Second-look Flexible Nephroscopy Combined With Holmium: Yttrium-Aluminum-Garnet Laser Lithotripsy Under Local Anesthesia: A Prospective Study

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OBJECTIVE To present a prospectively studied series of patients who underwent second-look flexible nephroscopy combined with holmium:yttrium-aluminum-garnet (Ho:YAG) laser lithotripsy under local anesthesia for residual stone removal after percutaneous nephrolithotomy (PCNL).

MATERIALS AND METHODS Thirty consecutive eligible patients who underwent a PCNL procedure in the previous 48-96 hours were included. The inclusion criteria were the following: (1) 1 or 2 residual stones 0.8-1.5 cm in diameter and (2) age >18 years. Approximately 15 mL of a 2% solution of lidocaine hydrochloride was injected through the nephrostomy tube, which was then clamped for 15 minutes. Flexible nephroscopy was combined with Ho:YAG laser lithotripsy set at 0.8 Joules and 8 Hz. Patients were asked to rate their pain intensity using the numeric rating scale (NRS).

RESULTS There were 14 (46.7%) men and 16 (53.3%) women in the study, with a mean age of 45.2 ± 17.5 years. Twenty-one (70%) patients had 1 stone and 9 (30%) had 2 stones needing fragmentation. Twenty-eight (93.3%) patients successfully underwent the procedure under local anesthesia. The mean NRS value was 1.39 ± 1.08 (range 0-5). For the entire group, there was a statistically significant difference between those patients with 1 stone vs 2 stones needing fragmentation (NRS scores of 1.1 ± 0.77 vs 2.1 ± 1.36, respectively, $P = .033$). Operative time >30 minutes was associated with higher NRS score. The stone-free rate under local anesthesia was 86.7%.

CONCLUSION For patients with a minimal to moderate residual stone burden after PCNL, second-look flexible nephroscopy can be combined with Ho:YAG laser lithotripsy using only local anesthesia. UROLOGY ■■: ■■–■■, 2016. © 2016 Elsevier Inc.

Percutaneous nephrolithotomy (PCNL) is the recommended treatment option for large or complex renal calculi.[1,2] Stone-free rates have been reported to range from 40% to 90% depending on stone size, configuration and composition, and on the surgeon's experience.[3] Treatment options for residual fragments after PCNL include shockwave lithotripsy (SWL),[4] retrograde intrarenal surgery (RIRS),[5] and second-look PCNL.[6] Typically, second-look PCNL is performed in the operating room under general anesthesia through the initial access tract. Alternatively, it can be performed in an outpatient setting with or without sedation using a flexible nephroscope.[6] For several years, we have been performing second-look procedures in the endoscopy suite using a flexible nephroscope under local anesthesia. In some of these procedures, when larger stones were still present, nephroscopy was combined with holmium:yttrium-aluminum-garnet (Ho:YAG) laser lithotripsy without any additional anesthesia. We have used this approach to avoid a formal second-look procedure performed in the operating room under general anesthesia. Herein, we present our findings from a series of patients who underwent second-look flexible nephroscopy combined with Ho:YAG laser lithotripsy for the removal of residual stones under local anesthesia. Although we assume that endourologists around the world might occasionally apply a similar approach, to the best of our knowledge, there are no reports in the literature presenting the criteria for the use of this intervention, its technical details, data on patient tolerability for the procedure, or its stone-free rates.

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MATERIALS AND METHODS

Between March 2005 and September 2015, a total of 962 patients underwent PCNL in prone position at our department. Among these, 30 consecutive eligible patients were selected to undergo second-look flexible nephroscopy combined with Ho:YAG laser lithotripsy under local anesthesia. The study was approved by the institutional review board. Typically, all patients had undergone a formal PCNL procedure 48-96 hours prior to the second-look procedure, in the operating room and under general anesthesia. The decision to not proceed with a formal second-look procedure under general anesthesia in the operating room was mainly based on the diameter and the number of residual stones. We set the following inclusion criteria: (1) 1 or 2 residual stones 0.8-1.5 cm in diameter and (2) age >18 years. Patients with at least 1 stone > 1.5 cm or more than 2 stones ≥ 0.8 cm were treated with a formal procedure under general anesthesia. Patients with multiple, residual fragments < 0.8 cm and/or multiple tracts were included if they had at least 1 stone needing lithotripsy and fulfilled the above inclusion criteria. Eligible patients were not given the option of a second-look procedure under general anesthesia and none refused to undergo the procedure under local anesthesia. Informed consent was obtained. Postoperative evaluations of the first PCNL were performed based on a kidney, ureter, bladder X-ray and nephrostogram 24-48 hours after the procedure. During recruitment of those 30 patients, 4 additional patients were excluded. One was younger than 18 years, 2 developed fever > 38°C in the early postoperative period, and 1 had significant bleeding postoperatively, which was caused by a pseudoaneurysm requiring selective arterial embolization. We routinely use aggressive flexible nephroscopy during our PCNL and we make every effort to render patients stone free in 1 session. In this series, only 2 patients were found to have unexpected residual stones after the first PCNL. In all other cases, we knew that patients were not stone free because the first PCNL was terminated for other reasons (Table 1).

