Stone Diseases

- **Treatment Options for Renal Stone:**
  1. watchful waiting
  2. Stone fragmentation techniques
  3. Flexible Uretrorenoscopy and Laser Lithotripsy
  4. Medical therapy (dissolution therapy)
  5. percutaneous nephrolithotomy (PCNL)
  6. open stone surgery

- **watchful waiting**

It is not necessary to treat every kidney stone. As a rule of thumb, the younger the patient, the larger the stone, and the more symptoms it is causing, the more inclined are we to recommend treatment.
Factors determining the need for treatment are:

1. Size of stone
2. Type of stone
3. Symptoms caused by the stone it self
4. Age of the patient
5. Jobe of patient (e.g Airline pilots)

- **Stone fragmentation techniques:**

A) Extracorporeal shock lithotripsy (ESWL)
The technique of focusing externally generated shock waves at a target (the stone). First used in humans in 1980. The first commercial lithotriptor, the Dornier HM3, became available in 1983. ESWL revolutionized kidney and ureteric stone treatment.
Three methods of shock wave generation are electrohydraulic, electromagnetic, and piezoelectric.
Electrohydraulic. Application of a high voltage electrical current between 2 electrodes about 1mm apart under water causes discharge of a spark. Water around the tip of the electrode is vaporized by the high temperature resulting in a rapidly expanding gas bubble. The rapid expansion and then the rapid collapse of this bubble generates a shock wave which is focused by a metal reflector shaped as a hemi-ellipsoid. .
Electromagnetic. Two electrically conducting cylindrical plates are separated by a thin membrane of insulating material. Passage of an electrical current through the plates generates a strong magnetic field between them, the subsequent movement of which generates a shock wave. An 'acoustic' lens is used to focus the shock wave.
Piezoelectric. A spherical dish is covered with about 3000 small ceramic elements, each of which expands rapidly when a high voltage is applied across them. This rapid expansion generates a shock wave.

X-ray, ultrasound, or a combination of both are used to locate the stone on which the shock waves are focused. Older machines required general or regional anaesthesia because the shock waves were powerful and caused severe pain. Newer lithotriptors generate less powerful shock waves, allowing ESWL with oral or parenteral analgesia in many cases, but they are less efficient at stone fragmentation.

Efficacy of ESWL
Likelihood of fragmention with ESWL depends on stone size and location, anatomy of renal collecting system, degree of obesity, and stone composition. Most effective for stones <2cm in diameter, in favourable anatomical locations. Less effective for stones >2cm diameter, in lower pole stones in a calyceal diverticulum (poor drainage), and those composed of cystine or calcium oxalate monohydrate (very hard).

Stone free rates for solitary kidney stones are 80% for stones <1cm in diameter, 60% for those between 1-2cm, and 50% for those >2cm in diameter. Lower stone free rates as compared with open surgery or PCNL are accepted because of the minimal morbidity of ESWL.

Side-effects of ESWL

ESWL causes a certain amount of structural and functional renal damage. Haematuria (microscopic, macroscopic) and oedema are common. Perirenal haematomas (0.5%). There is data suggesting that ESWL may increase the likelihood of development of hypertension. Acute renal injury may be more likely to occur in patients with pre-existing hypertension, prolonged coagulation time, coexisting coronary heart disease, diabetes, and in those with solitary kidneys.

Contraindications to ESWL

Absolute contraindications: pregnancy, uncorrected blood clotting disorders (including anticoagulation).

potential complications after ESWL

Common

• Haematurea for short period after procedure
• Pain in the kidney as small fragments of stone pass
• UTI from bacteria released from the stone, needing antibiotic treatment.

Occasional

• Stone will not break as too hard, requiring an alternative treatment
• Repeated ESWL treatments may be required
• Recurrence of stones.

Rare

• Kidney damage (bruising) or infection, .needing further treatment
• Stone fragments occasionally get stuck in the ureter(steinstrasse) requiring hospital admission and sometimes surgery to remove the stone fragment
• Severe infection requiring intravenous antibiotics and sometimes drainage of the kidney by PCN.

