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TOPIC PAPER

# Treatment selection for urolithiasis: percutaneous nephrolithomy, ureteroscopy, shock wave lithotripsy, and active monitoring

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**Abstract** Urolithiasis is a significant worldwide source of morbidity, constituting a common urological disease that affects between 10 and 15% of the world population. Recent technological and surgical advances have replaced the need for open surgery with less invasive procedures. The factors which determine the indications for percutaneous nephrolithotomy include stone factors (stone size, stone composition, and stone location), patient factors (habitus and renal anomalies), and failure of other treatment modalities (ESWL and flexible ureteroscopy). The accepted indications for PCNL are stones larger than 20 $mm^2$, staghorn and partial staghorn calculi, and stones in patients with chronic kidney disease. The contraindications for PCNL include pregnancy, bleeding disorders, and uncontrolled urinary tract infections. Flexible ureteroscopy can be one of the options for lower pole stones between 1.5 and 2 cm in size. This option should be exercised in cases of difficult lower polar anatomy and ESWL-resistant stones. Flexible ureteroscopy can also be an option for stones located in the diverticular neck or a diverticulum. ESWL is the treatment to be discussed as a option in all patient with renal stones (excluding lower polar stones) between size 10 and 20 mm. In addition, in lower polar stones of size between 10 and 20 mm if the anatomy is favourable, ESWL is the option. In proximal ureteral stones, ESWL should be considered as a option with flexible ureteroscopy Active monitoring has a limited role and can be employed in post-intervention (PCNL or ESWL) residual stones, in addition,

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asymptomatic patients with no evidence of infection and fragments less than 4 mm can be monitored actively.

**Keywords** Lithotripsy · Percutaneous nephrlithotomy · Ureteroscopy

## Introduction

The American Urological Association (AUA) has been the frontrunner in formulating guidelines for urolithiasis since 1991. Since then, a number of editions of guidelines have been published, with the 2016 guidelines on management of stone being the latest [1]. The European Association of Urology (EAU) has published similar guidelines since 2000. The latest updates have been published in 2010 [2]. We have reviewed the existing literature. In this chapter, we discuss the indications, techniques, and special situations for percutaneous nephrolithotomy (PCNL). Literature with a robust level of evidence was reviewed and cited as appropriate. The EAU, AUA, and the 2nd International Consultation on Urolithiasis guidelines were taken as reference.

## Preoperative work up

Intravenous urography (IVU) has been the gold standard in the work up for urolithiasis. Non-contrast computerized tomography (NCCT) scan is a quick, safe, and contrast-free alternative to excretory urography. Low-dose CT is the preferred modality of investigation in patient with BMI less than 30 as it has the advantage of reducing the long-term complications of radiation without compromising the sensitivity [3]. Randomized studies have shown that NCCT has similar or superior results to excretory urography in acute flank pain [4]. Contrast media should be avoided when there is an elevated creatinine level, in pregnancy or during lactation [5, 6]. Contrast is also contraindicated in iodine allergy. Additional information can be gained by computerized tomographic urography (CTU); however, to date, there is no level 1 evidence to suggest that CTU is superior to IVU in the work up of urolithiasis [7]. Besides identification of stones, computerized tomography (CT) provides information aiding in the selection of the appropriate treatment modality. It accurately provides information regarding the size, number and attenuation number of the stones, presence and degree of hydronephrosis, and the skin to stone distance. All these factors help in determining the appropriate treatment modality. X-ray KUB and ultrasound are used by few clinicians as preoperative investigations; however, this cannot be considered as a standard. These investigations help to plan PCNL access and predict the possible success rates. Ultrasound is useful as a tool in the preoperative workup if the method of access later is, indeed, an ultrasound guided puncture.

Recently, the applicability of 3D reconstruction ("staghorn morphometry") has been described for planning percutaneous access. Staghorn stone volume and its distribution as shown in CT urography-based staghorn morphometry may predict the requirement of the number of tracts and stage or percutaneous nephrolithotomy (PCNL) monotherapy and help in the classification of staghorn calculi. Staghorn morphometry differentiates staghorn calculi into type 1 (single tract and stage), type 2 (single tract-single/multiple stage, or multiple tract-single stage), and type 3 (multiple tract and stage) [8]. Kurien et al. [9] had shown that the adobe imaging program can be used in measuring the two-dimensional surface area, and it is accurate, fast, and highly reproducible in estimating two-dimensional stone surface area from radiographs. Measuring stone surface area from a radiographic image is accurate and reproducible with the help of an imaging program.

The EAU guidelines state that for all patients with known infection stones, or a recent history of urinary tract infection and/ or bacteriuria, antibiotics should be administered before the stone-removing procedure and continue for at least 4 days afterwards. For septic patients with obstructing stones, urgent decompression of the collecting system only with either percutaneous drainage or ureteral stenting is indicated. Definitive treatment of the stone should be delayed until the urosepsis is resolved [2].

