‘Nephrostomy-free’ percutaneous nephrolithotomy: experience in a UK district general hospital

DR YATES¹, RK SAFDAR¹, PA SPENCER², BT PARYS¹

Departments of ¹Urology and ²Radiology, Rotherham District General Hospital, Rotherham, UK

ABSTRACT

INTRODUCTION Percutaneous nephrolithotomy (PCNL) is the first-line treatment for large and complex renal calculi. Accepted UK practice is to insert a nephrostomy tube at the end of the procedure to drain the kidney and reduce potential complications. ‘Tubeless’ or ‘nephrostomy-free’ PCNL has been advocated in selected patients as it is thought to reduce length of hospital stay, analgesia requirements and pain experienced. We present our outcomes of a consecutive series ($n = 101$) of ‘nephrostomy-free’ PCNLs compared to standard PCNL over a 4-year period.

PATIENTS AND METHODS Between January 2004 and October 2006, we performed 55 standard (with nephrostomy tube) PCNLs (Group 1). From October 2006 onwards, we changed our technique and have performed 46 consecutive ‘nephrostomy-free’ PCNLs (JJ stent inserted), independent of patient and stone factors (Group 2). We have compared the two groups in terms of length of hospital stay (LOS), analgesia requirements, transfusion rates, haemoglobin (Hb) decrease and immediate, early and late complications.

RESULTS ‘Nephrostomy-free’ PCNL significantly reduced the length of hospital stay (2.8 vs 5.1 days; $P < 0.001$), morphine-based analgesia requirements (23% no morphine required vs 2.8%; $P < 0.001$), transfusion rate (2.5% vs 7%; $P < 0.01$) and mean Hb decrease (1.89 g/dl vs 2.25 g/dl; $P > 0.05$). Overall, no patient experienced a serious complication. All attempted ‘nephrostomy-free’ PCNLs were completed (stone clearance 95%) and no patient needed an unplanned nephrostomy. Only 5% in Group 2 needed their ureteric JJ stent removing earlier than planned secondary to pain. Both groups were comparable in terms of immediate, early and late complications, though three patients in Group 1 developed chronic loin pain and one patient in the ‘nephrostomy-free’ group developed a delayed perirenal haematoma.

CONCLUSIONS ‘Nephrostomy-free’ percutaneous nephrolithotomy is a safe, effective and feasible procedure independent of patient and stone factors. It decreases the length of hospital stay, the pain experienced and the need for morphine-based analgesia; we feel it should be the standard of care for patients undergoing a PCNL.

KEYWORDS

Percutaneous nephrolithotomy – ‘Tubeless’ PCNL – Renal calculi

CORRESPONDENCE TO

DR Yates, 114 Walkley Crescent Road, Sheffield S6 5BB, UK

E: d.yates@sheffield.ac.uk

Percutaneous nephrolithotomy (PCNL) is an endo-urolological procedure used for the fragmentation and removal of renal calculi. It was first described in 1976 by Fernstrom and Johansson¹ and has since completely replaced open stone surgery as first-line treatment for large or complex renal calculi. Specific indications include staghorn calculi, stones > 2 cm in size, stones in calyceal diverticula and stones refractory to extracorporeal shockwave lithotripsy (ESWL). In the UK, routine practice following PCNL has been to leave a nephrostomy drainage tube for a few days. A nephrostomy tube serves several purposes; it may tamponade bleeding originating from the access tract, to allow adequate drainage of urine and to enable access to the collecting

system if a secondary procedure is deemed necessary. However, a nephrostomy drain increases the morbidity of the operation as patients often find them painful and several international authors have suggested a ‘tubeless’ PCNL is feasible in selected cases,^{4–7} leading to decreased analgesia requirements, shorter hospital stay (LOS), a faster recovery and thus decreased cost of the procedure to the healthcare provider. We report on a comparative retrospective series of 101 PCNLs performed consecutively at our institution between 2004 and 2008, evaluating the outcomes of ‘nephrostomy-free’ PCNL in terms of complications, LOS, transfusion rates and analgesia requirements when compared to standard PCNL.

Patients and Methods

Study groups

From January 2004 to October 2006, a single surgeon (BTP), assisted by a single radiologist (PAS), performed 55 PCNLs with routine insertion of a 26-Fr Malecot nephrostomy drainage tube at the end of the procedure ($\pm$ JJ stent; Group 1). Based on international literature and conference abstracts reporting the feasibility of 'tubeless' PCNL, from October 2006 to June 2008 (study end) the same surgeon and radiologist performed 46 consecutive 'nephrostomy free' PCNLs, independent of patient and stone factors, with insertion of a ureteric JJ stent in the majority ($n = 39$; 85%; Group 2) as summarised in Table 1.

