



Urolithiasis



वक्तुण्ड महाकाय ॥ सूर्यकोटि समप्रभ ॥
निर्विघ्नम् कुरु मे देव सर्व कार्येषु सर्वदा ॥



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Urolithiasis

- Stone like bodies composed of urinary salts bound together by colloid matrix of organic matter
- Usually has a nucleus surrounded by layers of urinary salts
- Poly crystalline aggregate composed of varying amount of crystalloid and organic matrix



Ancient Egyptian and Indian Origins

- **The Oldest Stone:** The earliest known urinary stone was found by archeologists in an Egyptian mummy dating back to **4800 BC**.
- **Sushruta Samhita:** In the 6th century BC, the Indian surgeon Sushruta described the first detailed surgical steps for stone removal. He advised that surgery should only be a last resort and used herbal decoctions and "alkaline waters" first—a philosophy not too different from modern medical management.

Earliest stones in Egyptian mummies 4800 B.C.



Why talk about stones?

- One of the commonest and most painful urological disorder
- Troubling us for many centuries
- 10% life time chance of forming a stone
- Rising incidence with aging
- Affects men more than women



Famous Sufferers and Their "Cures"

- **Benjamin Franklin:** He suffered from a large bladder stone for much of his later life. Because the bumpy carriage rides in Philadelphia were so painful, he is credited with helping popularize the **flexible catheter** in America to find relief. He also famously wrote that he found more comfort in a warm bath than in any medicine.
- **Michelangelo:** The Renaissance master suffered from stones for decades. His letters reveal he drank "water from a certain fountain" (likely low in minerals) which he believed helped him pass "crumbles of gravel." Some art historians suggest the shape of the mantle in his *Separation of Land and Waters* on the Sistine Chapel ceiling is a hidden anatomical diagram of a human kidney.
- **William Shatner:** In a very modern twist, the *Star Trek* actor passed a kidney stone in 2005 and later **sold it on eBay** for \$25,000. He donated the proceeds to Habitat for Humanity, literally turning his pain into housing for others.

The Dutch Blacksmith's DIY Surgery (1651)

Perhaps the most famous—and gruesome—anecdote in urological history is that of **Jan de Doot**, a Dutch blacksmith. After enduring the agony of a bladder stone for years and having already survived two unsuccessful professional surgeries, he decided to take matters into his own hands.

In 1651, he reportedly sent his wife to the market, sat on a bench, and used a kitchen knife to perform a **lithotomy on himself**. He made an incision in his perineum, reached in with his fingers, and pulled out a stone the size of a hen's egg. Amazingly, he survived and was famously painted by Carel de Savoyen, proudly holding both the knife and the massive stone.



Napoleon's Stones and the Battle of Borodino

- Historians often speculate how kidney stones changed the map of Europe. During the **Battle of Borodino (1812)**, Napoleon Bonaparte was reportedly suffering from a severe bout of kidney stones and a bladder infection. Witnesses noted he was unusually lethargic and lacked his typical strategic sharpness. Some argue his physical distraction during this critical campaign contributed to the eventual downfall of his Grande Armée in Russia.



Epidemiology of Urolithiasis

Kidney Stone Incidence:

- Number of Americans affected by kidney stones yearly..1,000,000
- Portion of U.S. population affected annually..... 0.5%
- Portion of population who will have at least one kidney stone.....12%
- Of these, how many will have at least one recurrence..... 75%
- Relative risk of forming a second stone...60% to 80% over next 10
years (50% over next 5 years)
- Rate of Stone production for recurrent stone formers.... one stone
every 2 to 3 years

Etiology of Recurrent stones

Types of urinary stones

- Primary
- Without Inflammation
- acidic urine
 - Uric acid
 - Urate,
 - Xanthine
 - Ca CO_3
 - Cystine

- Secondary stones
- Inflammation present
- Alkaline Urine
- eg Ammonium magnesium stones
 - Triple PO_4 stones
 - Struvite stones

Etiological Classification of Urolithiasis

I. Enzyme disorders

1. Primary hyperoxaleuria
2. Xanthinuria
3. 2,8 Dihydroxyadeninuria

II. Renal tubular syndromes ;

1. Renal tubular acidosis;
2. Distal tubular defects
3. Carbonic anhydrase inhibitors.
4. Cystinuria.

III. uric acid lithiasis;

- | | |
|-----------------------------------|----------------------------------|
| 1. Idiopathic uric acid lithiasis | 2. Gout |
| 3. Low urine output states. | 4. Myeloproliferative disorders. |

IV. Hypercalciuric states ;

- | | |
|--------------------------------|--------------------------|
| 1. Primary hyperparathyroidism | 2. Milk-alkali syndrome |
| 3. Sarcoidosis | 4. Hypervitaminosis D |
| 5. Immobilization | 6. Hyperthyroidism |
| 7. Cushing's syndrome/disease | 8. Neoplastic disorders. |

Etiological Classification of Urolithiasis : contd

V. Urolithiasis associated with gastrointestinal disorders

1. Uric acid lithiasis

2. Enteric hyperoxaluria

VI. Idiopathic calcium Urolithiasis ;

Solute excess ;

*** Hypercalciuria**

1. Absorptive

2. Renal calcium leak

3. Renal Phosphate leak

Hyperoxaluria

Hyperuricosuria

Deficiencies of inhibitors of crystal formation.

Hypocitric aciduria with or without tubular disorders

VII. Secondary Urolithiasis:

Infection Urolithiasis

Obstruction Urolithiasis

Urinary diversion

Medullary sponge kidney; cystic disease.

Foreign chemicals and compounds.

Most Dense

Calcium phosphate

Calcium oxalate monohydrate (apatite)

Calcium oxalate dihydrate

Magnesium ammonium phosphate (struvite)

Cystine

Uric acid

Xanthine

Least Dense/
Radiolucent

Difficult to fragment with ESWL.

Easy to fragment with ESWL.

Too rare for sufficient data on fragmentation.



There are various types of stones

Hard stones

Soft stones

Brittle stones

Not so hard stones

Not so brittle stones

Basically of two types
CALCIUM stones and
NON CALCIUM
stones

Calcium Calculi

- *Absorptive Hypercalciuric nephrolithiasis
type I,II,III**
- *Resorptive Hypercalciuric nephrolithiasis
Primary Hyperparathyroidism**
- *Renal Induced Hypercalciuric nephrolithiasis**
- * Hyperuicosuric Calcium nephrolithiasis**
- *Hyperoxaluric Calcium nephrolithiasis**
- * Hypocitrauric Calcium nephrolithiasis**

Absorbtive Hypercalciuric nephrolithiasis

Type I: Independent of diet

Elevated Urinary Cal. Oxalate

15% of all Ca Stones

>150 -200mg/24 hr

Type 2: Dietary Dependent

50% of All Ca. Stones

Type 3 : Phosphate leak :

