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Immediate versus delayed shockwave lithotripsy for inaccessible stones after uncomplicated percutaneous nephrolithotomy



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KEYWORDS

Immediate;
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SWL;
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ABBREVIATIONS

BMI, body mass index;
CONSORT, Consoli-
dated Standards of
Reporting Trials;
HU, Hounsfield unit;
KUB, plain abdominal
radiograph of the kid-

Abstract Objective: To evaluate the efficacy and safety of immediate versus delayed shockwave lithotripsy (SWL) for inaccessible stones after uncomplicated percutaneous nephrolithotomy (PCNL).

Patients and methods: Between December 2011 and June 2014, patients with residual inaccessible stones after uncomplicated PCNL were prospectively randomised into two treatment groups; Group I, immediate SWL and Group II, delayed SWL at 1 week after PCNL. Patients with residual stones of ≥ 1.5 cm, a stone density of > 1000 Hounsfield units and body mass index of > 40 kg/m² were excluded from the study. The following data were reported: patients' demographics, stone characteristics after PCNL, hospital stay, perioperative complications, stent duration, and stone-free rate (SFR).

Results: In all, 84 patients (51 males and 33 females) with mean (SD) age of 39 (8.5) years were included in the study. Group I included 44 patients, whilst Group II included 40 patients. There was no statistically significant difference amongst the groups for patients' demographics, stone characteristics, and perioperative complications. The hospital stay was significantly shorter in Group I, at a mean

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neys, ureters and bladder;
 PCNL, percutaneous nephrolithotomy;
 SFR, stone-free rate;
 SWL, shockwave lithotripsy;
 US, ultrasonography

(SD) of 34 (3.7) vs 45 (2.9) h ($P < 0.001$). The duration of ureteric stenting was significantly lower in Group I as compared to Group II, at a mean (SD) of 12 (4.2) vs 25 (3.5) days ($P < 0.001$). The SFR was 93.2% and 95% in Groups I and II, respectively ($P = 0.9$).

Conclusions: Immediate SWL after PCNL is as effective and safe as delayed SWL with a lesser hospital stay and duration of ureteric stenting.

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Introduction

The goal of stone treatment is to use the least morbid, minimally invasive and effective method of stone clearance [1]. Percutaneous nephrolithotomy (PCNL) is considered the ‘gold standard’ minimally invasive procedure for the treatment of large and complex renal stones [2,3].

The stone-free rate (SFR) of PCNL monotherapy ranges from 76% to 84% and residual stones may be due to the migration of fragments into an inaccessible calyx [4,5]. A certain proportion of patients that undergo PCNL treatment will require some other ancillary therapeutic strategies to improve the SFR [6].

Clinically insignificant residual stone fragments are defined as residual calculi < 0.4 cm, meanwhile the patient is asymptomatic and the stone composition is not struvite or an infection stone [7]. Residual calculi are almost inevitable postoperatively and may lead to recurrent urolithiasis or protracted UTIs.

Significant residual stones after PCNL are a challenging issue. The development of flexible nephroscopy was an important step in dealing with this issue with subsequent increases in SFRs; however, significant bleeding or difficult pelvicalyceal anatomy, such as adjacent parallel calyx containing a stone, may limit its effect [8]. For those stones that cannot be readily reached with a flexible nephroscope, a second track can be made but with caution because of the increased risk of bleeding [9].

As compared to invasive procedures, the non-invasive nature and easy retreatment with shockwave lithotripsy (SWL) have resulted in it becoming a well-recognised auxiliary treatment for residual calculi with a small stone burden [10,11]. SWL is recommended as the first-line treatment option by the European Association of Urology (EAU) and AUA for renal calculi of < 2.0 cm [12], and it is commonly used to treat residual calculi after PCNL [11].

The aim of the present study was to evaluate the safety and efficacy of immediate vs delayed SWL for inaccessible stones after uncomplicated PCNL.

Patients and methods

Between December 2011 and June 2014, patients with residual inaccessible radio-opaque stones of > 0.7 and ≤ 1.5 cm after uncomplicated PCNL (i.e. PCNL without significant bleeding or pelvicalyceal system perforation and patient haemodynamically stable for 2 h postoperatively) were prospectively randomised (using the closed envelope technique) into two treatment groups; Group I, immediate SWL and Group II, delayed SWL at 1 week after PCNL.