Immediately at the end of the second-look procedure, patients were asked to rate the pain intensity using the numeric rating scale (NRS). We used the 11-item version, in which individuals are asked what number they would rate their pain, from 0 to 10. In this scale, 0 means no pain and 10 means the worst possible pain. Additionally, patients were asked if they would be willing to undergo a similar procedure in the future. Follow-up included ultrasonography 1 week after the second-look procedure, computed tomography (CT) imaging 20-30 days postoperatively and, finally, ultrasonography 3 months later. Patients were considered stone free if there were no visible stones ≥ 3 mm on CT imaging.

Table 1. Reasons for the presence of significant residual stones after the first PCNL

Cause	Number of Patients (%)
Termination of the procedure because of very long operating time without complete clearance (very large stone burden)	13 (43.3%)
Early termination due to significant bleeding	8 (26.66%)
Stones visible on fluoroscopy but impossible to find during the first PCNL	5 (16.7%)
Stones missed at first PCNL (not observed on fluoroscopy)	2 (6.66%)
Early termination due to a large perforation of the collecting system	1 (3.33%)
Early termination due to instrument failure	1 (3.33%)
Total	**30 (100%)**

PCNL, percutaneous nephrolithotomy.

All data were prospectively collected and recorded in Microsoft Excel. The primary end point was patient tolerability for the procedure and secondary end point was stone-free rate. We grouped pain severity ratings according to Serlin et al[7] as follow: 0 was defined as no pain; 1-4, mild pain; 5-6, moderate pain; and 7-10, severe pain. Statistical analysis was performed using the SPSS Statistics for Windows Version 22. The Mann-Whitney *U* test and chi-square test (χ^2) were used for comparison of the NRS values and independent samples *t* test for metric values. A *P* value of <.05 was considered statistically significant.

Technique

A 12 or 14 Fr bladder catheter was first inserted. The patient was then placed in the prone position. A C-arm fluoroscopy unit was always available. Approximately, 15 mL of a 2% solution of lidocaine hydrochloride (Xylocaine, AstraZeneca) was injected through the nephrostomy tube into the collecting system, and the tube was clamped. If the patient had undergone multitract PCNL, the same amount of lidocaine was equally distributed to the existing tubes. After 10-15 minutes, the nephrostomy tube was removed, lidocaine gel (Xylocaine gel, AstraZeneca) was applied into the percutaneous tract, and the flexible nephroscope was inserted. An Amplatz sheath was not used. In a case involving multi-tract PCNL, we first removed the tube from the tract deemed to offer the best access into the collecting system. The other tubes were removed successively and nephroscopy was performed through the other tracts, as needed. Lidocaine gel was applied before nephroscope insertion into each tract after tube removal. The procedure was performed with a 15 Fr flexible fiberoptic nephroscope (Richard Wolf, Knittligen Germany). A Dornier Medilas Ho:YAG laser (Dornier MedTech Europe GmbH, Wessling, Germany) was also used. A 330 μm laser fiber was used, and the laser settings were 0.8 Joules and 8 Hz, with the aim of reducing stone size to an extractable level. Stone fragments generated during lithotripsy and all other smaller residual stones were extracted using nitinol baskets and graspers. At the end, a final nephroscopy was performed, the nephroscope was removed, and a self-adhesive urostomy bag was applied to the skin at the entry point. The bladder catheter was then removed. Patients were discharged from the hospital on the same day.

RESULTS

The procedure was performed 48, 72, and 96 hours after the first PCNL in 9 (30%), 15 (50%), and 6 (20%) patients, respectively. No oral pain medications or other form of analgesia was given prior to the procedure. Patient characteristics and results are summarized in Table 2. Twenty-one (70%) patients had 1 stone and 9 (30%) patients had 2 stones needing laser lithotripsy. The number of stones eliminated on the second-look procedure, including those needing fragmentation, ranged from 1 to 27 (Table 2). Mean operative time was 29.1 ± 13.8 minutes (range 13-68). Operative time was calculated based on the time from the initial insertion to the final withdrawal of the flexible nephroscope.