5%of All Ca. Stones

Resorptive Hypercalciuric nephrolithiasis

Primary Hyperparathyroidism

5 to 10 % of all Calcium stones

Renal Induced Hypercalciuric nephrolithiasis

Renal Tubular Defect —————→ **Hypercalciuria**

Low Serum Calcium —————→ **Parathormone** ↑

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graph LR; A[Renal Tubular Defect] --> B[Hypercalciuria]; B --> C[Low Serum Calcium]; C --> D[Parathormone ↑];
```

Secondary Hyperparathyroidism
Treatment Hydrochlorothiazide

Hyperuricosuric Calcium nephrolithiasis

- Excessive dietary Intake of Purines
- Endogenous Purine Production

Elevated Urinary Uric acid level $>600\text{mg}/24\text{ hrs}$
Urinary Ph 5.5

Treatment Allopurinol

Hyperoxaluric Calcium nephrolithiasis

Increased Urinary Oxalate >40mgs/24 hrs

- * Inflammatory bowel disease**
- * chronic Diarrhoeal States**
- * Urinary Calcium <100mg/24 hrs**

Treatment Calcium Supplementation

*** Hypocitrauric Calcium nephrolithiasis**
Hypokalemia
renal tubular Acidosis Type I

Citrate is Inhibitor of Stones
Energy of Crystallisation

Spontaneous Nucleation

Crystal Growth



Non Calcium Calculi

1. Struvite stones : Infection Stones

2. Uric Acid stones

3. Cystine stones

4 Xanthine Stones

**5 Rare ; silicate stone
: Triamterene**

Theories of Urolithiasis

1. Nucleation Theory
2. Crystal Inhibition Theory
3. Epitaxy :Heterogenous nucleation Theory
4. Mass Precipitation Theory (Intranephronic Calculosis)
5. Fixed Particle Hypothesis
6. Randall's Theory
7. Carr's Hypothesis
8. Super saturation-Crystallization Theory
9. Stone matrix Theory

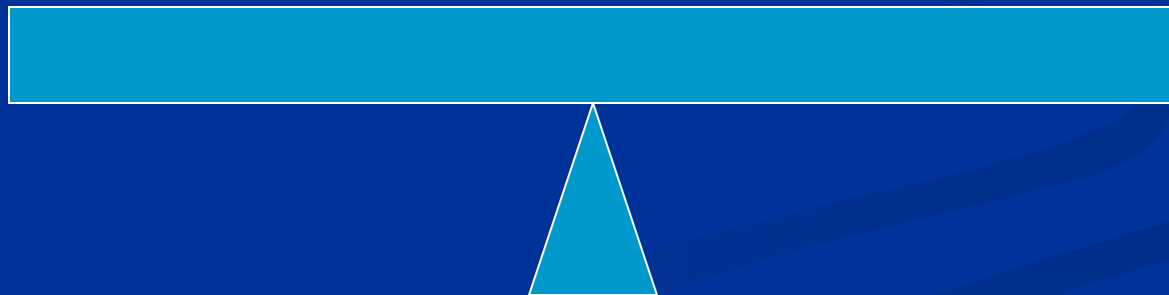
Organic matrix of serum and urinary proteins (Alpha 1,Alpha 2 globulin, albumin glycoaminoglycons, mucoproteins) provide framework for deposition of crystals in urine.

Pathogenesis of Urolithiasis

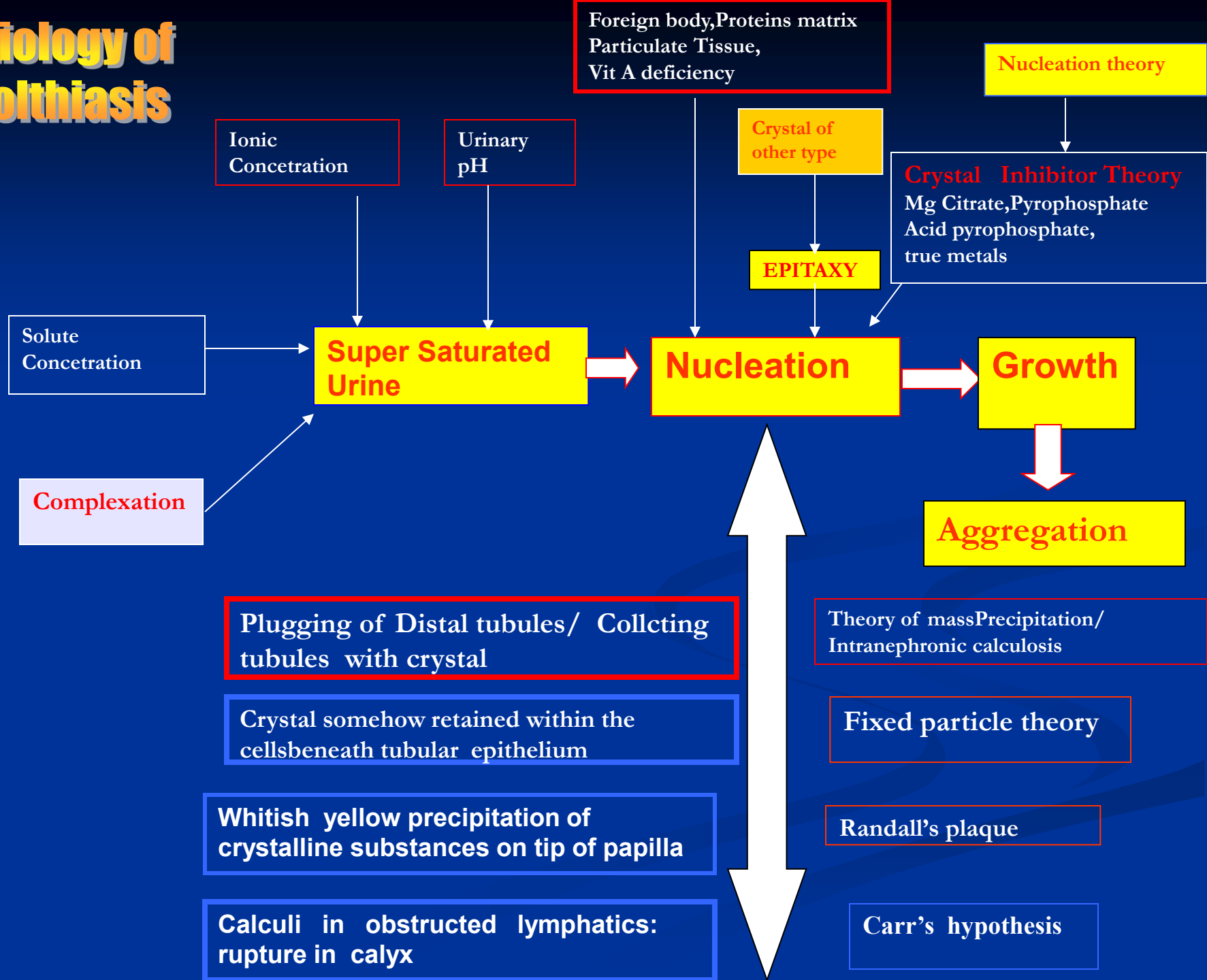
How are urinary stones formed ?

- Stasis e.g. obstruction
- Presence of nucleus e.g. bacteria
- Decreased urine volume – super saturation (concentrated)
- Stone promoters: sodium, calcium, oxalate

- Dilute urine – good hydration
- Stone inhibitors - citrate



Aetiology of Urolithiasis



Urinary pH

- Physiological variation
 - : Acidic urine in morning
 - : Alkaline urine after meals.
- Urinary Infection:
 - Pyogenic Cocci- Alkaline pH— NH_4
 - E.Coli. —Acid pH— Ca Oxalate
 - Disturbs colloid content of urine.
 - Colloids keep urates and oxalates in solution
- Adequate urinary drainage:
Urinary stasis— Shift of pH — Infection.

Solute Concentration

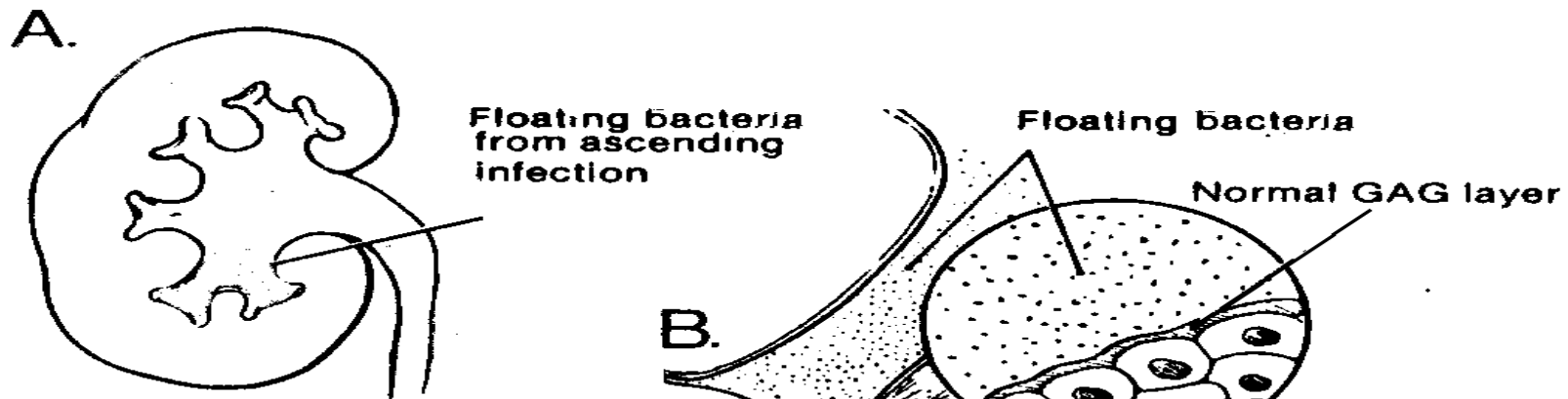
- Hot climate: concentration of urine.
- Concentration of Monovalent ions Activity coeff.
- Two ion concentration:
 - increased precipitate
 - Activity coefficient products
- Increased K_{sp} Metastable: Initiates crystallis:
 - Heterogenous Nucleation
- Increased K_{tp} :Formation Product.
 - Super saturation increased – unstable.

COMPLEXATION

- Availability of Specific Ions
- Na⁺ ionic form – Oxalates
- Free oxalates decreased
- CaSO₄ Ca joins with SO₄ ions

Strvite stones

Pathogenesis of struvite stones



Flocculation of mucopolysaccharides

GAG layer denuded by NH_3

Adherent Bacteria invade urothelium inciting inflammatory response

C.

Normal GAG layer



Amalgam of mucopolysaccharides, mucoproteins resulting from inflammatory response and crystallizing minerals

E.

With time... dense stone

Thippun

Symptomatology of Upper Urinary Tract stones

Symptomatology of Upper Urinary Tract stones

**Pain in
abdomen**

Urinary Obstruction by
stones



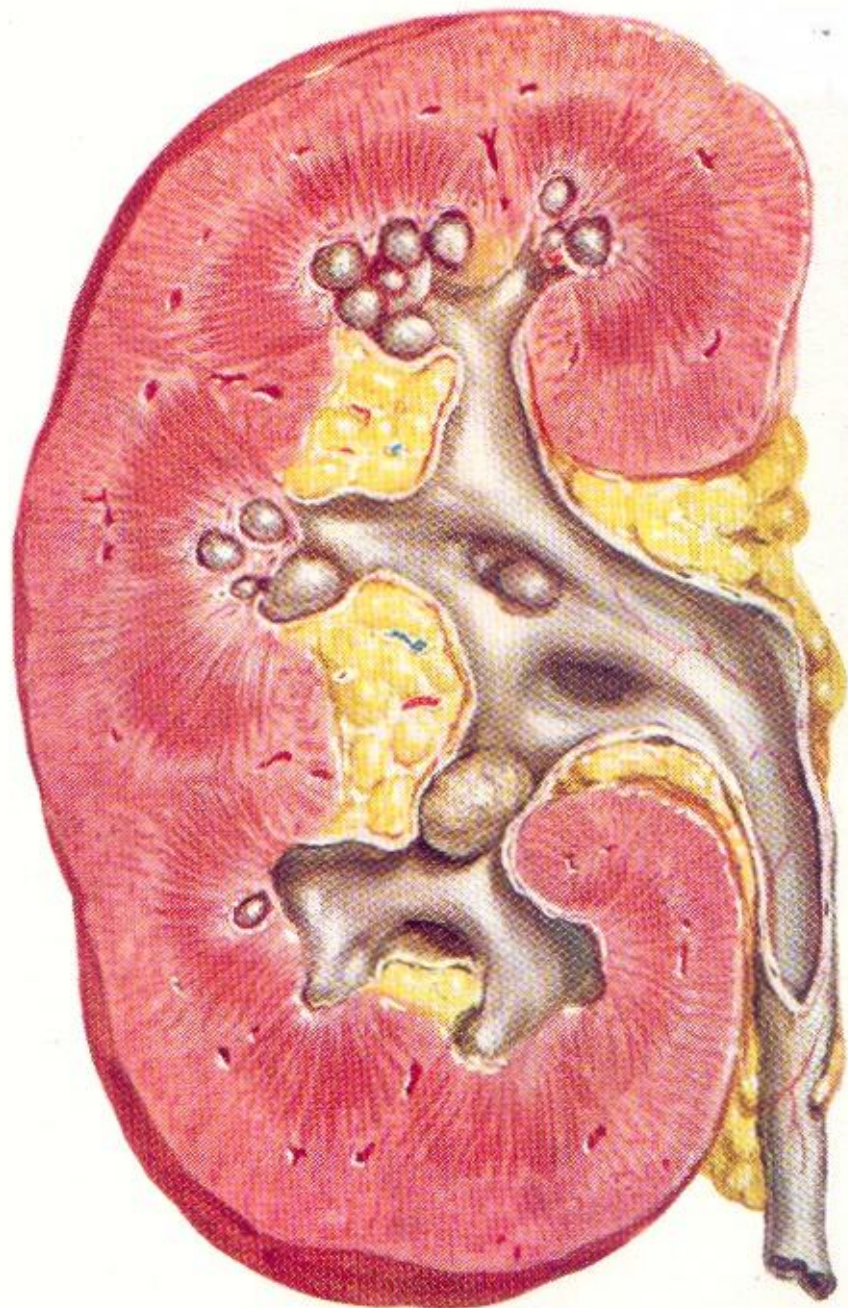
Intraluminal Pressure
Stretching of collecting system

Colicky Pain

Share same
neurogenic
pathways

Stretching of renal
capsule

**Non colicky Renal
pain**

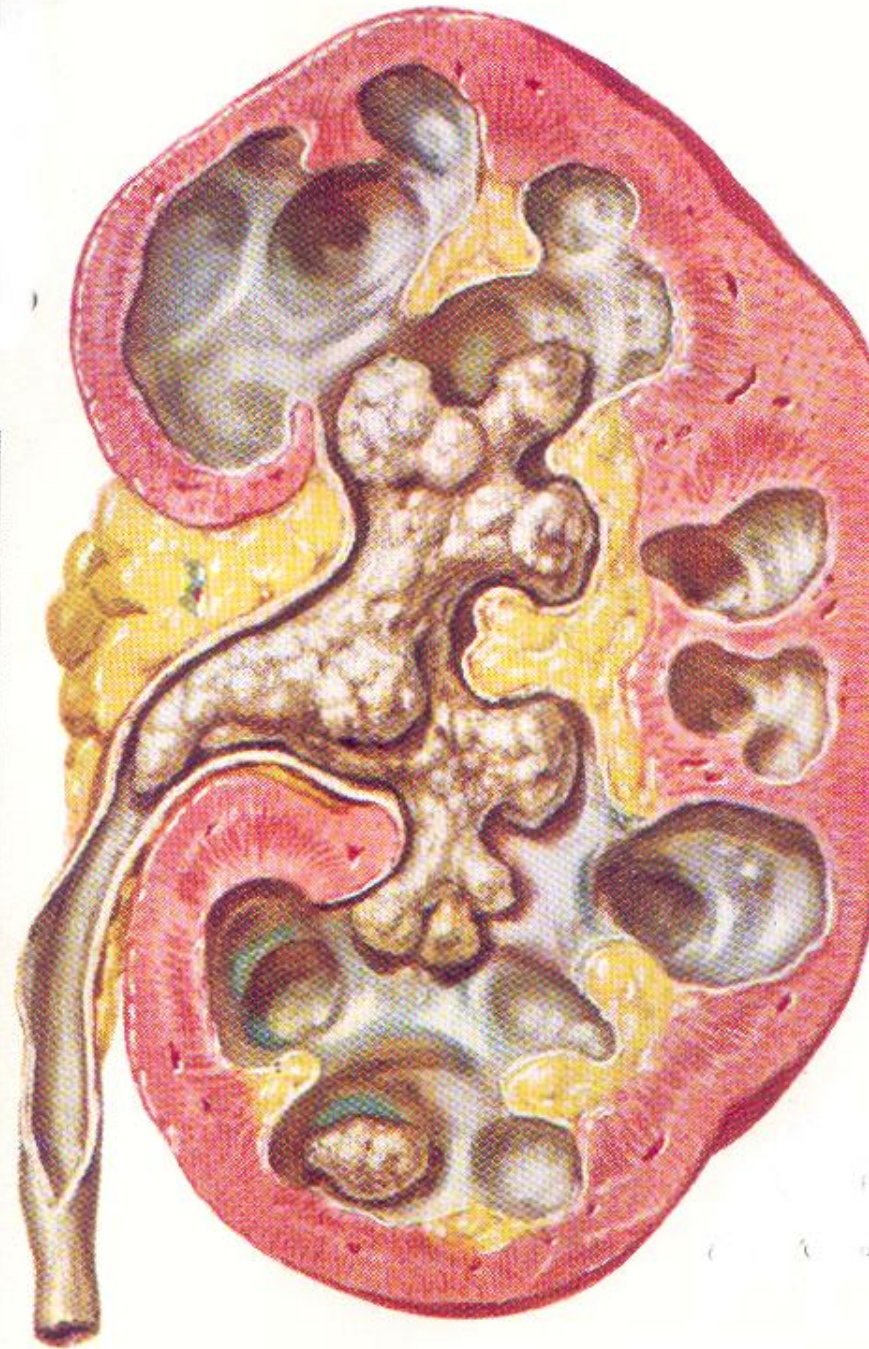
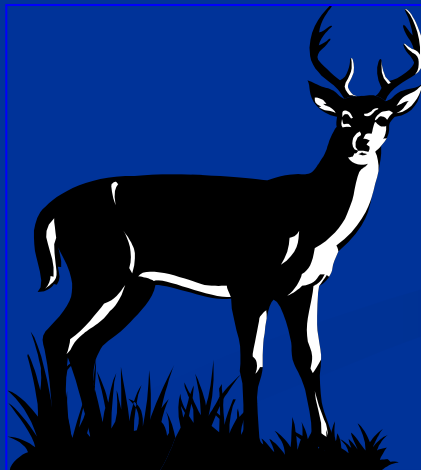


MULTIPLE SMALL CALCULI

- Renal Calyx :Periodic intermitant pain dull pain in back or flanks ,Precipt.by large fluid intake, usually non obstructing, pass on Spontaneously
- S/o obstruction ; long term retension, Infection,

Renal pelvis: >1cm produces Obstruction, severe pain at costo-vertebral angle lateral to sacrospinalis just below 12th rib, varies excruciating sharp to dull aching Radiates to flanks. Upper ipsilateral quadrant.

Staghorn Calculus; may not obstruct, SILENT, Recurrent UTI

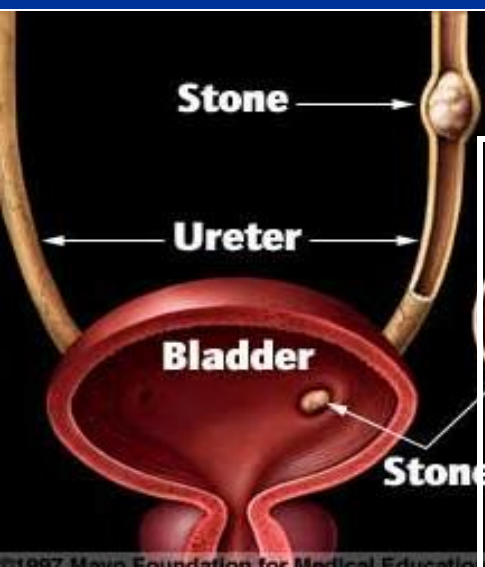


Renal pain varies with the site of stone



Upper ureter: Radiates to lumbar region, flanks

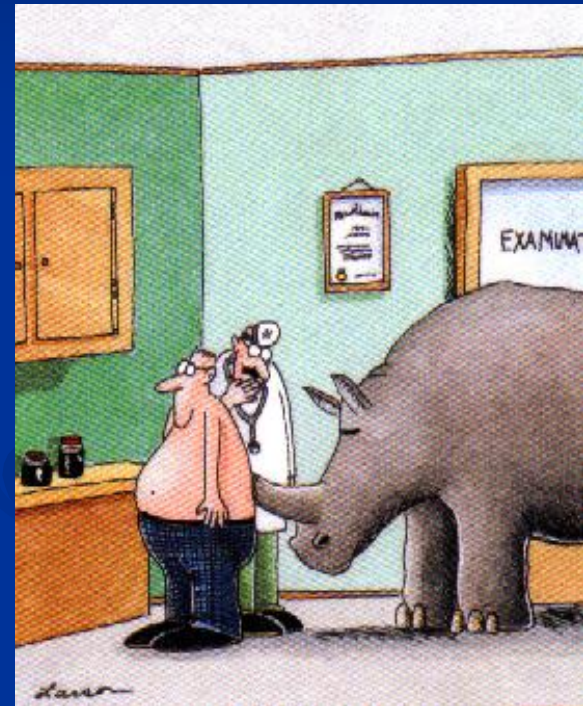
Middle ureter: Radiated parallel to costal margin, caudally / anteriorly
Obstructing produce more pain, still more when passing down (Autoregulatory mechanism reduce intra renal pressure)



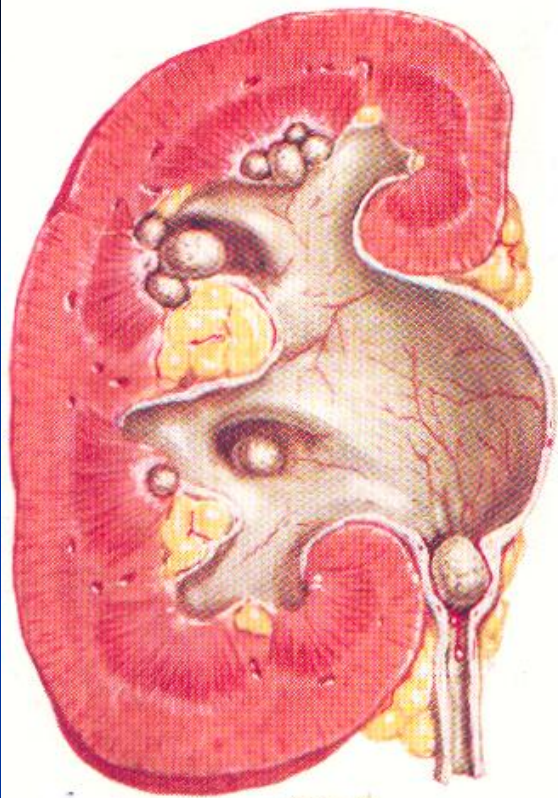
Distal ureter: radiation to groin or Testicles in males, Labia majora in females Ilio -inguinal nerve, genital branch of genito-femoral nerve

IntraMural ureter: suprapubic pain, pain at the tip of penis
Loss of testicular sensation

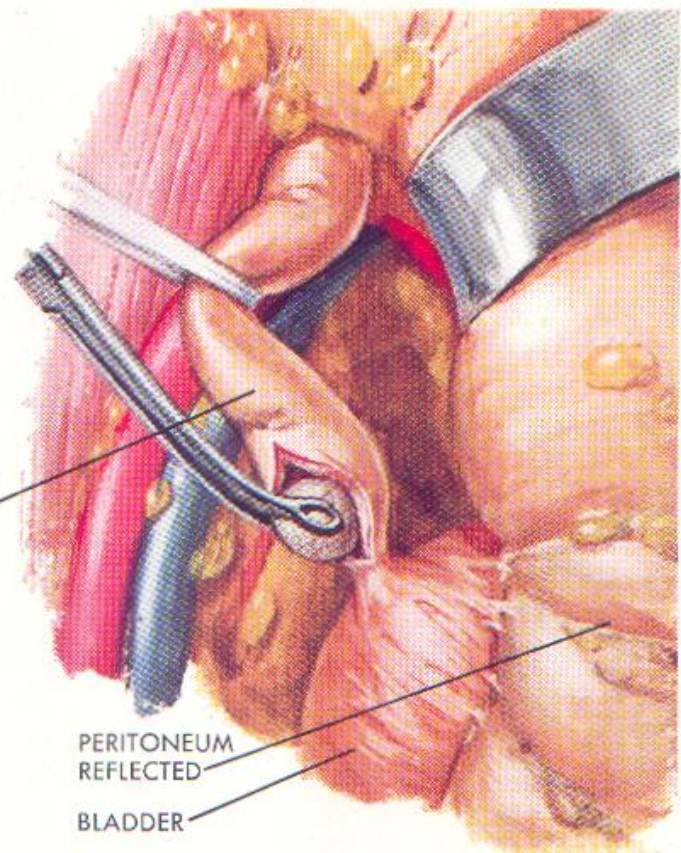
'Staghorn' stone



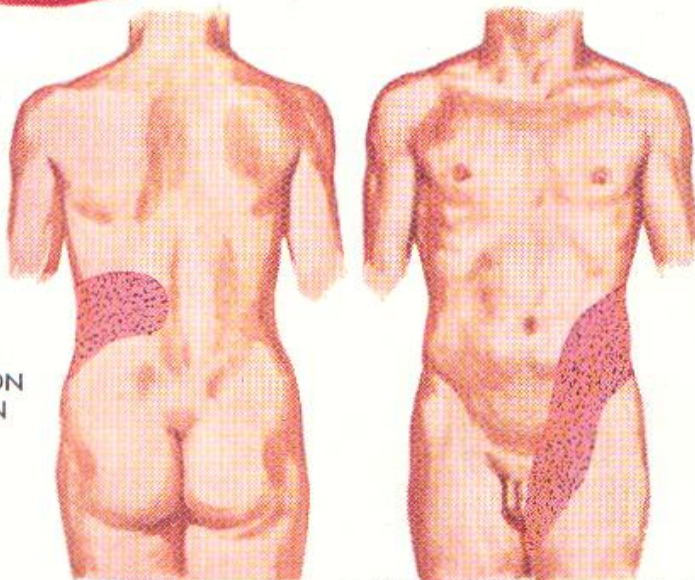
“Maybe its not a kidney stone after all”



DILATED
URETER

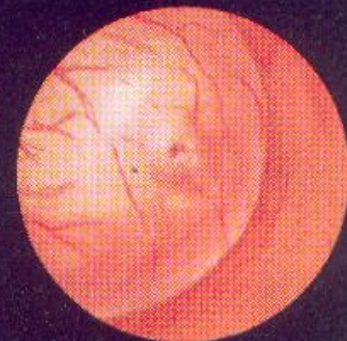