Approvals were obtained from our institutional ethics committee and informed written consents were taken from all patients. Patients aged < 18 years, body mass index (BMI) > 40 kg/m², stone density of > 1000 Hounsfield units (HU), multiple residual stones, and serum creatinine level of ≥ 2 mg/dL were excluded.

As there were no previous similar studies, we conducted a pilot study including 10 patients prior to this study. Those 10 patients were submitted to immediate SWL for residual stones after PCNL. The hypothesis of the pilot study was that immediate SWL after PCNL would not result in additional morbidity for the patients. Using a study power of 80% and 95% CI, the overall complication rate detected in the pilot study was five of the 10 patients, all of which were grade I according to the modified Clavien–Dindo grading system. By reviewing our database, the overall complication rate for delayed SWL for residual stones after PCNL with similar inclusion and exclusion criteria was 19%. Using the OpenEpi, Version 2, open source calculator, the sample size was estimated to be 84. Making an allowance of 5% for possible discontinuations the total sample size was 88 patients who were randomly divided into both groups (44 each). The Consolidated Standards of Reporting Trials (CONSORT) flow diagram of the study is shown in Fig. 1.

The following data were reported: preoperative investigations including complete laboratory investigations, plain abdominal radiograph of the kidneys, ureters and bladder (KUB), pelvi-abdominal ultrasonography (US) and non-contrast CT of the urinary tract, patients’ demographics, stone characteristics after PCNL,

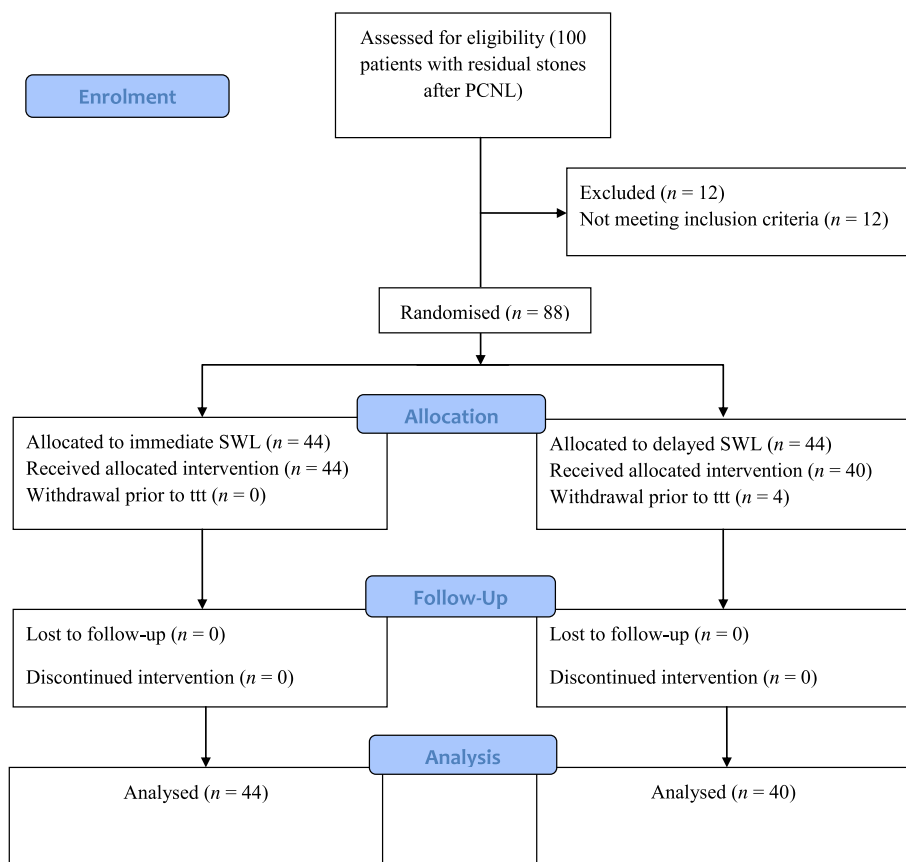


Figure 1 CONSORT flow diagram of the study. ttt, time to treat.

hospital stay, perioperative complications, stent duration, and SFR. In Group II the time of SWL session was added to the hospital stay.

Technique

In all patients, 1 g third-generation cephalosporin was administered i.v. 1 h preoperatively. PCNL was performed under spinal anaesthesia and fluoroscopic control.

