Original Article

Percutaneous Nephrolithotomy in the Management of Complex Upper Urinary Tract Calculi: The Singapore General Hospital Experience

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Abstract

Introduction and Objectives*: Presently, percutaneous nephrolithotomy (PCNL) is a well-established and effective method of treating upper urinary tract stones at our institution. The aim of this paper was to evaluate a single surgeon's four-year experience of PCNL in the Singapore General Hospital. *Materials and Methods*: Between January 1996 and December 2000, 300 PCNLs were performed on 280 renal units. The mean age was 53.7 years. PCNL was performed on 57 complete staghorn calculi (20.4%), 83 partial staghorn calculi (29.6%), 66 large pelvic calculi (23.6%), 60 impacted uretero-pelvic junction (UPJ) and upper ureteric stones (21.4%) that failed extracorporeal shock wave lithotripsy (ESWL) and 14 symptomatic lower pole calculi (5%). *Results*: The stone-free rate on discharge was 88.2% (n = 247). At 3 months and 1-year post PCNL, the stone-free rate was 91.1% (n = 255) and 95.7% (n = 268), respectively. The average postoperative stay was 4.5 days. Complications included 1 urosepsis post-PCNL (0.4%) and 2 arterio-venous fistulae (0.7%). Only 1 patient (0.4%) required blood transfusion. Thirty-four patients (12.1%) required ESWL and 4 needed ureteroscopy (1.3%). *Conclusion*: In experienced hands, the use of PCNL for upper urinary tract calculi is safe and effective.

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Introduction

Open surgical removal had been the standard treatment for urolithiasis till the early 1980s when introduction of percutaneous techniques and extracorporeal shock wave lithotripsy (ESWL) revolutionised stone management.

Percutaneous extraction of stones from the renal pelvis was first reported by Rupel and Brown 60 years ago.[1] However, minimal progress was made till 1976 when Fernstrom and Johannson[2] developed the technique of percutaneous nephrolithotomy (PCNL) with simultaneous dilation of the tract to provide access to the kidney for stone removal. This resulted in a significant improvement in both technique and capability of the procedure. It was not until the mid-1980s with reports confirming its advantages and with further refinement of the technique did PCNL becomes acceptable in daily practice.[3-7]

Presently, PCNL is a well-established and effective method of treating renal stones with success rates of greater than 90% being reported.[8] Even in patients with multiple medical problems and complex stone burdens, it is possible to achieve success rates of up to 83% especially when other treatment modalities, such as ESWL and ureteroscopy, are used in a combined approach.[9] When compared with open stone surgery, PCNL is associated with lower morbidity and has greater patient acceptance because of its less invasive nature, shorter hospital stay and early return to work.[8,10,11]

Now, after 10 years performing percutaneous nephrolithotomy at the Department of Urology, Singapore General Hospital, we re-evaluate our present results and technique in the management of upper urinary tract stones.

Materials and Method

From January 1996 to December 2000, a total of 300 PCNLs were performed by a single surgeon on 280 renal units. Currently, the indications for PCNL in our institution are a large stone burden, e.g. a staghorn calculus or renal calculi >2 cm, and stones that have failed ESWL.[12]

Preoperative assessment included history, physical examination, urine culture, complete blood count, serum

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electrolyte, creatinine estimation and excretory urography. Information retrieved included urological history, pretreatment procedures, stone location, renal anatomy, complications, need for secondary procedures, immediate treatment results, length of hospitalisation, follow-up results and subsequent recurrence rates.

All patients received intravenous antibiotics on induction of anaesthesia. PCNL was done as a one-stage procedure in the operating room with the patient under general anaesthesia. Cystoscopy was performed and guide wire was inserted into the ureter. A balloon catheter was placed over the guide wire and inflated at the pelvi-ureteric junction to facilitate percutaneous needle puncture and also to prevent stone migration into the ureter during fragmentation of the renal calculi. The patient was then placed in a modified prone position, cleansed and draped in the usual sterile fashion. Retrograde pyelography was then performed and percutaneous access was established with C-arm fluoroscopy using an 18-gauge needle. The percutaneous tract was dilated with sequential dilators or balloon dilators to 28F before placement of an Amplatz sheath in the collecting system.

