Contemporary practice of percutaneous nephrolithotomy: review of practice in a single region of the UK

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ABSTRACT

INTRODUCTION Most series of percutaneous nephrolithotomy (PCNL) from single specialised centres represent optimum results achievable and may not reflect outcomes of everyday practice. We analysed the practice in our region.

PATIENTS AND METHODS Medical records of 178 patients undergoing PCNL in 2002 in 12 participating hospital trusts were retrospectively analysed.

RESULTS Even outside the tertiary referral centres, there was a 6-fold difference between trusts in the frequency of PCNL. In 28% of cases, another stone-removing modality had been tried first. Failed renal puncture was a major cause of abandoning surgery (9%). An indication of the difficulty in obtaining complete stone clearance is that only 107 (60%) operation notes recorded complete clearance, while 75 (42%) patients required a subsequent procedure (13% a secondary PCNL). Use of supra 12th rib punctures was small (6%) as was the rate of 'tube-less' PCNL (4%). Some 22% had simultaneous ureteric stent insertion. Approximately 8% of cases required a blood transfusion. Thirty-eight patients (23%) had a proven infection (UTI) pre-operatively ($> 10^4$ organisms; > 10 white blood cells) with almost all patients receiving antibiotics at anaesthesia induction. Postoperative sepsis rates (temperature $> 38.5^\circ\text{C}$) were similar in those with and without a pre-operative UTI (18.4% versus 14.3%) and pre-operative antibiotics appeared to have little extra protective effect. Severe sepsis was rare with no patient requiring intensive care admission for this reason. Median length of stay postoperatively was 5 days.

CONCLUSIONS These results present important figures to quote when counselling patients pre-operatively, albeit that the degree of difficulty (and hence the likelihood of problems) is identifiable from stone and anatomical configurations. In addition, the present data are a more accurate reflection of urinary stone surgery in non-tertiary, general urological practice.

KEYWORDS

Percutaneous nephrolithotomy – Renal calculi – Outcomes – Complications

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Percutaneous nephrolithotomy (PCNL) has become the mainstay of treatment for large renal calculi over the past 30 years since Fernstrom and Johansson first removed a renal calculus through a nephrostomy tract in 1976.¹ The practice of PCNL, having been refined over time, continues to evolve and has largely replaced open stone surgery for the treatment of complex upper tract stones unsuitable for extracorporeal shockwave lithotripsy (ESWL) or ureteroscopy. This has been aided by advances in technology and equipment resulting in stone removal with less morbidity, shorter convalescence, and reduced cost compared with open surgery.^{2,5}

Excellent outcomes have been reported following PCNL with stone-free rates approaching 95%. Nevertheless, most published series of PCNL are from single centres with a dedicated sub-specialist interest in stone management.

These represent optimum results achievable and may not reflect outcomes of everyday practice in non-specialised units. The aim of the study was to analyse the current practice of PCNL in our region.

Patients and Methods

The region comprises 12 participating hospital trusts. Of these, two were tertiary referral centres with a recognised expertise in stone management, while the rest (10) comprised district general hospitals (secondary centres) providing a range of urological interventions. All patients undergoing a PCNL procedure in 2002 were identified using theatre records and medical records scrutinised retrospectively. In trusts performing more than 20 procedures

per year (3 trusts), only the data from the first 20 patients were analysed. There was no case selection and no one was excluded. Data collection included stone demographics, operative technique, as well as pre-operative and postoperative management of the patients.

Results

In total, medical records of 178 patients undergoing PCNL in 2002 were suitable for analysis. The mean patient age was 51 years (range, 15–81 years).

There was considerable variation in the number of procedures performed by each department, ranging from 3–24 cases per year (Fig. 1). Six of the participating hospital units were performing five or less PCNL procedures a year. PCNL in the paediatric population is undertaken at a specialist paediatric unit and has been excluded from the current analysis.

PCNL was not the primary treatment modality in a significant proportion of patients. It is noteworthy that 68 (38%) patients had previously received another form of unsuccessful intervention. These included ESWL in 34 (19%), ureteroscopy (with intracorporeal lithotripsy) in 14 (8%) and a previous attempt at PCNL in 20 (11%) patients.

Of the 20 patients who had undergone a previous initial PCNL, all but two had had the initial procedure performed in the same secondary hospital. Two cases were referred on to a tertiary stone centre. There appeared to be no substantial difference in the proportion of patients undergoing initial or secondary procedures between secondary and tertiary stone centres.

