UROLOGYPRACTICE

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Impact of Stone Density on Percutaneous Nephrolithotomy Outcomes with a Dual Frequency Ultrasonic Lithotripter: Computerized Tomography Based Outcomes at a Low Volume Center

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Abstract

Introduction: We studied the safety and efficacy of the CyberWand™ lithotripter and how stone density affects the efficacy.

Methods: We retrospectively analyzed the outcomes of percutaneous nephrolithotomy performed using the CyberWand dual frequency ultrasonic lithotripter at our institution between November 2009 and July 2015. A total of 63 procedures were performed on 57 renal units and, thus, we may be considered a low volume center. We assessed the outcomes of each renal unit in terms of the clinically insignificant residual fragment rate, complication rate, operating room time, estimated blood loss and length of hospitalization. We evaluated the effect of HU of the stone (less than 1,000 HU considered soft and greater than 1,000 HU considered hard) on outcome.

Results: Our outcomes using the CyberWand lithotripter were comparable to those of other lithotripsy modalities in terms of the complication rate and clinically insignificant residual fragment rate. We achieved clinically insignificant residual fragment status (defined as less than 4 mm residual stone size) in 54% of renal units and the overall complication rate was 24%. There were no appreciable differences between soft stones and hard stones in terms of any outcome parameter including complication rate, clinically insignificant residual fragment rate and operative time.

Conclusions: The CyberWand lithotripter is an acceptable, noninferior modality of percutaneous lithotripsy of renal calculi. The efficacy of the CyberWand lithotripter is not affected by stone density.

Key Words: ultrasonography; lithotripsy; nephrostomy, percutaneous; kidney calculi

Abbreviations and Acronyms

CIRF = clinically insignificant residual fragment

CT = computerized tomography

DFUL = dual frequency ultrasonic lithotripsy

Ho:YAG = holmium: yttrium-aluminum-garnet

IR = interventional radiology

KUB = plain x-ray of the kidneys, ureters and bladder

PCNL = percutaneous nephrolithotomy

POD = postoperative day

US = ultrasound

Submitted for publication November 15, 2015.

No direct or indirect commercial incentive associated with publishing this article.

The corresponding author certifies that, when applicable, a statement(s) has been included in the manuscript documenting institutional review board, ethics committee or ethical review board study approval; principles of Helsinki Declaration were followed in lieu of formal ethics committee approval; institutional animal care and use committee approval; all human subjects provided written informed consent with guarantees of confidentiality; IRB approved protocol number; animal approved project number.

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2352-0779/16/35-393/0
UROLOGY PRACTICE

http://dx.doi.org/10.1016/j.urpr.2016.01.003
Vol. 3, 393-398, September 2016
Published by Elsevier

Intracorporeal lithotripsy is an integral part of percutaneous nephrolithotomy surgery and allows for the rapid removal of renal calculi. The common modalities of lithotripsy today include pneumatic, single frequency ultrasonic, dual frequency ultrasonic, Ho:YAG laser and combined pneumatic/ultrasonic energy sources.

Lithotripsy approaches to PCNL have been in existence since the 1970s with the advent of electrohydraulic lithotripters, which were based on spark gap technology initially introduced by Yutkin in 1955. Despite various technical improvements and extensive clinical experience with electrohydraulic lithotripters, this modality has a significant rate of renal pelvic perforation, estimated to be as high as 17.6%.[1]

Laser technology, specifically Ho:YAG, is one PCNL surgical modality that is highly favored because of its reliability and high success rate.[2,3] However, the laser lithotripter requires manual retrieval of stones with a grasper or basket, making it technically less efficient. The excessive thermal energy produced by lasers can also damage the urothelium, leading to bleeding and perforation. Laser fiber use is usually reserved for calyces accessible only by a flexible cystoscope or flexible ureteroscope.

Another popular PCNL modality is the single frequency ultrasonic lithotripter. Although effective for simultaneous fragmentation and removal of most urinary stones, they are not universally successful, especially for harder stones such as cysteine and calcium oxalate monohydrate stones.[4–6]

Several in vitro and clinical studies have demonstrated that the combined pneumatic/ultrasonic lithotripter (LithoClast® Ultra) is effective for the penetration of hard and soft stones, practical for clinical use and safe.[7–9] However, the pneumatic component of the combined lithotripter at a higher frequency can potentially overcome the suction and disperse small fragments throughout the collection.[10] Overheating and malfunction have also been reported but only after extensive use of the ultrasonic component at the 100% setting.[10]

Dual frequency ultrasonic lithotripsy is a novel design that incorporates coaxial high frequency and low frequency ultrasonic probes that act synergistically to comminute stones while simultaneously suctioning fragments. DFUL has been applied commercially to PCNL surgery as the CyberWand lithotripter (Olympus).[11]

CyberWand DFUL has multiple potential advantages over older lithotripsy methods. In vitro studies of the CyberWand have shown that it can penetrate the stone burden twice as fast as the LithoClast Ultra without clogging or overheating at maximum settings.[11] Krambeck et al found no appreciable difference between the dual probe CyberWand and a traditional ultrasonic lithotripter in a small multicenter randomized controlled trial.[12] Hadj-Moussa et al reported no appreciable difference among the CyberWand, pneumatic/ultrasonic and single frequency ultrasonic lithotripters in a single center retrospective cohort study.[13] We report our low volume, single institutional experience with CyberWand DFUL during a 6-year period.

Materials and Methods

Institutional review board approval (13-072) was obtained for patient data acquisition. After obtaining a CyberWand system at our institution in 2009, a total of 52 patients underwent 63 PCNL procedures using the CyberWand from November 2009 to July 2015. All demographic, admission, operative and discharge records are kept electronically in our electronic medical record system (Epic, Verona, Wisconsin) and we were able to retrospectively obtain data regarding these patient profiles. Data on patient age, operative time, fluoroscopy time, stone size, stone density (HU), stone location, percutaneous access location, estimated blood loss, need for transfusion, hospitalization duration, discourse, readmission rate, major complications, and minor complications were collected and analyzed.

All imaging studies are available through our picture archiving and communication system, and all were reviewed and interpreted by a radiologist at our institution. Stone location and size were determined by radiology dictation of noncontrast CT and confirmed by manual measurement by a urology resident at our institution. Stone size was defined as the longest axis of the largest stone in the axial and coronal view. If there were multiple stones of similar size, the measurements of their longest axis were summed. When evaluating postoperative stone residual we considered stone size less than 4 mm as a clinically insignificant residual fragment.[14]

Analysis of the data was performed obtaining the means and standard deviations of the parameters. Comparison of continuous data was performed using Student's t-test. Comparison of categorical data was performed using the chi-square test. All data were stored and analyzed using Microsoft® Excel® with $p < 0.05$ considered statistically significant.

We excluded patients without CT followup and those whose stone was removed with the grasper or basket only. There were no poor operative candidates based on cardiac and pulmonary evaluations and no pregnant females in our study. A total of 10 patients were excluded from our study for the reasons previously mentioned.

Every patient underwent a complete preoperative evaluation including CT, urinalysis and urine culture. If urinalysis