Rigid nephroscopy was performed initially, with the ultrasonic lithotripsy device being used to evacuate clot and as much stone fragments as possible. Occasionally, a pneumatic lithotripsy device was used, particularly for harder stones such as oxalate monohydrate stones. Flexible nephroscopy with pressurised irrigant was then used and each calyx was examined for residual fragments. Larger calyceal stones were fragmented with electro-hydraulic lithotripsy or laser lithotripsy. The rigid nephroscope and ultrasonic device were used to evacuate fragments from the renal pelvis once all calyces have been examined. Additional tracts were established, when indicated, using the same access technique.

When the kidney appeared stone-free fluoroscopically and endoscopically, a re-entry nephrostomy tube was placed over the stiff wire and was sutured to the skin. It was used for renal drainage as well as providing a tamponade effect on the percutaneous tract. Postoperative care included the continued usage of intravenous antibiotics as well as careful monitoring of nephrostomy drainage. Radiographs, including a nephrostogram when required, were performed 48 hours postoperatively to assess for residual fragments, antegrade flow and integrity of the collecting system. A decision was then made about the need for secondary PCNL to be performed at the time of nephrostomy tube removal to ensure stone-free status.

The stone-free rate for the PCNL was determined by review of all uro-radiographic studies done postoperatively, which included an intravenous urogram at 3 months post-PCNL up to the last follow-up visit.

Results

There were 183 men and 97 women (mean age 53.7 ± 12.2 years) with 57 complete staghorn calculi (stone burden involving 75% to 100% of the collecting system), 83 partial staghorn calculi (stone burden involving 50% to 75% of the collecting system),[13] 66 large pelvic calculi, 60 impacted uretero-pelvic junction calculi and 14 symptomatic lower pole calculi. The stones were bilateral in 6 patients and unilateral in the left and right renal units in 129 and 137 patients, respectively. Anatomical abnormalities were documented in 9 renal units; 2 horseshoe kidneys and 7 uretero-pelvic junction obstructions. Of the 280 renal units, 83 had previous ESWL (29.6%) and 7 had previous open renal split surgery (2.5%) on the same affected site. Upper pole accesses were performed in 126 PCNLs (42%), lower pole accesses in 152 PCNLs (50.7%) and mid pole accesses in 22 PCNLs (7.3%).

Immediate postoperative radiographic films showed evidence of residual stones in 36 renal units (12.9%). Twenty patients had a second PCNL (7.1%) and 16 had ESWL (5.7%) before discharge.

Stone-free rate on discharge was 88.2% (n = 247). Among 33 renal units with residual fragments >2 mm, 18 was treated with ESWL 1 month later (6.42%). Others wanted to be treated conservatively and expectantly. Four patients had ureteroscopy and laser lithotripsy for ureteric stone fragments. Stone-free rates at 3 months and 1 year were 91.1% (n = 255) and 95.7% (n = 268), respectively. Twelve (4.2%) PCNL procedures were considered failures as there were still residual fragments of above 2 mm in transverse diameter; 7 failures were in patients with previous open renal split surgery and 5 were in patients who refused ESWL after the initial PCNL.

The average operation time was 90 minutes (range, 35 to 185 minutes). The mean postoperative stay was 4.5 days (range, 2 to 13 days) with 63.5% below 4 days.

Complications included 2 arteriovenous fistulae (0.7%), being treated effectively with embolisation, and 1 urosepsis post-PCNL (0.4%). Only 1 patient (0.4%) in our series required blood transfusion.

Discussion

ESWL has been proven to be an efficient therapeutic modality for treatment of urolithiasis of the upper urinary tract.[14] However, the major limitations to the treatment of renal calculi by ESWL are the size of the stone and distal obstruction. Thus, percutaneous stone removal techniques are still needed as the primary mode of therapy in patients with complex upper tract stones. Technique and instrumentation for PCNL have advanced considerably in the last two decades, resulting in good outcome and minimal complications. This minimally invasive approach has been shown to decrease patient's morbidity and cost, and shorten convalescence when compared to open surgical techniques.[15] PCNL and ESWL have revolutionised the treatment of upper urinary tract calculi in our institution, such that open renal surgery is now rarely necessary (3%).

Indications

Over the past 10 years, the indications for PCNL and ESWL management of upper urinary tract stones have become better defined. In general, complex staghorn calculi or a large stone burden are more successfully treated with PCNL than with ESWL, as PCNL's success is more independent of the stone burden.[8] In our series, the most common indication for PCNL was a large stone burden, as seen in 197 renal units (70.4%), while the second most common reason for PCNL was failure of ESWL (29.7%).