STONE IN LOWER END OF URETER IN PROCESS
OF REMOVAL THROUGH URETEROSTOMY



DISTRIBUTION
OF PAIN IN
URETERAL
COLIC

CYSTOSCOPIC
VIEW OF
URETEROCELE
WHICH MAY
OR MAY NOT
CONTAIN A
CALCULUS



Hematuria

Intermittent hematuria, occasional tea coloured urine, Most patients microhematuria

Infection

All obstructing stones present with signs of Infection- more Pain, More obstruction, Vicious cycle, Struvite stones, infection stones, calcium phosphate stones, matrix stones with minimal Crystalline component



Pyonephrosis

Infected Hydronephrosis, Gross pus in collecting system
Asymptomatic Bacterimia ----- renocutaneous fistula

Nausea and Vomiting

Chronic renal failure usually bilateral stones
IV fluids--- euvolemia effective for ureteric peristalsis

Associated Fever

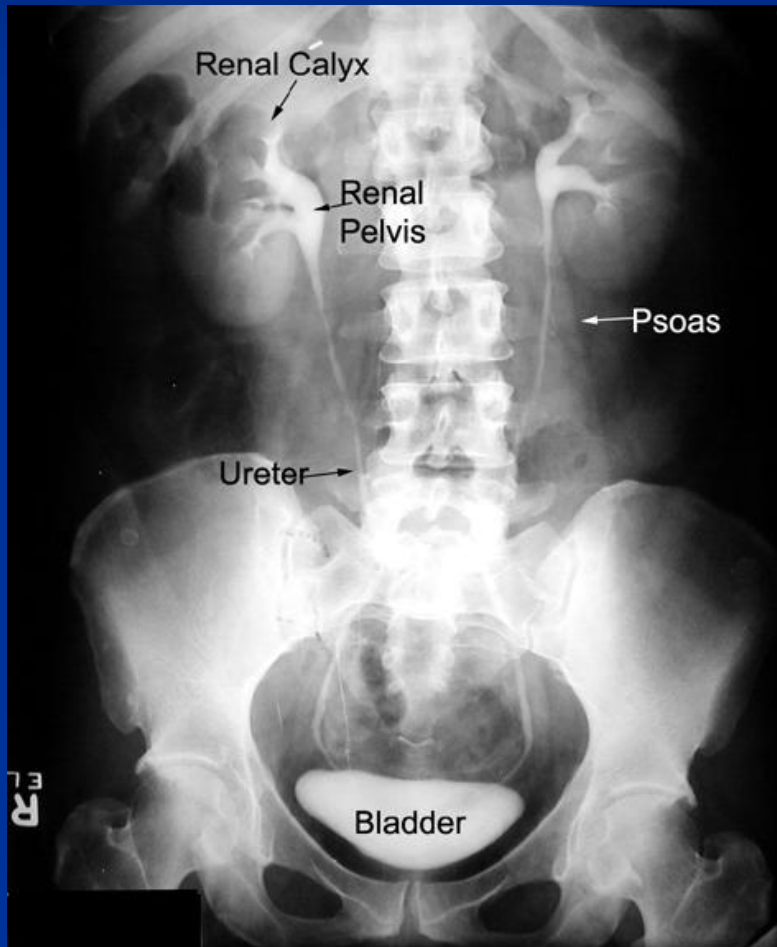
xanthogranulomatous pyelonephritis

Investigations for stones

Investigations for Upper Urinary Tract Stones

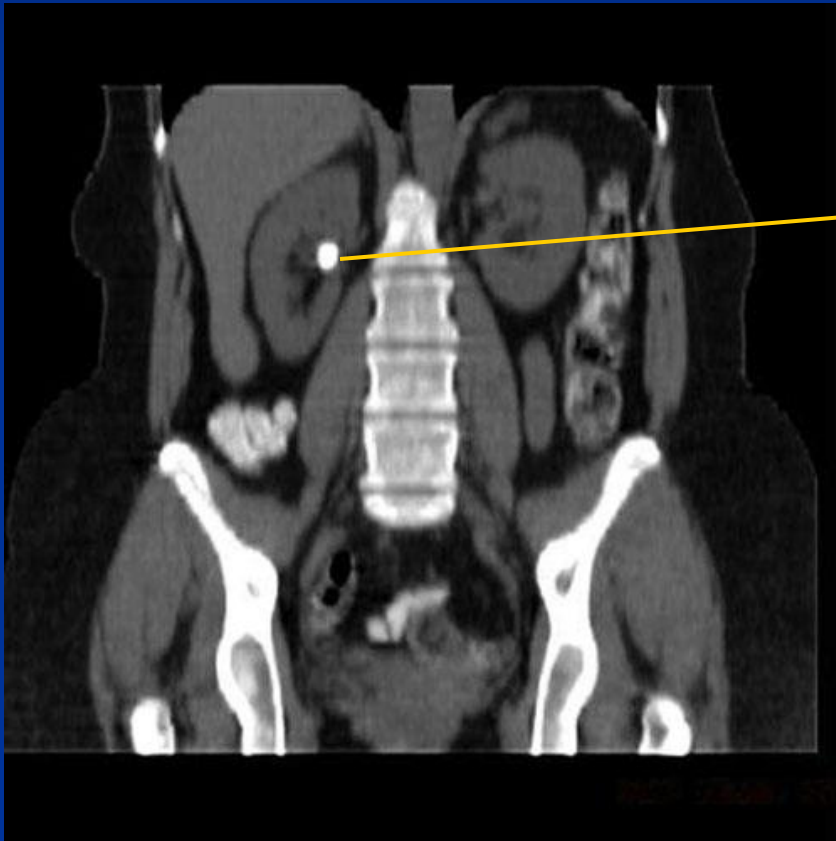
1. K.U.B.: First investigation
Must even before I.V.P.
2. U.S.G.: Suspicious areas of Stones can be useful in
Non functioning Hydroenphrosis, Pronephrosis
PCN can be done
Operator Dependent.
3. I.V.P.: Gold Standard of Investigation
Structure and function
Non functioning Kidney: Problem
Renal Tuberculosis
Intra calyceal calcification.

Intra Venous Urogram / IVP



- Multiple KUB over a period of time
- Bowel preparation given
- Intra venous contrast material to opacify kidney and collecting system
- Stones appear as opacity or filling defect
- Good for diagnosing stones in entire collecting system

CT Scan



- No contrast exposure
- ‘short’ study – 10 mins
- Radio opaque and lucent stones seen
- Hydronephrosis and hydroureter
- Evidence of inflammation

Ultrasound



■ Kidney

- stones
- hydronephrosis / hydroureter
- parenchyma disease

■ Bladder

- stones
- prostate enlargement

Investigations cont.

•

4. DTPA Scan: GFR available

Differential kidney function

Non functioning: Poorly visualised

Grades of obstruction.

5. R.G.P.: Ureteric obstruction

Stone or stricture PUJ

Congenital anomalies.

Management of urinary stones

- Pain management
- Control infection
- Relieve obstruction
- Definitive treatment of stone

Non surgical management

- Hydration
- Only for small stones which are expected to pass spontaneously
- Ureter stones < 5mm
- Trial of 2-3 weeks
- ? Traditional medications
e.g. Panputti, Cystone, Varunadi Quath, Gokhar Guggal etc

‘Dissolving a stone’

- Only in pure uric acid stone ($< 10\%$)
- Alkalinize urine with sodium bicarbonate tablets
- Lower blood uric acid levels with allopurinol
- Rate of dissolution: 1cm per month

Modalities of management Of Renal stones

- ESWL
- PCNL
- URS
- RURS
- Open Renal surgery
- Minimum Invasive Surgery
 - Robotics Surgery

You've got gall stones, kidney stones, and bladder stones...
Welcome to the Stone Age.



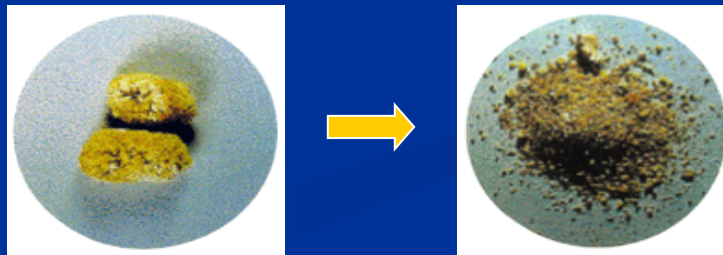
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Extracorporeal Shockwave Lithotripsy (ESWL)

‘A thousand grains of sand pass through the eye of a
needle before a single pebble’

W. Spencer



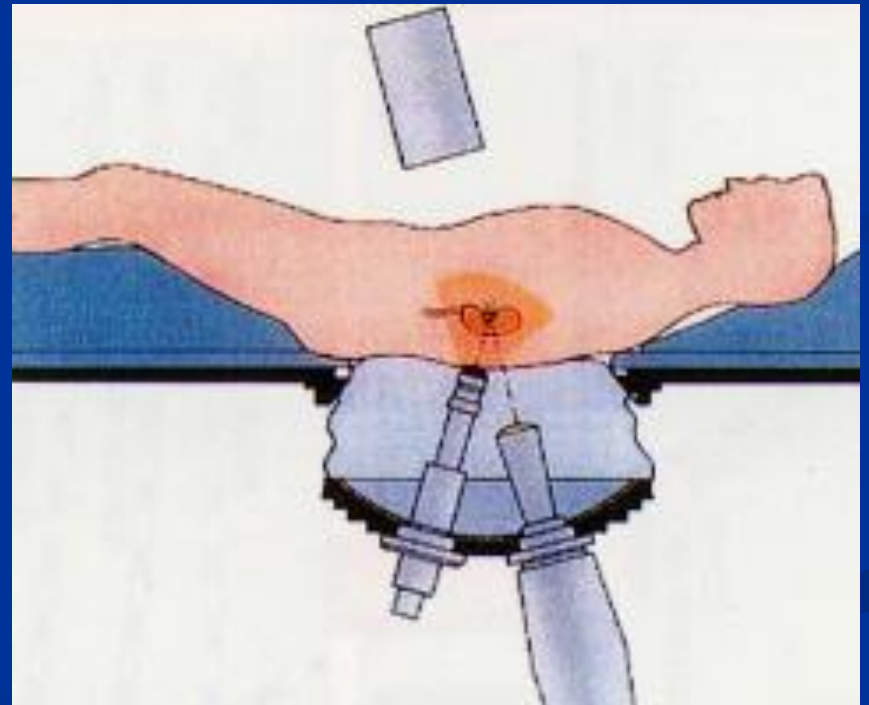
Observation

- ▶ Needs an Analytical Eye
- ▶ CIS platinum
- ▶ Penicillin
- ▶ Dornier Aircraft



ESWL

- Initially developed by aviation company, Dornier
- Shock waves generated by a spark
- Transmitted via water
- Energy absorbed by acoustic surface (stone)
- Stone shatters and fragments drained by urine



Development of ESWL



- Available since 1980s
- Modern-day non water bath
- Stone localised with x-ray or ultrasound
- Can be used to treat stones in kidney, ureter and bladder
- Success dependant on size and position of stone

ESWL treatment

- Day surgery
- Duration of about 1 hour
- Sedation, occasional GA
- Return to work in 24 hours
- Hydration to promote stone passage



E.S.W.L.:

Extra-corporeal Shock Wave Lithotripsy

■ Types:

- Supersonic Emitters
- Finite amplitude Emitters
 - (Piezo ceramic, Electromagnetic)

■ Components:

- Shock wave generator
- Coupling mechanism
- Stone Visualization System
- Fluroscopy/Ultrasound

.....ESWL

Shock wave physics

- high amplitude ,low frequency waves.
- generated in liquid medium like water.
- Transmission goes unimpeded till acoustic interface is present.
- Exert an compressive force part of which is reflected , causing stone to disrupt



..... ESWL

- Basic Components of Lithotripter



Energy source



Focusing system



Imaging unit



Coupling mechanism





ESWL cont

□ Indications:

- Renal Calculi 2.5cm – 3.5 cm
- Ureteric Calculi: Proximal + Distal.

■ Pre-requisites:

- Functioning Kidney
- No outlet obstruction.

■ Large Stones Infected Stone

- Obstructing Stone First
- D.J. Stent
- Several sessions may be required.
- PCNL for Debulking of stones.
- ESWL for endoscopically inaccessible stones.

Limitations of ESWL:

1. Stone Factors:
 - Large stone
 - Cystine/Oxalate Mono
 - Too soft Brushite
 - Radiolucent Matrix stone.
2. Kidney Factors:
 - Obstructed Kidney
 - Non-functioning Kidney
 - Inferior Calyceal Stones
 - Metaplasia or papillary Carcinoma
 - Renal artery calcification
3. Patient Factors:
 - Skeletal Abnormalities
