diet - ↓ methionin

  D penicillamin

  tiopronin (Thiola, Acadione)

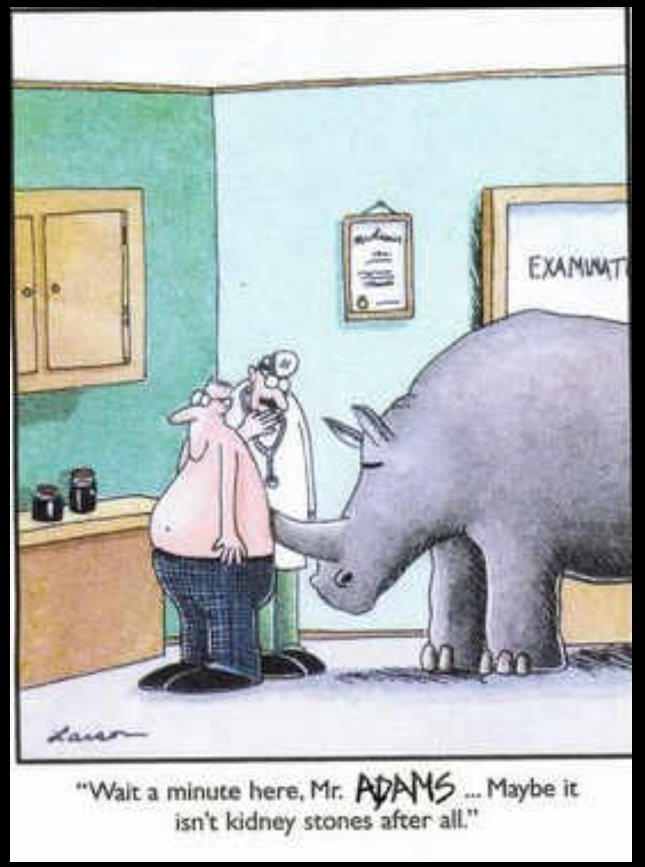
  others: vitamin C, glutamin, acetazolamid



Cystin stone

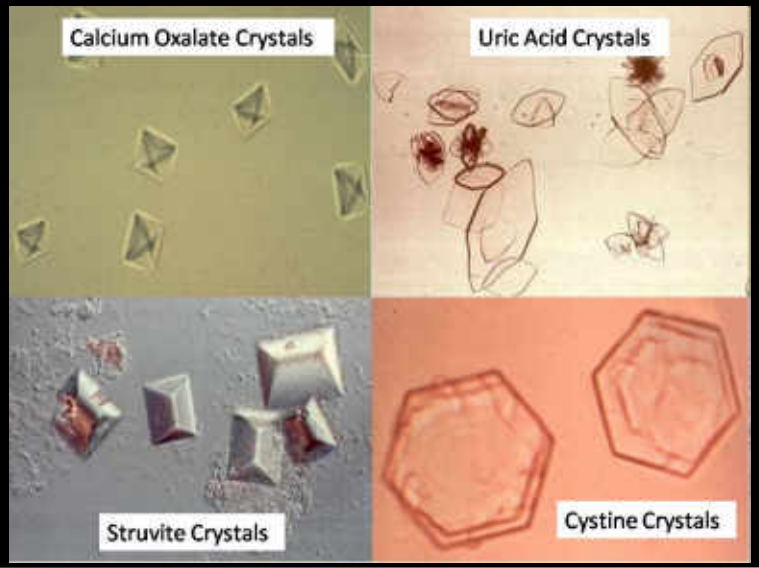
Clinical signs

- renal stone - no pain, or blunt renal pain
- ureteric stone - renal colic ± radiation
- Diff: acut abdomen
- haematuria
- frequency
- complications:
  - obstruction
  - infection
  - chills / fewer
  - renal failure



Diagnosis I.

- Anamnesis: familial, concomittant diseases, operations, feeding, medicines
- Phisical examination, differential diagnostic signs (acut abdomen)
- Urine sediment: blood, white blood cells, crystals, bacteria
- Urin culture
- Laboratory examinations
- 24 h urin collection for Ca, P, uric acid, (Mg, citrate, oxalate)



Diagnosis II.