Group 1 comprised 55 consecutive patients who underwent a PCNL with a nephrostomy tube. The additional insertion of a ureteric JJ stent was necessary in only 14 patients (25%). Group 2 consisted of 46 consecutive patients who underwent a 'nephrostomy-free' PCNL, and a ureteric stent was routinely inserted in the majority of cases ($n = 39$; 85%). Seven patients (15%) in the 'nephrostomy-free' PCNL group had a very straightforward procedure with minimal bleeding and a decision was taken not to insert a ureteric stent. Both groups were comparable in terms of age, sex, mode of presentation, size/site of stone and ASA. Of patients in Group 1, 50% had had a previous treatment compared to 25% in Group 2. More pertinently, the previous PCNL rate was 13% versus 7.6%. It is thought that this reflects the change to offering PCNL as a first-line treatment to more patients with renal calculi, so the latter Group 2 have less patients within it having had previous failed non-PCNL type treatments (Table 1). Stone characteristics were similar in both groups. The median size of stones (non-staghorn) in Groups 1 and 2 were 13.8 mm (range, 5–25 mm) and 12.1 mm (range, 5–23 mm), respectively. Four patients (8%) in Group 1 had an identified metabolic cause for their renal calculi (all cystinuria) compared to only one patient (2.5%) with cystinuria in Group 2. Mean serum calcium and uric acid levels are shown in Table 1. An abnormally high serum calcium level (> 2.7 mmol/l) was identified in two patients (4.5%) from Group 2 only. An abnormally high serum uric acid level (> 450 μ mol/l) was identified in three (5.4%) patients from Group 1 and three (6.8%) patients from Group 2. Of Group 1 patients, 50% had undergone previous treatment for renal calculi (ESWL 13% [$n = 7$], PCNL 13% [$n = 7$] and ureteroscopy 24% [$n = 13$]). Only 25.6% of Group 2 patients had undergone previous treatment (ESWL 5% [$n = 2$], PCNL 7.6% [$n = 3$], ureteroscopy 13% [$n = 6$]).

Technique

The overall technique of PCNL was consistent throughout the whole study period, the only alteration being the omission

of the nephrostomy drainage tube ($\pm$ insertion of a ureteric stent) at the end of the procedure, after October 2006. Following informed consent, thromboprophylaxis, prophylactic i.v. antibiotics (Ceforoxime 750 mg i.v.) and general anaesthesia, the patient had a 6-Fr ureteric catheter insert-

Table 1 Patient demographics and stone factors in the two groups

	Group 1	Group 2
Number of patients	55	46
Stent inserted at time PCNL	14 (25%)	39 (85%)
Age (years)		
Median	49	51
Range	22–82	22–76
Sex		
Male	34 (62%)	30 (66%)
Female	21 (38%)	16 (34%)
Presentation (%)		
Pain	78	64
Macro. haematuria	13	13
Incidental	4.6	5
UTI	2.2	2.5
Micro. haematuria	2.2	8
Other	0	8
Stone number (%)		
Single	38	33
Multiple	42	57
Staghorn	20	10
Stone size (mm)		
Median	13.8	12.1
Range	5–25	5–23
Stone site (%)		
Lower pole	47	47
Renal pelvis	25	20
Other	28	33
Calcium (mmol/l)		
Mean	2.28	2.41
Range	1.89–2.44	2.17–2.82
Abnormal (>2.7)	0	2 (4.5%)
Uric acid (μ mol/l)		
Mean	305	307
Range	123–728	104–487
Abnormal (> 450)	3 (5%)	3 (6.8%)
Previous treatment (%)		
ESWL	13	5
PCNL	13	7.6
URS	24	13
Nil	50	74.4

ed transurethrally. This was secured in place by taping to a 16-Fr Foley catheter. The patient was turned into a prone position and access to the collecting system was performed (by consultant radiologist PAS) using retrograde opacification (methylene blue/Omnipaque) and planar fluoroscopy. After contrast aspiration with an 18-G access needle, a J-tip 0.035-inch guide-wire was passed antegradely down the ureter. A second wire was placed to act as safety wire. A skin incision was made and the tract dilated using a balloon dilator (Cook Urological, USA) and a pre-loaded 30-Fr Amplatz working sheath was left in the tract. If necessary to achieve complete stone clearance, a second access tract was established using the same technique. A 26-Fr Nephroscope was introduced down the Amplatz sheath to survey the collecting system and remove or fragment any stones identified. Fragmentation was achieved with intracorporeal ultrasound lithotripsy (Wolff). Fragments were retrieved with stone graspers, forceps or via the use of various baskets. Stone clearance was confirmed both endoscopically and fluoroscopically. Prior to October 2006, a 26-Fr Malecot nephrostomy tube was inserted (and a 6-Fr JJ stent if indicated). Subsequent to October 2006, after confirming stone clearance, only a 6-Fr JJ stent was inserted antegradely and the wound was closed with two deep mattress sutures (2/0 monocryl). The ureteric catheter was removed at the end of the procedure and the Foley catheter remained in situ. Postoperative care for Group 1 ('nephrostomy' group) consisted of ward removal of the nephrostomy tube on postoperative days 2 or 3, after a successful period of overnight clamping (no severe pain, fever). The urethral catheter was also removed the same day. The patient was discharged after having a plain radiograph (KUB) to confirm stone clearance. The nephrostomy stayed *in situ* longer if there was significant bleeding or pain/fever on clamping. The patients were seen in the out-patients department 6 months later with a KUB. Postoperative care for Group 2 patients consisted of routine monitoring, KUB, removal of the urethral catheter on the second day and discharge. The ureteric JJ stent was removed via flexible cystoscopy under local anaesthesia 2 weeks later. The patients were seen in the out-patient department 6 months later with a KUB. All patients, if not contra-indicated, received 48 h of i.v. Cefuroxime (750 mg) and thromboprophylaxis (40 mg Enoxaparin). Peri- and postoperative analgesia varied between patients but the options available included morphine-based analgesia (epidural, patient controlled analgesia [PCA], i.v./s.c. bolus), paracetamol, Tramadol, non-steroidal anti-inflammatories [NSAIDs] and 'others', e.g. Co-codamol, Nefopam.

