The American Urological Association
Ureteral Stones Clinical Guidelines Panel

Report on

The Management of Ureteral Calculi

Clinical Practice Guidelines

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The Ureteral Stones Clinical Guidelines Panel consists of board-certified urologists who are experts in stone disease. This *Report on the Management of Ureteral Calculi* was extensively reviewed by nearly 50 urologists throughout the country in January 1997. The panel finalized its recommendations for the American Urological Association (AUA) Practice Parameters, Guidelines and Standards Committee, chaired by Joseph W. Segura, M.D. in July 1997. The AUA Board of Directors approved these practice guidelines in August 1997.

The Summary Report also underwent independent scrutiny by the Editorial Board of the *Journal of Urology*, was accepted for publication in July 1997 and appeared in its November 1997 issue. *A Doctor's Guide for Patients* and *Evidence Working Papers* have also been developed; both are available from the AUA.

The American Urological Association expresses its gratitude for the dedication and leadership demonstrated by the members of the Ureteral Stones Clinical Guidelines Panel in producing this guideline.

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Introduction

Advances over the past two decades in urologic technology and interventional techniques have dramatically increased the available choices for management of ureteral calculi. As a consequence, however, questions have arisen regarding the selection of particular treatment modalities, taking into consideration such factors as the size, location and composition of the stone and the presence or absence of infection. To help clarify treatment issues, the American Urological Association (AUA) convened the Ureteral Stones Clinical Guidelines Panel and charged it with the task of producing practice recommendations based primarily on outcomes evidence from the treatment literature. The result of the panel's efforts is this *Report on the Management of Ureteral Calculi.*

Recommendations in this report are to assist physicians specifically in treatment of solitary stones within the ureter. Ureteral calculi present serious problems because they can cause severe flank pain (ureteral colic) and possible obstruction of the collecting system. They account for the majority of emergency room visits due to pain from urinary tract stone disease. Therapeutic goals are to treat urinary tract infection if present, to remove all stone material and to relieve obstruction without causing ureteral damage.

The choice of treatment can be a source of controversy given the range of alternative modalities now available, each with advantages and disadvantages—which makes ureteral calculi an especially appropriate subject for evidence-based recommendations. A summary of this report has been published in the *Journal of Urology* (November 1997). *A Doctor's Guide for Patients* and *Evidence Working Papers* are available for purchase through the AUA.

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Methodology

To develop recommendations for treatment of ureteral calculi, the Ureteral Stones Clinical Guidelines Panel reviewed the literature on ureteral stones from 1966 to January 1996 and extracted and meta-analyzed all relevant data to estimate as accurately as possible both desirable and undesirable outcomes of alternative treatment modalities. The panel followed an explicit approach to the development of practice policy recommendations (Eddy, 1992). This approach emphasizes the use of scientific evidence in estimating outcomes. If the evidence has limitations, the limitations are clearly stated. When panel opinion is necessary, the explicit approach calls for an explanation of why it is necessary and/or discussion of the factors considered. For a full description of the methodology, see Chapter 1.

Background

Ureteral calculi are stones that usually form in the renal collecting system, then progress down the ureter. They tend to become lodged at sites where the ureter narrows. The three most common entrapment sites are at the ureteropelvic junction, over the iliac vessels and at the ureteral meatus.

The composition of ureteral calculi varies, but most stones are composed of calcium salts such as calcium oxalate monohydrate and calcium oxalate dihydrate. Less common materials include cystine, uric acid and struvite. In size, stones vary from less than 2 mm to greater than 2 cm in diameter. The majority of stones are less than 4 mm in width, small enough to pass spontaneously in most patients. A stone's size is an important factor—together with symptom severity, degree of obstruction, the presence or absence of infection and level of renal function—in deciding whether to manage the stone initially by observation, awaiting spontaneous passage, or to intervene actively.

