Do Patients Benefit from Miniaturized Tubeless Percutaneous Nephrolithotomy? A Comparative Prospective Study

Thomas Knoll, M.D., Ph.D., M.Sc., Felix Wezel, M.D., Maurice Stephan Michel, M.D., Ph.D., Patrick Honeck, M.D., and Gunnar Wendt-Nordahl, M.D.

Abstract

Background and Purpose: A benefit of miniaturized percutaneous nephrolithotomy (MPCNL) compared with conventional percutaneous nephrolithotomy (PCNL) has not been demonstrated as yet. Thus, the aim of this study was to evaluate the outcome of conventional vs MPCNL and to determine if MPCNL offers an advantage for the patient.

Patients and Methods: A prospective, nonrandomized series of 50 consecutive patients with solitary calculi (lower pole or the renal pelvis) were treated either by conventional PCNL (26F) or MPCNL (18F). Ultrasound or holmium laser were used for lithotripsy. Patients were treated tubeless after uncomplicated MPCNL, with thrombin-matrix tract closure and antegrade Double-J catheter placement. After PCNL, all patients received 22F nephrostomies. Demographic data, stone characteristics, perioperative course, and complication rates were assessed.

Results: Patients characteristics were comparable in both groups, except for stone size, which was 18 ± 8 mm (MPCNL) and 23 ± 9 (PCNL; P = 0.042). Operative time was comparable in both groups (48 ± 17 vs 57 ± 22 min, not significant [NS]). After MPCNL, 96% were stone free at day 1 vs 92% after PCNL (NS). Significant complications did not occur in both groups. Minor complications were: Fever, 12% (MPCNL) vs 20% (PCNL; NS); bleeding, 4% vs 8%; perforations, 0% vs 4% (all NS). Overall outcome was not influenced by body mass index. Calcium oxalate stones were predominant with 75%. Patients after tubeless MPCNL had less pain (visual analogue score, 3 ± 3 vs 4 ± 3; P = 0.048.) and needed slightly less additional pain medication (25 ± 12 mg/d vs 37 ± 10 mg/d piritramid; NS). Hospital stay was significantly shorter after MPCNL (3.8 ± 28 vs 6.9 ± 3.5 d; P = 0.021.).

Conclusions: Both techniques were safe and effective for the management of renal calculi. While stone-free rates were comparable in our series, MPCNL showed advantages in terms of shorter hospital stay and postoperative pain. The lower stone burden and the tubeless fashion of MPCNL, however, might have influenced these results.

Introduction

Urolithiasis is a widespread disease, with approximately 750,000 cases per year in Germany.1,2 Of urinary stone formers, 25% have recurrent stone formation.3 Therefore, urolithiasis has a significant impact on life quality and socioeconomic factors.

Percutaneous nephrolithotomy (PCNL) is recommended as standard therapy for kidney stones >20 mm, while shock-wave lithotripsy (SWL) is recommended for smaller renal calculi.4,5 The stone clearance of lower-pole calculi after SWL is limited, however, thus leading to an extended indication for PCNL even for stones between 10 and 15 mm in many centers.6 This trend is further promoted by the introduction of mini-PCNL (MPCNL), which is postulated to be less invasive compared with standard PCNL because of the miniaturized instruments. The perioperative morbidity and hospital stay may be further reduced by omitting the placement of a postoperative nephrostomy (tubeless MPCNL).7 Although being logical at first glance, however, no clear advantage of the miniaturized equipment has been demonstrated yet, and some authors deny a benefit of MPCNL procedures.8 The aim of our study was to evaluate the perioperative course of standard and tubeless MPCNL to determine if the
Efficacy of retrograde ureteropyeloscopic holmium laser lithotripsy for intrarenal calculi >2 cm

M. J. Bader · C. Gratzke · S. Walther · P. Weidlich · M. Staehler · M. Seitz · R. Sroka · O. Reich · C. G. Stief · B. Schlenker