- Ultrasonography
  - Renal stone – direct signs
  - Ureteric stone – indirect signs
- Plain abdominal film
- Intravenous urography – before operation mandatory!
- CT
- MR urography
- (scintigraphia)

Conservative treatment

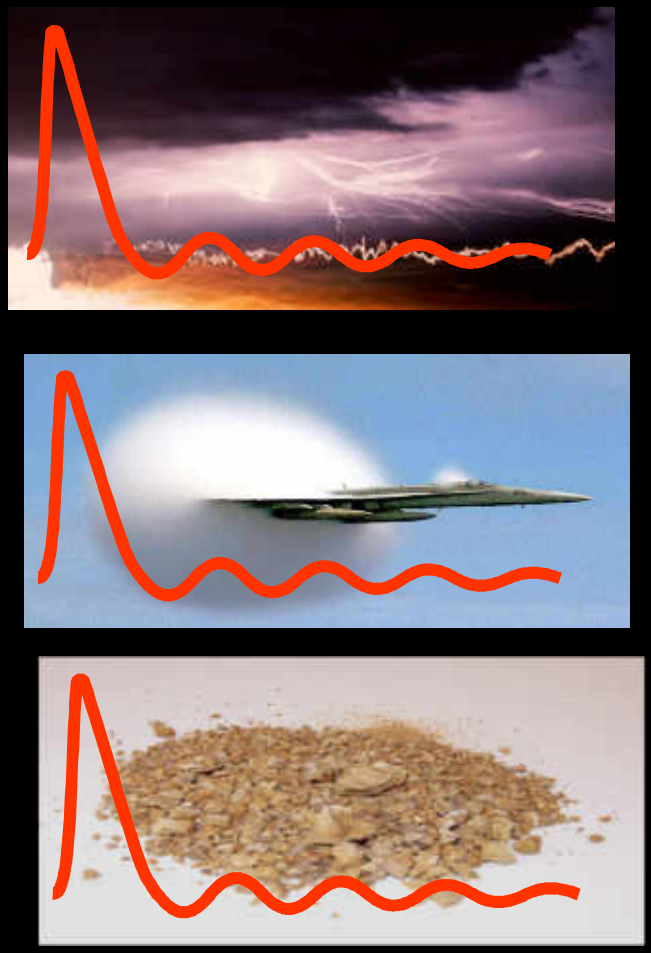
- Stone < 5 mm - can pass spontaneously
- Wait: max. 4-6 weeks
  - no chronic occlusion
  - no infection
  - no functional disorder
  - no serious complaint
- TH: high fluid intake, combined spasmolytics and pain killers, Rowatinex, non steroid anti-inflammatory drugs, Ca channel blockers, α-blockers

Operative treatment

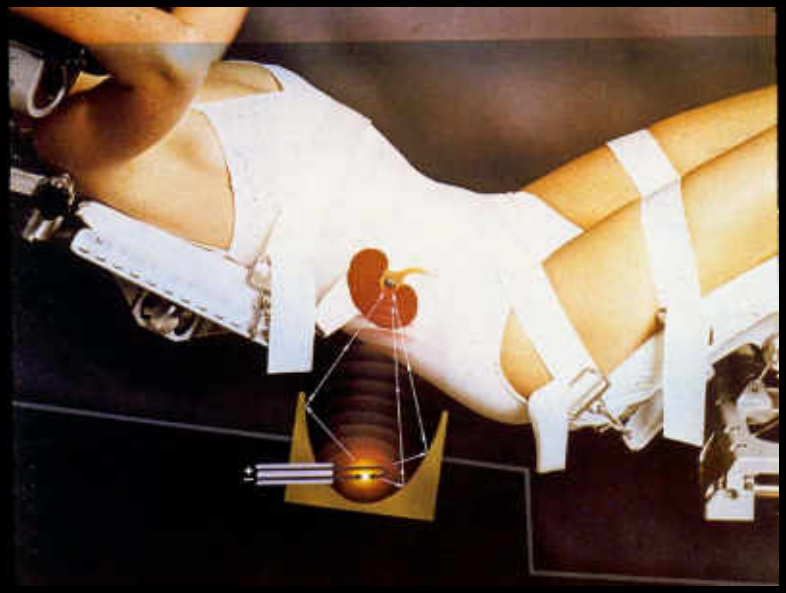
- First choice: ESWL 85-95%
- Endoscopic: PCNL
  URS
  laparoscopy
- Combined therapy: PCNL + ESWL
  laparoscopy + PCNL
- Open operations - 1-2 %

