Treatment of Ureteral and Renal Stones: A Systematic Review and Meta-Analysis of Randomized, Controlled Trials

Brian R. Matlaga,*,† Jeroen P. Jansen,‡ Lisa M. Meckley,† Thomas W. Byrne† and James E. Lingeman§

From The James Buchanan Brady Urological Institute, Johns Hopkins Medical Institutions, Baltimore, Maryland, Mapi Group, Boston and Boston Scientific Corp., Natick, Massachusetts, and Indiana Clinic Urology, Indiana University School of Medicine, Indianapolis, Indiana

Abbreviations and Acronyms

AUA = American Urological Association

EAU = European Association of Urology

PNL = percutaneous nephrolithotomy

RCT = randomized, controlled trial

SFR = stone-free rate

SR = semirigid

SWL = shock wave lithotripsy

URS = ureteroscopy

Submitted for publication October 18, 2011.

Study received institutional review board approval.

Supported by Boston Scientific.

* Correspondence: The James Buchanan Brady Urological Institute, The Johns Hopkins University School of Medicine, Park 2, 600 North Wolfe St., Baltimore, Maryland 21287 (e-mail: bmatlaga@jhmi.edu).

† Financial interest and/or other relationship with Boston Scientific.

‡ Financial interest and/or other relationship with Mapi Values.

§ Financial interest and/or other relationship with Boston Scientific, Lumenis, Olympus, Karl Storz Endoscopy, Midwest Mobile Lithotripsy and Midstate Mobile Lithotripsy.

For another article on a related topic see page 316.

Purpose: We compared the clinical outcomes of patients with ureteral or renal stones treated with ureteroscopy, shock wave lithotripsy using HM3 (Dornier®) and nonHM3 lithotripters, and percutaneous nephrolithotomy.

Materials and Methods: A systematic literature search identified 6, 4 and 3 randomized, controlled trials of treatment of distal and proximal ureteral stones, and renal stones, respectively, published between 1995 and 2010. Overall stone-free, re-treatment and complication rates were calculated by meta-analytical techniques.

Results: Based on the randomized, controlled trials evaluated the treatment of distal ureteral stones with semirigid ureteroscopy showed a 55% greater probability (pooled RR 1.55, 95% CI 1.13–2.56) of stone-free status at the initial assessment than treatment with shock wave lithotripsy. Patients treated with semirigid ureteroscopy were also less likely to require re-treatment than those treated with shock wave lithotripsy (nonHM3) (RR 0.14, 95% CI 0.08–0.23). The risk of complications was no different between the 2 modalities. Only 2 of the 4 randomized, controlled trials identified for proximal ureteral stones evaluated flexible ureteroscopy and each focused specifically on the treatment of stones 1.5 cm or greater, limiting their clinical relevance. The degree of heterogeneity among the studies evaluating renal stones was so great that it precluded any meaningful comparison.

Conclusions: Semirigid ureteroscopy is more efficacious than shock wave lithotripsy for distal ureteral stones. To our knowledge there are no relevant randomized, controlled trials of flexible ureteroscopy treatment of proximal ureteral calculi of a size commonly noted in the clinical setting. Collectively the comparative effectiveness of ureteroscopy and shock wave lithotripsy for proximal ureteral and renal calculi is poorly characterized with no meaningful published studies.

Key Words: kidney, ureter, calculi, lithotripsy, ureteroscopy

KIDNEY stones are a common and costly disease. Recent epidemiological investigations show that approximately 10% of the population in the United States is affected by kidney stone disease in their lifetime and this rate is increasing.[1] Medical evaluation for and treatment of kidney stones places a significant economic burden on society. The Urologic Diseases in America project estimated an annual cost of more than $2 billion in the United States alone.[2]

Most patients with symptomatic kidney stones are treated with SWL or URS.[3] Each modality has relative

0022-5347/12/1881-0130/0
THE JOURNAL OF UROLOGY®

Vol. 188, 130-137, July 2012
Printed in U.S.A.
DOI:10.1016/j.juro.2012.02.2569

advantages and disadvantages, and for certain clinical scenarios one may be more optimal than the other. However, selecting the optimal treatment can be challenging. Despite published Cochrane Reviews and clinical treatment guidelines there are no universally accepted paradigms to manage upper urinary tract calculi.[4,5]

In the years since the mentioned reviews were done a number of new clinical investigations have attempted to resolve this issue. Thus, we performed a systematic review and network meta-analysis to compare the outcomes of the treatment of ureteral and renal stones with SWL and URS based on currently available RCTs.