Renal Access

The numbers of upper pole and lower pole accesses are similar (42% versus 50.7%). In general, a lower pole posterior calyx is preferred for renal access when it is sufficient to ensure removal of all stone material.

In certain situations, renal access through the upper pole is more desirable as it more closely parallels the axis of the renal collecting system resulting in better visualisation. Access to the uretero-pelvic junction and the upper ureter is also facilitated by upper pole puncture. In the event that the stone is in a horseshoe kidney, upper pole access is crucial, as the abnormal anatomic reflection of the peritoneum results in bowel positioning around the lower pole, making lower-pole access dangerous. In the upper pole access group, we had 67 staghorn calculi (53.2%), 57 pelvic and pelviureteric calculi (45.1%) and 2 horseshoe kidney calculi (1.7%). Our indications for upper pole access were staghorn calculi, horseshoe kidney, upper pole calculi and cases that required upper ureteral access (e.g. ureteric stones).

Among 33 renal units that received more than one puncture (11.8%), 23 had staghorn stones (82.1%) and 10 had pelviureteric stone (17.9%). This experience is similar to other authors.[10,16]

Operation Time and Treatment Sessions

It takes an average of 90 minutes to complete PCNL in our department. This reflects, in part, our preference to remove as many stones as possible during the primary procedure. The treatment strategies include establishing additional dilated tracts when necessary and the use of rigid and flexible instruments during the primary procedure. Extreme care is necessary during PCNL procedures to minimise complications and also to maximise stone removal, since even a small amount of bleeding can obscure stone fragments. The strategy occasionally prolongs the procedure but we believe that the benefits of a high stone-free rate, low complication rate and decrease need for post-PCNL ESWL more than outweigh the longer operating time. In 58 renal units with operative time over 120 minutes (20.7%), factors that contributed to the length of operation were when additional accesses were performed in high stone burden cases. The mean postoperative stay was 4.5 days.

Stone-free Rate

Our stone-free rates for PCNL with or without ESWL were 88.2% on discharge and up to 95.7% after 1 year. This rate is comparable with other international centres. The attention to technical details of the endourological procedure appears to be paramount in determining good outcome. Stone clearance rates are markedly influenced by the use of flexible nephroscopy and careful planning of renal access. Aggressive use of a flexible nephroscopy usually minimises the number of renal access tracts and decreases the need for subsequent ESWL. It ensures maximal visualisation of the collecting system, thus providing maximal stone clearance through the available access.

In recent years, evolving trends in the endoscopic management of complex renal calculi have resulted in improved stone-free status of patients treated with PCNL at our institution. These trends include:

1) increased usage of upper pole access,
2) percutaneous access is obtained by the urologist as part of a single-stage procedure,
3) use of flexible nephroscope after the rigid nephroscope with ultrasonic lithotripsy,
4) increased usage of secondary PCNL at the time of nephrostomy tube removal, to ensure better stone-free rate status, and
5) decreased reliance on ESWL after PCNL.

Complications

One of the most common and worrisome complications following percutaneous renal surgery is renal haemorrhage. Bleeding can occur at any point from intraoperatively to immediate or late postoperative period. Although the small vessels are routinely injured during PCNL, they rarely cause significant bleeding to warrant a blood transfusion. We had 2 patients with arterio-venous fistula, leading to postoperative bleeding requiring angio-embolisation. Both these cases needed multiple accesses (1 with upper and lower pole accesses, 1 with mid and lower pole accesses) to remove the infective staghorn calculi.

The overall blood transfusion rate after PCNL in our institution was 0.4%. This compares favourably to the reported transfusion requirement of 3% at other centre.[9]

We believe that using balloon to create the nephrostomy tract leads to less bleeding because the tract can be dilated rapidly in one step resulting in less trauma. Furthermore, the inflated balloon provides constant pressure to tamponade the small vessels that are routinely injured during percutaneous manipulation. This tamponade effect of the inflated balloon does not occur with the Amplatz sequential dilator system, which requires stepwise serial dilation of the tract. Also, Amplatz dilators can be advanced too far, causing perforation and vascular injury.

We had 1 patient who developed urospesis (0.4%) post PCNL. The low rate of urosepsis is comparable to other series (0.6%).[9] Our strict regime of negative preoperative urine culture, preoperative oral antibiotics and perioperative intravenous antibiotics had minimised the risks of urosepsis.

Conclusion

Experience and improvement in the technique of PCNL have resulted in higher stone-free rate at our institution. In experienced hands, the use of PCNL for complex upper urinary tract calculi is safe and effective.

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