ESWL

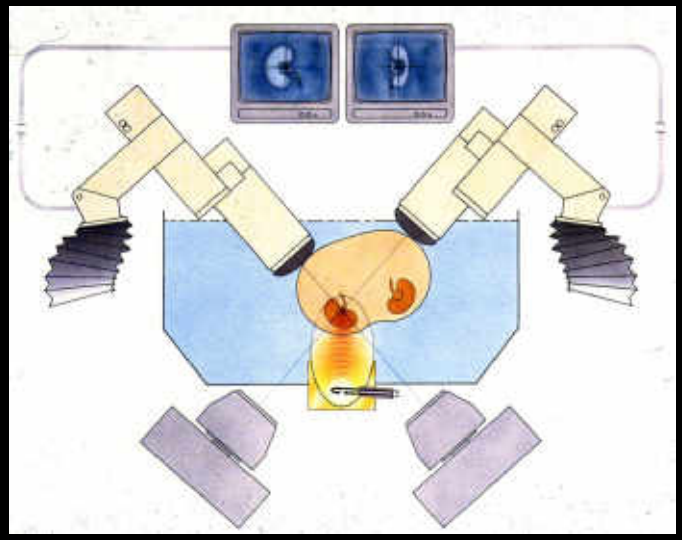
- **Extracorporeal Shock Wave Lithotripsy**
- **Shock wave (SW) – focused acoustic waves, generated externally by a lithotriptor and transmitted into the body, building to a strength sufficient to fragment a stone only at the target site**
- **stone fragments pass spontaneously**
- **First treatment: München 1980 february**



ESWL



Targeting



INDICATION

First treatment of choice, except:

- **Size: renal stones - larger than 20-25 mm**
  ureteral stones – larger than 10 mm or impacted
- **Composition:**
  - **uric acid stones**
  - **bad stone desintegration: COM cystin, brushit**

CONTRAINDICATIONS

GENERAL

- uncorrected bleeding disorders
- untreated hypertension
- aortic or renal aneurysm
- pregnancy
- pacemakers: standby
- CAVE: anticoagulation treatment, drugs
- abnormality of body habitus

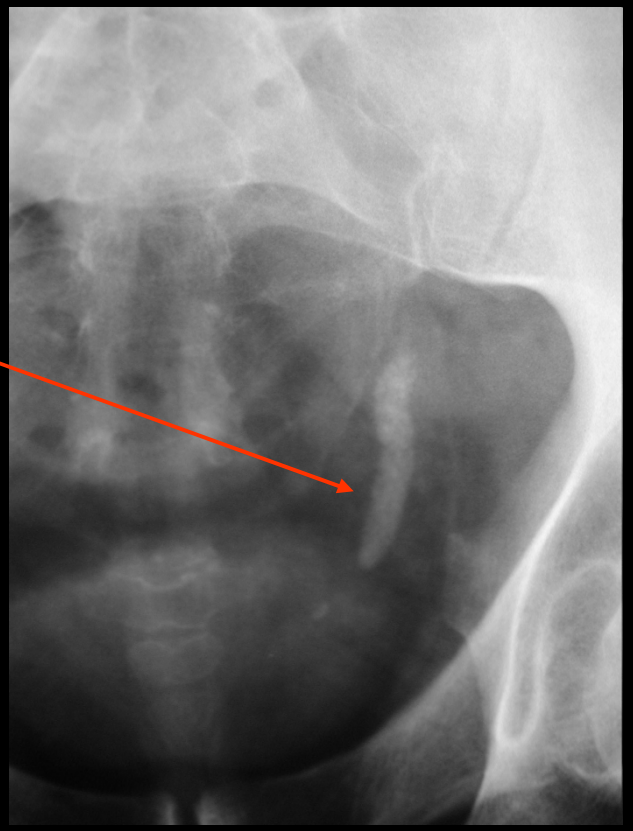
UROLOGICAL

- non functioning kidney
- untreated uroinfection
- obstruction distal to the stone
- functional impairment of ureteral motility, immobolization
- anatomic anomalies in form and position of kidney

