

# A review article on management of Urolithiasis by percutaneous nephrolithotomy.

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**Abstract**—The management of urolithiasis has radically changed over the past two decades. Open surgery has been almost completely replaced by minimally invasive procedures. Percutaneous nephrolithotomy (PCNL) is considered to be the first line of treatment for large renal stones. Its use is associated with a multitude of complications. A thorough bibliographic search was performed for this review. Although PCNL comes with higher morbidity, its efficacy is unbeaten by other minimally invasive modalities. Improved skills and modifications of the procedure may reduce the probability of adverse outcomes. However, it is still associated with complications, even life-threatening ones. Since its introduction more than 30 years ago, PCNL has claimed its position as the minimally invasive procedure of the first choice for the treatment of large and complex renal stones. PCNL numbers are rising in recent years.

**Index Terms**—Complications, percutaneous nephrolithotomy, urinary lithiasis

## I. INTRODUCTION

In the last years, the surgical management of the stone disease has been transformed from an invasive treatment with inpatient hospitalization and long convalescence to a minimally invasive treatment with little or no hospital time and a short recovery period since open surgery now represents <1% of stone procedures. Treatment guidelines have not supported the superiority of one treatment option over another. However, the European Association Guidelines advice ureteroscopy (URS) or Extracorporeal Shock Wave Lithotripsy (ESWL) for stones in the ureter and Percutaneous nephrolithotomy (PCNL), retrograde intrarenal surgery (RIRS) or ESWL for kidney stones. The choice of specific treatment will be influenced by stone size and location, stone composition, previous stone history, patient habitus, patient and surgeon preference, and previous surgical treatments.

## II. EVIDENCE ACQUISITION

In this nonsystematic review, PubMed and MEDLINE databases were thoroughly searched from 1990 to the submission of this manuscript, using the terms: ‘PCNL’ and ‘Percutaneous Nephrolithotripsy’.

## III. PERCUTANEOUS NEPHROLITHOTOMY

Since the first creation of a percutaneous tract for stone removal reported in 1976, specific indications for PCNL have emerged, including the treatment of large, hard infected stones, obstruction-related stones, extracorporeal lithotripsy failures, and stones related with anatomic variations. The usual indications for PCNL are stones larger than 20 mm, staghorn calculi and partial staghorn calculi, large stones in the lower pole, and calyceal diverticular stones. The contraindications for PCNL include pregnancy, bleeding disorders, and uncontrolled urinary tract infections. PCNL attains stone-free rates of up to 95%. Data from meta-analysis suggest that larger lower polar stones have lower clearance rates and higher retreatment rates. However,

Table 1: Stone location and size, Suggested treatment

|                                                 |                               |
|-------------------------------------------------|-------------------------------|
| Proximal ureteral stone (mm)                    |                               |
| >10                                             | URS (ante-or retrograde) ESWL |
| <10                                             | ESWL or URS                   |
| Distal ureteral stone (mm)                      |                               |
| >10                                             | URS ESWL                      |
| <10                                             | ESWL or URS                   |
| Kidney stone (mm) (all but lower pole 10-20 mm) |                               |
| >20                                             | PCNL RIRS or ESWL             |
| 10-20                                           | ESWL or endourology           |
| <10                                             | ESWL or RIRS PCNL             |
| Lower pole stone                                |                               |
| As for the upper pole                           |                               |

|                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------|
| URS: Ureterscopy, ESWL: Extracorporeal shock wave lithotripsy, PCNL: Percutaneous nephrolithotomy, RIRS: Retrograde intrarenal surgery |
|----------------------------------------------------------------------------------------------------------------------------------------|

There is some controversy about the optimal procedure for the management of lower polar stones of <2 cm. Based on the literature, PCNL seems to have higher stone-free rates and lower auxiliary procedures rates but with the cost of slightly increased complication rates.

However, according to others, PCNL has similar recurrence rates and complication rates in comparison to ESWL. In the pediatric population, stone-free rates after first- and second-look PCNL are 70.1%–97.3% and 84.6%–97.5%, respectively, with an overall complication rate of 20%. In the general population, PCNL has overall complication rate of up to 83%, with minor complications being urine extravasation (7.2%), transfusion (11.2%–17.5%), and fever (21%–32.1%). Major complications such as septicemia (0.3%–4.7%), colonic injury (0.2%–0.8%), or pleural injury are less common. The preoperative evaluation involves a close study and analysis of imaging which includes a computerized tomography (CT) urography.