Statistical analysis

The chi-squared test was performed for statistical analysis of qualitative variables and Student's *t*-test for quantitative variables. A *P*-value of < 0.05 was considered significant.

Results

The comparative outcomes of PCNLs in Groups 1 and 2, in terms of complications, transfusion rate, haemoglobin (Hb) change, length of hospital stay and analgesia requirements, are shown in Table 2. Stone clearance as determined at time of PCNL or on postoperative imaging was achieved in 71% (*n* = 39) of patients in Group 1 compared to 95% (*n* = 44) in Group 2. We have no plausible explanation for this discrepancy; given the fact the patients in both groups were comparable in terms of age, sex, mode of presentation, size/site of stone and ASA and the procedures were performed consecutively by the same surgeon/radiologist, we can only assume this has occurred as a coincidence rather than a true reflection of differing case complexity.

Table 2 Comparative outcomes of PCNL in the two groups

	Group 1 (<i>n</i> = 55)	Group 2 (<i>n</i> = 46)
Stone clearance, <i>n</i> (%)	39 (71%)	44 (95%)
Postoperative Rx required, <i>n</i> (%)	16 (29%)	2 (5%)
Complications, <i>n</i> (%)		
Immediate	2 (3.6%)	2 (5%)
Early	5 (9%)	7 (15.9%)
Late	3 (5.4%)	1 (2.2%)
Transfusion, <i>n</i> (%)*	3 (5.4%)	1 (2.2%)
Haemoglobin, median g/dl (range)		
Pre-operative	14.2 (10.8–16.8)	14.5 (9.6–18.5)
Postoperative	11.9 (8.4–15.5)	12.5 (6.3–16.5)
Difference	2.25 (0.2–6.2)	1.89 (0.2–6.2)
Length of stay (days), median (range)*	5.1 (3–9)	2.8 (2–5)
Analgesia, <i>n</i> (%)		
Paracetamol	43 (78%)	36 (82%)
Tramadol	31 (57%)	26 (59%)
NSAIDs	22 (40%)	8 (19%)
Others	22 (40%)	14 (32%)
Morphine-based analgesia*	53 (97.5%)	34 (77%)
– PCA	32 (58%)	14 (32%)
– Epidural	4 (7%)	1 (2.2%)
* <i>P</i> < 0.05.		

This led to 29% ($n = 16$) of Group 1 patients requiring further treatment (ESWL mainly) for residual fragments compared to only 5% of Group 2 ($n = 3$). Of the 39 patients in Group 2 who had a ureteric JJ stent inserted as part of the PCNL, 95% ($n = 44$) had this removed as planned via a flexible cystoscope 2-weeks postoperatively. Two patients (5%) had to have it removed prematurely secondary to refractory stent pain, without adverse consequences. The majority of stones removed underwent formal stone analysis. Stone constituents in Group 1 were calcium oxalate in 20%, calcium phosphate (CaPO_4) 18%, mixed calcium oxalate / CaPO_4 30%, uric acid 9%, cystine 9% and unknown in 14%. In Group 2, stone constituents included calcium oxalate 31%, CaPO_4 10%, mixed calcium oxalate / CaPO_4 25%, uric acid 8%, cystine 2.5%, magnesium ammonium phosphate 5% and unknown in 18.5%.

Postoperative complications were categorised as immediate (peri-operatively), early (< 28 days) and late. Immediate complications occurred in both Groups 1 and 2 in only 2 patients (3.6% and 4.5%, respectively), in which significant bleeding necessitated the procedure to be abandoned. Overall, early complications occurred in 9% ($n = 5$) of Group 1 patients compared to 15.9% ($n = 7$) of Group 2. In Group 1, the five specific complications included pneumonia, bowel ileus, urinary tract sepsis necessitating admission to the intensive care unit (ITU), urinary retention and significant loin pain. In Group 2, the seven complications included respiratory failure necessitating ITU admission in two patients, haematuria requiring re-admission in two, clot colic, stent pain and stent migration. No patient in the 'nephrostomy-free' PCNL group (Group 2) developed an early serious side-effect specific to non-drainage of the kidney following PCNL, *e.g.* renal parenchymal bleeding, nephrostomy tract haemorrhage, perinephric haematoma/abscess or clot colic necessitating ureteric stenting. Late complications developed in three (5.4%) patients in Group 1 (chronic loin pain in all three) and only one (2.2%) patient in Group 2, though this was a perinephric haematoma presenting as a subcutaneous abscess which was treated conservatively with intravenous antibiotics resulting in spontaneous discharge and resolution. The postoperative transfusion rate was 5.4% ($n = 3$) in Group 1, compared to only one (2.2%) patient in Group 2 ($P < 0.01$). The median decrease in Hb postoperatively was 2.25 g/dl (range, 0.2–6.2 g/dl) in Group 1, compared to a difference of 1.89 g/dl (range, 0.2–6.2 g/dl) in Group 2 ($P > 0.05$).