Abstract The objectives of this study are to assess the efficacy and safety of retrograde ureteroscopic holmium laser lithotripsy for intrarenal calculi greater than 2 cm in diameter. A total of 24 patients with a stone burden >2 cm were treated with retrograde ureteroscopic laser lithotripsy. Primary study endpoints were number of treatments until the patient was stone free and perioperative complications with a follow-up of at least 3 months after intervention. In 24 patients (11 women and 13 men, 20–78 years of age), a total of 40 intrarenal calculi were treated with retrograde endoscopic procedures. At the time of the initial procedure, calculi had an average total linear diameter of 29.75 ± 1.57 mm and an average stone volume of 739.52 ± 82.12 mm$^3$. The mean number of procedures per patient was 1.7 ± 0.8 (range 1–3 procedures). The overall stone-free rate was 92%. After 1, 2 and 3 procedures 54, 79 and 92% of patients were stone free, respectively. There were no major complications. Minor postoperative complications included pyelonephritis in three cases (7.5%), of whom all responded immediately to parenteral antibiotics. In one patient the development of steinstrasse in the distal ureter required ureteroscopic fragment disruption and basketing. Ureteroscopy with holmium laser lithotripsy represents an efficient treatment option and allows the treatment of large intrarenal calculi of all compositions and throughout the whole collecting system even for patients with a stone burden of more than 2 cm size.

Keywords Kidney calculi · Ureteroscopy · Holmium laser · Lithotripsy

Introduction Percutaneous nephrolithotomy (PCNL) represents the gold standard for the management of large renal calculi due to its stone-free rate of more than 90% independent of stone size, location or composition [1–5]. The morbidity associated with PCNL is acceptable for the majority of patients [5–7]. However, the low but significant rate of major complications include acute renal loss, chronic renal failure and prolonged urine leakage [7]. However, for a certain group of patients with large renal stones, PCNL is not considered to be the ideal treatment [8, 9]. The indication for a different surgical approach (e.g., retrograde ureteroscopic treatment) of large upper urinary tract calculi includes morbid obesity (i.e., body mass index > 30), bleeding diathesis, severe cardiopulmonary disease, certain anatomic factors such as severe kyphoscoliosis and renal ectopia and the inability to tolerate the potential morbidities and/or complications of PCNL, as well as failed prior PCNL [8–10].

A new generation of flexible ureteroscopes with reduced distal tip and midshaft size are now widely available. Compared to their predecessors access to the complete upper urinary tract in up to 94% of cases is facilitated [11]. Due to these improvements the therapeutic role of ureteroscopic treatment is may be extended.

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Holmium Laser
Efficacy and Safety in Treatment of ESWL-Refractory Stones

Lecture at the seminar “Exchange of Experience”, Genova, September 20, 2002

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Purpose
The aim of this study was the evaluation of efficacy and safety of stone disintegration procedures using holmium laser in a highly selected group of patients with ESWL-refractory stones.

Method
27 uretero-renoscopies were performed with the use of laser stone disintegration (holmium laser AURIGA, WaveLight). Size, location, and composition of stones were evaluated. Results of procedures, complication, and duration of hospital stay were assessed.

Results
Within the last twelve months 27 out of 362 patients treated by ESWL necessitated stone disintegration with the holmium laser using in 22 of cases rigid and in five cases flexible uretero-renoscopies.

Stone Location
- upper calyx 2
- mid calyx 1
- lower calyx 3
- proximal and mid ureter 17 and 4 cases respectively

In 74 percent of the cases stones were composed to more than 80 percent of ca-oxalate monohydrate. The laser energy ranged from 600 to 1400 mJ with an average number of 2589 pulses. With 25 patients (93 percent) complete disintegration into fragments < 3 mm was achieved. In two cases the partial disintegration of stones (19 and 18 mm) was completed by ESWL. A retro-grade migration of the stone was not observed.

Ureter perforation occurred in two cases. In one of them the lesion was attributed directly to the cutting effect of laser. All complications were healed by stent placement for four until six weeks. Postoperatively one patient became fever over 38,5 °C and was cured with antibiotics. There were no severe intra- or postoperative complication. The average postoperative stay in hospital was 1.8 days.

Conclusions
The holmium laser appears to be an effective and safe tool for endoscopical treatment of stones resistant to ESWL shock wave therapy. Taking into account that in 93 percent of cases the sufficient disintegration even of the hardest ca-oxalate monohydrate stones could be achieved within one single session, we would recommend this method for routine clinical use.

Care should be taken to avoid the direct contact of the laser probe with the ureteral tissue.
Holmium Laser in Endourology

Lecture at Bayrisches Laser Zentrum (BLZ), Munich, March 01, 2004

Werner Falkenstein
StarMedTec GmbH, Starnberg, Germany

Summary

A holmium laser is a pulsed laser system with a wavelength of approximately 2 µm with absorption properties midway between those of a Nd:YAG laser and a CO2 laser.

By choosing suitable laser parameters, the laser can easily be adapted to the application intended. It is equally suitable for athermal ablation of hard and soft tissues and for lithotripsy, regardless of the color or composition of the calculus.

