

Tubeless Percutaneous Nephrolithotomy: First 200 Cases in Israel

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ABSTRACT: **Background:** Tubeless percutaneous nephrolithotomy is defined as PCNL without postoperative nephrostomy tubes. It is reported to reduce postoperative pain, hospital stay and recovery time. To date the procedure has been reserved for selected patients.

Objectives: To assess our initial experience in extending the implementation of tubeless PCNL without preoperative patient selection.

Methods: All consecutive PCNLs performed during 2004–2008 were evaluated. Tubeless PCNL was performed when residual stones, bleeding and extravasation were excluded intraoperatively. Staghorn stones, stone burden, supracostal and multiple accesses, anatomic anomalies, solitary kidneys and operative time were not considered contraindications. We analyzed the clinical data and the choice of tubeless PCNL over time.

Results: Of 281 PCNLs performed during the study period 200 (71%) were tubeless. The patients' average age was 53 years (range 28–82 years), the stone burden was 924 mm² (400–3150 mm²), operative time was 99 minutes (45–210 min), complication rate was 14% and immediate stone-free rate 91%. There were 81 conversions to standard PCNL (29%) due to expected second-look (n=47, 58%), impression of bleeding (n=21, 26%), suspected hydrothorax (n=7, 9%) and extravasation (n=6, 7%). The transfusion rate was 1%. The median hospital stay was 1 day (1–15 days) and recovery time 7 days (5–20 days). The rate of implementing the tubeless procedure increased steadily along time from 46% to 83% ($P = 0.0001$).

Conclusions: Tubeless PCNL can be safely and effectively performed based on intraoperative decisions, without preoperative contraindications. They are easily accommodated by experienced endourologists and provide real advantages.

KEY WORDS: calculi, kidney, percutaneous nephrolithotomy, nephrostomy, stent

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Percutaneous nephrolithotomy completely changed the approach to large and complex renal calculi. First introduced in the early 1980s, PCNL decreased morbidity and minimized invasiveness, progressively replacing the open surgical approach [1-3]. The standard PCNL procedure consists of a tiny percutaneous access to the kidney and the formation of a working tract connecting the flank surface with the intrarenal collecting system to allow endoscopic stone disintegration and removal. A temporary nephrostomy tube is usually left in place at the end of the procedure to allow drainage, tamponade of bleeding, and delayed second-look nephroscopy. This tube and the persistent urinary leakage after its removal, however, significantly inconveniences both patient and medical personnel, in addition to increasing analgetic requirements and prolonging hospitalization and recovery time [4-6]. To obviate these problems, a tubeless approach was devised in 1997 and was reportedly successful in selected groups of patients [6-9]. The tubeless PCNL involves internalization of the postoperative renal drainage by placement of an internal stent and bladder catheter instead of the traditional nephrostomy tube [4]. We present here our experience with the tubeless PCNL technique in Israel. We extended its applicability by not adhering to the exclusion criteria noted in the literature, i.e., we did not select patients preoperatively.

PATIENTS AND METHODS

The study cohort consisted of all consecutive patients who underwent PCNL between January 2004 and December 2008 in our department. All patients were considered eligible for tubeless PCNL without preoperative selection. No institutional review board approval was needed because the study was not randomized, all the performed procedures represented well-established and commonly practiced operations, and there were no experimental elements. Prophylactic perioperative wide-spectrum antibiotics were administered in cases with sterile urine, while patients with bacteriuria were treated according to the antibiogram.

The renal access was performed in the operating room by the endourological team, with the patient under general anesthesia (detailed in [10]). Briefly, our approach consisted of prone positioning, fluoroscopic guidance, flexible cystos-