PCNL was done in the flank-free modified supine position [13]. The skin was punctured at the posterior axillary line. Renal access was achieved under fluoroscopic guidance. Alken's dilators were used sequentially allowing the introduction of a 30-F Amplatz sheath through which a 26-F nephroscope was used. Stone disintegration was accomplished using a pneumatic intracorporeal lithotripter. A nephrostomy catheter was inserted at the end of the procedure. The ureteric catheter was replaced by a JJ stent. For inaccessible stones of >0.7 and ≤ 1.5 cm immediate SWL was performed in Group I, whilst delayed SWL (1 week after PCNL) was carried out in Group II.

All patients were treated by SWL using the electromagnetic Dornier Lithotripter S (Dornier MedTech GmbH, Germany). For Group I, SWL was performed

2 h after PCNL, whilst for Group II, SWL was done 1 week later. For SWL, patients in both groups received i.v. analgesia in the form of 1 mg/kg meperidine hydrochloride and/or 1.5 μ g fentanyl.

Fluoroscopy was used for stone localisation. SWL treatment was done with a priming dose of low amplitude SWs, a 3–4 min pause following the priming dose and slowing the SW rate (60 SWs/min). The SW number per SWL procedure was limited to a maximum of 3200 SWs. When the maximum number of SWs was reached or when minute stone remnants or no residual fragments were visible the session was finished.

At the end of each session and on discharge, patients were instructed to drink liberal fluids. Oral analgesia was also prescribed to be taken if needed. They were also instructed to check for expected haematuria, passage of fragments, fever, and severe colic.

Complete blood counts were done for all patients in both groups 2 h after PCNL. On the first postoperative day pelvi-abdominal US was carried out in all patients and the nephrostomy tube was removed. Perioperative complications were classified according to the modified Clavien–Dindo grading system [14].

For Group II, pelvi-abdominal US was done after the SWL session then weekly for 3 weeks for both groups. At each visit the patient was reviewed for any

complications and KUB was done and accordingly the stent was removed once the patient became stone free (no identifiable stone fragments or residual stones of <0.4 cm). The overall SFR was calculated at 3 weeks after the SWL session for each group.

Statistical analysis

We used Statistical Package for the Social Sciences (SPSS®) 17.0 for Windows software (SPSS, Inc., Chicago, IL, USA). The numerical data are presented as the mean and standard deviation (SD). Categorical data are summarised as percentages. The Student's *t*-test was used for continuous variables and the chi-square and Fisher's exact tests were used for categorical variables. A $P < 0.05$ was considered to indicate statistical significance.

Endpoints

The primary endpoint was to evaluate additional morbidity after immediate SWL for residual stones after uncomplicated PCNL compared to delayed SWL, and the secondary endpoint was the SFR.

Results

There was no statistical difference between the two groups for the patients' demographics (Table 1) and both groups had similar residual stone characteristics (Table 2).

SWL parameters and data for both groups are presented in Table 3. There was no statistically significant

Table 1 Patients' demographic data.

Variable	Group I	Group II	<i>P</i>
No. of patients	44	40	
Age, years, mean (SD)	39.9 (9.6)	38.5 (7.8)	0.47
Gender, <i>n</i> (%)			0.91
Male	26 (59)	25 (62.5)	
Female	18 (41)	15 (37.5)	
BMI, kg/m ² , mean (SD)	30.53 (5.4)	29.46 (4.6)	0.33

Table 2 Residual stone characteristics.

Variable	Group I	Group II	<i>P</i>
Residual stone size after PCNL, cm, mean (SD)	1.1 (0.08)	1.2 (0.1)	0.44
Stone side, <i>n</i> (%)			
Right	20 (45.5)	21 (52.5)	0.67
Left	24 (54.5)	19 (47.5)	
Stone density, HU, mean (SD)	782.6 (206.2)	765.4 (211.3)	0.7

Table 3 SWL parameters for both groups.

	Group I	Group II	<i>P</i>
Anaesthesia	Sedation	Sedation	–
Localisation	Fluoroscopy	Fluoroscopy	–
Mean (SD)			
Rate, SWs/min	77 (4)	76 (5)	0.3
Energy, kV	18.4 (1.1)	18.6 (0.9)	0.4
Number of SWs	2450 (256)	2508 (232)	0.3

Table 4 Complications classified using the Clavien–Dindo grading system.