In particular medium-power (30–40 W) holmium laser units are ideally suited for today's endourology thanks to their wide range of applications, their effective and safe use, and their comparably favorable capital investment requirements and running costs.

Key words: holmium laser, endourology, lithotripsy, strictures, BPH, LITT, enucleation, TURP, prostate.

Introduction: Characteristics of Holmium Lasers

For some years now holmium lasers have been available for endourological applications [1,2]. Like the Nd:YAG laser the holmium is a solid-state laser operating in the infrared segment of the spectrum, except that its wavelength of 2 µm is twice as much of an Nd:YAG laser of 1 µm.

While Nd:YAG lasers are characterized by low water absorption and their ability to deeply penetrate the tissue, the wavelength of the holmium laser beam is easily absorbed by water, so its depth of penetration, at approximately 0.4 mm, is therefore low. Being a pulsed laser with a pulse duration of several hundred microseconds and high absorption in tissue, the effect of a holmium laser is restricted to the area close to the fiber tip. It creates a minimal zone of coagulation around the treatment area of approximately 0.5 mm – large enough to prevent bleeding in most cases and to facilitate hemorrhage-free procedures. A satisfactory cutting effect can be achieved by using repetition rates starting at 15–20 Hz. Furthermore, the water content of uroliths and other calculus turned out to be high enough for adequate energy absorption; therefore calculi can be destroyed regardless of their color, hardness, or composition.

<table>
<thead>
<tr>
<th>Laser</th>
<th>Wavelength (nm)</th>
<th>Absorption coefficient (cm⁻¹)</th>
<th>Coagulation zone (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd:YAG</td>
<td>1064</td>
<td>0.55</td>
<td>4–18</td>
</tr>
<tr>
<td>Ho:YAG</td>
<td>2080</td>
<td>30</td>
<td>0.4</td>
</tr>
<tr>
<td>Er:YAG</td>
<td>2940</td>
<td>12500</td>
<td>0.04</td>
</tr>
<tr>
<td>CO2</td>
<td>10600</td>
<td>995</td>
<td>0.125</td>
</tr>
</tbody>
</table>

Table 1 Absorption properties of different laser systems in water [3]
Holmium Laser

Medium Power Holmium Lasers in Endourology

Lecture at the seminar "Exchange of Experience", Genova, September 20, 2002

J. Rassweiler, T. Frede, O. Seemann, M. Schulze
Department of Urology, SLK Kliniken Heilbronn, University of Heidelberg, Germany

Introduction

The first laser introduced for endourological applications was the Nd:YAG laser in the early eighties. At that time only the Nd:YAG laser was available with power levels high enough for surgical applications and a wavelength (1064 nm) that could be transferred through highly flexible quartz-fibers necessary for endoscopic applications.

First introduced for many different applications, its main application is still its ability to coagulate relatively large volumes of tissue e.g. when coagulating bladder tumors or genital warts. With additional tricks (blackening of fiber tip, electro optic feedback system "fibertom") it can be used for cutting tissue (e. g. urethral strictures) too, but due to its low absorption in tissue, due to a correspondingly deep penetration and being a continuously emitting laser it shows large thermal side effects, which are not limited to the actual application site, but go far beyond it. The overall benefit of this laser type reduced these side effects considerably.

Any attempts to use this type of laser for lithotripsy failed just as the absorption of the stones was too low or the power transmission capability of the fibers was insufficient when running the laser in the q-switched mode.

1985 the flashlamp pumped dye laser was introduced. Though being effective in destructing different types of stones, these lasers proved out to be expensive tools regarding the initial investment and the running costs as the laser medium, a coloured liquid, had to be changed frequently. Nevertheless, staying competitive a urological clinic of high standing had to offer both laser types.

However, one was hoping the laser industry would be able to offer an affordable laser system based on solid-state laser technology that can be used for a large variety of endourological applications, with high efficacy and safety in application.

Holmium Laser

For a couple of years the holmium laser has been offered for endourological applications. Its wavelength (2100 nm) is very well absorbed by water. As water is the main constituent of tissue it can easily be vaporized by this holmium laser. As it is a pulsed laser its emission consists of short pulses with a duration of several hundred microseconds. When applied to a high repetition rate a nice cutting effect can be established. Due to its high absorption in tissue and its short pulse duration, the effect of the holmium laser pulses applied is limited to the area close to the tip of the fiber. Nevertheless, it still creates a small coagulation zone surrounding the vaporized area thick enough to prevent bleeding in most cases. Furthermore, it has been proved that the water content of urinary stones was high enough to yield enough absorption for destructing all types of stones regardless of colour, composition, and hardness.
New Endourologic Technology for Simultaneous Holmium:YAG Laser Lithotripsy and Fragment Evacuation for PCNL: Ex-Vivo Comparison to Standard Ultrasonic Lithotripsy

M.S. Michel, M.D.,* P. Honeck, M.D.,* and P. Alken, M.D.