Treatment methods

Accepted alternatives for treating patients with ureteral calculi can be grouped into five general categories:

- Observation (also termed "expectant management" and "watchful waiting");
- Shock wave lithotripsy (SWL);
- Ureteroscopy (URS);
- Percutaneous nephrolithotomy (PNL); and
- Open surgery (referring to any method of open surgical exposure of the ureter and removal of stones).

In addition, laparoscopy is used as a salvage procedure in special circumstances, and there is the traditional treatment alternative of blind basketing. However, as practiced with modern techniques using guide wires and fluoroscopic control, blind basketing is no longer "blind."

Observation

As noted above, the majority of ureteral stones are small enough to pass spontaneously with a controllable degree of patient discomfort. For these stones, observation is an obvious treatment choice. Drugs used to manage ureteral colic in the interim before passage include narcotic analgesics and nonsteroidal anti-inflammatory agents.

In deciding initially for or against active intervention, the size and location of the stone may be prime factors. Stones with a width of 5 mm or less have perhaps a 50 percent chance of spontaneous passage if in the proximal ureter and a somewhat better chance if in the distal ureter. Accurate estimation of size may be a problem because often a radiograph overestimates actual stone size and may also (about 15 percent of the time) underestimate size (Otnes and Sandnes, 1978).

However, size may not be the most important factor. If a patient is experiencing excruciating pain, active intervention may be appropriate regardless of stone size. If urinary tract infection is present, the kidney is at risk for development of pyelonephritis and/or pyonephrosis. Urgent intervention is indicated, again regardless of stone size.

Another factor is degree of obstruction. At one extreme, a patient with an asymptomatic stone in the distal ureter not causing obstruction may be observed for a year or more before the stone finally passes or a decision is made to choose an active treatment. At the other extreme—total obstruction—renal function starts to deteriorate in two weeks (Gillenwater, 1996). Also, a patient with a solitary kidney and/or transplant kidneys or with borderline renal function may not be able to tolerate any degree of obstruction.

Shock wave lithotripsy

Shock wave lithotripsy (SWL) has become the most frequently utilized method for active management of calculi in the urinary tract (Appendix D, page 64). SWL is based on the principle that a high-pressure shock wave will release energy when passing through areas of differing acoustic impedance. Shock waves generated outside the body can be focused on a stone using a variety of geometric techniques. The shock wave passes through the body and releases its energy as it passes into the stone. Thousands of such shock waves may be required. The goal is to reduce the stone to particles small enough to pass without significant pain.

Shock wave lithotripsy has few short-term complications, its noninvasive nature has much appeal and the technique is widely available. SWL does have disadvantages for management of hard, dense stones not easily fragmented, such as those made of calcium oxalate monohydrate. Also, because multiple treatments may be needed, SWL may not provide the required frequency of service if only mobile SWL is available and ancillary procedures may be necessary for management of fragments. Certain characteristics of individual patients, such as obesity or orthopedic problems, may make these patients poor candidates for SWL.

Ureteroscopy

The advent of ureteroscopy in the 1980s dramatically altered the management of symptomatic ureteral calculi. Rigid ureteroscopy has been used in conjunction with ultrasonic lithotripsy, electrohydraulic lithotripsy (EHL), laser lithotripsy and pneumatic lithotripsy to successfully fragment ureteral calculi. Also, many stones can be removed with basket extraction under direct vision after dilation of the intramural ureter.

Currently the three most commonly employed methods for intracorporeal lithotripsy of ureteral stones, via the flexible, semirigid or rigid ureteroscope, are EHL, laser lithotripsy and pneumatic lithotripsy. Ultrasonic lithotripsy is occasionally used for lower ureteral calculi, but its use has been supplanted to a large extent by the above three methods.

Percutaneous stone removal

Percutaneous nephrolithotomy (PNL), which became popular as a primary technique for stone removal in the early 1980s, can theoretically be used for all stones. In practice, shock wave lithotripsy (SWL) and ureteroscopy (URS) are now used in the majority of situations where PNL was once employed to remove ureteral calculi. However, large stones or complex, impacted stones in the proximal ureter are often best managed by PNL.