## Indications

The indications for percutaneous nephrolithotomy are determined by stone factors (stone size, stone composition, and stone location), patient factors (habitus and renal anomalies), and failure of other treatment modalities (Extracorporeal shock wave lithotripsy (ESWL) and flexible ureteroscopy). The usual indications for PCNL are stones larger than 20mm$^2$, staghorn andpartial staghorn calculi, and stones in patients with chronic kidney disease. The contraindications for PCNL include pregnancy, bleeding disorders, and uncontrolled urinary tract infections [2].

## Stone factors

### Stone size

PCNL monotherapy is the treatment of choice for "large stones". Generally speaking, the definition of a large stone is ≥2 cm [10]. PCNL attains stone free rates of upto 95% as it offers direct removal of stone fragments through the nephrostomy tract. For stones smaller than 2 cm in size, the

treatment algorithm becomes more complicated because of multiple variables involved.

AUA guidelines recommend PCNL as a treatment of choice for staghorn calculi. A retrospective study with 200 patients has shown that renal deterioration occurs in as much as 28% of patients with staghorn calculi treated conservatively. Consequently, staghorn stones should be aggressively managed surgically [11]. PCNL clearance rate is threefold greater than that of ESWL [12]. The following are the treatment options for staghorn calculi [1]:

1. Percutaneous nephrolithotomy should be the first-line treatment for most patients. (Level 2 evidence)
2. (ESWL) should not be used as the preferred treatment modality for staghorn stones.
3. Open surgery should be recommended only if the stones are not expected to be removed in a reasonable number of stages.
4. Nephrectomy should be considered in nonfunctioning kidneys [1].

To summarize, PCNL is the first choice for staghorn calculi. Open surgery is acceptable in situations where minimally invasive expertise is not available to clear the stone in a reasonable number of procedures and tracts. Nephrectomy should be considered for nonfunctioning kidneys.

### Location of stones

Larger stones of the lower pole are best managed by PCNL as the first treatment option irrespective of the lower pole anatomy [3]. Treatment of lower pole stones should be guided by the diameter of the stone. Data from metanalysis suggest that larger lower pole stones have a lower clearance rate and a higher retreatment rate [12]. A large multicentre prospective randomized trial comparing PCNL with ESWL showed PCNL to have a significantly higher stone free rate (91%) compared to ESWL (21%). In addition, the need for ancillary procedures and retreatment rates was higher for ESWL as compared to PCNL [13, 14]. The calyceal stone burden is the most important factor in predicting stone clearance.

A calyceal diverticulum is a non-secretory urothelium lined compartment in communication with the renal collecting system. Asymptomatic stones in a diverticulum may be left alone; however, stones causing pain, haematuria, and infection should be treated.. Although there have been no randomized trials comparing laparoscopy with PCNL and ureteroscopy, PCNL is considered to be the gold standard in the management of calyceal diverticulum stones. In comparison to ESWL, PCNL has higher stone free rates, with similar recurrence and complication rates [15]. The stone free rates for PCNL range from 85 to 93%. PCNL can provide excellent access for obliteration of the diverticular sac if required [16].

### Composition and hardness of stone

Stone composition and fragility is a "key" factor in determining the modality of treatment to be choosen. The composition of the stone is an important factor for predicting the success rates of renal calculus fragmentation. Specific stone compositions have different clearance rates because of the varying fragility of the stones. Cystine stones are harder to fragment, and hence, cystine stones larger than 15 mm should not be treated with ESWL. PCNL would be a good option in these patients [2]. The measurement of stone density with NCCT helps in predicting success rates of ESWL and the need for PCNL. Stones with >1000 Hounsfield units (HU) show poor results with ESWL [17, 18]. Struvite stones are best dealt with percutaneous nephrolithotomy under visual control as total stone clearance is a prerequisite to avoid recurrences in infectious stones.

#### *Miniperc*

Miniperc is PCNL done with sheath size less than or equal to 20 Fr. Miniperc has the advantage of minimal blood loss and speedy recovery, but the stone clearance rates are similar [8].

The tract size in miniperc ranges from 12 to 20 Fr. The energy source for breaking the stones can be either lithoclast or laser. The ideal indication for miniperc is stones of size 1 to 2.5 cm.

#### *Microperc*™

Microperc is further advancement and miniaturisation of PCNL. Microperc uses 16 G needle. The 16 gauge needle accommodates the fiberoptics, irrigation channel, and the laser fiber. It is used to treat renal calculus upto 1.5 cm. A comparative study done by Sabnis et alit was proved that Microperc™ is a safe and effective alternative to flexible ureteroscopy for the management of small renal calculi and has similar stone clearance and complication rates when compared to flexible ureteroscopy [19].

The EAU guidelines state that for large ESWL-resistant stones, PCNL is the best alternative for efficient removal, thereby avoiding too much shock wave energy to the renal tissue [2].