Abstract

Percutaneous nephrolithotomy (PCNL) is a well established procedure and accepted as the standard of care for the treatment of large renal calculi. Since the introduction of the holmium:yttrium-aluminum-garnet (Ho:YAG) laser into clinical practice in 1990, it has been used successfully to treat various urologic conditions. Today it is the modality of choice for retrograde intracorporeal stone disintegration ureteroscopically, and has also been used successfully for PCNL. One disadvantage when using the Ho:YAG laser for disintegration of renal calculi is the need for graspers to extract fragments and the mobilization of fragments due to the lack of simultaneous suction. We present our experience with a Ho:YAG laser in combination with simultaneous suction in an in-vitro model using a new endourologic technique in comparison to conventional ultrasonic lithotripsy.

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Since the introduction of the holmium:yttrium-aluminum-garnet (Ho:YAG) laser into clinical practice in 1990, it has been used successfully to treat various urologic conditions. Today it is the modality of choice for retrograde intracorporeal stone disintegration ureteroscopically, and has also been used successfully for PCNL. One disadvantage when using the Ho:YAG laser for disintegration of renal calculi is the need for graspers to extract fragments and the mobilization of fragments due to the lack of simultaneous suction. We present our experience with a Ho:YAG laser in combination with simultaneous suction in an in-vitro model using a new endourologic technique in comparison to standard ultrasonic lithotripsy.

Materials and Methods

To evaluate the disintegration we used artificial stones (made of plaster of Paris). Ten stones were used for ultrasonic disintegration (group 1) and 10 stones for were subjected to laser disintegration (group 2). Stones of macroscopically similar size were selected for both groups. After selection, the stones were weighed to guarantee similar weights in both groups.

The specially designed device consists of a 34-cm-long stainless steel tube (14F) with a separate 12F outflow channel for the suction. This steel tube was linked to a micromanipulator (Storz, Tuttlingen, Germany). The device was manufactured specially for our purposes by Storz (Fig. 1). The micromanipulator allows fixation as well as exact positioning of the laser fiber within the steel tube. The assembly of the laser/suction device was simple and uncomplicated.

Department of Urology, University Hospital Mannheim, Mannheim, Germany.
*Both authors contributed equally to this work.


Material und Methoden

Nach Einzelfallberichten und kleinen Untersuchungsreihen in der Literatur, die sich mit der perkutanen Versorgung von kindlichen Harnsteinen des oberen Harntraktes befassten [9, 10, 11], wurde die Mini-Perc erstmals 2001 als eigenständiges Verfahren publiziert [4]. Ziel des Mini-Perc-Verfahrens war, die geringe Morbidität der ESWL mit den guten Ergebnissen in Bezug auf die Steinfreiheit der konventionellen PCNL zu kombinieren.

Minimally Invasive Tract in Percutaneous Nephrolithotomy for Renal Stones

Fan Cheng, M.D., Weimin Yu, M.D., Xiaobin Zhang, M.D., Sixing Yang, M.D., Yue Xia, M.D., and Yuan Ruan, M.D.

Abstract

Aim: The aim of this study was to assess the efficacy, safety, and morbidity of minimally invasive tract in percutaneous nephrolithotomy (Mini-PCNL) for renal stones in comparison with the standard PCNL.

Patients and Methods: In a randomized trial, 69 patients (72 renal units) undergoing Mini-PCNL (group 1) from May 2004 to December 2007 were compared with a similar group of 111 (115 renal units) patients undergoing standard PCNL (group 2). Patients who needed more than one percutaneous tract or who had simultaneously undergone the two techniques on the same renal unit were excluded from the study group. Chi-square 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 two groups had comparable demographic data and some outcome of characteristics such as time of stay in hospital, postoperative pain, dose of postoperative analgesics, ratio of positive fever, and stone-free rates for some types of stones (e.g., staghorn stone and simple renal pelvis stone). The stone-free rate for multiple caliceal stones (85.2% vs. 70.0% in group 1 and group 2) was significantly higher in the Mini-PCNL group (p < 0.05). The incidence of bleeding necessitating transfusion (1.4% vs. 10.4% in group 1 and group 2) was significantly lower in the Mini-PCNL group (p < 0.05). In group 1, operative time for different stone types such as staghorn stone, simple renal pelvis stone, and multiple caliceal stones were 134.3 ± 19.7, 89.4 ± 21.5, and 113.9 ± 20.3 minutes, respectively, which were significantly longer than that for group 2 (118.9 ± 21.5, 77.0 ± 17.6, and 101.2 ± 19.1 minutes) (p < 0.05).