PNL has unquestioned advantages: (1) If the stone can be seen, it can almost always be destroyed. (2) The ureter may be directly inspected so that small fragments may be identified and removed. (3) The process is rapid, with success or failure being obvious immediately.

One disadvantage is that the expertise required for this operation is not as widely available as it once was, because a greater number of urology training programs are focusing less on PNL and more on shock wave lithotripsy and ureteroscopy for stone management.

Open surgery

A variety of specific operations may be performed in order to remove a ureteral calculus. Depending on anatomy and stone location, a ureterolithotomy may be performed either through a flank, dorsal or anterior skin incision. However, standard ureterolithotomy is rarely performed today, except in cases of complex patient anatomy or large volume ureteral calculi. As of 1996, the incidence of open surgery for the treatment of all stones was about 1 to 2 percent. In most cases, the surgery was used to treat renal staghorn calculi.

Treatment recommendations

Panel recommendations for the treatment of ureteral calculi apply to standard and nonstandard patients as delineated by the following criteria:

The **standard patient** is defined as a nonpregnant adult:

- who has a solitary ureteral stone composed of material other than cystine or uric acid;
- who has not been previously treated for this stone;
- whose medical condition, including renal functional status, body habitus and urinary tract anatomy, permit performance of any of the accepted active treatment modalities including use of anesthesia;
- whose situation is such that all accepted modalities are available and that permits use of any of these modalities.

Nonstandard patients are defined as prepubescent children and other patients who do not meet the above criteria delineating the standard patient. For nonstandard patients, the choice of available treatment options may be limited.

The terms "standard," "guideline" and "option," as used in the panel's recommendations, refer to the three levels of flexibility for practice policies defined in Chapter 1 (page 8). A standard is the least flexible of the three, a guideline more flexible and an option the most flexible. Options can exist because of insufficient evidence or because patient preferences are divided. In the latter case particularly, the panel considered it important to take into account likely preferences of individual patients when selecting from among alternative interventions.

The first three of the following recommendations apply to both proximal and distal ureteral stones. Subsequent recommendations are categorized, first, by whether the stone is located in the proximal or distal ureter and, second, by whether the stone is 1 cm or less in diameter or greater than 1 cm in diameter. The proximal or upper ureter is divided from the distal or lower ureter at the point where the ureter narrows as it curves over the iliac vessels.

Recommendation: For stones with low probability of spontaneous passage

Standard

- A patient who has a ureteral stone with a low probability of spontaneous passage must be informed about the existing active treatment modalities, including the relative benefits and risks associated with each modality.

The decision that a stone has a low probability of spontaneous passage is based on both the facts of the case and professional experience. Factors that weigh in the decision are the size of the stone, the shape of the stone, the patient's internal anatomy and the history of previous stone passage. In general, patients whose stones are 0.5 cm or less in diameter have a good chance of spontaneous passage, whereas the chance of spontaneous passage for larger stones diminishes considerably.

Although, as a practical matter, it is evident that the availability of equipment and the expertise of an individual practitioner may affect the choice of a treatment intervention, it is unacceptable to withhold certain treatments from the patient and not offer them as alternatives because of personal inexperience or unfamiliarity with one of the accepted treatment modalities or because of the local unavailability of equipment or expertise.

Recommendation: For stones with high probability of spontaneous passage

Guideline

- In a patient who has a newly diagnosed proximal or distal ureteral stone with a high probability of spontaneous passage, and whose symptoms are controlled, observation with periodic evaluation is recommended for initial treatment.

(continued on page 6)

Recommendations

For stones with low probability of spontaneous passage

Standard

A patient who has a ureteral stone with a low probability of spontaneous passage must be informed about the existing active treatment modalities, including the relative benefits and risks associated with each modality.

For stones with high probability of spontaneous passage

Guideline

In a patient who has a newly diagnosed proximal or distal ureteral stone with a high probability of spontaneous passage, and whose symptoms are controlled, observation with periodic evaluation is recommended for initial treatment.