PCNL = percutaneous nephrolithotomy

copy and insertion of a ureteral catheter, retrograde pyelography, renal puncture, tract dilation up to 20-30 Fr and stone ultrasonic and pneumatic fragmentation using rigid 18-26 Fr nephroscopes. Holmium laser and tipless nitinol baskets were inserted through flexible nephroscopes for locations unreachable by rigid instruments. When necessary, ancillary accesses were obtained, following a similar technique to the one described above. At the end of the procedure, a 7 Fr internal double J stent was placed antegradely. Contrast nephrography, flexible nephroscopy, backward endoscopic surveillance of the working tract and hemodynamic assessment served to rule out perforation, residual stones and active bleeding. The nephrostomy tube was removed and the wound was either tied or sealed with Dermabond® (2-octyl cyanoacrylate, Ethicon, USA) [11]. The patients who were intraoperatively suspected of having residual stones, significant bleeding and/or extravasation were converted to standard PCNL procedures by the placement of a 16 Fr Foley catheter as the nephrostomy tube. The stone-free status was evaluated by unenhanced computed tomography on the morning after the procedure. Patients with residual fragments were referred for ancillary procedures (e.g., shockwave lithotripsy, ureteroscopy, etc.). Clinical data and outcome were analyzed as was the rate of tubeless PCNL procedures performed over time by our endourological team.

RESULTS

A total of 273 patients underwent 281 PCNLs during the study period. Adhering to the study protocol, we performed 200 (71%) tubeless PCNLs on 192 patients whose average age was 53 years (range 28–82). Their average body mass index was 29 kg/m² (range 21–46), stone burden 924 mm² (range 400–3150), male/female ratio 1.3 and right/left ratio 0.8. Fifty-seven patients (29%) were treated for staghorn stones. The following anatomic anomalies and particularities were encountered: 22 previously operated kidneys (11%), 6 calyceal diverticula (3%), 5 solitary kidneys (3%), 3 duplex systems (2%) and 2 horseshoe kidneys (1%). Bilateral same-session tubeless PCNLs were performed in 8 patients (4%). A supracostal approach was used in 60 cases (30%) and multiple accesses in 14 (7%). The median operative time was 99 minutes (range 45–210 min). The postoperative average changes in the creatinine and hemoglobin levels were not significant. The median analgetic requirement per patient was 0.4 mg/kg Dolestine® (pethidine HCL, Teva, Hungary).

The immediate stone-free rate was 91%. Residual stones with an average burden of 52 mm² (range 20–100 mm²) were identified in 18 renal units: 4 of them were referred for shockwave lithotripsy, 6 for retrograde intrarenal surgery that was performed at the time of internal stent removal, and 8 were followed expectantly.

The complication rate was 14%. Two patients (1%) displayed a postoperative decrease in hemoglobin concentration that

Table 1. The rate of tubeless percutaneous nephrolithotomy procedures over time

Year	Rate of tubeless PCNL	P value relative to the first year of the current study	P value relative to the preceding year
2004	43% (32/75)*	–	–
2005	73% (32/44)	0.007	0.007
2006	83% (44/53)	0.0001	0.3
2007	77% (33/43)	0.002	0.8
2008	83% (59/71)	0.0001	0.5

*The denominator represents the total number of PCNLs per year

required blood transfusion: this occurred after the initiation of full anticoagulant therapy to treat postoperative pulmonary emboli in one of them and due to delayed bleeding from an arteriovenous malformation in the other. Tubeless PCNL complications also included urinary tract infection (n=9, 6 immediate and 3 late), hydrothorax (n=2), pleural empyema (n=2), pulmonary emboli (n=1), and arteriovenous malformation necessitating embolization (n=2). The median hospitalization was 1 day (range 1–15) and recovery time 7 days (range 5–20). The average follow-up was 24 months (1–60 days).

Assessment of the rate of tubeless PCNLs among all the PCNLs performed by us over time revealed a steady increase from 46% in the first year to 83% in the last year of the study ($P < 0.001$) [Table 1].

There were 81 (29%) conversions from tubeless to standard PCNLs. These conversions were decided upon following an intraoperative impression that a second-look PCNL to clear residual stones was to be expected in 47 (58%) patients, the impression of active bleeding in 21 (26%), suspected hydrothorax in 7 (9%) and significant extravasation in 6 (7%).