Complication	Group I, <i>n</i> (%)	Group II, <i>n</i> (%)	<i>P</i>
Clavien–Dindo grade			
Grade I	8 (18.2)	7 (17.5)	0.84
Haematuria	5 (11.4)	4 (10)	
Fever ≤38 °C	5 (11.4)	5 (12.5)	
Grade II (subcapsular haematoma)	1 (2.3)	0	
Grade IIIa (urinoma)	1 (2.3)	1 (2.5)	0.5
Grade IIIb	0	0	
Grade IV	0	0	
Grade V	0	0	

difference in the mean (SD) drop in haemoglobin level between the groups, at 1.8 (0.4) vs 1.7 (0.1) g/dL for Groups I and II, respectively ($P = 0.12$). The mean (SD) hospital stay was significantly lower in Group I, at 34 (3.7) vs 45 (2.9) h ($P < 0.001$). The duration of ureteric stenting was significantly lower in Group I as compared to Group II, at a mean (SD) of 12 (4.2) vs 25 (3.5) days ($P < 0.001$). The SFR was 93.2% and 95% in Groups I and II, respectively ($P = 0.9$). Complications that occurred in both groups are shown in Table 4.

Discussion

Whilst PCNL is highly effective in treating large stone burdens, occasionally residual fragments are left and a secondary procedure is needed [15]. SWL is a non-invasive outpatient anaesthesia-free procedure and has the merits of rapid recovery, low morbidity, satisfactory results, feasible retreatment, and limited contraindications [16].

To our knowledge, no previously published study has compared the efficacy and safety of immediate vs delayed SWL for inaccessible stones after uncomplicated PCNL.

In the present study, no serious complications, including perirenal haematoma, massive haematuria or sepsis, were encountered either after PCNL or after SWL.

The overall rate of complications after SWL in both groups, including renal colic, gross haematuria, subfebrile body temperature, and Steinstrasse, was similar to previous reports [17,18].

Renal colic associated with spontaneous stone fragments passage was successfully managed with over-hydration, antispasmodics, and oral analgesics. In our present study, gross haematuria was detected in five (11.4%) and four patients (10%) in Groups I and II, respectively ($P = 0.84$), all cases resolved spontaneously without blood transfusion. In Group II, gross haematuria occurred due to the direct effect of SWs on the renal tissue, whilst in Group I gross haematuria occurred due to the direct effect of SWs on the renal tissue in addition to renal parenchymal injury during PCNL.

A subfebrile body temperature developed in five patients (11.4%) in Group I and five patients (12.5%) in Group II ($P = 0.84$). No sepsis was detected in our present study. In their study, Salem et al. [18] reported that Steinstrasse occurred in 24.2% of patients who underwent SWL and that the development of Steinstrasse was significantly correlated to stone size ($P < 0.01$). In our present study, no Steinstrasse occurred, which can be explained by the relatively small size of the residual calculi after PCNL, in addition to ureteric stenting in all patients.

Shen et al. [19] performed a systematic review with a meta-analysis to assess the necessity of stenting before SWL in the management of upper urinary stones. Their results showed significant benefits of stenting before SWL in terms of Steinstrasse.

Subcapsular haematoma occurred in one patient (2.3%) in Group I and was managed conservatively. Urinoma occurred in one patient in each group and resolved within 3 days using conservative measures. The mean (SD) hospital stay was significantly shorter in Group I, at 34 (3.7) vs 45 (2.9) h ($P < 0.001$). Also, the mean (SD) duration of ureteric stenting was significantly shorter in Group I as compared to Group II, at 12 (4.2) vs 25 (3.5) days ($P < 0.001$). The SFR was 93.2% and 95% in Groups I and II, respectively ($P = 0.9$).

The present study has some limitations. This research is not a multicentre study, the sample size is relatively small, and the cost-effectiveness is not evaluated. We recommend further comparative studies with flexible nephroscopy and/or a second track regarding the outcomes and cost-effectiveness.

Conclusions

Immediate SWL after uncomplicated PCNL is as effective and safe an auxiliary procedure as delayed SWL for residual calculi with a lesser hospital stay and duration of ureteric stenting.

Source of funding

None.

Conflicts of interest

None.

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