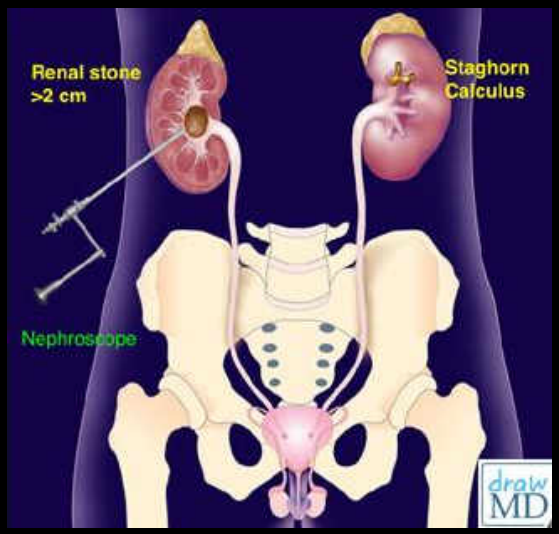
COMPLICATIONS

- **Peri- and intrarenal, subcapsular haematoma**
  - **UH: 1-2 %, CT, MRI: 20-25 %**
- **haematuria**
- **renal colic**
- **occlusion, Steinstrasse**
- **infection, fewer**
- **rare: haemoptoe,**

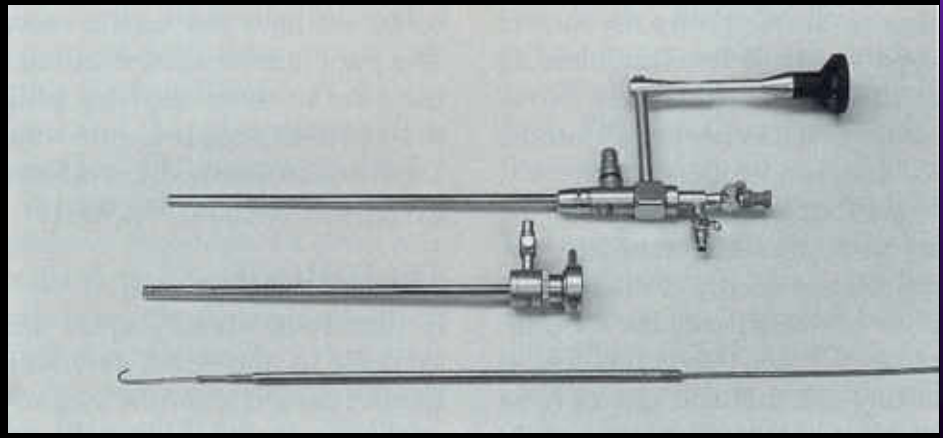
  haemorrhage of the surr. organs
- **ecchymosis**
- **renal functional disorders**



PCNL

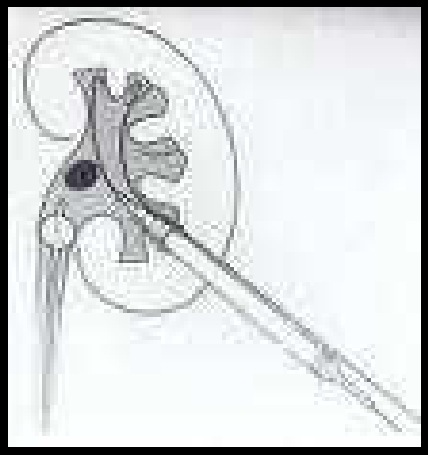


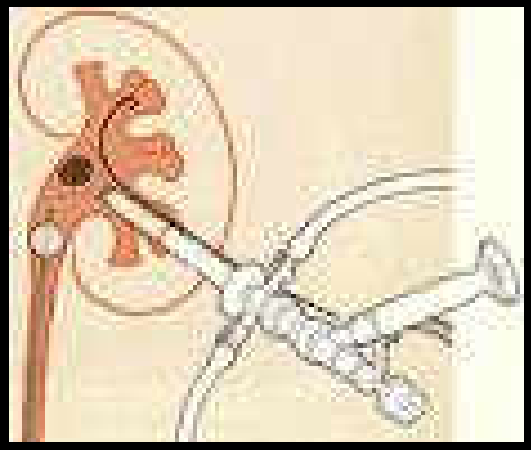
- Percutaneous NephroLytholapaxy
- Indications
  - Renal stones unsuitable for ESWL
  - Failure of ESWL
  - Other: for treatment of strictures (PUJ) or other anatomical disorders
- Contraindications
  - uncorrected bleeding disorder
  - untreated uroinfection
  - relative: hepato-splenomegaly
    - obesity
    - body deformities