DISCUSSION

Since the introduction of PCNL about 30 years ago, efforts have been made to improve the technique in order to decrease trauma to the kidney and the percutaneous tract, and reduce postoperative morbidity, hospital stay and costs. One of the clinically tested modifications is the mini-perc approach that was first reported in pediatric patients [12,13]. This version of PCNL uses 13-20 Fr working sheaths and was soon adapted for adults, resulting in reduced operative time, less postoperative morbidity and shorter hospital stay. It did not, however, obviate the need for the placement of nephrostomy tubes that – although providing drainage, tract tamponade and maintenance of access for second look – are associated with postoperative pain. Pietrow et al. [14] used a narrower tube (10 Fr instead 22 Fr) and noted greater comfort in the immediate postoperative period without sacrificing safety. Giusti and colleagues [15] recently re-addressed the topic of mini-perc and nephrostomy tube diameter size in a series of 134 patients who were treated by either mini-perc (n=40), regular (n=67), or tubeless PCNL (n=27). The results of

their study failed to demonstrate significant advantages for the mini-perc approach: rather, the postoperative pain was related to the presence of a nephrostomy and not to its size [15]. Another major inconvenience related to nephrostomy tubes is urinary leakage, sometimes persisting for more than 24 hours after tube removal. Our experience showed that this can be avoided by immediate wound sealing using tissue adhesives once post-renal obstruction has been excluded [11].

The concept of a tubeless technique represents a novel alternative in the search to miniaturize the procedure [4]. Bellman et al. [5] reported their initial experience with a series of 50 patients who underwent various percutaneous procedures: 30 were left with a nephrostomy tube for 2–3 hours and 20 were not given any flank drainage. Comparing this series with a matched group of 50 standard PCNLs, the authors reported significant reduction in hospitalization, recovery time, analgetic requirements and treatment-related cost. Five years later, Limb and Bellman [4] completed 112 successful tubeless procedures, representing almost one-third of all their percutaneous procedures. Prospective randomized studies designed to compare tubeless vs. mini vs. standard PCNL confirmed the superiority of the tubeless PCNL in terms of reduced postoperative patient discomfort, shorter hospitalization and speedier recovery [8,9]. Recognition of these advantages encouraged the endourological community to continue searching for further extension of the technique. Reporting the findings of their study in 43 patients, Aghamir et al. [16] concluded that totally tubeless PCNL is feasible and more advantageous in comparison to standard PCNL, while Shah et al. [17] successfully performed bilateral simultaneous tubeless PCNL in a series of 10 patients. To the best of our knowledge, however, all tubeless PCNL studies reported to date were performed in selected cases. The selection criteria varied from study to study, and included normal anatomic and functional kidneys, not previously operated kidneys, a stone burden smaller than 3 cm, operative time shorter than 2 hours, a subcostal approach, and not more than two accesses [4-9,16,17]. In a previous report [10] we investigated whether there is any correlation between pre- and intraoperative factors and conversion from tubeless PCNL to standard PCNL. We compared 66 patients (52%) who underwent tubeless PCNL with 60 (48%) who received standard PCNL. Neither the preoperatively assessed factors (age, body mass index, gender, stone burden and complexity, anatomic anomalies, previously operated kidneys), nor the intraoperative variables (supracostal and multiple accesses, type of tract dilation, operative time) correlated with conversion to standard PCNL ($P > 0.05$). The overall complication rate was 9% in the tubeless group and 13% in the standard group ($P > 0.05$).

Our current study represents an additional step towards extending the applicability of tubeless PCNL. All our patients were scheduled for tubeless PCNL without preoperative selection. This meant including solitary, anomalous and previously operated kidneys; multiple and supracostal accesses; complex

and large stones; and lengthy operations. Overall, 71% of our patients could still be successfully treated by the tubeless approach. Furthermore, our ability to apply this approach improved steadily with time, reaching a rate of more than 80% of all procedures carried out in the last 3 years. Our success rate of tubeless operations improved significantly after we had carried out 32 procedures, possibly reflecting a learning curve. In a study designed to assess the learning curve for standard PCNL in terms of operating and fluoroscopic time, Tanriverdi and co-workers [18] found that a non-experienced urologist achieves surgical competence after performing 60 operations. It follows, therefore, that the learning curve for an experienced endourologic team to accommodate the tubeless procedure is significantly shorter.