The length of hospital stay (LOS) differed significantly between the two groups. The median LOS for Group 1 was 5.1 days (range, 3–9 days) compared to only 2.8 days (range, 2–5 days) for the 'nephrostomy-free' PCNL group (Group 2; $P < 0.001$).

The mode/combination of analgesia employed varied between each patient but the options available were constant

throughout the study period and included Paracetamol (oral, i.v. or rectal), Tramadol (oral/i.v.), NSAIDs (oral or rectal), morphine-based analgesia (epidural, PCA, i.v./s.c. bolus) or others (codeine-based analgesia, *e.g.* Co-codamol, Nefopam). In Group 1, 97.5% ($n = 53$) used some form of morphine-based analgesia, 78% ($n = 43$) paracetamol, 57% ($n = 31$) Tramadol, 40% ($n = 22$) NSAIDs and 40% ($n = 22$) others. In Group 2, 77% ($n = 34$) required morphine-based analgesia, 82% ($n = 36$) paracetamol, 59% ($n = 26$) Tramadol, 19% ($n = 8$) NSAIDs and others in 32% ($n = 14$). There was a significant difference in respect of the morphine-based analgesia requirements needed in each group. As mentioned, only 2.5% ($n = 2$) of patients in Group 1 underwent a PCNL without the need for morphine analgesia compared to 23% ($n = 10$) in Group 2 ($P < 0.001$). Specifically, this led to an overall reduction in the need for PCA in 26% of patients (58% Group 1 versus 32% Group 2; $P < 0.001$) and a reduction in the number of epidurals sited of 4.6% (7% Group 1 versus 2.2% Group 2). The total number of analgesia options available to the patients were five (paracetamol, Tramadol, NSAIDs, morphine-based analgesia and others). We performed a crude calculation of the average 'analgesia score' (number of analgesics used/total number analgesics available [5]) in each of the two groups. Patients in Group 1 used an average of 3.3 analgesics compared to 2.55 in Group 2 ($P < 0.05$). Unfortunately, due to the retrospective nature of the study and the high incidence of PCAs, it was not possible to collate quantitative data accurately for the amount of morphine in milligrams required per group or perform visual pain analogue scores.

Discussion

Wickham *et al.*,² in 1984, were the first to suggest the idea, in selected cases, of omitting the insertion of a nephrostomy tube at the end of a PCNL. A short while later, in 1986, Winfield *et al.*³ argued against this concept, reporting that omission of the nephrostomy tube after percutaneous stone removal led to extended hospitalisation and pain (two patients). It became, and still is in many UK centres, standard practice to insert a nephrostomy tube at the end of a PCNL. Bellman *et al.*⁴ re-introduced this concept of 'tubeless' percutaneous stone surgery in 1997. He challenged the requirement for routine placement of a nephrostomy tube and reported on a total of 50 patients who underwent 'tubeless' renal procedures (nephrolithotripsy, endopyelotomy plus endopyelotomy and stone extraction). The initial 30 patients had a JJ stent and a Councill nephrostomy tube, the latter being removed 2–3 h postoperatively. The subsequent 20 patients received only a JJ stent and constituted the true 'tubeless' group. Their outcomes were compared to a control group of 50 who had undergone 'tubed' standard percutaneous procedures. No significant complications occurred