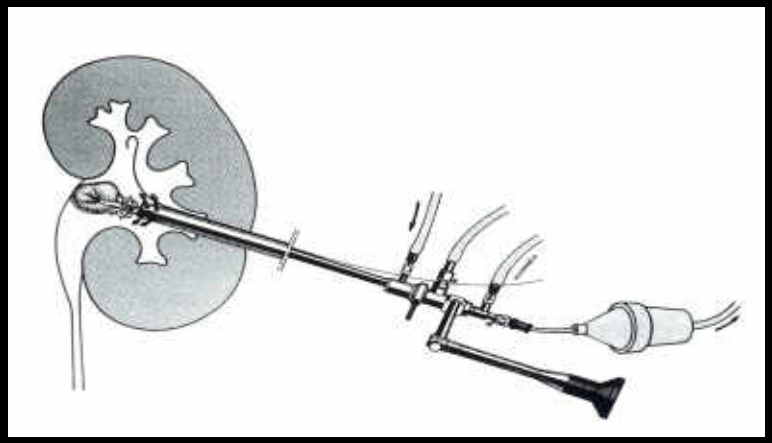


TECHNIQUE

- insertion of ureteric catheter, filling contrast material
- punction of the renal calyx under X-ray or US giudance
- insertion of guide wire, dilatation of the working channel with telescopic dilatators
- insertion of the nephroscope
- removal of the stone or disintegration of the stone with: UH, electohydraulic energy, electrokinetic energy, laser energy
- nephrostomy tube