 - Contractures
 - Excessive Weight >300 lbs
 - Bleeding Disorders
 - Pregnant Women
 - Cardiac pace maker

Follow up: ESWL

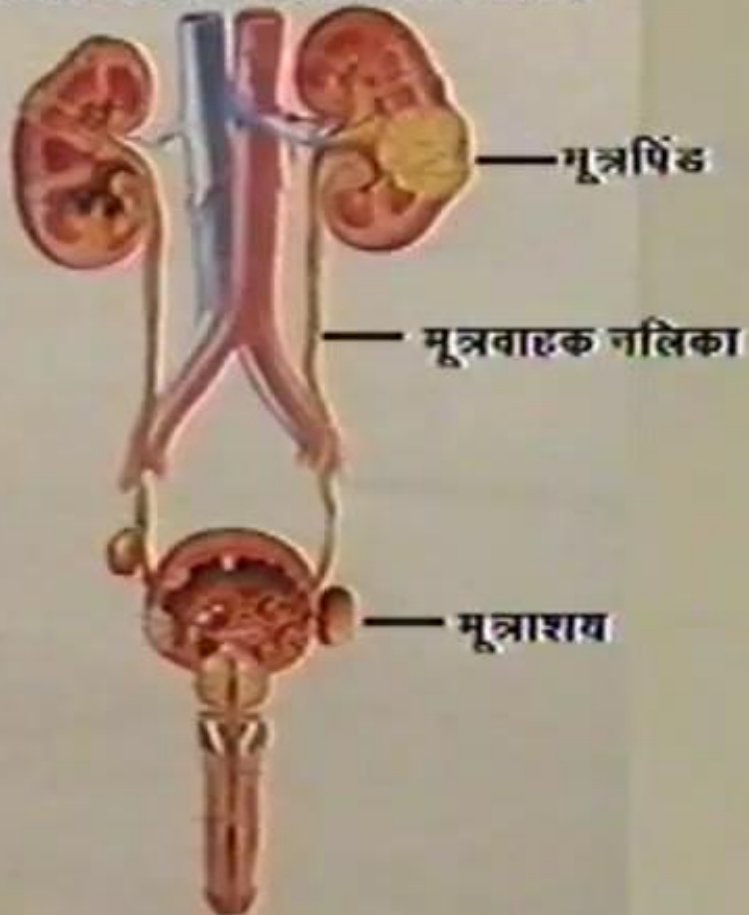
- ❖ Short wave produce
 - ❖ Intra Renal, Peri Renal Hematomas.
Subcapsular.
- ❖ Hematuria up to one week
- ❖ Steinstrasse
- ❖ Sepsis
- ❖ Hypertension
- ❖ Renal atrophy.

Hematuria POP

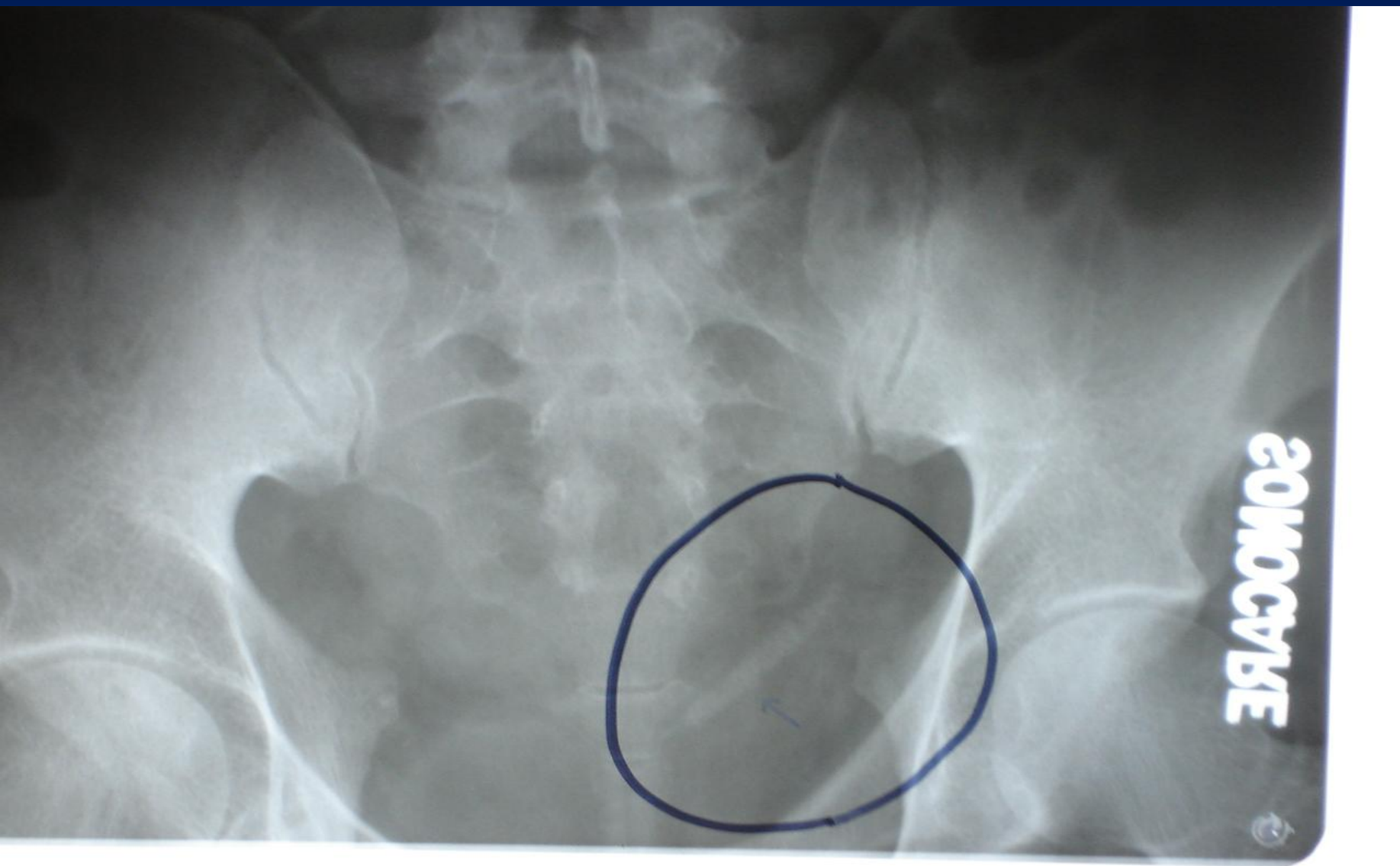
....

- Transient haematuria.
- Colic.
- Fever. . . Occurs in few patients
-
- Symptomatic treatment required .

DISEASES OF THE URINARY TRACT





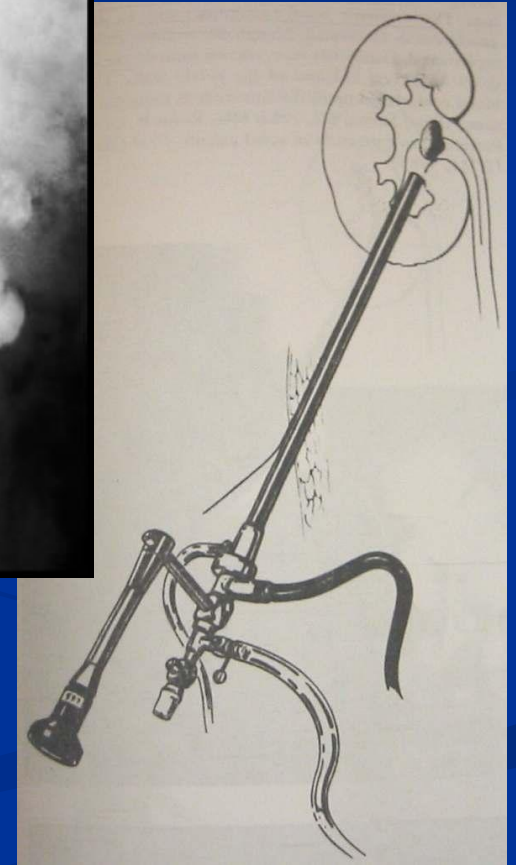
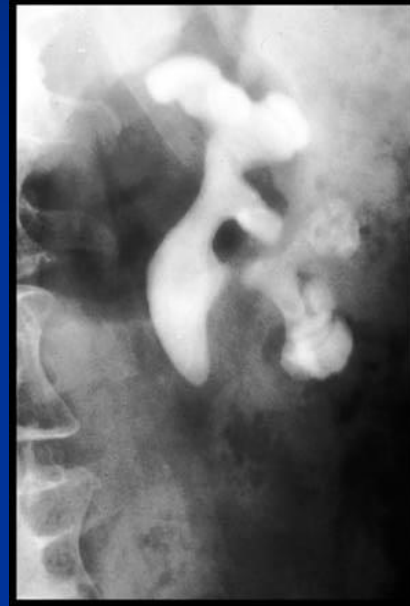


PCNL

Per Cutaneous nephrolithotomy

Percutaneous surgery

- Small puncture made on skin overlying kidney
- Tract dilated
- Access to kidney developed for
 - removal of stones



PCNL

(percutaneous nephrolithotomy)

- Small hole for big stones
- Very large stones can be fragmented with laser and removed via small skin puncture
- More than 1 puncture can be made
- General anaesthesia, surgery duration 1-3 hours, hospital stay 3 days



End product



Nephrostomy tube



Stones

PCNL: Procedure

- Initial Puncture After Ureteric Catheter
Usually done in post axillary line in to post. Inferior Calyx
- 2. Dilatation of tract till your Reach 24Fr.
Amplaz System: Sequential Plastic Dialator
Alkan System: Telescoping Metal Dial
- 3. Visualization of (Nephroscopy) Collecting System
- 4. Crushing of Stones with:
Electrohydraulic System
Ultrasonic System Suction to
Pneumatic Lithotripsy clear the debris
Laser System : Holmium Laser
- 5. Remaining Calculi picked up Flexible Ureteroscope

PCNL :Indications:

- Hard Stones/Too soft stones
- Inferior Calys stones/PU Junction
- Infundibular narrowing
- Non functioning Kidney
- Large Stones > 3 cms
- ESWL Failures: Not Breaking,Residual stone. Hage

Not indicated when

Stones that cannot be focussed

Anamolies of urinary tract/skelaton

Transplanted Kidney.



HITECH UROLOGY INSTITUTE

F

S.W.KA

25-08-2001

15cm 3.5MHz 4

USP





Ureterorenoscope

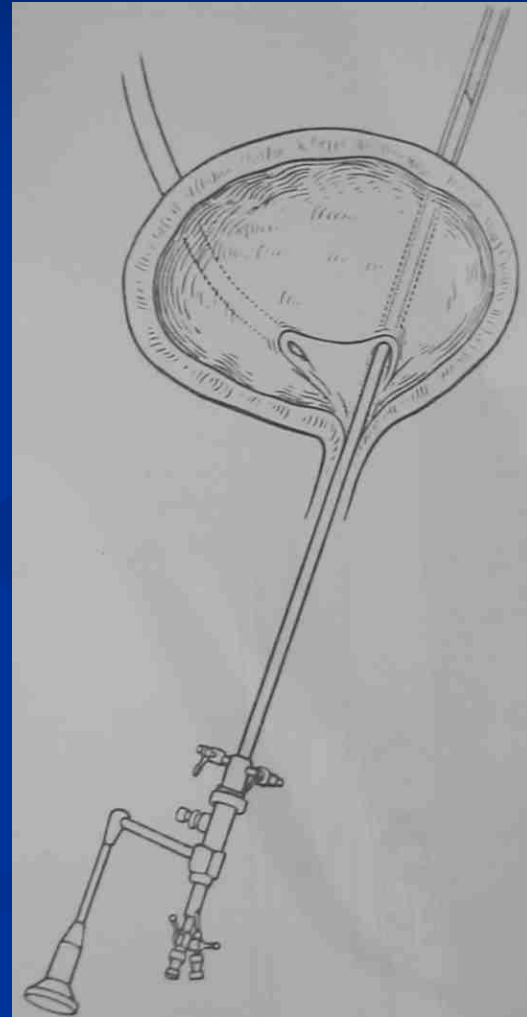
Endoscopic ureter procedures

Endoscopic ureter procedures

- Uretero renoscope
- Better optics and video
- Revolutionized treatment of pathologies in the ureter
- Mainstay of treatment now, more developments in future

Endoscopic ureter procedures

- GA, RA
- Cystoscopy, identification of ureteric orifice
- Ureteroscopy with guide wire
- Able to reach renal pelvis



Ureteroscopy for stones

- Treatment of choice for lower ureter stones > 5mm
- Good alternative for upper ureter stone > 5mm
- Lithotripsy – laser, ultrasound, EHL, pneumatic



Ureteroscopy for stones



Laser lithotripsy

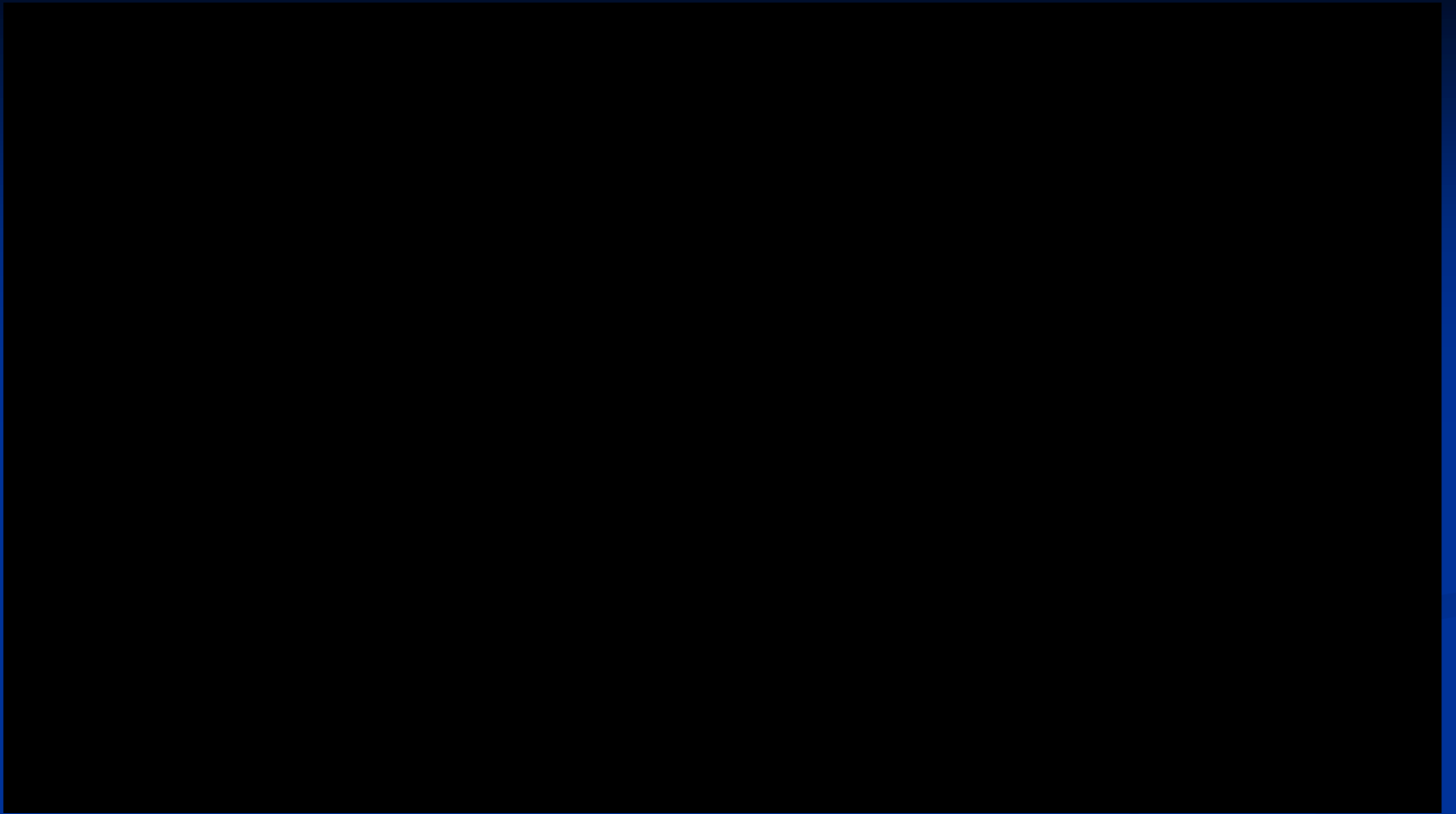
URS: Uretero Renoscopy

- Ureteroscopy + Renoscopy
- Introduction of Rigid Ureteroscope for Visualization & Crushing of Stones
- Cystoscopy & Passing of guide wire
- Dilation of Ureteric orifice
- Visualization of stone: Basketing/Crushing
- Lithotrite System Available:
 1. Electrohydrolic Lithotripsy
 2. Ultrasonic Crushing
 3. Pneumatic Lithotripsy: Swiss Lithoclast
 4. Laser System : Holium Laser

URS cont

- Effective in Lower Ureteric Stones
- Effectivity decreases as you ascend up
- Pelvic stone could be removed.
- Factors Affecting:
 - * Stone Burden
 - * Location
 - * Length of time since stone impacted
 - * H/o Retroperitoneal Surgery
 - * Experience of Operator.

USP



Open renal surgery for Nephrolithiasis

Operative Procedures for Upper Urinary Tract Stones:

- Pyelolithotomy: Extra Renal pelvis
- Transverse/Spiral Pyelotomy
- Extended Pyelolithotomy: Intra Renal
 - (Gil-vernet)Pelvis, Large Stone, Stag Horn.
- Radial Nephrolithotomy
- Anatomic Nephrolithotomy
- Partial Nephrectomy
- Nephrectomy
- Ureterolithotomy
- PCN or open Nephrostomy.

**Are there any
indications for
Open Renal Surgery
in era of
ESWL and PCNL**

Catastrophic Scenarios:

The Failure of Minimally Invasive Salvage

The following cases represent common high-stakes complications of PCNL and ESWL where the immediate availability of a skilled open surgeon is the critical dividing line between recovery and mortality

- Massive Hemorrhage Post-PCNL: The Pseudoaneurysm Rupture
- The Catastrophe: Initial Event: A patient undergoes routine PCNL for a large stone.
- The procedure is complicated by moderate bleeding, managed initially with a large nephrostomy tube (conservative measures).
- Delayed Complication: Days or weeks later, the patient develops sudden, exsanguinating hematuria and hypovolemic shock due to the rupture of an unstable Renal Artery Pseudoaneurysm (RAP) caused by the initial tract dilation.
- The Failure Point (Lack of Open Capacity): The hospital lacks 24/7 interventional radiology (IR) capability for the primary treatment (Angiographic Embolization).

- The patient is too unstable or the bleeding is too rapid to allow for transport to a tertiary center with IR/Open capability.
- The surgeon on call is proficient in PCNL but lacks experience or confidence in performing an Emergency Open Nephrectomy or Renal Vascular Repair under emergent, unstable conditions.