The choice of puncture either fluoroscopic or ultrasound (US) guided is dictated by the calyceal anatomy and the surgeon's expertise in a particular technique. Regardless of the choice of access ureteric catheter is placed in all cases. The conventional PCNL is done in a prone position. This allows direct access to the posterior calyx. In the prone position, the bowels do not come in the line of puncture. PCNL can also be done in the supine position which has the advantages of combined antegrade and retrograde approaches, easier switch of regional to general anesthesia, and usefulness in patients with cardiac comorbidities. However, in the supine position, we would not be able to establish multiple channels and the space is limited. The Bart's modified of Valdivia position uses both X-ray and US guidance in combination.

The advantages of US-guided access include the nonuse of radiation, minimal chance of visceral injury and proven safety in pregnancy. The downside of using US as an access modality are need for expertise, need for fluoroscopy in the dilatation stage of the procedure. In fluoroscopic-guided puncture (FGA), there is the ability to gain access to the kidney through an end on the posterior calyx. The obvious

disadvantage of this approach is the increased risk of radiation to the operator, patient as well as surgeon. Further, unlike the US-guided access there is no real-time visualization of visceral organs such as the kidney or the liver, thus potentially adding to the risk of injury to these organs. The kidney should be approached from below the 12th rib to reduce the risk of pleural complications. The site of entry on the skin is usually just inferior and several centimeters medial to the tip of the 12th rib. The triangulation technique is the most common technique used for achieving FGA.

Endoscopic guided renal access (EGA) involves the use of a flexible ureteroscope for identifying the ideal calyx for puncture and the calyx entry. Once the guide wire is passed in the rest of the steps which include dilatation are done either under endoscopic vision or under fluoroscopic guidance. In a study, the endoscopic-guided access (EGA) was compared with FGA. EGA was found to be better in terms of fluoroscopy time and the need for secondary procedures.

The operating time is limited to 90 min because it has been shown in the number of studies of the risk of fluid absorption with prolonged surgery. Complications such as hemorrhage and higher infection rates are associated with longer operation times. If it is decided that the procedure is to be staged the 14 Fr malecot tubes are inserted in the secondary access tracts. These serve the dual purpose of achieving mature tracts and providing a conduit for subsequent intervention. The primary tracts are dilated up to 26 Fr while the secondary tracts are dilated until 20 Fr. A single tract with the use of flexible instrumentation can be performed and involves the creation of a strategic tract which clears majority of stones. Once the bulk is cleared, stones present in inaccessible calyces are approached with flexible instruments. The disadvantage of this approach is the additional cost for instrumentation.

Standard PCNL is performed with the use of 24–30 Fr instrumentation. Continuous technological advancement has led to the miniaturization of endoscopic instrumentation, leading to newer concepts in percutaneous surgery such as the microperc and miniperc.

#### IV. MINIPERC

Miniperc is PCNL done with sheath size  $\leq 20$  Fr. Miniperc was originally devised for handling stones in children, but it has been widely used in adults because of its ability to minimize blood loss and hasten recovery and with similar clearance rates.

In miniperc, the scopes used range from 8 Fr to 16 Fr and the tract size varies from 12 Fr to 20 Fr. Both pneumatic lithotripsy devices and laser can be used for stone breaking modalities in mini PCNL. Mini-PCNL can also be used in situations where the infundibulum is narrow, and the smaller size of the scope can be used to navigate through the narrow infundibulum. Miniperc is ideally suited for treating stones of sizes varying from 1 to 2.5 cm. Stones of slightly larger sizes can also be tackled via miniperc by using modalities such as additional tracts.

In a prospective study conducted by Mishra et al., the authors were able to prove that Miniperc has equal efficacy in clearing stones when compared to standard PCNL, whereas it has an advantage of less bleeding and tubeless procedure as well in some cases. They also noted that miniperc has a drawback of lengthy operative time.

#### V. MICROPERC

Microperc uses 16G all seeing needle and a 0.9 mm flexible microperc telescope (8 Fr microsheath with 4.8 Fr shaft) and the stone is fragmented with laser. The ureteric catheter drains the pelvicalyceal system continuously. Intermittent manual suction through the ureteric catheter further reduces the intrarenal pressure. Microperc is currently used to manage single renal calculus or multiple renal calculi, which can be accessed with a single puncture and cumulative diameter of  $<1.5$  cm in diameter.