Stone demographics

Ninety-one patients had treatment to a left-sided stone, 86 to a right-sided stone, and only one patient underwent bilateral simultaneous PCNL. Table 1 describes the position of the stones in the upper urinary tract. Stone dimensions were poorly recorded in medical notes with only 52% (92/178) clearly documenting the maximal diameter (range,

Table 1 Position of stone being treated in the urinary tract

Site	Number (%)
Pelvis (at or above the PUJ)	53 (30%)
Calyx	44 (25%)
Ureter (proximal)	8 (4%)
Calyceal diverticulum	6 (3%)
Multiple sites	68 (38%)
Unclear	2 (1%)

5–72 mm). In records where no size was given, stones were commonly described as a partial or complete staghorn. The majority of patients (108/178; 61%) had a single calculus, while the rest had multiple stones (70/178; 39%). In cases where the treated stones were smaller than would be expected for those undergoing PCNL, there usually was an associated anatomical or functional upper tract abnormality. For example, in the 6 patients with a maximum stone diameter of < 10 mm, the encountered abnormalities included: 2 cases with calyceal diverticular stones; 1 concomitant pelvi-ureteric junction (PUJ) obstruction, 1 ileal loop urinary diversion; and 2 had multiple calculi but no specifically documented indication for PCNL.

In total, 6% (10) of patients were known to have a concurrent anatomical abnormality at the time of percutaneous surgery (5 horseshoe kidney; 4 PUJ obstruction; 1 duplex kidney). With respect to calculi within calyceal diverticulum, all but one of 6 cases were operated on by experienced tertiary centre urologists.

Surgical technique

Renal puncture was performed by the operating urologist in 55% (98) of cases, while in 43% (76) the help of a radiologist was enlisted. Interestingly, while the decision whether to employ a radiologist or urologist for renal puncture was primarily determined by local availability of expertise in the district general hospitals, renal puncture was always performed by a urologist (with sub-specialist training in complex stone management) in tertiary stone referral centres. The procedure was abandoned in 16 cases (9%) and in all but one this was due to failed puncture. In the other case, it proved difficult to access the stone due to insufficient length of the nephroscope. There was no difference in the successful puncture rate between urologist and radiologist. The supra 12th rib approach was rarely employed (10 cases) and was mainly limited to two departments.

Dilatation technique was recorded in only 51% of patients (90 cases) with a slight majority (46 cases) in

favour of balloon rather than telescopic devices. When recorded (141 cases), the stone fragmentation devices used were: impaction device in 55 (42%); ultrasound in 27 (21%); electrohydraulic in 21 (16%); multiple devices in 6 (5%); and laser fragmentation in 1 patient. In 31 patients (17%), stone fragmentation was not required and the stone was removed *in toto*. Stone clearance was judged to be complete in only 107 (60%) cases at the end of procedure and 75 (42%) had further stone treatment, mostly to the same stone. Further treatment consisted of ESWL in 34 (19%), a second PCNL in 23 (13%), ureteroscopy in 14 (8%) and open removal in 4 (2%).

Postoperative management

A 'totally tubeless' technique was used in only 5 cases with 3 further patients having a ureteric stent only. Thirty-six patients (22%) had a ureteric stent inserted at the end of the procedure along with a nephrostomy tube. There was a wide variation in practice with some departments inserting a stent in all cases, whereas others rarely employed them. Postoperative imaging to assess stone status included a nephrostogram in 107 cases (60%), while 71 patients (40%) underwent a plain radiograph alone. Radiological imaging was generally performed within 2 days following surgery. While the choice of radiological investigation was determined by clinical parameters, two departments routinely performed a nephrostogram postoperatively.

Complications

Fourteen (8%) patients had a blood transfusion with mean transfused volume of 2.5 units (range, 1–8 units). Eight of these patients had more than one puncture attempt. Of the 14 patients requiring transfusion, seven had tract dilatation performed by the balloon dilator, one had Alken sequential dilatation and the technique not recorded in six others. Twenty-five (14%) patients had sepsis (described as a pyrexia of 38.5°C) but no patients were admitted to intensive care with severe sepsis. Other complications encountered are described in Table 2. There were no significant differences between tertiary and secondary centres with regards to postoperative transfusion or sepsis rates. Two patients went on to have an open nephrectomy – one due to uncontrolled bleeding and the other due to puncture of the inferior vena cava requiring repair and subsequent open nephrectomy. Although both patients underwent PCNL in non-tertiary referral centres, given the small numbers, a credible conclusion cannot justifiably be drawn from this data.