- Catastrophic Outcome: The patient bleeds out, progressing from hypovolemic shock to Disseminated Intravascular Coagulation (DIC) and Multi-Organ Failure (MOF), ultimately leading to death, solely because the definitive control—surgical ligation of the main renal vessels or an emergency nephrectomy—was delayed or avoided.

Visceral Injury Post-PCNL: Undiagnosed Colonic Perforation

- The Catastrophe:
- Initial Event:
 - PCNL is performed using an access route that is slightly postero-lateral, unknowingly passing through a retrorenal colon (an anatomical variant present in up to 2% of cases).
- Delayed Complication: Post-operatively, the patient develops fever, severe abdominal pain, and an evolving picture of peritonitis. Bowel contents (feces, gas) begin to leak through the nephrostomy site, confirming a colonic perforation.
- The Failure Point (Lack of Open Capacity): The facility's general surgeon or the urologist is not immediately available or equipped for a Laparotomy (open abdominal exploration) and Colonic Repair/Diversion (e.g., colostomy).
- There is a delay in recognizing the severity of the injury, treating it conservatively with antibiotics until the patient becomes septic.
- Catastrophic Outcome: The patient develops overwhelming fecal peritonitis and septic shock. The lack of timely, definitive open surgical repair—often requiring open access to control the contamination and repair the bowel—leads to refractory shock, multi-organ system failure, and mortality.

ESWL Complication: Unmanaged Infected "Steinstrasse"

The Catastrophe:

- **Initial Event:** A patient with a large, partially infected renal stone undergoes ESWL. The shock waves successfully fragment the stone, but the fragments coalesce in the ureter, forming a dense, obstructing column known as a "Steinstrasse."
- **Delayed Complication:** The obstruction leads to a rapid build-up of infected, pressurized urine (**obstructive pyonephrosis**). The patient becomes acutely ill with high fever, chills, and signs of **urosepsis**.
- **The Failure Point (Lack of Open Capacity/Urological Expertise):**
 - While the immediate treatment is drainage (stent or PCN), the massive stone burden in the ureter is too large or too hard for subsequent **Ureteroscopy (URS)** to clear quickly.
 - The only option left for definitive, rapid clearance to eliminate the septic focus is an **Emergency Open Ureterolithotomy** (incision into the ureter to remove the stone mass).
 - If the surgeon is only trained in basic endoscopic methods and cannot perform the ureterolithotomy, the stone remains, and the infection cannot be completely cleared.
- **Catastrophic Outcome:** Despite temporary drainage, the persistent, massive infective stone burden fuels the sepsis. The patient's condition deteriorates into **septic shock** and subsequent death.

Why This Justifies Teaching Open Surgery

These scenarios are why **open surgery is indispensable for a comprehensive urologist, not as a primary treatment, but as the essential rescue maneuver:**

- **The Need for Definitive Control:** In the face of catastrophic hemorrhage or severe hollow-viscus injury, *no* amount of endoscopic skill can replace the ability to open the abdomen or flank, directly visualize the injury, clamp the vessels, and suture the defect.
- **Anatomical Mastery:** Training in open surgery instills a profound, tactile understanding of the retroperitoneal and renal anatomy. This knowledge is what allows a surgeon to swiftly identify and control a bleeding segmental artery or locate a displaced colon during an emergency.
- **The "Uncommon" Emergency:** While major complications are rare, they are almost universally life-threatening. A urological department that serves a large population **must** maintain the open surgical skill set to manage the 1% of patients who will require this life-saving intervention.

The ability to perform open surgery is the final safety valve in modern stone disease management, ensuring that the patient who develops a catastrophic complication from a minimally invasive procedure does not succumb due to a lack of surgical expertise.

Procedure	Indication (Typical Stone Size)	Operating Time (Range)	Blood Loss / Transfusion Rate	Stone-Free Rate (SFR)	Major Complications (Clavien ≥III)	Residual Stone Definition/Rate
ESWL (Extracorporeal Shock Wave Lithotripsy)	Renal stones ≤ 2 cm	45-60 minutes	Minimal	50-70% (for single session)	1-5% (Steinstrasse, urosepsis, perinephric hematoma)	≤ 4 mm fragments acceptable; High initial rate (30-50%)
URS (Ureteroscopy)	Ureteral stones; Renal stones ≤ 2 cm (Flexible URS)	60-90 minutes	Minimal	80-95% (Ureteral); 60-90% (Flexible RIRS)	2-5% (Ureteral perforation/avulsion, stricture, urosepsis)	Defined as >2 mm fragments; Varies greatly, often <10% after successful procedure.
PCNL (Percutaneous Nephrolithotomy)	Renal stones >2 cm, Staghorn calculi	60-120 minutes	100-500 mL (Transfusion 5-10%)	75-95% (Single Procedure)	10-20% (Hemorrhage, Sepsis, Pleural/Colonic injury, AV fistula)	Defined as >4 mm fragments; Typically 5-15%,
Open Pyelolithotomy (Simple)	Large renal pelvis stone without complex caliceal extension	60-90 minutes	100-300 mL (Transfusion <5%)	95-100%	5-10% (Wound infection/hernia, prolonged ileus)	Near (Direct visual inspection of the pelvis)