Table 3 Published series of 'tubeless' PCNL 1984–2008

First author	Year	Country	<i>n</i>	LOS	Tx	Success	Comment
Wickham ²	1984	UK	100	2.8 days	6%	94%	First group to suggest feasibility of 'nephrostomy free' PCNL in selected cases
Bellman ⁴	1997	USA	50 ^a vs 50	0.6 ^b vs 4.5 days*	0%	n/s	^a 30 of 'tubeless' PCNL group had a Council catheter for 2–3 h postoperatively ^b Discharged with urethral catheter <i>in situ</i>
Delnay ¹⁶	1998	USA	33	1.5 days	0%	94%	Two-thirds of patients discharged within 24 h
Goh ⁵	1999	USA	10	2.3 vs 3.6 days*	0%	80%	Only 10 kidneys (8 patients) had 'tubeless' PCNL. 6 had JJ stent and 4 external ureteric catheter
Lojanapiwat ²⁴	2001	Thailand	37	3.63 days	0%	92%	External ureteric catheter inserted for 48 h. Mean Meperidone 38.57 mg
Feng/Bellman ¹²	2001	USA	10	1.9 days	0%	n/s	Prospective, randomised. Standard (34-Fr) vs Mini-perc (26-Fr) vs 'tubeless'
Limb/Bellman ¹⁷	2002	USA	112 (86)	1.25 days	6%	93%	Leading institutions first 112 patients (1995–2000). 86/112 had PCNL
Yang/Bellman ²³	2004	USA	138	1.82 days	6.8%	94.5%	Same cohort as Limb & Bellman ¹⁷ but subset analysis of obese/morbidly obese patients showing no effect on outcome
Karami ¹¹	2004	Iran	30	1.5 vs 3 days	0%	90%	'Totally tubeless'. Pentazosin 30 mg vs 90 mg. Complications 6.6% vs 3.3%
Desai ¹³	2004	India	10	3.4 vs 4.4/4.3 days*	n/s	n/s	'RCT' 30 patients. Large bore tube vs small bore vs tubeless. Pethidine 87.5 mg vs 217/140 mg Urine leak 4.8 h vs 21.4/13.2 h
Aghamir ¹⁰	2004	Iran	43 vs 43	1.6 vs 5.2 days*	n/s	n/s	Morphine 9.8 mg vs 28.4 mg*
Shah ¹⁸	2005	India	40	26 h	5%	87%	30% bothersome symptoms from stent, 60% needed treatment for stent symptoms
Sofer ⁸	2007	Israel	66 vs 60	1 vs 4 days*	3%	92%	Prospective. Intra-operative exclusions. Pethidine 0.4 mg/kg vs 1.2 mg/kg*
Mandhani ¹⁹	2007	India	52	2.52 vs 2.35	n/s	n/s	Only study to compare specifically stent with no stent in 'tubeless' PCNL. No difference found
Karami ¹⁴	2007	Iran	201	3.5 days	10.9%	91%	Largest published series to date. 7.9% UTI. No serious complications
Abou-Elela ²²	2007	Egypt	128	1.7 days	n/s	90.4%	18 of 128 actually 'tubed'. External ureteric catheter. Significant bleed 1.5%, haematuria 4.6%, peri-renal collection 2.3% and extravasation on postoperative retrograde in 12%
Gupta ⁶	2008	India	135 vs 185	1.8 vs 2.9 days*	n/s	n/s	Pethidine 68 mg vs. 210.5 mg*
Agrawal ¹⁷	2008	India	101 vs 101	21.8 h vs 54.2 h*	n/s	n/s	Randomised. Inclusion criteria used. Meperidone 181.7 mg vs. 126.5 mg. Urine leakage from nephrostomy site less in 'tubeless group'; 0/101 vs. 7/101
Singh ⁹	2008	India	30 vs 30		n/s	n/s	Inclusion criteria. Analgesia requirement less ($P < 0.001$)
Crook ¹⁵	2008	UK	100	2.9 days	1%	90%	Only contemporary UK published series. 'Totally tubeless'
Al-Ba'adani ²⁰	2008	Yemen	121	50.69 h	4.13%	86%	6-Fr externalised ureteric catheter (mean 45 h). 9.9% complications (5 perirenal collections, 1 urine leak)
Mouracade ²¹	2008	France	33	1.9 days	0%	n/s	7-Fr ureteric catheter (removed after 1 day in 91%) and electrocautery to tract. 15% complications

* $P < 0.05$.

Tx, blood transfusion; n/s, not significant.

in any patient. Hospitalisation was 0.6 days (patients were discharged with a urethral catheter *in situ*) for the study group and 4.6 days for the controls ($P = 0.0001$). Average morphine sulphate (i.v./i.m) usage was 11.58 mg versus 36.0 mg ($P = 0.0001$). A cost saving of US\$2,112 (129% decrease) per case was noted for the 'tubeless' group.⁴

In 1999, Goh *et al.*⁵ reported on their experience with a small series of 10 'tubeless' PCNLs. Whilst reporting both reduced morbidity and safety/efficacy of 'tubeless' PCNL, they introduced two further concepts. It was practice, when not inserting a nephrostomy tube, to drain the kidney with a ureteric JJ stent and so they termed this type of procedure 'almost totally tubeless' PCNL, which most proponents of 'nephrostomy-free' PCNL still practice. However, a second idea suggested by Goh and colleagues, and one that has gained more recent support, was to drain the kidney temporarily with an externalised ureteric catheter (removed at 48 h), obviating the need for a subsequent procedure to remove the JJ stent.⁵