Two patients, 1 man and 1 woman, were not able to tolerate the procedure and required additional sedation.

Table 2. Patient characteristics and procedure results

Characteristics	
Gender, %	
Male	14 (46.7%)
Female	16 (53.3%)
Mean age, years (SD)	45.2 ± 17.5
BMI (kg/m^2), %	
Underweight (<18.50)	1 (3.33%)
Normal range (18.50-24.99)	8 (26.67%)
Overweight (25-29.99)	11 (36.67%)
Obese (≥30)	10 (33.33%)
Comorbidity, %	
Hypertension	9 (30%)
Diabetes mellitus	6 (20%)
Cardiovascular disease	4 (13.33%)
Thyroid dysfunction	3 (10%)
Chronic renal disease	3 (10%)
COPD	2 (6.67%)
Access tracts, %	
1	18 (60%)
2	5 (16.7%)
3	6 (20%)
4	1 (3.3%)
Number of stones needing laser lithotripsy, %	
1	21 (70%)
2	9 (30%)
Stone location, %	
Upper calyx	11 (36.67%)
Middle calyx	8 (26.67%)
Lower calyx	2 (6.67%)
Upper and middle calyx	4 (13.33%)
Upper and lower calyx	1 (3.33%)
Middle and lower calyx	3 (10%)
Renal pelvis and upper calyx	1 (3.33%)
Total number of stones extracted, %	
1-5	18 (60%)
6-10	8 (26.67%)
11-15	1 (3.3%)
>15	3 (10%)
Mean operative time, minutes (SD)	29.1 ± 13.8
Mean fluoroscopy time, seconds (SD)	27.7 ± 14.9
Stone-free rate under local anesthesia, %	26 (86.7%)
Overall stone-free rate, %	28 (93.3%)
Mean NRS (SD)*	1.39 ± 1.08
NRS 0	5 (16.67%)
NRS 1-4	22 (73.3%)
NRS 5-6	1 (3.3%)
NRS 7-10	2 (6.67%)

BMI, body mass index; COPD, chronic obstructive pulmonary disease; NRS, numeric rating scale; SD, standard deviation.
* For those completing the procedure under local anesthesia.

Specifically, they felt significant pain during laser lithotripsy. In both cases, the procedure was completed successfully after the intravenous (IV) administration of midazolam of 3 mg for the woman and 4 mg for the man. Both gave the procedure an NRS score of 9. For the 28 patients who successfully completed the procedure under local anesthesia, the mean NRS score was 1.39 ± 1.08 (range 0-5). Twenty-six (87%) patients said they were willing to undergo the same procedure again in the future. The 2 patients who received IV sedation and 2 additional patients stated that the procedure was uncomfortable and that they would have preferred to have it performed under a general anesthetic. These 2 latter patients gave an NRS score of 2 and 5. The first patient, with an NRS score of 2, explained that the procedure was not very painful but she felt very uncomfortable knowing that someone had been working inside her kidney while she was fully alert.

When comparing the NRS scores between male and female patients, no statistically significant difference was found, regardless of whether those patients who received IV sedation were included or excluded (P = .192 and P = .131, respectively). For the entire group, there was a statistically significant difference between those patients with 1 stone vs 2 stones needing laser lithotripsy. In this case, the pain severity was lower for those patients with 1 stone (NRS 1.1 ± 0.77 vs 2.1 ± 1.36, P = .033) (Fig. 1). This difference was not significant when male and female patients were examined separately (P = .904 and P = .133, respectively). Mean operative time was 23.1 ± 7.34 minutes for those with 1 stone vs 43.25 ± 16.56 minutes for those with two stones needing fragmentation (P = .01). Operative time >30 minutes was associated with higher NRS score regardless of the number of stones requiring lithotripsy (P = .025). No difficulty with lying prone while awake was noticed and no complications related to local anesthesia occurred. No complications directly related to the second-look procedure were recorded, with the exception of 1 case with prolonged leakage form the access tract (>48 hours), which ceased spontaneously.

The stone-free rate under local anesthesia was 86.7% and increased to 93.3% when the 2 patients who received IV sedation were also included (Table 2). Two patients were not stone free. Both had 1 access tract, and stones could not be reached with the flexible instrument because of an unfavorable angle between the tract and the stone-bearing calyx. They both received subsequent treatment, 1 with SWL and the other with RIRS.