METHODS

Study Identification and Selection

We used certain criteria to consider published studies for review, including population (adults who required intervention for renal or ureteral calculi), intervention (SR-URS, flexible URS, SWL-HM3, SWL-other, that is second, third and fourth generations, and PNL), study design (RCTs comparing any of mentioned modalities) and publication date (URS and PNL studies from 1995 to 2010 and SWL studies from 1980 to 2010).

For the predefined search strategy of the MEDLINE ®, Embase™ and Cochrane databases we used terms related to renal and ureteral stones, URS, SWL and PNL. Titles and abstracts were screened to ascertain whether studies met predefined selection criteria. Those that met the criteria and those for which it was unclear whether the criteria had been met were further screened using the full text report. Two reviewers extracted details on study design, population characteristics, interventions, SFR, retreatment rate, auxiliary procedures and complications.

For SFR the fraction of patients with a successful outcome of the total number of patients treated was extracted for each time point reported. For studies describing SFR at only 1 time point the outcome was assigned to 1) the end of followup if it was reported that the evaluation time point varied by patients during followup, 2) a specific week if that information was provided, or 3) week 1 if no time related information was provided. In studies mentioning initial SFR and SFR after re-treatment the initial SFR was assigned to week 1 if no specific evaluation time was reported. Success after re-treatment was assigned to the time at the end of followup or to the time point reported.

All trials were evaluated for validity with the assessment instrument of Jadad et al, which comprises 7 items and assigns a score of 0 to 5 with 5 representing the highest quality.[6] The results of this validity assessment were not explicitly used for analysis but they served as additional information to determine the quality of the evidence base when interpreting results.

Meta-Analysis

Bayesian network meta-analysis techniques were used to combine the results of the identified studies.[7–10] Logistic regression models were applied to analyze initial SFR, re-treatment rate and complications. We also performed analysis using all available data on SFR with time.[11] For each outcome goodness of fit to the data was compared for fixed and random effects models, as measured by deviance information criteria.[12]

Noninformative prior distributions were used for all parameters of interest to avoid the criticism of Bayesian analyses that prior beliefs (priors) influence results. WinBugs was used for analysis.[13] Outcome measures are shown as the estimated RR. For the number of auxiliary procedures the rate ratio was used to reflect differences between treatments.

RESULTS

Study Identification and Selection

The literature search resulted in 2,641 potentially relevant studies. The abstract review excluded 2,425 studies (92%) from analysis, primarily since they did not provide comparisons of interest. Of the 216 remaining studies 203 (94%) were excluded by the full text review since they did not describe comparisons of interest (101 or 50%) or were observational (102 or 50%). Thus, 13 RCTs were included in analysis (tables 1 and 2).[14–26]

Verze,[14] Zeng,[15] Pearle,[16] Hendrikx[17] and Peschel[18] et al assessed distal ureteral stone treatment. We constructed an evidence network to show different pairwise comparisons of these trials (fig. 1, *A*). There was direct evidence for the comparison of SR-URS vs SWL-other and SWL-HM3. There was no direct comparison of SWL-other vs SWL-HM3 but this was estimated indirectly with the available studies. The reported clinical and patient characteristics indicated that the distal ureteral stone studies reflected comparable populations (table 1).

Four groups evaluated intervention for proximal ureteral stones.[19–22] The evidence network shows that Francesca et al compared SWL-other with SWL-HM3[22] while Salem compared SR-URS with SWL-HM3.[19] This allowed for an indirect comparison of SR-URS with SWL-other (fig. 1, *B*). The study by Lee et al comparing flexible URS with SWL-other[21] and the study by Basiri et al comparing PNL with SR-URS[20] were excluded from the network due to the large stone size in these populations. The series by Chan et al included stones at multiple sites but did not show results by stone location.[23] Thus, this study could not be analyzed further.

Two renal stone studies included patients with stones in the lower renal pole and compared PNL with SWL-other and any URS with any SWL.[24,25] These series showed differences in the average stone burden. Another study evaluated treatment of stones in the renal pelvis using SWL-other vs SWL-HM3.[26] Due to the differences in clinical characteristics in the studies no quantitative comparison was done.

Study quality ranged from 1 to 3 on the scale of Jadad et al (table 1).[6] While the maximum score is 5,