Since the re-introduction of 'tubeless' PCNL by Bellman *et al.*,⁴ there have been numerous subsequent reports corroborating the evidence that 'tubeless' PCNL, when compared directly to standard 'tubed' PCNL, leads to decreased pain and morbidity, decreased analgesic requirements and decreased length of hospital stay. These studies also demonstrated that 'tubeless' PCNL was not associated with an increased risk of complications, *e.g.* blood transfusion, emergency nephrostomy, significant bleeding needing intervention or worse stone clearance rates (Table 3).^{6–15} Agrawal *et al.*⁷ conducted a randomised comparison of 101 'tubeless' PCNLs (Group B; with JJ stent) with 101 standard PCNLs (Group A; with nephrostomy). All patients had an 'uneventful' postoperative recovery. The average visual pain analogue scale score on postoperative day 1 for Group A was 59 ± 5.1 versus 31 ± 4.8 in Group B ($P < 0.01$). The mean analgesia requirement (Meperidine) for Group A was significantly more than Group B, 126.5 ± 33.3 mg and 81.7 ± 24.5 mg, respectively ($P < 0.01$). Urinary leakage from the nephrostomy site was not seen in any of the 'tubeless' patients compared to seven (7%) of the standard PCNLs. Average hospital stay in Group B was 21.8 ± 3.9 h compared to 54.2 ± 5 h in Group A ($P < 0.01$).⁷ Gupta *et al.*⁶ retrospectively compared 135 'tubeless' PCNLs (with JJ stent) with 185 standard PCNLs. Mean hospital stay was significantly shorter for the 'tubeless' group (1.8 days vs 2.9 days) and the analgesia requirement (68 mg vs 210.5 mg of Pethidine) was also significantly less in the 'tubeless' group. Complications were similar in the two groups.⁶ Sofer *et al.*⁸ prospectively evaluated a consecutive series of 126 patients, specifically assessing if 'tubeless' PCNL could be offered based on intra-operative findings without imposing pre-operative restrictions, *e.g.* stone burden < 3 cm, need for two normally functioning renal units. Based on their protocol,

they performed 66 (52%) 'tubeless' PCNLs and 60 (48%) standard PCNLs. The overall transfusion rate was 3%. The average analgesia requirement (pethidine HCl) was 0.4 mg/kg and 1.2 mg/kg ($P < 0.01$) and the median hospital stay was 1 day and 4 days ($P < 0.0001$).⁸

The vast majority of published reports of 'tubeless' PCNL have imposed some form of inclusion and exclusion criteria, based on both pre-operative and intra-operative findings. This introduces some bias to the outcomes when comparing 'tubeless' to standard PCNL, as 'tubeless' PCNL on the whole has been restricted to specifically selected cases. Some authors have only performed 'tubeless' PCNL on patients who pre-operatively have been demonstrated to have normal serum renal function, two normally functioning renal units (*i.e.* no solitary kidneys), have smaller stone burdens (*e.g.* < 3 cm) and no staghorn calculi. Intra-operatively, reported exclusion criteria for a 'tubeless' PCNL include the need for more than two access tracts, significant bleeding, significant perforation of the pelvicalyceal system, residual stone, the need for a 'second-look' nephroscopy, renal anomalies and obstructive renal anatomy. No study has allocated patients to 'tubeless' PCNL regardless of pre-operative or intra-operative findings, *i.e.* they have not performed 'tubeless' PCNLs on 'all-comers', which would be a more unbiased method of assessing the overall safety and feasibility of 'tubeless' PCNL.

As well as comparative studies of 'tubeless' PCNL with standard PCNL, there have been a number of non-comparative case series reports evaluating 'tubeless' PCNL.^{14–18} Karami *et al.*¹⁴ reported on their 5-year experience of 'tubeless' PCNL in 201 patients, which represents the largest published series to date. Stone clearance rate was 91.04%. The mean hospital stay was 3.5 days (range, 2–5 days). Postoperative ultrasonography did not reveal significant fluid collection. Twenty-two (10.9%) patients needed a blood transfusion and 16 (7.9%) patients had a UTI. They concluded 'tubeless' PCNL was safe, effective and feasible.¹⁴ Crook *et al.*¹⁵ are the only group to have reported on a contemporary series of 'tubeless' PCNLs from a UK centre. They performed 'totally tubeless' PCNL (no JJ stent or nephrostomy) in 100 patients over a 10-year period. Transfusion rate was 1% and the mean fall in haemoglobin was 1.4 g/dl. The minor and major sepsis rates were 5% and 1%, respectively. The mean length of stay was 2.9 days (range, 1–10 days). Stone clearance was 90%. The study concluded PCNL, without nephrostomy or stent, is a safe and well-tolerated procedure in selected cases and should be an accepted standard of care for selected patients.¹⁵

Most of the 'tubeless' studies have reported on what is regarded as 'almost totally tubeless' PCNL, *i.e.* a ureteric JJ stent has been an integral part of the procedure. A disadvantage of this approach is that the stent needs to be removed at a later date which may incur further cost

(depending on method of stent removal), inconvenience and possible morbidity. There have been a few reports of 'totally tubeless' PCNL in the recent literature. As well as the UK series described above, Karami *et al.*¹¹ performed a comparative study of 30 'totally tubeless' PCNLs with standard PCNL controls, though they did have specific inclusion criteria. Both the length of stay (1.5 days vs 3 days) and the average analgesia requirement (30 mg vs 90 mg Pentazosin) were significantly less in the 'totally tubeless' group. The transfusion rate was zero and the complication rate was similarly small (6.6% vs 3.3%).¹¹ Aghamir *et al.*¹⁰ reported on 43 'totally tubeless' PCNLs, comparing them to a cohort of 43 standard PCNL controls. They also employed exclusion criteria but again demonstrated that 'totally tubeless' PCNL leads to decreased length of stay (1.6 days vs 5.2 days; $P < 0.001$) and decreased analgesia requirements (9.8 mg vs 28.4 mg morphine; $P < 0.001$) compared to standard PCNL.¹⁰ Mandhani *et al.*¹⁹ compared the outcome of 52 'tubeless' PCNL with ($n = 25$) and without ($n = 27$) the insertion of a JJ stent. The mean pain score, analgesic requirements and mean hospital stay were comparable in both groups, and the authors concluded that avoiding the use of a JJ stent may not compromise the safety of 'tubeless' PCNL.¹⁹