DISCUSSION

In this prospective feasibility study, we have found that patients with 1 or 2 post-PCNL stones 0.8-1.5 cm in diameter can be treated with flexible second-look nephroscopy and laser lithotripsy using only local anesthesia. The procedure was very well tolerated by most patients, the vast majority of them (90%) reporting no pain or mild pain. Only 2 patients were not able to tolerate the procedure, and required sedation. It is noteworthy that these 2 patients were among the first treated with this approach, leading us to believe that lack of experience has played a significant role on the negative outcome.

Treatment options for post-PCNL fragments include SWL,[4] RIRS,[5] and second-look PCNL.[6] Merhej et al[4] evaluated the combined approach of PCNL and SWL in the treatment of staghorn calculi and reported a stone-free rate of 67%, an insignificant residual fragment rate of 26%, and a residual stone rate of 7%. Zeng et al[5] reported an overall 89.3% stone-free rate using RIRS after single-tract PCNL for staghorn stones in solitary kidneys. Second-look nephroscopy

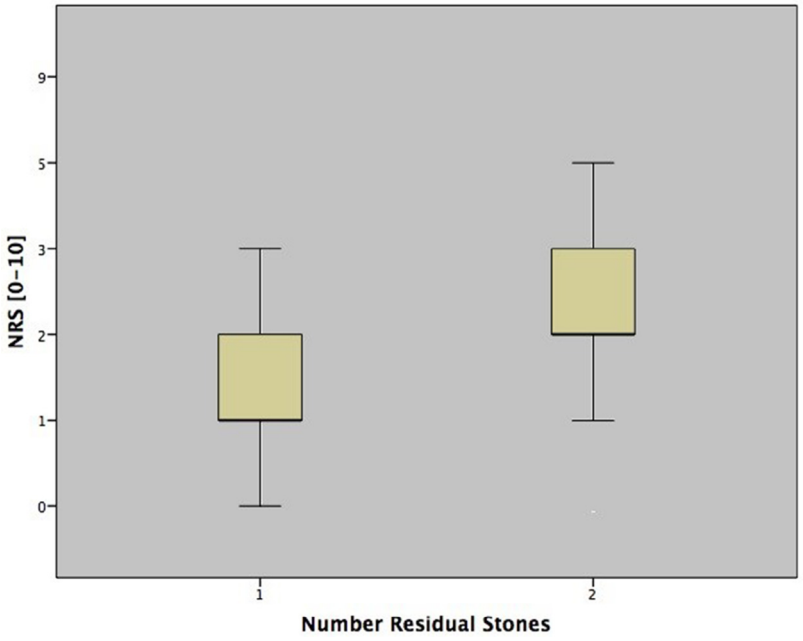

Figure 1. Significant difference in pain scores in patients with 1 stone vs 2 stones requiring lithotripsy ($P = .033$). (Color version available online.)

is probably the most attractive option to eliminate residual fragments because the existing tract offers easy access to the collecting system.[6,8-11] Shahrour et al[10] reported a 51% stone-free rate after the initial procedure in a series of patients who had undergone single-tract PCNL and this percentage increased to 76% after the second-look procedure. Similarly, in a pediatric population, initial PCNL followed by second-look nephroscopy resulted in a final stone-free rate of 87%.[11] Some authors recommend that a second-look nephroscopy be performed routinely in all patients to remove residual fragments and prevent future adverse events.[12,13] Others have tried to eliminate the need for routine second-look nephroscopy by increasing the accuracy of postoperative imaging using CT[3,14] or by combining aggressive flexible nephroscopy with high magnification rotational fluoroscopy during the initial PCNL.[15-17]

Although the above strategies can reduce the number of second-look nephroscopies, it seems that the complete elimination of the procedure from clinical practice is impossible. There is always the possibility that residual fragments may be left behind; for example, in cases of severe bleeding[17] or retained contrast. Nevertheless, second-look nephroscopy is an additional procedure associated with patient morbidity, and the use of a flexible nephroscope under local anesthesia or sedation is a step that can be taken to diminish patient's discomfort.[6] The idea to apply Ho:YAG laser lithotripsy during second-look nephroscopy using only local anesthesia came about due to a lack of surgical tables and anesthesiology staff at our hospital. Basically, because this was a feasibility study, we decided to set very specific criteria to achieve the highest possible stone-free rate combined with the lowest possible level of patient discomfort. The criteria used here were directly related to our surgical technique. We routinely leave behind a 22 Fr nephrostomy tube after the initial PCNL. Therefore, stones up to 0.7 cm at their largest diameter can be removed intact. Larger stones need to be fragmented. This is why we used the cutoff size of 0.8 cm. Because we did not know the tolerability of the procedure under local anesthesia, we decided that no more than 2 stones would be fragmented. Additionally, only stones up to 1.5 cm were included because we assumed that the reduction of stone size from 1.5 cm to 0.7 cm was an achievable task under local anesthesia. Using these criteria, we achieved a stone-free rate of 86.7% when only local anesthesia was employed, and this increased to 93.3% with additional sedation in 2 more patients. It is interesting that in several cases, we were able to fragment and then remove stones that otherwise would have required additional access tracts, obviously under general anesthesia. This is 1 of the major advantages of our technique. Stones were left behind due to clearly unfavorable angles between the access tract and the stone-bearing calyx in only 2 patients. On the other hand, this is the major disadvantage of this approach. These 2 patients could have been treated with additional access tracts if they were under general anesthesia.