In a comparative study done by Sabnis et al., it was proved that microperc is similar to RIRS in terms of stone clearance and complications for small renal calculi.

#### VI. COMPLICATIONS OF PERCUTANEOUS NEPHROLITHOTOMY

Most of the complications post-PCNL are minor. Minor complications include fever and nephrostomy leak. Major complications can either be related to

access or stone removal. The pleura might be injured more during supracostal access than infracostal. We usually use the infracostal approach for routine access unless special indications such as the requirement of upper pole access.

Injury to the liver during PCNL is rare. If there is severe bleeding, angioembolization can be done.

Splenic injury is also a rare during PCNL. Intraoperatively, one should suspect splenic injury if the patient is hemodynamically unstable and there is no visible bleeding. In case of uncontrollable hemorrhage, splenectomy may be required. This is usually confirmed by intraoperative US guidance.

Injury to the colon, can occur in 0.2%–1%. The factors associated with increased risk are female gender, low body mass index, previous bowel surgery, and left side access. Symptoms include rectal bleeding, fever, pain, ileus elevated counts, and gas or feces from the percutaneous nephrostomy (PCN) tube. Intraoperative diagnosis is usually made after injection of contrast reveals colonic enhancement. Post-operative diagnosis can be made by CT or contrast study. The treatment of colonic injury is antibiotics and bowel rest. In case of delayed diagnosis, the PCN tube should be removed and a drain kept after consulting a general surgeon.

Duodenal and jejunal injury is extremely rare in PCNL. CT scan helps in diagnosing duodenal injury in the postoperative period. The preferred treatment is open surgical approach, whereas, nonoperative management with bowel rest, nasogastric suction, with or without percutaneous duodenal drainage, and renal collecting system drainage has also been described. Mild fever post-PCNL occurs in about one-third of the patients, but the incidence of sepsis is much lower, in patients treated with appropriate perioperative antibiotics. Postoperative sepsis can be prevented by preoperative antibiotics, low-pressure irrigation, and use of drainage when required. Intravascular fluid overload can occur if there is injury to vessels, increased duration of surgery, hypotonic solutions, high-pressure irrigation, patients with cardiac comorbidities such as congestive cardiac failure. Extravasation of fluid during PCNL occurs due to injury to the collecting system. Systemic absorption leads to volume overload and electrolyte abnormalities. If fluid extravasation is identified in the post-operative period, then it should be aspirated percutaneously under US guidance.

Post-PCNL bleeding is the most dreaded complication following PCNL. Most of the post-PCNL bleeds subside with conservative management. The causes of post-PCNL bleed are mainly multiple punctures and increased intraoperative time. Super selective angioembolization (SAE) is an efficacious and safe method of controlling post-PCNL bleeding. Pseudoaneurysm is the most common finding on SAE responsible for post-PCNL bleeding.

Residual stone fragments following PCNL can occur in up to 8% of the patients. When left untreated, approximately half of these patients will experience a stone-related event, for which more than half will require a secondary surgical intervention. For these reasons, urologists should take all these measures to prevent their creation, carefully identify their existence postoperatively, and actively deal with them by a second look at flexible nephoscopy and/or flexible ureterorenoscopy.

#### VII. PREVENTION OF COMPLICATIONS

Appropriate training and adequate surgical skills, proper patient selection, recognition and correction of associated comorbidities, and thorough knowledge of renal anatomy and its vasculature are mandatory to prevent PCNL complications. Surgical skills and surgeons' learning curves influence PCNL outcomes, especially the complication rate. When PCNL is performed in a dedicated stone center, a decreased operative time, a higher rate of uncomplicated access and stone extraction, and a shorter hospitalization is noted.

#### VIII. CONCLUSION

Even if PCNL is associated with the increased number of complications, the percentage of the procedures used for calculi management is increasing. The reasons are several: limitations of the competitors ESWL and URS, new technological and surgical developments, but as well expansion of indications, justified by smaller instruments, and the use of flexible instruments. Proper patient selection and preparation as well as meticulous operative techniques may prevent the occurrence of complications. Prompt diagnosis of the complication and institution of appropriate measures to correct the problem will also limit its magnitude. The majority of complications can

be treated conservatively and only some may require intervention.

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#### CONFLICTS OF INTEREST

There are no conflicts of interest.

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