Residual stones and significant bleeding remain the two main concerns that could preclude a tubeless PCNL approach. Our 91% stone-free rate, as demonstrated on immediate postoperative CT scanning, appears to indicate an accurate intraoperative assessment of residual stones. However, in 47 of our patients who were converted to standard PCNLs, we left a nephrostomy tube in place, expecting that a second-look procedure would be needed. This expectation was determined by either suboptimal endoscopic surveillance of the entire collecting system with the flexible nephroscope (e.g., clots, bleeding, inaccessible calyces) or the radiolucent characteristics of the stone that limited its detection by intraoperative fluoroscopy.

According to Portis et al. [19], performing PCNLs in the interventional radiology suite using combined flexible nephroscopy and high magnification rotational fluoroscopy improves intraoperative detection of residual stones. They compared that method to postoperative CT scans and reported sensitivity, specificity, negative predictive value and accuracy rates of 100%, 95%, 100% and 96%, respectively, for detecting fragments > 4 mm. This approach could contribute to increased tubeless PCNL applicability and better stone-free rates, but it necessitates accessibility to an advanced interventional fluoroscopic machine, and that currently means a very limited number of facilities.

The other main intraoperative problem – the evaluation of bleeding severity – is based on clinical assessment of the patient's hemodynamic status and the surgeon's experience. In the present study we did not encounter hemodynamic instability, although one-quarter of the cases that were switched to the standard PCNL were due to the surgeon's impression of active bleeding. We recognize that our increasing familiarity with the presence of bloody discharge after removing the working sheath and its resulting lack of clinical significance taught us that we could avoid the placement of nephrostomy tubes in most cases. Transfusion (at a rate of 1%) was only indicated after full anticoagulant therapy had been given: this raises the question whether the nephrostomy tube had contributed to stopping the bleeding or whether the surgeon had overestimated the extent of bleeding, which ceased spontaneously in most cases. Similar clinical observations have lately led to the search for solutions to

actively stop the bleeding and avoid the placement of a nephrostomy tube in patients who had been rendered stone-free. Sealant hemostatic materials, such as fibrin glue and gelatin matrix, have been shown to efficiently and safely control the bleeding [20,21], but we did not use them due to cost restraints. Endoscopic electrofulguration was also shown to adequately stop bleeding points along the tract [22], and could contribute to further expanding the number of cases suitable for a tubeless PCNL.

Another consideration to be addressed is whether the use of internal stents might adversely affect patients' quality of life and involve increased costs related to the stents' delayed cystoscopic removal. It is well known that stents are associated with significant side effects. In a prospective series of 135 stented patients, Leibovici and collaborators [23] showed that quality of life was affected in 45% of them due to flank pain, symptoms in the lower urinary tract, anxiety and sleep disturbance. However, these findings were reported after an average dwelling time of 62 days. In our study, the stent was placed for only 5 days on average, a factor that significantly decreased the rate and severity of stent-related side effects. Notably, it has been clearly shown that postoperative nephrostomy tubes are associated with significantly more intense postoperative pain than internal stents in patients after PCNL [8-10].

Finally, it was not our aim in the current study to assess costs related to the need for cystoscopic removal of the stent. Our previous experience demonstrated that the median hospitalization was 1 day for the tubeless PCNL and 4 days for the standard PCNL ($P < 0.0001$), and that the median back-to-work time was 7 and 15 days respectively ($P < 0.001$) [10]. These improvements in hospital stay and recovery time with the tubeless PCNL most probably resulted in significantly more cost savings than the cost of the additional cystoscopy needed for postoperative stent removal. Bellman et al. [5], who explored this issue, reported significantly lower treatment-related costs in tubeless procedures compared to standard ones.

CONCLUSIONS

Our findings demonstrated that tubeless PCNLs can be safely and effectively performed by an experienced endourologic team without limiting the number of eligible candidates by preoperative patient selection. However, for operations in which there is intraoperative uncertainty regarding residual stones, as well as those in which significant bleeding or perforation occurs and/or other major complications are suspected (e.g., hydrothorax, injury to adjacent organs), PCNL should be carried out in the standard fashion, leaving a nephrostomy tube in place. We believe that this study will contribute to the further popularization of the tubeless technique for the benefit of the patient, the medical team, and the health care system.

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