## Role of flexible ureteroscopy

For renal pelvic and calyceal urolithiasis larger than 1.5 cm, flexible ureteroscopy is currently not regarded as

the first option. Flexible ureteroscopy would be one of the options available for lower polar stones between 1.5 and 2 cm in size. This option should be exercised in cases of difficult lower polar anatomy and ESWL-resistant stones. Flexible ureteroscopy can be an alternative to PCNL for the treatment of stones located in the diverticular neck or a diverticulum. Stonesin the ureter can be treated with semi-rigidureterscopes and stones in the kidney treated with flexible ureeroscopes. The miniaturisation of the instruments allows easier access within the ureter without prior dilatation in more than 50% of the patients and easier approach of the proximal ureter. Stone disintegration through a rigid ureteroscope can be achieved with in situ lithotripsy. The spectrum of lithotripters includes ultrasonic lithotripsy, electro hydraulic lithotripsy, ballistic lithotripsy, pneumatic lithotripsy, and laser lithotripsy.

## Role of ESWL

ESWL has been established as a major therapeutic and minimally invasive option for the treatment of renal stones the last 20 years. The technical development of the latest 3rd generation lithotripters that use electromagnetic energy also led to a reduction of retreatment rates, increased the stone free rate up to 88.5%, and reduced treatment time per session [20].

The EAU guidelines states that ESWL is the treatment to be discussed as a option in all patient with renal stones (excluding lower polar stones) between size 10 and 20 mm. In addition, in lower polar stones of size between 10 and 20 mm if the anatomy is favourable, ESWL is the option. In proximal ureteral stones, ESWL should be considered as a option with flexible ureteroscopy [2].

### *Indications for conservative treatment of stone*

Conservative management can also be given in renal caluclus if it is in the lower pole and nonobstructing and less than 10 mm [21]. Skolarios et al. [22] in their systematic review have mentioned that in a case of lower pole stones which are less than 10 mm and are asymptomatic can be managed conservatively and monitored by either CT or USG in a well-informed patient who is compliant for follow-up. In case of post-intervention such as PCNL or ESWL, in asymptomatic patients with no evidence of infection, fragments less than 4 mm can be monitored actively.

Stones with a size of less than 4 mm have an 80% chance of spontaneous expulsion. Stones with a size of more than 7 mm have a 20% chance of spontaneous passage. This should be taken into consideration when offering medical expulsive therapy.

The indications for intervention in such small stones are

1. Infection.
2. Failure of medical expulsive therapy.
3. Non-progressive stones.
4. Stones larger than 7 mm in size.
5. Anomalous kidneys.
6. Renal dysfunction.

## Medical expulsive therapy

Medical expulsive therapy (MET) is an important tool in the treatment of ureteric stone. It prevents the need for surgical intervention and reduces the associated complications.

There is ample of evidence in literature supporting the spontaneous ureteral stone passage. Intervention by means of drugs which help in ureteral relaxation in the region of a concretion could aid in stone passage. Various medications have been utilized to support the passage of ureteral stones.

Guidelines on Urolithiasis by European Association of urology 2016 recommends in patients with newly diagnosed ureteral stones <10 mm, if active removal is not indicated, observation with periodic evaluation is an optional initial treatment medaicla expulsive therapy which can be used during such time.

MET should only be used in patients who are comfortable with this approach and when there is no obvious advantage from immediate active stone removal. Meta-analyses have shown that patients with ureteral stones treated with α-blockers or nifedipine are more likely to pass stones with fewer episodes of colic than those not receiving such therapy.

The chance of spontaneous expulsion depends on stone size, site, and the internal anatomical structure of the ureter, The possible causes of stone retention are spasm, edema, and ureteral infections, which are modifiable factors. The goals of medical conservative therapy are to prevent modifiable factors and control painful symptoms until stone expulsion. The drugs that can be used are alpha blockers, calcium channel blockers, PDE5 inhibitors, NSAIDs, Corticosteriod, etc.

In summary, the recommendations and guidelines suggest that intravenous urography (IVU) has been the gold standard in the work up for urolithiasis. However, these days non-contrast computerized tomography (NCCT) scan is a quick and safe, contrast-free alternative to excretory urography. Ultrasound is useful as a tool in the preoperative workup if the method of access is ultrasound guided. Additional information can be gained by contrast enhanced CT scan (CTU), CT is a useful tool in planning PCNL in anomalous kidneys.

The factors which determine the indications for percutaneous nephrolithotomy include stone factors (stone size, stone composition, and stone location), patient factors (habitus and renal anomalies), and failure of other

treatment modalities (ESWL and flexible ureterscopy). The usual indications for PCNL are stones larger than 20 $mm^2$, staghorn and partial staghorn calculi, and stones in patients with chronic kidney disease. The contraindications for PCNL include pregnancy, bleeding disorders, and uncontrolled urinary tract infections.

For renal pelvic and calyceal urolithiasis larger than 1.5 cm, flexible ureteroscopy is not the first option. Flexible ureteroscopy can be one of the options for lower pole stones between 1.5 and 2 cm in size. This option should be exercised in cases of difficult lower polar anatomy and ESWL-resistant stones. Flexible ureteroscopy can also be a option for stones located in the diverticular neck or a diverticulum.

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**Compliance with ethical standards**

**Conflict of interest** None.

**Ethical standards** All ethical standards are complied.

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