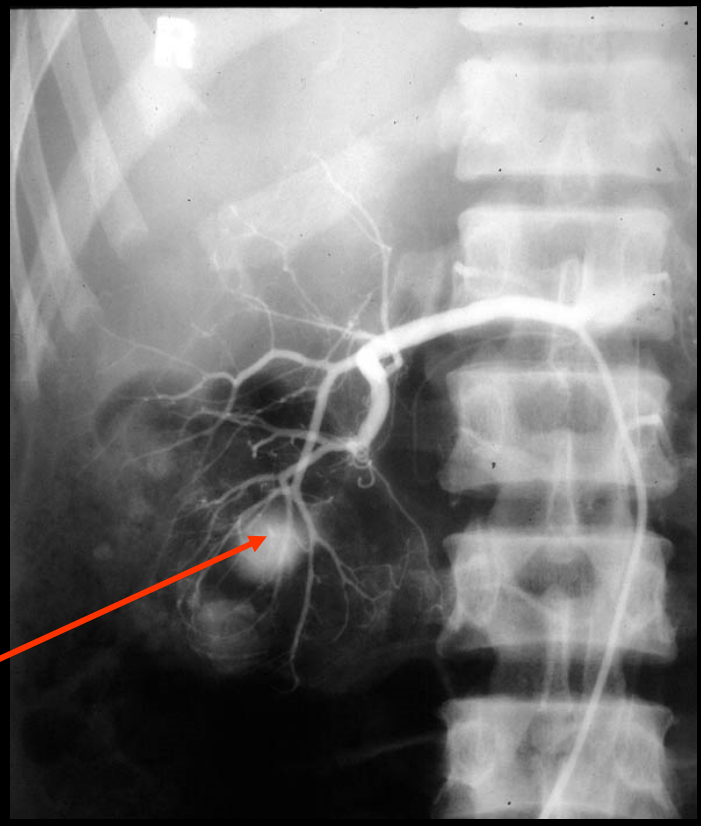






PCNL COMPLICATIONS

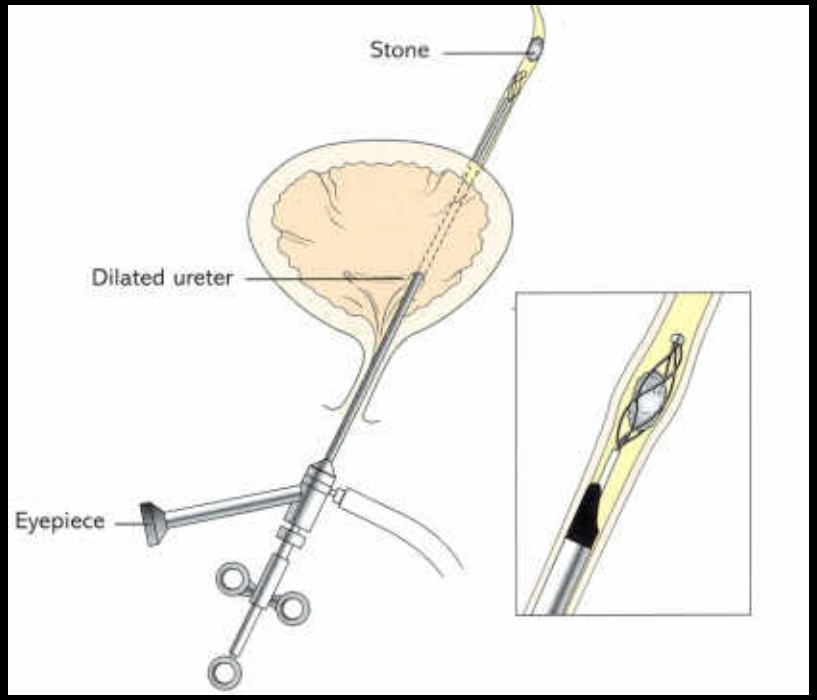
- injuries of the adjacent organs: liver, spleen, colon, pleura, lung, vessels
- bleeding
- extravasation of irrigating fluid
- urine leakage, urinoma
- infection
- arteriovenous fistula



URS

- **Uretero-Renoscopic Surgery**

- **Indications**
  - **– diagnostic, biopsy**
  - **– for treatment of ureteric stone**
    - **lower – retrograde**
    - **upper – antegrade**
  - **- for treatment of ureteral strictures,**

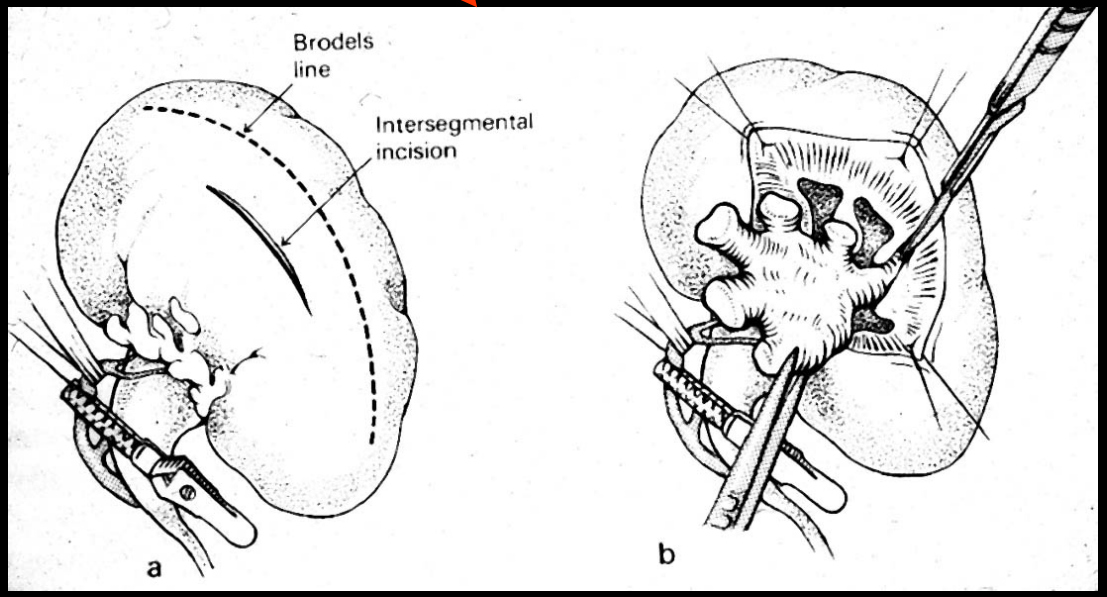


URS COMPLICATIONS

- Success rate: 90-95%
- Complications:
  - Technical failure: BPH, ureteric problems
  - Bleeding
  - Infection
  - Ureter laceration, perforation or rupture
  - Stricture
  - VUR

Open operations

- pyelotomy, pyelocalycotomy
- radier nephrotomy
- marginal nephrotomy
- ureterotomy



Good clinical judgement comes from experience, and experience comes from bad judgement.

R. Clayman