Open Nephrolithotomy/ AN (Anatrophic Nephrolithotomy)	Complete Staghorn Calculi	120-200 minutes	500-1000 mL (Transfusion 20-40%)	95-100%	15-30% (Renal failure due to ischemia, wound morbidity, high blood loss)	Near (Meticulous <i>ex vivo</i> stone removal and caliceal inspection)
Bench Surgery (Extracorporeal AN + Autotransplant)	Extremely complex staghorn or renovascular pathology in a solitary kidney.	240-480 minutes (Total time)	500-1500 mL (Transfusion 20-50%)	99-100%	20-40% (Vascular thrombosis, graft loss, ureteral stricture, Delayed Graft Function)	Near (Surgery performed <i>ex vivo</i> with perfect visibility)

The Inverse Relationship between Invasiveness and SFR Minimally Invasive (ESWL/URS/PCNL)

- Characterized by shorter operating times and less blood loss, but often accept a trade-off in lower single-session Stone-Free Rates (SFRs) and a significant rate of residual stones (CIRFs, $\leq 4 \text{ mm}$ fragments). These procedures may require multiple sessions to achieve definitive clearance
- .Open Surgery (Pyelolithotomy/AN/Bench): Characterized by longer operative times and significantly higher intraoperative blood loss/transfusion rates, but these methods achieve the highest SFRs in a single setting, which is the primary goal in complex, infected, or staghorn cases where residual fragments pose a severe risk of sepsis and recurrence.

Complication Type and Severity

- PCNL carries the highest risk of acute, life-threatening complications (e.g., severe hemorrhage/transfusion, visceral injury, sepsis), typically classified as Clavien Grade III or IV.
- Open Surgery (Pyelolithotomy/AN) complications tend to be related to the surgical incision (wound infection, hernia, prolonged pain) and the need for clamping/ischemia (risk of renal functional loss), but the definitive control allows the surgeon to manage hemorrhage immediately, often preventing the delayed, catastrophic bleeds seen post-PCNL.
- Bench Surgery combines the trauma of open surgery with the risks of transplantation (graft thrombosis, ureteral complications), yielding the highest overall morbidity rate, but is only performed to salvage a kidney that would otherwise be lost.

Advances in Open Renal surgery

- Development of Intra sinusoidal surgery
- Ability of removing large stones without cutting renal parnchyma
- Understanding of Renal Pelvis
 - Transverse or Spiral pyelotomy
- Regional renal Hypothermia
 - Anatomic nephrolithotomy
- Auto transplantation or Bench surgery
- Intra operative gadgets
 - Endoscopy
 - Radiography
 - USG

Indications

- Size and no of stones
 - Large extensive stones, Stag horn
 - Multiple : Single go stone free
- Anatomical and congenital abnormality
- Outlet obstruction stones not accepted
- Non functioning kidney
- Failure of ESWL and PCNL
- Contraindications for either procedures
- Residual
 -

Indications contd

- Unavailability and expertise and hardware for ESWL and PCNL
- Economic conditions
- Complications of Advanced procedures

Operative Evaluation

- Opposite kidney : Presence and Function
- Lateral IVP to localize stones
- Kochs and Stones
 - Inter calacyceal calcification
 - both may co exist
- MULTIPLE STONES
 - no of stones , branches of stones
 - Superimposed stones
 - Small stones < 1cm Think again

Incision

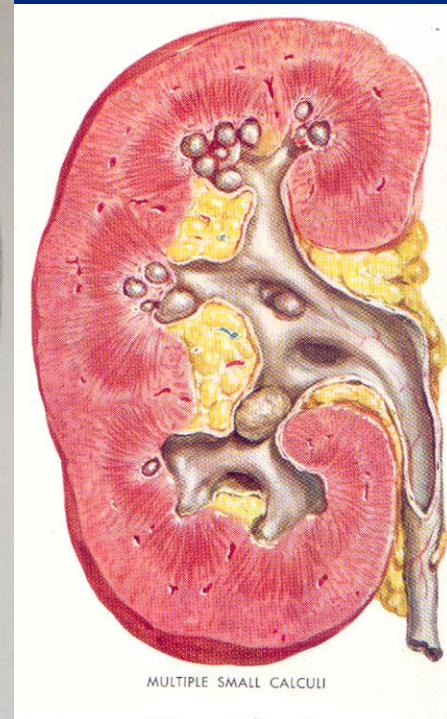
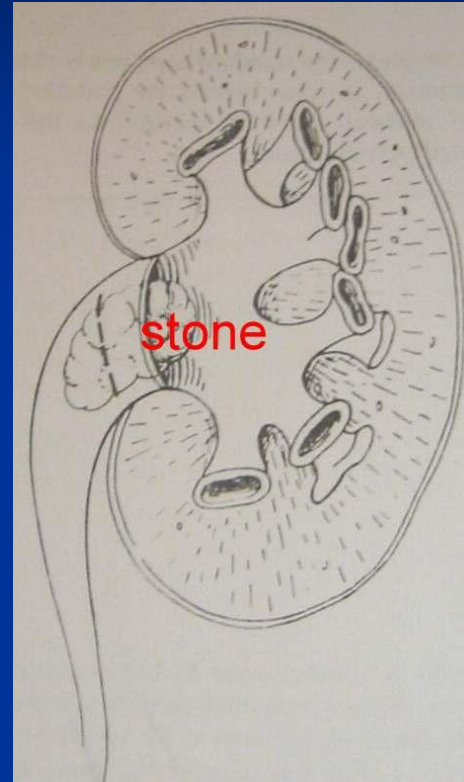
- Law of Incision
 - Horizontal line passing through hilum laterally ,most lateral rib it intersects should be removed
- Flalinks Incision
 - Sub costal
 - 12th rib Bed
 - 11th rib Bed
- lumbotomy incision
- Nagamatsu Flap incision

Open renal surgery for stones

- 1% of total surgery for stones
- Concurrent with other procedures
- Abnormal anatomy, not amenable to endoscopic procedures

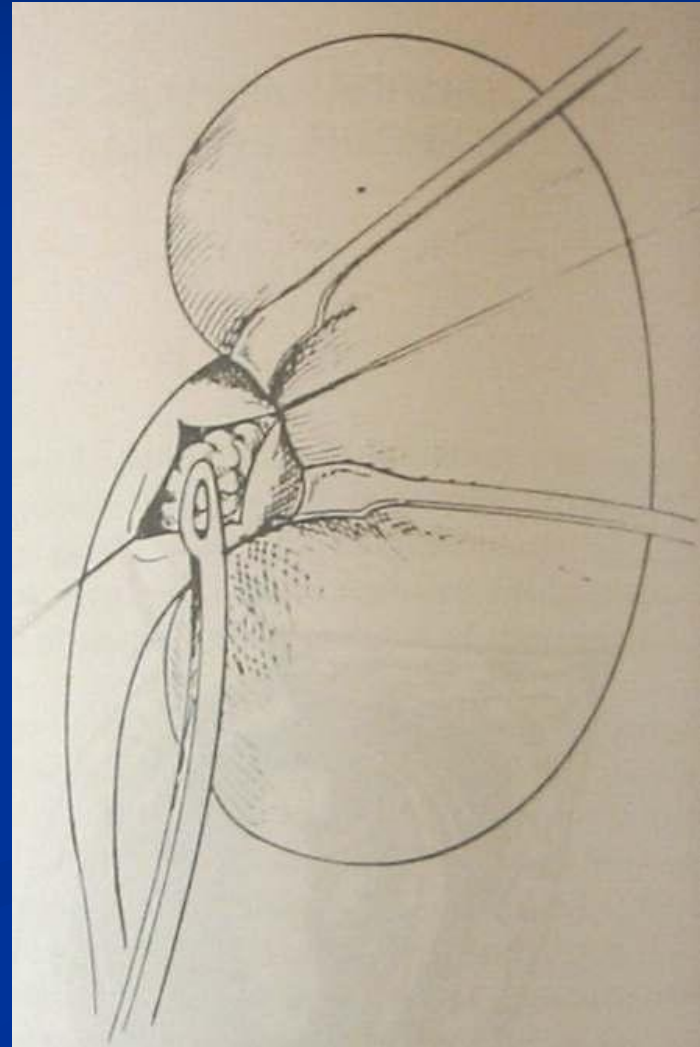
Pyelolithotomy

- Lateral position, flank incision
- Extraperitoneal approach
- Retroperitoneal space
- Exposure of kidney and renal pelvis
- Incision on renal pelvis



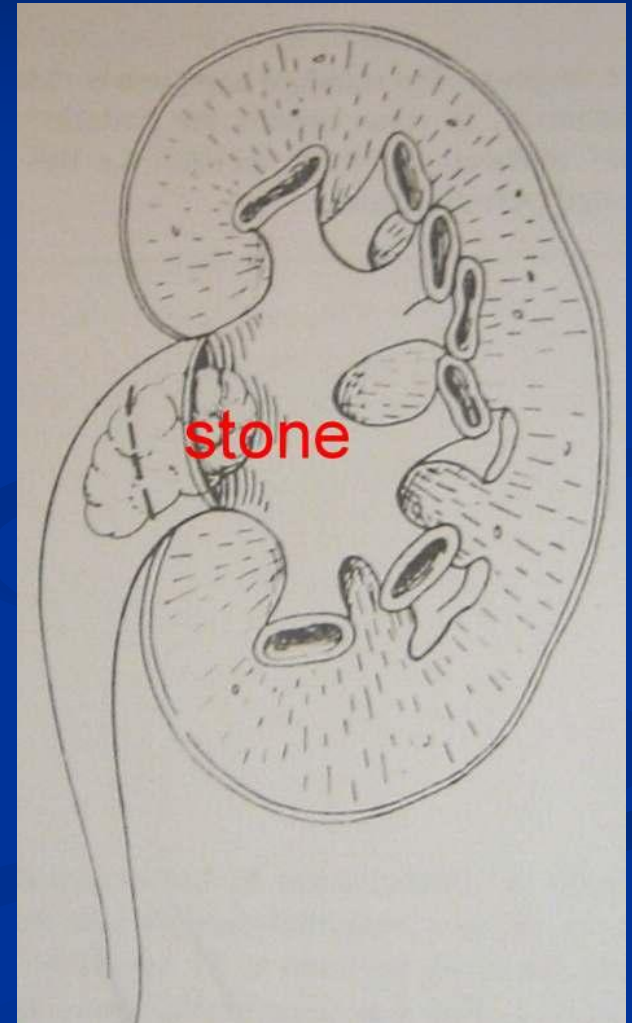
Pyelolithotomy

- Removal of stone with stone forceps
- Placement of JJ stent
- Repair of renal pelvis with absorbable sutures
- Drain



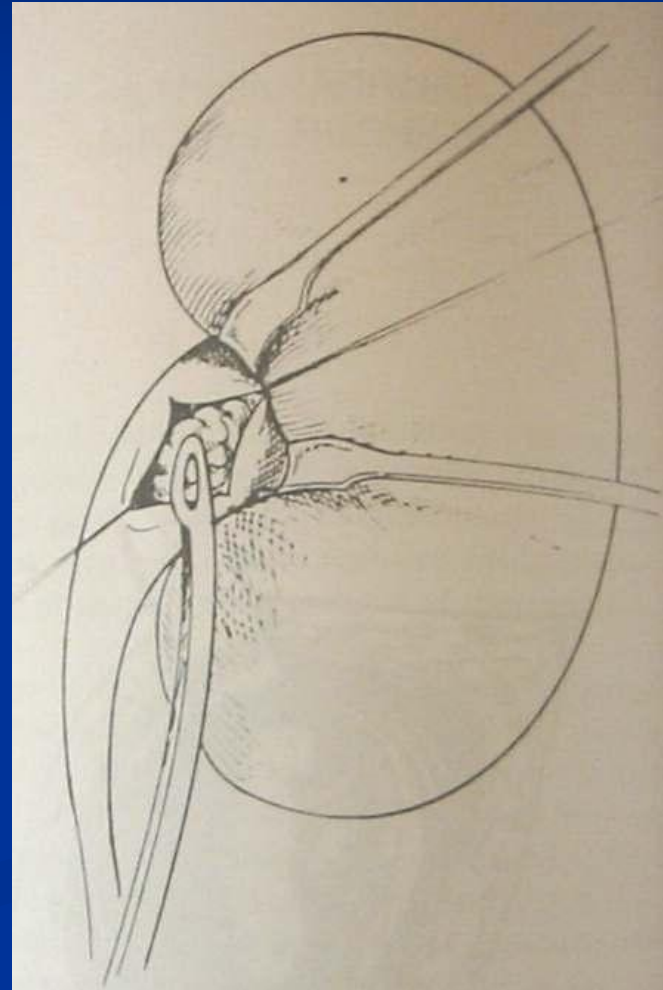
Pyelolithotomy

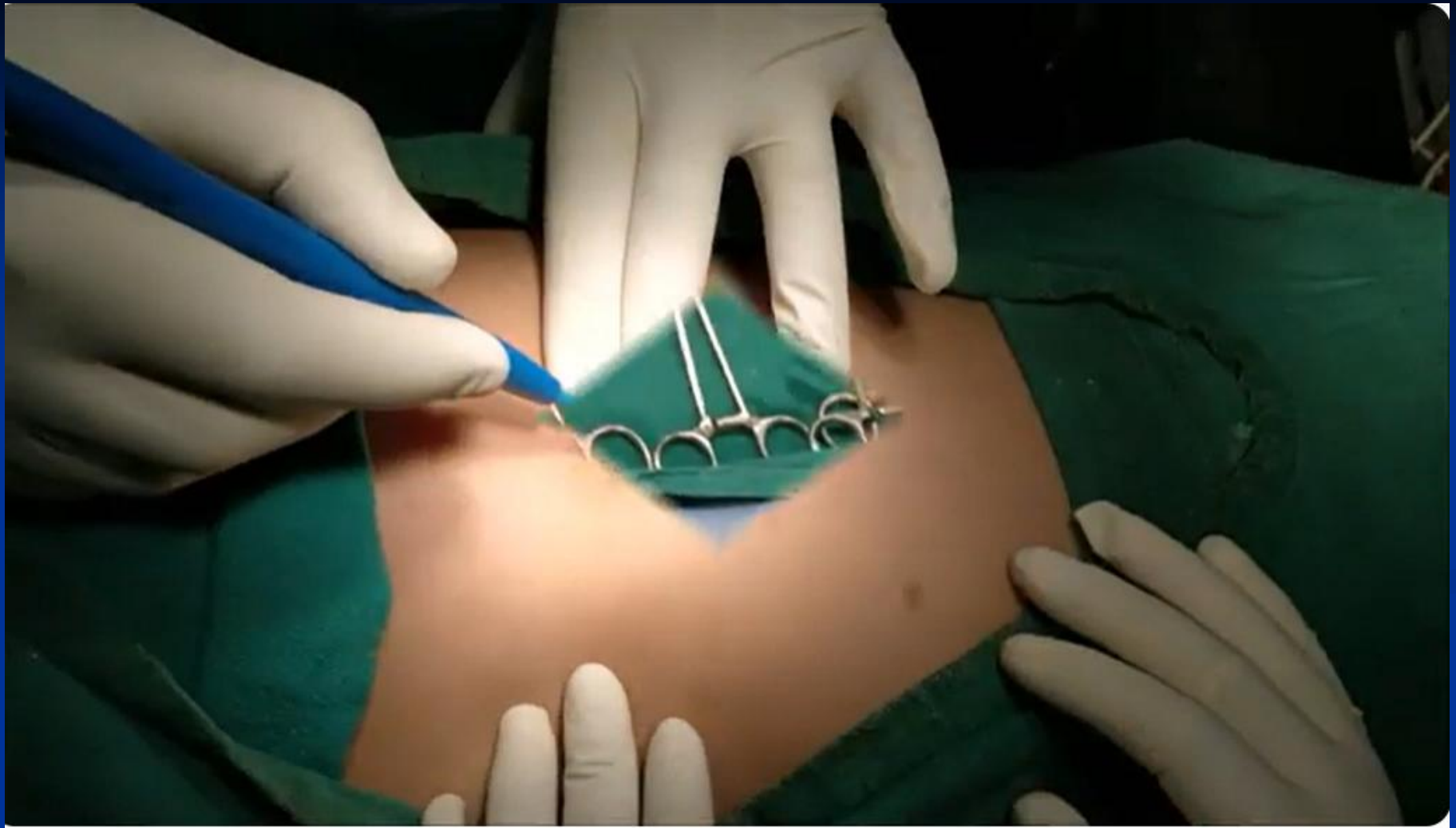
- Lateral position, flank incision
- Extraperitoneal approach
- Retroperitoneal space
- Exposure of kidney and renal pelvis
- Incision on renal pelvis



Pyelolithotomy

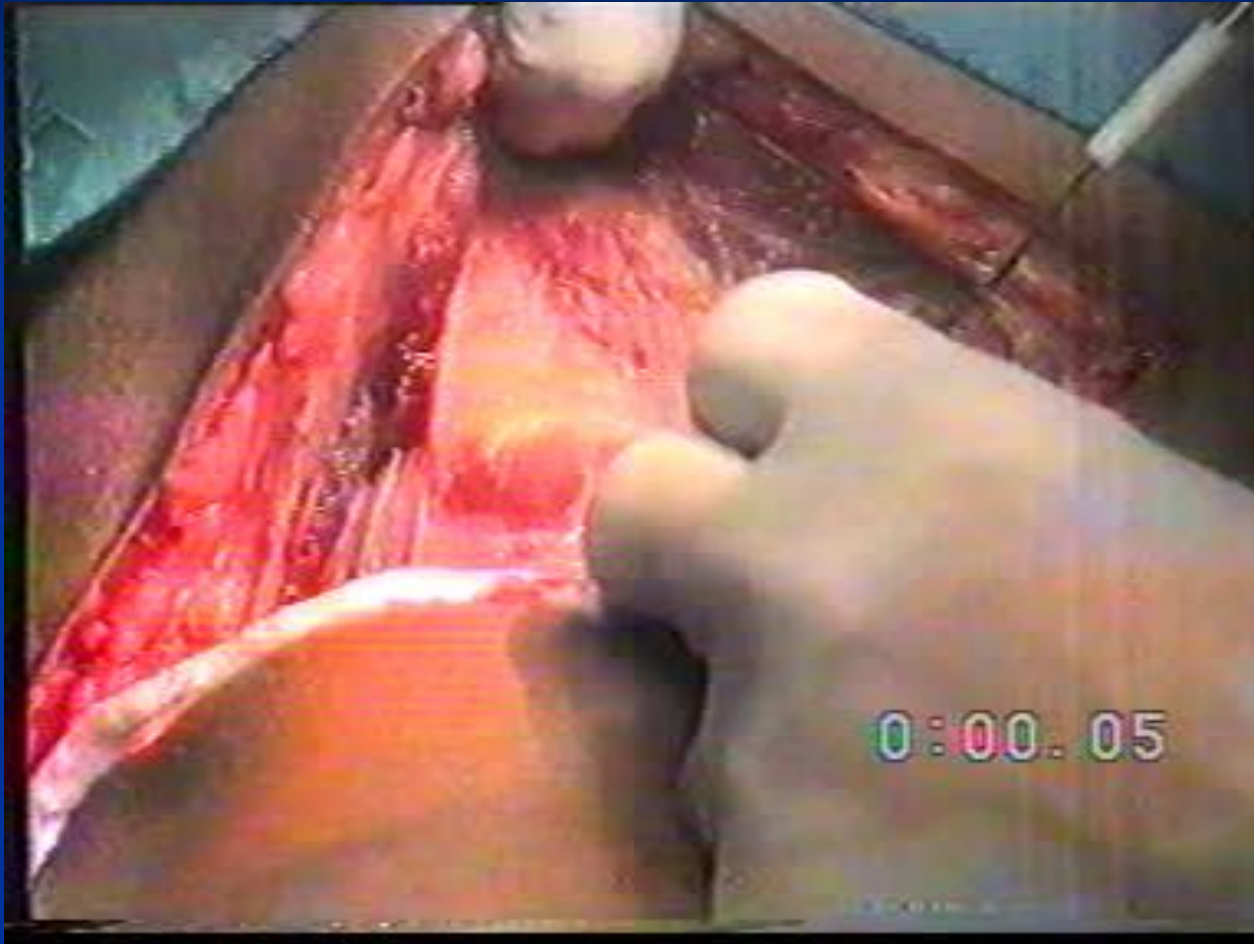
- Removal of stone with stone forceps
- Placement of JJ stent
- Repair of renal pelvis with absorbable sutures
- Drain



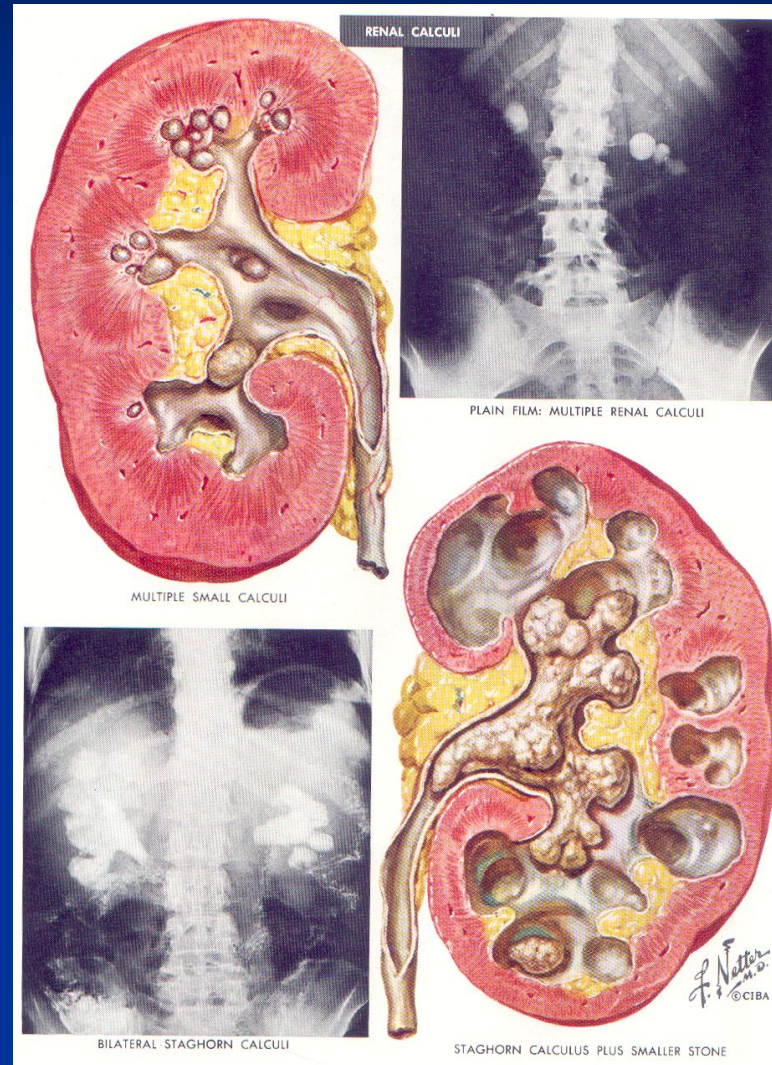


Open Pyelolithotomy, Removal of Kidney stone

Pyelolithotomy



Nephrolithotomy



NEPHROLITHOTOMY AND PYELOLITHOTOMY

STONE REMOVED VIA INCISION
IN LATERAL MARGIN OF KIDNEY
POLE; RENAL VASCULAR PEDICLE
COMPRESSED BY BULLDOG CLAMP
TO CONTROL BLEEDING

KIDNEY SPLIT AND WIDELY
LAID OPEN FOR REMOVAL OF
MULTIPLE STONES

STONE REMOVED
VIA INCISION IN
RENAL PELVIS

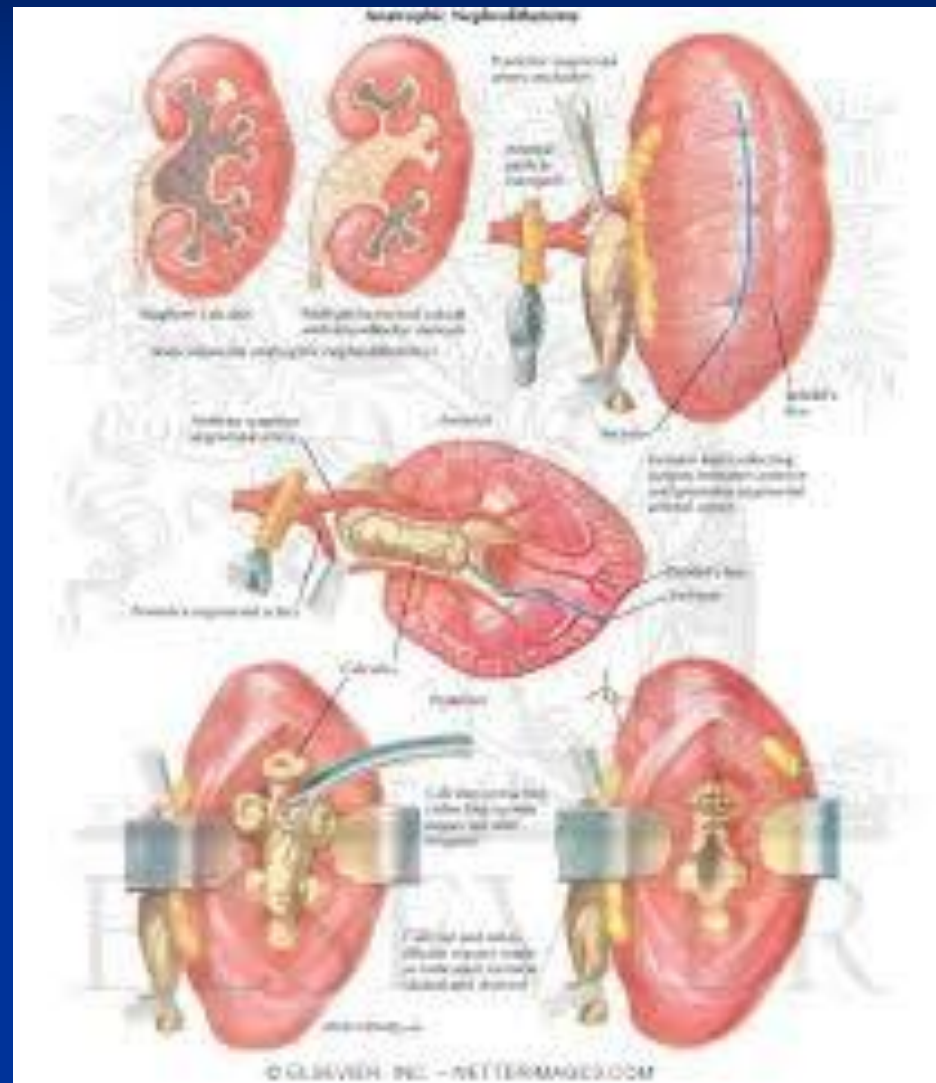
DILATED
URETER

PERITONEUM
REFLECTED

BLADDER