Microbiology

Pre-operative, mid-stream specimen of urine (MSSU) analysis results were available in all but 11 cases (6%). Median time between MSSU analysis and surgery was 7 days. Of the 167 available results, 38 (23%) were positive

Table 2 Postoperative complications

Complications	No. (%)
Return to theatre	5 (2.8)
• Nephrectomy	2
• Cystoscopy and evacuation of bladder clots	1
• Retrograde ureteroscopy and stone extraction (day 7 postoperatively)	1
• Retrograde ureteric stent insertion (day 10 postoperatively)	1
Re-admission within 30 days following discharge	5 (2.8)
Early abandonment	4 (2.2)
Respiratory/cardiac complications	4 (2.2)
Emergency nephrectomy due to excessive bleeding	1 (0.6)
Puncture of the IVC	1 (0.6)

(defined as a significant growth of a single pathogen, with pyuria). Rates of postoperative sepsis, however, were fairly similar in those with and without proven UTI (18.4% versus 14.3%, respectively). The majority of patients (173; 97%) received prophylactic intravenous antibiotics prior to surgery, while 5 patients had no record of antibiotic therapy. The choice of antibiotics varied slightly between units, with gentamicin being used most commonly (95% of cases) but with a marked variation in doses (range, 80–400 mg); a cephalosporin was used in 29% of cases.

The median postoperative hospital stay was 5 days (range, 4–10 days). All but two patients were followed up in the out-patient clinic. Both these patients had been rendered stone-free having had small, uncomplicated stones with no underlying biochemical abnormality predisposing to stone formation.

Discussion

PCNL is currently the procedure of choice for the management of large, complex, upper urinary tract calculi and represents a specialised and technical procedure. Our regional data highlight a large 6-fold variation in the numbers of procedures performed in each department. The goal of PCNL is to render the patient stone-free and, when this is used as a measure of success, there was no real difference between units performing small and large numbers of procedures. Half of the hospitals analysed performed fewer than 5 PCNL procedures per year, thus making it difficult to draw statistically valid conclusions with regards to frequency of activity and stone-free rates. Incomplete documentation of stone dimensions (stated in only 52% of cases) negates meaningful and statistically significant comparisons. In addition, units performing more

procedures were likely to be treating larger and more complex stones, potentially resulting in less favourable stone clearance rates. Nevertheless, whether units performing insufficient numbers of a specialised procedure infrequently should continue to do so remains a contentious issue. Additionally, whether combining the experience of various units would result in improved outcomes remains a matter of speculation.

The overall stone-free rate of patients treated within this region is only 60% and is lower than those described in current medical literature. Furthermore, the heterogeneous nature of the data, which includes a number of patients with staghorn calculi and large stones, may also contribute to the lower than expected clearance rate. In addition, the relationship between stone size and stone clearance could not be explored further due to incomplete records (stone dimensions were recorded in only 52% of cases) and lack of standardisation with respect to surgical technique and post-operative imaging. Most studies from large, single centres with an established expertise in the management of renal tract calculi quote stone clearance rates of 79–95%.^{5–6} To our knowledge, the present data reflect ‘real-life’ activity and are likely to be a truer representation of urinary stone surgery in a diverse, non-specialised geographical region.

Notably, although 60% of patients were initially judged to be stone-free, 42% underwent additional treatment for remaining stones. This seeming discrepancy highlights the issue that though the surgeon’s assessment regarding stone clearance at the completion of procedure is reasonably accurate, in a small number (4 patients) follow-up radiograph confirmed unexpected residual calculi requiring an additional procedure.

Failed puncture was the main cause for abandoning the procedure. While, most papers from single institutions fail to comment on the frequency of failed puncture, our puncture failure rate of 8.5% would appear to be higher than those quoted in contemporary literature (between 1–10%). This difference may well reflect the heterogeneous nature of the studied cohort, and like-for-like comparisons may be more appropriate. Moreover, referral to a specialised, stone centre performing a high number of procedures ought to be considered for more complex cases.

It is noteworthy that PCNL was not the first-line therapy for 38% of patients who had previously undergone another form of unsuccessful stone treatment. Some 27% of stones had been previously treated with either ESWL or ureteroscopy; in a further 11%, this was the second attempt at stone clearance via a percutaneous approach. Whether this reflects poor case selection is not apparent from our study. In addition, decision-making in stone surgery remains a multifactorial issue, dependent on patient, urologist and local availability factors. It is also unclear whether patients requiring a second PCNL have a better outcome if referred to a tertiary stone centre.