Some authors have compromised between 'totally tubeless' PCNL and 'almost totally tubeless' PCNL by leaving an externalised ureteric catheter for a temporary period (up to 48 h). This idea was first reported by Goh *et al.*,⁵ in 1999, but more recently several authors have also supported this idea. Al-Ba'adani *et al.*²⁰ presented their experience of 121 patients who underwent 'tubeless' PCNL leaving a 6-Fr ureteric catheter. Blood transfusion rate was 4.13% and mean reduction in Hb was 1.57 g/dl. The complication rate was 9.9%. Five patients developed a perirenal collection and two patients a urinary leak. The ureteric catheter was left for a mean duration of 45.67 h. Mean hospital stay was 50.69 h and postoperative analgesia was required in only 18.2% (mean, 22.9 mg diclofenac sodium per patient).²⁰ Mouracade *et al.*²¹ reported on 33 patients who had a 'tubeless' PCNL for a 'moderate stone burden', with insertion of a 7-Fr ureteric catheter. They also electrocauterised the working tract using a 26-Fr resectoscope with a rollerball electrode. The mean length of hospitalisation was 1.9 days and a mean Hb decrease of 0.8 g/dl. Complications developed in 15% ($n = 5$) of patients, one needing insertion of a JJ stent. The catheters were removed by postoperative day 1 in 91% of patients.²¹ Abou-Elela *et al.*²² performed 128 'tubeless' PCNLs with an external ureteric catheter. They had to convert 18 to 'tubed' PCNLs at the time of surgery. The mean length of stay was 1.7 days and significant (100–250 ml) perirenal collections developed in three (2.3%) patients. The postoperative retrograde study revealed minor extravasation in 14 patients (12%) and significant extravasation in three (2.3%).²²

Our retrospective evaluation of a consecutive series of 101 PCNLs performed at our institution over a 4-year period illustrates that a 'nephrostomy-free' PCNL is a safe procedure that leads to a decreased length of hospital stay (2.8 days vs 5.1 days; $P < 0.001$) decreased pain for the patient and, therefore, a reduced need for morphine-based analgesia. Of the 'nephrostomy-free' group, 23% used no morphine-based analgesia at all, compared to only 2.5% of the standard PCNL group ($P < 0.001$). We changed our technique of PCNL from 'tubed' to 'almost totally tubeless' in October 2006, routinely leaving a JJ stent. However, in specific situations (very straightforward procedure with minimal bleeding) we opted not to leave a stent ($n = 7$; 15%). We employed no inclusion or exclusion criteria to patients needing an 'almost tubeless' PCNL, thus all patients presenting after October 2006 ($n = 46$) underwent a 'nephrostomy-free' PCNL regardless of pre-operative or intra-operative findings. No patient who had a planned 'nephrostomy-free' procedure had to have a nephrostomy inserted at the time of surgery. Only 5% ($n = 2$) of patients in the 'nephrostomy-free' PCNL group had to have their JJ stent removed prematurely (for pain in both patients), demonstrating that the stent is generally tolerated for the full 2-week postoperative period until planned removal. We are aware that JJ stents have an associated morbidity and the need for flexible cystoscopy removal adds further cost, time, inconvenience and potential morbidity. In light of our encouraging results with a 'nephrostomy-free' PCNL and our shared concerns regard the insertion of a stent, we have recently moved towards leaving a ureteric catheter, which we attach to the Foley urethral catheter, with removal of both on the ward on the second postoperative morning. This obviously removes the need for future stent removal. This change to procedure will subsequently be audited to assess the need for a JJ stent. We have also shown that omitting the insertion of a nephrostomy tube does not lead to an increase in operative complications. The transfusion rate was lower in the 'nephrostomy-free' group (2.5% vs 7%; $P < 0.01$) and the mean decrease in Hb level was comparable (1.89 g/dl vs 2.25 g/dl; $P > 0.05$). Immediate complications were equal. Two patients in each group had significant bleeding necessitating the procedure to be abandoned. Early complications (< 28 days) were more common in the 'nephrostomy-free' group (15.9% vs 9%) but they were neither specific to the omission of the nephrostomy nor significant. Late complications were more common in the 'nephrostomy' group where three patients (5.4%) developed chronic loin pain. One patient (2.2%) in the 'nephrostomy-free' group did develop a significant perinephric haematoma that only became evident when the patient presented with a subcutaneous abscess at 35 days postoperatively; this was successfully managed conservatively.