STONE IN LOWER END OF URETER IN PROCESS
OF REMOVAL THROUGH URETEROSTOMY

Anatrophic Nephrolithotomy



Bench Surgery (formally known as Extracorporeal Renal Surgery with Auto transplantation).

- Bench surgery is not a procedure of routine urology, but an ultimate, last-resort technique that showcases the highest level of open surgical mastery, primarily used to save a kidney that would otherwise require nephrectomy.
- Bench surgery is a sequential, three-stage operation where the kidney is temporarily removed from the patient's body (nephrectomy), repaired on a sterile, chilled "bench" table (*ex vivo*), and then transplanted back into the same patient (autotransplantation), typically into the iliac fossa.

Stage	Procedure	Rationale
I. Nephrectomy	The diseased kidney is removed, usually via a traditional open flank or laparoscopic/robotic approach, isolating the renal artery, vein, and ureter carefully.	To allow the kidney to be removed from the warm, bloody, restricted retroperitoneal space.
II. Extracorporeal Repair (The Bench Surgery)	The kidney is placed in a sterile basin on a table and immediately flushed with cold preservation solution (e.g., University of Wisconsin solution) and packed in ice slush. The repair is done in a totally bloodless, hypothermic field .	Hypothermia drastically reduces the kidney's metabolic rate, prolonging the safe ischemic time (Cold Ischemia Time) to several hours, allowing for meticulous, complex repair that is impossible <i>in situ</i> .
III. Autotransplantation	The repaired kidney is re-implanted into the patient's iliac fossa (the pelvis), similar to a standard kidney transplant. The renal artery and vein are anastomosed to the patient's iliac vessels, and the ureter is reimplanted into the bladder (ureteroneocystostomy).	The iliac fossa provides easy access for microvascular anastomoses and a shorter, straighter course for the repaired ureter to the bladder.

Indication	Rationale for Bench Surgery
Complex Urolithiasis (Rare Today)	Used for massive, extremely complex, or recurrent staghorn calculi, especially when associated with severe infundibular stenosis or intra-renal collecting system strictures that cannot be safely managed by multiple-access PCNL or Anatomic Nephrolithotomy <i>in situ</i> . Allows complete stone removal and repair of strictures under direct vision.
Complex Renal Tumors (Primary Indication)	For large, central, or multifocal tumors (e.g., in genetic syndromes like von Hippel-Lindau) located in a solitary kidney or bilateral disease, where <i>in situ</i> partial nephrectomy (PN) is technically impossible or would have an unacceptably high risk of positive margins or warm ischemia time.
Complex Renovascular Disease	For repair of extensive, branched renal artery aneurysms, or diffuse renal artery stenosis (e.g., due to fibromuscular dysplasia) that requires microvascular repair or multiple vessel reconstructions impossible to perform safely inside the body.
Long-Segment Ureteral Loss/Stricture	For severe, long-segment strictures (e.g., from prior radiation, trauma, or surgery) where the remaining ureter is too short for a standard repair, and the kidney cannot be mobilized enough for a simple psoas hitch or Boari flap. The kidney is removed and reimplanted to provide a shorter distance to the bladder.

Ureteric stone

- Acute Ureteric Colic
- History & Physical Exam. Flank Abd.Pain
- Urine Analysis(Hematuria)
- KUB(Probable Stone):
- Stone Uncertain: IVU or USG
- Stone Seen : management on Size

■ <4mm	■ 4-6mm	■ Over 6mm
Spontaneous	Spontaneous	Spontaneous
Passage likely	passage possible	passage unlikely
(90%)	(50%)	(10%)
Observation	Procedural	Procedural
	Therapy	Therapy
	Possible	usual

Ureteroscopy with stone extraction.

Ureteric Stone : Management

Upper Ureteric Stone:

- ❖ ESWL alone
- ❖ Push & Bang
(Ureteroscopy (URS) with ESWL)
- ❖ Ureteroscopy alone
(Basketing or crushing)
- ❖ Surgery

Ureteric Stone : Management cont.

Middle Ureteric Stone:

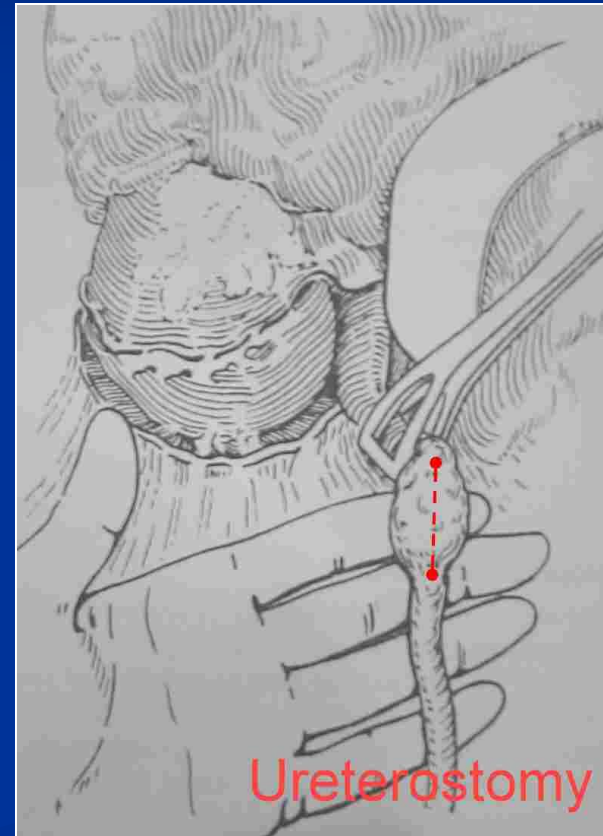
1. Ureteroscopy (URS) crushing
2. ESWL
3. Laparoscopy
(Retroperitoneoscopy / Trans peritoneal)
4. Open Surgery

3. Lower Ureteric Stones:

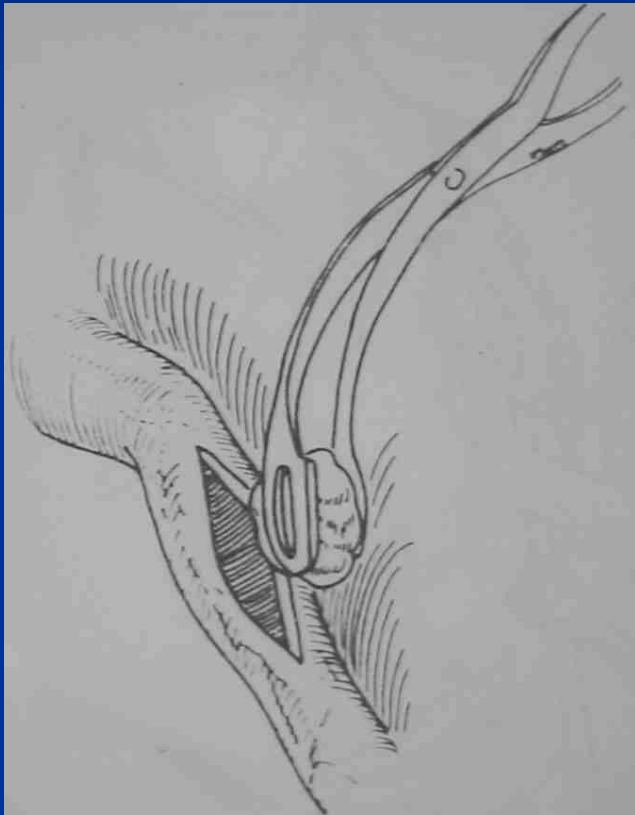
1. Ureteroscopy(URS)
2. Ureterotomy with catheterisation
3. Open Surgery.

Ureterolithotomy

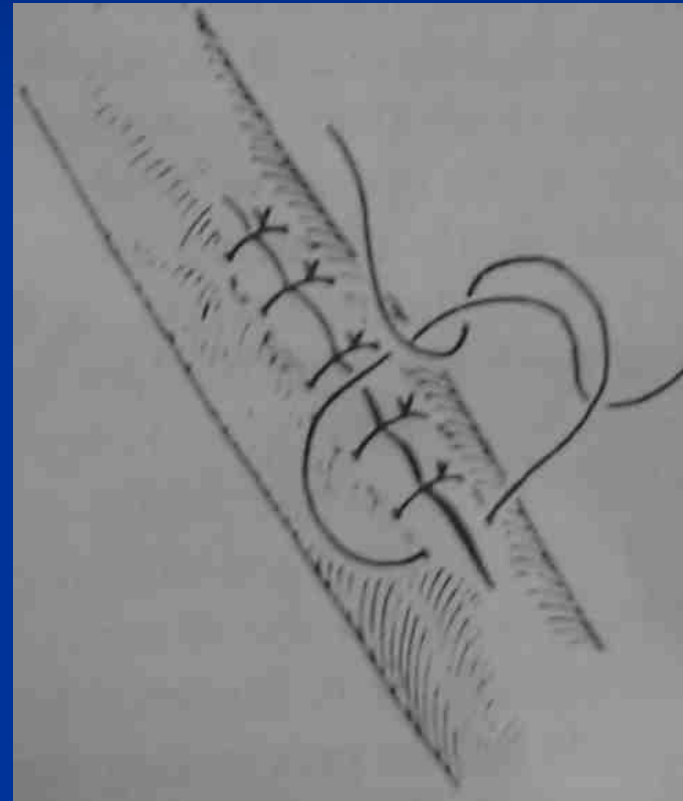
- Flank incision
- Retroperitoneal space
- Dilated ureter with stone identified
- Incision on ureter over stone
- Stone delivered



Ureterolithotomy



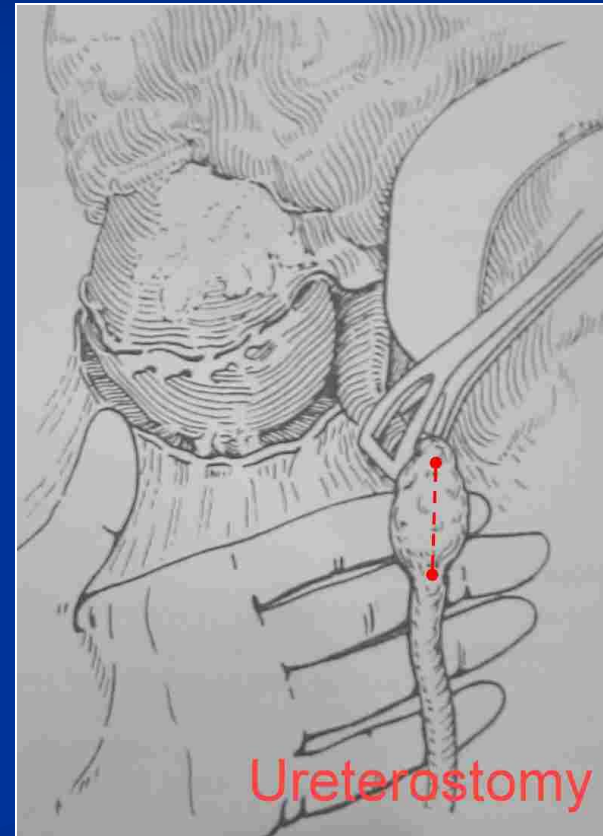
Removal of stone



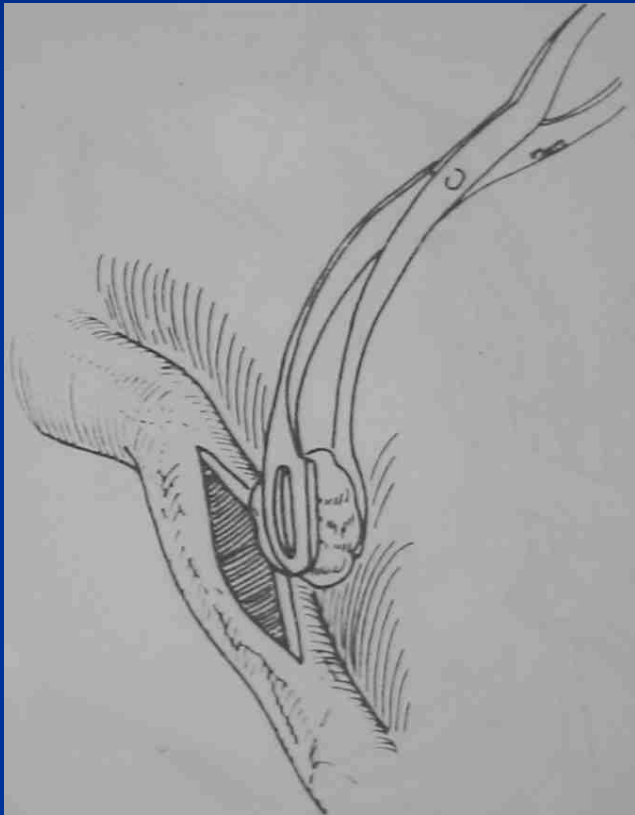
Repair of ureterostomy

Ureterolithotomy

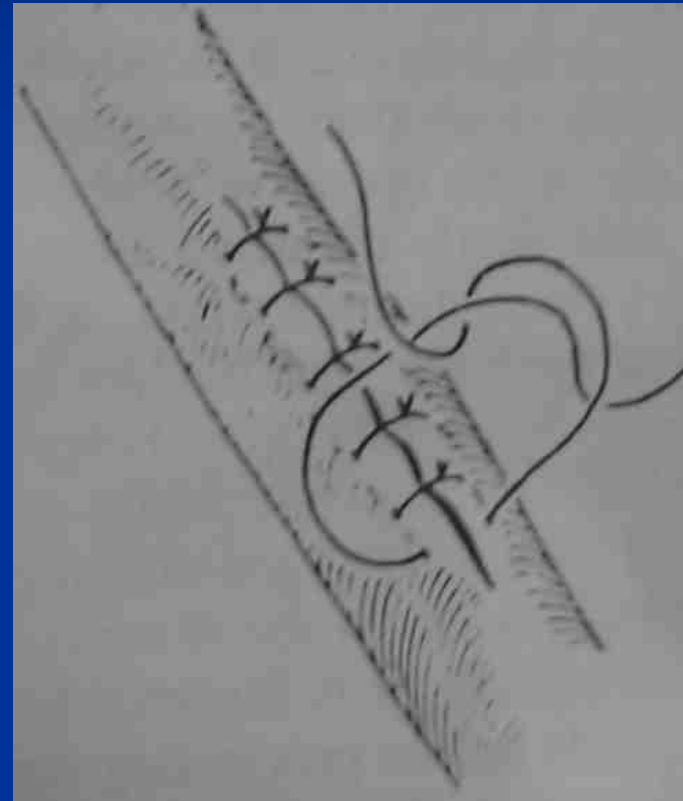
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- Stone delivered



Ureterolithotomy



Removal of stone



Repair of ureterostomy

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Laparoscopic Ureterolithotomy

Port placement



- 3 ports
- Central port for space creation and camera
- One 5mm, one 10mm port for suture deployment

Creation of space



- Incision below tip of 12th rib
- Finger dissection down to Gerota's fascia, break through Gerota's
- Deploy balloon

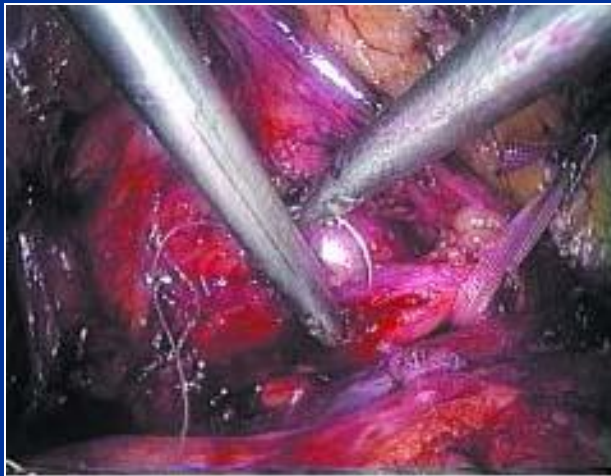