The number of pre-operative positive MSSUs is comparable to figures reported in the literature. Rao and co-workers⁷ noted significant pre-operative bacteriuria in 36% of patients undergoing stone surgery. In addition, a much higher rate of postoperative pyrexia (temperature > 37.5°C) was observed in patients following PCNL surgery (74% of cases). Moreover, although the study by Rao *et al.*⁷ confirmed a statistically significant association between pre-operative bacteriuria and the development of postoperative bacteraemia (bacteraemia in 37% of patients with a positive MSSU compared to 8% in those with a negative urine culture pre-operatively), this was not observed in our analysis. The postoperative sepsis (temperature > 38.5°C) rates were similar in those patients without pre-operative confirmed UTI. A sterile pre-operative urine culture is the desired standard but does not necessarily preclude bacteriuria following surgery due to the well-acknowledged association between urinary stones and harboured bacteria. It has been reported that 35% of patients with sterile urine undergoing PCNL without prophylactic antibiotics developed postoperative bacteriuria.⁸

Despite the advent of the pre-operative assessment clinic prior to PCNL, patients still continue to be assessed less than 1 week prior to surgery. In our review, over half the departments took an MSSU less than 1 week before surgery. Clearly, patients with a positive urine culture risk the possibility of having insufficient time for administration of appropriate antibiotics before the day of surgery. We, therefore, recommend that a suitable urine sample be collected at least 2 weeks prior to surgery.

The preponderance of gentamicin as the preferred prophylactic antibiotic is in keeping with wide-spread practice, since the majority of uropathogens will display sensitivity to aminoglycosides. Noteworthy is the fact that of the 30 patients (16.9%) with an in-dwelling ureteric stent, nine received only gentamicin at induction. It is recommended that, in patients with ureteric stents, prophylaxis should include gentamicin in combination with ampicillin or a cephalosporin since *Enterococcus* spp. and *Staphylococcus epidermidis* have been shown to be the most frequent colonising bacteria in such patients and may be found in up to a third of patients with pre-operative sterile urine.^{9,10} Gentamicin in isolation can be ineffective against these pathogens in 25–50% of cases. Due to the wide variation in the choice of antibiotics, dosage and time of administration in our study, it is difficult to draw statistically valid conclusions, and a comprehensive discussion of antibiotic prophylaxis in PCNL is beyond the scope of this paper.

The site of kidney puncture is a vital part of a successful PCNL. Typically, a subcostal puncture is used; however, in certain circumstances, a supracostal approach may be desirable for improved access, *e.g.* with staghorn and proximal ureteric stones. The drawback of supracostal punctures is an increased incidence of intrathoracic complications as well as a higher rate of spleen and hepatic

injury.^{11–15} The use of supra twelfth rib punctures, perhaps reflecting the small throughput in a number of hospitals, was limited to only 6% of cases and none of whom had any complications.

The totally 'tubeless' PCNL has been increasingly reported in a number of recent papers, but use of this technique in our region has been limited to just 3% of cases. There is little doubt that this practice is likely to increase with time as more experience is gained. A totally tubeless procedure was adopted in cases involving removal of small stones (15–20 mm), minimal manipulation and nominal blood loss, and is in keeping with criteria described in recent publications.^{14,15} Tubeless PCNL has been reported to be associated with lower analgesic requirements and greater cost-efficiency.¹⁶ The average stay of these patients was 3.33 days (unlikely to reach statistical significance as only 3 recorded stays), and may merely reflect the fact they were smaller stones with presumably shorter operating times.

The rate of blood transfusion is comparable with previous reported data (7–7.9%).^{17,18} Our data support the principle that patients having multiple punctures are more likely to require a blood transfusion.¹⁷ In all but one recorded case requiring a blood transfusion, a balloon dilation technique was employed. This would appear contrary to recent papers suggesting a lower transfusion rate with pneumatic dilation compared to multi-incremental techniques.^{19,20} However, we have only reported a small number of cases and the dilation technique was on the whole poorly recorded.

Conclusions

PCNL has well-established indications and continues to evolve as a safe and effective technique. Our review demonstrates a significant variation in the number of a sub-specialist procedure being performed in urology departments even within the same region. It is imperative that the role of tertiary stone centres is clearly defined with provision of suitable opportunities for targeted training for PCNL. In addition, meticulous data collection and critical analysis will ensure improved patient care, while decreasing adverse events; therefore, it is mandatory that all institutions providing this service review their own practice. Outcome statistics from dedicated large-stone centres have little bearing on local contemporary practice, and we believe that our data represent important figures regarding everyday practice which can be used to quote to patients when counselling them regarding percutaneous stone treatment.

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