B) Intracoporeal techniques of stone fragmentation (fragmentation within the body)

1-Electrohydraulic lithotripsy (EHL)

The shock wave is not focused, so the EHL probe must be applied within 1mm of the stone to optimize stone fragmentation. EHL has a narrower safety margin than other lithotripsy, and should be kept as far away as possible from the wall of the ureter, renal pelvis, or bladder to limit damage to these structures, and at least 2mm away from the cystoscope, ureteroscope, or nephro-scope to prevent lens fracture. ***Principal uses*** Bladder stones (wider safety margin than in the narrower ureter).

2-Pneumatic (ballistic) lithotripsy

A metal projectile contained within the handpiece is propelled backwards and forwards at great speed by bursts of compressed air. It strikes a long, thin, metal probe at one end of the handpiece at 12Hz (12 strikes per second) transmitting shock waves to the probe, which when in contact with a rigid structure such as a stone, fragments the stone. Pneumatic lithotripsy is very safe . Also low cost and low maintenance. However, its ballistic effect has a tendency to cause stone migration into the proximal ureter or renal pelvis, where the stone may be inaccessible to further treatment. The metal probe cannot bend around corners, so it cannot be used for flexable ureteroscopic treatment of stones within the kidney. ***Principal uses*** Ureteric stones.

3-Ultrasonic lithotripsy

An electrical current applied across a piezoceramic plate located in the ultrasound transducer generates ultrasound waves of a specific frequency (23,000-25,OOOHz). The ultrasound energy is transmitted to a hollow metal probe, which in turn is applied to the stone. The stone resonates at high frequency and this causes it to break into small fragments (the opera singer breaking a glass) which are then sucked out through the centre of the hollow probe. Soft tissues do not resonate when the probe is applied to them, and therefore are not damaged. Can only be used down straight instruments. ***Principal uses*** Fragmentation of renal calculi during PCNL.

4-Laser lithotripsy

The holmium: YAG laser. Principally, a photothermal mechanism of action, causing stone vaporization. Minimal shock-wave generation, and therefore less risk of causing stone migration. Can be used with flexible uretroscope . Zone of thermal injury is limited from 0.5 to 1mm from the laser tip. No stone can withstand the heat generated by the holmium: YAG laser. *Principal uses* Ureteric stones, small intrarenal stones.

- **Flexible ureteroscopy and laser treatment**

Flexible ureteroscopy and laser fragmentation offers a more effective treatment option compared with ESWL, with a lower morbidity than PCNL, but usually requires a general anaesthetic (some patients will tolerate it with sedation alone). It can also allow access to areas of the kidney where ESWL is less efficient or where PCNL cannot reach. It is most suited to stones <2cm in diameter.

Indications for flexible ureteroscopic kidney stone treatment

1• ESWL failure. 2• Lower pole renal stone 3• Cystine stones. 4• Obesity such that PCNL and ESWL access are technically difficult or impossible 5• Musculoskeletal deformities such that stone access by PCNL or ESWL is difficult or impossible (e.g. kyphoscoliosis). 6• Stone in a calyceal diverticulum 7• Stenosis of a calcyceal infundibulum or 'tight' angle between renal pelvis and infundibulum. . 8• Bleeding diathesis where reversal of this diathesis is potentially dangerous or difficult. 9• Horseshoe or pelvic kidney. 10 • Patient preference.

Disadvantages

Efficacy diminishes as stone burden increases—it simply takes a long time . fragmentation rates for those expert in flexible ureteroscopy are -70-80% for stones <2cm in diameter and 50% for those >2cm in diameter .

- **Percutaneous nephrolithotomy (PCNL)**

PCNL is the removal of a kidney stone via a 'track' developed between the surface of the skin and the collecting system of the kidney. General anaesthesia is usual, though regional or even local anaesthesia (with sedation) can be used.

Indications for PCNL

PCNL is generally recommended for stones >3cm in diameter, those that have failed ESWL and/or flexible ureteroscopy and laser treatment. It is the first-line option for staghorn calculi, with ESWL and/or repeat PCNL being used for residual stone fragments.