Laparoscopic ureterolithotomy



- Stone identified by visual and tactile
- Proximal control of stone
- Longitudinal incision over stone with lap knife or scissors

Laparoscopic ureterolithotomy



- Stone freed from adherent mucosa
- Stone delivered and removed via bag
- Ureterotomy closed with few interrupted vicryl 4.0
- Drain
- Double J stent removed after 3 weeks

LAPAROSCOPIC URETEROLITHOMY

DR. A. D. D. D. D.

DR. P. S. D. D. D.

DR. A. D. D. D. D.

DR. B. D. D. D. D.

**Recurrence is part of
natural history of
Urolithiasis**

Struvite Stones Open surgery

Residual stones after surgery approx 15%

Recurrence Rate (6 years) 30%

Risk of Urinary tract Infection 40%

Griffith et al 1978

Prevention Of Struvite Stones

1. Complete removal of stones
- 2 Concept of stone cancer
3. Long term Antibiotics
4. Management of obstruction
5. Urease Inhibitor

Conclusion

Nephrolithiasis is a chronic illness that requires an integrated combination of medical and surgical care. Medical care is concerned mainly with the recurrent stones, and surgical care is concerned mainly with the removal of existing stones.

A small fraction of patients have calcium oxalate stones due to specific disorders, such as Primary hyperparathyroidism, Renal tubular acidosis, and Primary or acquired forms of Hyperoxaluria. The treatment of Patients with these disorders or of patients who have uric acid or cystine stone is not controversial and is effective in preventing recurrences.

In majority of patients (80%). Calcium oxalate stones do not form as a result of specific disease. but rather as result of Idiopathic hypercalciuria, hyperuricosuria, or hypocitrauria. As treatments of Idiopathic hypercalciuria, hyperuricosuria respectively thiazides and allopurinol have been found effective in controlled trials.

Although hydration, dietary counselling to reduce the oxalate and calcium intake and oral citrate has not been tested adequately,

Virtually all Physician recommend hydration to patients in whom stones form

**Recommendation of Consensus conference on
" Prevention and treatment of Kidney Stones"
National Institute of Health 1988**

Prevention of stones

Prevetion of Stones:

- Nothing Done 50% Recur in 5 years.
- Risk factor analyzed, irrespective of cause water intake to be increased. 2 hours after meal, Nocturnal Diuresis.
- Metabolic Evaluation.

All scientific studies have proved
that only proven
factor which can prevent
Stone formation is.....

water and only water



The I.R.S. (Internal Renal Stone) Needs You!

Can't remember to drink enough fluids? Do you find yourself getting caught up for hours on the Internet, or watching movie videos the length of "Gone with the Wind" without drinking any water?

If you answered "yes,"

then the I.R.S (Internal Renal Stone) wants you!

The I.R.S. Tax Plan increases fluid wealth. By following this plan,

you will increase both fluid intake and urinary output.

The I.R.S. Tax Plan consists of several tax schedules.

These include Kitchen Tax, Meal Tax, Nighttime Bathroom Use Tax, Penalty Tax, Restaurant Tax, Snack Tax, Summertime Tax, Work Tax and Water Fountain Tax. You may add as many taxes as you would like to "pad" your I.R.S. Tax Return

water tax

.Kitchen Tax" - One glass whenever you've entered your kitchen and wish to leave (this is more of a "toll" than a tax).

."Meal Tax" - One extra glass with each meal except if you eat out at a restaurant where you will need two extra glasses.

"Nighttime Bathroom Use Tax" - One glass whenever you get out of bed to go to the bathroom at night.
(We do not usually drink very much at night when we're asleep.)

.

water tax

."Summertime Tax" - During the summer months or whenever the outside temperature is over 75 degrees, you must double all the other taxes!

."Time Tax" - One glass if you've managed to avoid all the other taxes for at least two hours.

."Water Fountain Tax" - Whenever you pass a water fountain, you are required to take a drink consisting of at least 10 swallows.

."Work Tax" - One glass whenever you leave your designated work area or desk.

water tax

- - "Penalty Tax" - If you eat or drink a food item you've been instructed to avoid or limit, you must drink at least two extra glasses.
 - "Restaurant Tax" - When you eat out at a restaurant you need to double the meal tax to two glasses. This is because restaurant food is high in salt which causes you to retain water.
 - "Snack Tax" - At least one extra glass if you have a snack between meals or at bedtime.

Daily intake >1.6 liter/day

Intake during meals

Two hours after meals

**Water produced by metabolism
is lowest at this time**

Increase intake before sleep

so that you have to wake up once in night

It will prevent urinary stasis in night

Prevention of Urolithiasis.

1. Alkalinizing Agent: Oxalate Stones 2nd ry
K citrate to hypocitruria
2. Cellulose PO₄: Absorptive hypercalciuria I
3. PO₄ Supplements: Renal PO₄ leak
4. Thiazides: Renal hypercalciuria
5. CaSupplem : Enteric hyperoxaluric CaNc
6. Allopurinol Uric Acid
7. Acetohydroxymic Acid: Urease Inhibitor
Infection Stones
8. Penicillamine Cystine
Mercaptopropionylglycine.