Conclusions

Performing a 'nephrostomy-free' PCNL is a safe and feasible procedure independent of patient and stone factors. The complication rate is comparable to standard PCNL and there is definite benefit in terms of length of hospital stay, pain experienced and morphine-based analgesia requirements. For this reason and based on all the supporting literature described previously, we feel 'nephrostomy-free' PCNL should become the accepted standard of care for patients in the UK needing percutaneous stone surgery.

References

1. Fernstrom I, Johansson B. Percutaneous pyelolithotomy. A new extraction technique. *Scand J Urol Nephrol* 1976; **10**: 257–9.
2. Wickham JE, Miller RA, Kellett MJ, Payne SR. Percutaneous nephrolithotomy: one stage or two? *Br J Urol* 1984; **56**: 582–5.
3. Winfield HN, Weyman P, Clayman RV. Percutaneous nephrostolithotomy: complications of premature nephrostomy tube removal. *J Urol* 1986; **136**: 77–9.
4. Bellman GC, Davidoff R, Candela J, Gerspach J, Kurtz S, Stout L. Tubeless percutaneous renal surgery. *J Urol* 1997; **157**: 1578–82.
5. Goh M, Wolf Jr JS. Almost totally tubeless percutaneous nephrolithotomy: further evolution of the technique. *J Endourol* 1999; **13**: 177–80.
6. Gupta NP, Mishra S, Suryawanshi M, Seth A, Kumar R. Comparison of standard with tubeless percutaneous nephrolithotomy. *J Endourol* 2008; **22**: 1441–6.
7. Agrawal MS, Agrawal M, Gupta A, Bansal S, Yadav A, Goyal J. A randomized comparison of tubeless and standard percutaneous nephrolithotomy. *J Endourol* 2008; **22**: 439–42.
8. Sofer M, Beri A, Friedman A, Aviram G, Majeesh NJ, Chen J *et al.* Extending the application of tubeless percutaneous nephrolithotomy. *Urology* 2007; **70**: 412–6, discussion 416–7.
9. Singh I, Singh A, Mittal G. Tubeless percutaneous nephrolithotomy: is it really less morbid? *J Endourol* 2008; **22**: 427–34.
10. Aghamir SM, Hosseini SR, Gooran S. Totally tubeless percutaneous nephrolithotomy. *J Endourol* 2004; **18**: 647–8.
11. Karami H, Gholamrezaie HR. Totally tubeless percutaneous nephrolithotomy in selected patients. *J Endourol* 2004; **18**: 475–6.
12. Feng MI, Tamaddon K, Mikhail A, Kaptein JS, Bellman GC. Prospective randomized study of various techniques of percutaneous nephrolithotomy. *Urology* 2001; **58**: 345–50.
13. Desai MR, Kukreja RA, Desai MM, Mhaskar SS, Wani KA, Patel SH *et al.* A prospective randomized comparison of type of nephrostomy drainage following percutaneous nephrostolithotomy: large bore versus small bore versus tubeless. *J Urol* 2004; **172**: 565–7.
14. Karami H, Jabbari M, Arbab AH. Tubeless percutaneous nephrolithotomy: 5 years of experience in 201 patients. *J Endourol* 2007; **21**: 1411–3.
15. Crook TJ, Lockyer CR, Keoghane SR, Walmsley BH. Totally tubeless percutaneous nephrolithotomy. *J Endourol* 2008; **22**: 267–71.
16. Delnay KM, Wake RW. Safety and efficacy of tubeless percutaneous nephrostolithotomy. *World J Urol* 1998; **16**: 375–7.
17. Limb J, Bellman GC. Tubeless percutaneous renal surgery: review of first 112 patients. *Urology* 2002; **59**: 527–31, discussion 531.
18. Shah HN, Mahajan AP, Hegde SS, Bansal M. Tubeless percutaneous nephrolithotomy in patients with previous ipsilateral open renal surgery: a feasibility study with review of literature. *J Endourol* 2008; **22**: 19–24.
19. Mandhani A, Goyal R, Vijjan V, Dubey D, Kapoor R. Tubeless percutaneous nephrolithotomy – should a stent be an integral part? *J Urol* 2007; **178**: 921–4.
20. Al-Ba'adani TH, Al-Kohlany KM, Al-Adimi A, Al-Towaity M, Al-Baadani T, Alwan M *et al.* Tubeless percutaneous nephrolithotomy: the new gold standard. *Int Urol Nephrol* 2008; **40**: 603–8.
21. Mouracade P, Spie R, Lang H, Jacqmin D, Saussine C. Tubeless percutaneous nephrolithotomy: what about replacing the double-J stent with a ureteral catheter? *J Endourol* 2008; **22**: 273–5.
22. Abou-Elela A, Emran A, Mohsen MA, Reyad I, Bedair AS, Kader MA. Safety and efficacy of tubeless percutaneous renal surgery. *J Endourol* 2007; **21**: 977–84.
23. Yang RM, Bellman GC. Tubeless percutaneous renal surgery in obese patients. *Urology* 2004; **63**: 1036–40, discussion 1040–1.
24. Lojanapiwat B, Soonthornphan S, Wudhikarn S. Tubeless percutaneous nephrolithotomy in selected patients. *J Endourol* 2001; **15**: 711–3.