Conclusion: Mini-PCNL is safe and effective for managing renal calculi in adult patients. Although smaller working sheath is associated with longer operative time, Mini-PCNL has significantly lower incidence of bleeding necessitating transfusion and higher stone-free rate for multiple caliceal stones in comparison with the standard PCNL.

Introduction

The advent and continuous evolution of percutaneous nephrolithotomy (PCNL) have led to a revolution in the management of renal stones. PCNL is now the mainstay of treatment for patients with renal calculi and is a safe and successful method used for removal of different types of stones. Several modifications and refinements in nephroscopes have improved observation, and the use of slender nephroscopes has further enhanced the outcome and decreased the morbidity.

In the present study, minimally invasive tract in PCNL (Mini-PCNL) is defined as a PCNL technique with small working sheath, which is performed using an 8/9.8F ureteroscope through a 16F percutaneous renal access tract. It seems that using a smaller-sized percutaneous tract than the standard PCNL has the potential advantage of decreased bleeding and trauma to renal parenchyma, which may effectively reduce intraoperative and postoperative complications. However, no study is available to consider and compare the clinical curative effect of Mini-PCNL. We have performed a randomized comparison of Mini-PCNL with the standard PCNL to evaluate the efficacy, safety, and morbidity of Mini-PCNL for renal stones.

Patients and Methods

Between May 2004 and December 2007, 287 patients undergoing PCNL were incorporated into this randomized study at our center, including 142 in the Mini-PCNL group and 139 in the standard PCNL group. One hundred eighty patients (98 men and 82 women) who met the inclusion...
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*Both authors contributed equally to this work.*
Holmium Laser
Stone Therapy in Modern Endourology Requires Holmium Laser

Interview with PD Dr. med. Sven Lahme, August 2005, St. Trudpert Hospital, Pforzheim, Germany

Sven Lahme
Department of Urology, St. Trudpert Hospital, Pforzheim, Germany

For more than 20 years the extracorporeal shock-waves lithotripsy (ESWL) is well established in the field of treating urinary calculi. Nevertheless, the present trend towards endoscopic treatments can’t be ignored. What do you think this is reduced to?

As a matter of fact, ESWL has changed the treatment of urinary calculi. Thanks to ESWL a treatment option is now available that combines minimal invasivity with low morbidity and qualifies for uroliths in the upper urinary tract as well as ureteroliths. However, apart from these advantages one has to allow for the fact that ESWL only leads to the disintegration of calculi, so the passing of the particles has to be watched. Therefore the stone free rate depends on size and localization of calculi. Especially in lower renal calices only 60 percent of patients become stone free. Another aspect is the period of treatment after ESWL. Although ESWL is an outpatient treatment, it will take weeks and months till the patient will be stone free. On the other hand there is, these days, the patient wishing for a short-term clean-up of calculi.

What did entail the increasing spread of endoscopic treatments of calculi?

Technological advance and the gain of practical experience in ureterorenoscopy has lead to reduced morbidity in endoscopy. Nowadays rigid uretero-scopes show an instruments cross-section of 6,5 Fr. They enable primary endoscopy of the ureter in patients of all ages, thus in children too. The stone free rate of distal ureteroliths adds up to 90 percent, the course of treatment only takes a couple of days. Due to the procedure’s good results, national and international urology societies recommend primary endoscopy treatments of distal ureteroliths.

How about the endoscopy of the renal pelvis calices system? Is primary endoscopy justifiable there as well?

Renal pelvis and renal calices calculi are still the domain of ESWL – though with the mentioned difficulties that can lead to residual calculi and growth of calculi again. Performing a flexible endoscopy of the upper urinary tract is, these days, from a technical point of view no problem anymore. The development of flexible endoscopes that enable an active deflection up to 270 degrees has contributed considerably to this achievement. Apart from these endoscopes there are active secondary deflection endoscopes too, so nowadays one can rightly claim there would be hardly any spot of the calices of the renal pelvis that is inaccessible for endoscopes.

Does this mean you are recommending the primary endoscopic treatment of renal calices calculi?

I don’t. I only want to go so far as to recommend the flexible endoscopy to the patient either as treatment alternative or for removing residual concrements after ESWL. It’s not without its little problems that medical societies make no mention of these treatment alternatives in their guidelines. Still, having performed