- **Open stone surgery**

Indications

1. • Complex stone burden (projection of stone into multiple calyces, such that multiple PCNL tracks would be required to gain access to all the stone)
2. • Failure of endoscopic treatment (technical difficulty gaining access to the collecting system of the kidney)
3. • Anatomic abnormality that precludes endoscopic surgery (e.g. retrorenal colon)
4. • Body habitus that precludes endoscopic surgery (e.g. gross obesity, kyphoscoliosis—open stone surgery can be difficult)
5. • Patient request for a single procedure where multiple PCNLs might be required for stone clearance
6. • Non-functioning kidney

A)Non-functioning kidney

Where the kidney is not working, the stone may be left in *situ* if it is not causing symptoms (e.g. pain, recurrent urinary infection, haematuria). However, staghorn calculi should be removed, unless the patient has comorbidity that would preclude safe surgery because of the substantial risk of developing serious infective complications. If the kidney is non-functioning, the simplest way of removing the stone is to remove the kidney.

B)Functioning kidneys—options for stone removal Small- to medium-sized stones

• Pyelolithotomy

• Radial nephrolithotomy

C)Staghorn calculi

• Anatrophic (avascular) nephrolithotomy
• Extended pyelolithotomy with radial nephrotomies (small incisions over individual stones)
• Excision of the kidney, 'bench' surgery to remove the stones, and autotransplantation

Specific complications of open stone surgery

Wound infection (the stones operated on are often infection stones); flank hernia; wound pain. (With PCNL these problems do not occur, blood transfusion rate is lower, analgesic requirement is less, mobilization is more rapid and discharge earlier—all of which account for PCNL having replaced open surgery as the mainstay of treatment of large stones.) There is a significant chance of stone recurrence after open stone surgery (as for any other treatment modality) and the scar tissue that develops around the kidney will make subsequent open stone surgery technically more difficult.

- **Medical therapy (dissolution therapy)**

Uric acid and cystine stones are potentially suitable for dissolution therapy. Calcium within either stone type reduces the chances of successful dissolution.

A) Uric acid stones:

Uric acid stones form in concentrated, acid urine. Dissolution therapy is based on hydration, urine alkalinization, allopurinol, and dietary manipulation—the aim being to reduce urinary uric acid saturation. Maintain a high fluid intake (urine output 2-3L/day), 'alkalinize' the urine to pH 6.5-7 (sodium bicarbonate or potassium citrate). In those with hyperuricaemia or urinary uric acid excretion >1200mg/day, add allopurinoi 300-600mg/day (inhibits conversion of hypoxanthin and xanthine to uric acid). Dissolution of large stones (even staghorn calculi) is possible with this regimen.

B) Cystine stones:

Cystinuria is an inherited kidney and intestinal transepithelial transport defect for the amino acids cystine, ornithine, arginine, and lysine ('COAL') leading to excessive urinary excretion of cystine. Autosomal recessive inheritance; prevalence of 1 in 700 are homozygous (i.e. both genes defective); occurs equally in both sexes. ~3% of adult stone formers are cystinuric and 6% of stone-forming children.

Treatment of existing stones and prevention of further stones

The aim is to:

• Reduce cystine excretion (dietary restriction of the cystine precursor amino acid methionine and also of sodium intake to <100mg/day).
• Increase solubility of cystine by alkalinization of the urine to >pH 7.5, maintenance of a high fluid intake, and use of drugs which convert cystine to more soluble compounds.(D-penicillamine, N-acetyl-D-penicillamine, and mercaptopropionylglycine bind to cystine—the compounds so formed are more soluble in urine than is cystine alone.)

Treatment for failed dissolution therapy

Cystine stones are very hard and are therefore relatively resistant to ESWL. Nonetheless, for small cystine stones, a substantial proportion will still respond to ESWL. Flexible ureteroscopy (for small) and PCNL (for larger) cystine stones are used where ESWL fragmentation has failed.