Clearly, the most important issue to discuss regarding our approach is the patient's tolerability for the procedure. Pain is a very subjective symptom and is difficult to quantify. We used the NRS because of its ease of administration. NRS has been used in several studies as a tool to measure pain intensity, and there is no clear evidence that it is superior or inferior to other tools, such as metric scales.[7] The mean NRS scores for our study was 1.39, and 27 patients (90%) reported no pain or mild pain, indicating that the procedure was very well tolerated. It has been postulated that lithotripsy per se is not painful and that the pain

experienced during PCNL is mainly caused by the perforation and dilatation of the renal capsule and parenchyma.[18] Because the renal capsule has already been disrupted and the tract is already established in second-look procedures, it is not surprising that the vast majority of the patients responded very well. Distension of the collecting system from the irrigation fluid is also a possible cause of pain during second-look nephroscopy. In our practice, the use of a 16 Fr nephroscope through a 22 Fr tract ensures sufficient outflow around the instrument and precludes the distension of the collecting system. This is especially true in cases of multitract PCNL, where additional outflow is offered from the other tracts. Finally, a third possible cause of pain is trauma to the urothelium from inadvertent activation of the laser fiber against the wall of the pelvicalyceal system. Preventing this source of pain is probably the greatest value of the administration of local anesthetic at the outset of the procedure. We also found that the procedure was very well tolerated by those having supracostal access. Four cases in this study had supracostal access, either as the sole access or as a part of a multitract PCNL. All 4 patients had no pain or mild pain during the procedure (NRS scores of 0, 1, 1, 2).

Differences in pain perception were found between patients needing laser lithotripsy of 1 stone vs 2 stones, with those needing lithotripsy of only 1 stone reporting less pain. A possible explanation for this is that laser lithotripsy was more prolonged in cases with 2 stones, and the longer procedure had a greater risk of accidentally hitting the urothelium. It has also been suggested that procedure duration is a critical parameter in the pain experience.[19,20] Patient discomfort due to remaining in a prone position for a prolonged time and increased anxiety may contribute to increased pain scores. This was also true in our series where operative time >30 minutes was associated with higher NRS values regardless of the number of stones requiring lithotripsy. However, even in cases where the operative time was > 30 minutes the NRS score was in the category of "no pain" or "mild pain," indicating that the procedure is easily tolerated by most patients. Additionally, because the effects of lidocaine are restricted in time (30-60 minutes),[21] in some cases with prolonged procedures the anesthetic effect had probably diminished. The use of a different anesthetic drug, such as bupivacaine or ropivacaine, with a longer duration of action might be the solution for cases in which a prolonged operative time is anticipated. However, lidocaine has been shown to not only be efficacious but also to be very safe in our study, in that no complications were recorded related to the drug. Similar safety has been reported from other medical disciplines using lidocaine on mucosal surfaces.[22]

The limitations of our study are the relatively small number of patients and the lack of a comparison group of patients treated under general anesthesia. However, this feasibility study have shown very encouraging results that, if confirmed by others, may represent a significant step to reduce the morbidity of second-look PCNL for patients with minimal to moderate residual stone burden. Therefore, further studies are needed with larger series and particularly a randomized study to compare the stone-free rates of second-look PCNL under local vs general anesthesia. Additionally, a comparison between prone and supine position would be interesting. The latter, although not tested in this study, seems applicable as well.

CONCLUSION

We have shown that for selected patients with minimal to moderate residual stone burdens following PCNL, second-look flexible nephroscopy can be combined with Ho:YAG laser lithotripsy using only local anesthesia. The procedure was feasible and appeared to be well tolerated by most of the patients. Further studies are needed to confirm these findings.

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