For treatment by shock wave lithotripsy

Guideline

Routine stenting to increase efficiency of fragmentation is not recommended as part of shock wave lithotripsy.

For stones of 1 cm or less in proximal ureter

Standard

Open surgery should not be the first-line active treatment.

Guideline

Shock wave lithotripsy is recommended as first-line treatment for most patients.

(continued on next page)

Recommendations *(continued)*

For stones greater than 1 cm in proximal ureter

Guideline

Open surgery should not be the first-line treatment for most patients.

Option

Shock wave lithotripsy, percutaneous nephrolithotomy and ureteroscopy are all acceptable treatment choices.

For stones of 1 cm or less in distal ureter

Standard

Open surgery should not be the first-line treatment.

Guideline

Blind basketing without fluoroscopy and guide wire cannot be encouraged as a treatment choice.

Option

Shock wave lithotripsy and ureteroscopy are both acceptable treatment choices.

For stones greater than 1 cm in distal ureter

Standard

Blind basketing is not recommended as a treatment choice.

Guideline

Open surgery should not be the first-line treatment for most patients.

Option

Shock wave lithotripsy and ureteroscopy are both acceptable treatment choices.

Up to 98 percent of stones less than 0.5 cm in diameter, especially in the distal ureter, may be expected to pass spontaneously. How long until passage occurs, over what period of time passage takes place and the degree of colic or other symptoms are all unpredictable and often bear heavily on the decision to intervene in such patients. In the panel's opinion, for most of these patients the high probability of spontaneous passage justifies observation as the initial treatment. However, difficulties in tolerating pain, multiple trips to the emergency room or other factors may mandate treatment in a patient whose stone might otherwise be expected to pass.

Recommendation: For treatment by shock wave lithotripsy

Guideline: Routine stenting to increase efficiency of fragmentation is not recommended as part of shock wave lithotripsy.

It has become common practice to place a ureteral stent, usually a double-J stent, for more efficient fragmentation of ureteral stones using SWL. The data analyzed by the panel did not support the routine use of such stents when the goal is to improve the stone-free results of SWL. The data showed no improved fragmentation with stenting. Routine stenting may be justifiable for other purposes such as management of symptoms associated with the passage of stones.

Recommendation: For stones of 1 cm or less in proximal ureter

Standard: Open surgery should not be the first-line active treatment.
Guideline: Shock wave lithotripsy is recommended as first-line treatment for most patients.

Although open surgery will usually be successful, relatively longer hospitalization and greater postoperative morbidity with open surgery mean that SWL should be the first-line treatment for most patients. Ureteroscopy and PNL are acceptable choices in situations where SWL may not be appropriate or as salvage procedures for failed SWL.

Recommendation: For stones greater than 1 cm in proximal ureter

Guideline: Open surgery should not be the first-line treatment for most patients.
Option: Shock wave lithotripsy, percutaneous nephrolithotomy and ureteroscopy are all acceptable treatment choices.

Treatment results for large stones in the upper ureter are less predictable than for small stones. Shock wave lithotripsy, PNL and URS are all acceptable options in the upper ureter, but URS may become less appropriate as the stones encountered become larger. Open surgery, despite the excellent stone-free results, should not be the first-line treatment in most patients with large stones. The reasons are the same as for patients with small stones: relatively greater postoperative morbidity and longer hospitalization. Open surgery may well be appropriate for nonstandard patients and is certainly an acceptable alternative as a salvage measure.

Recommendation: For stones of 1 cm or less in distal ureter

Standard: Open surgery should not be the first-line treatment.
Guideline: Blind basketing without fluoroscopy and guide wire cannot be encouraged as a treatment choice.
Option: Shock wave lithotripsy and ureteroscopy are both acceptable treatment choices.

Blind basketing refers to basket manipulation of distal ureteral stones as practiced prior to the advent of ureteroscopy and fluoroscopy around 1981. The high success rates attending ureteroscopic stone removal utilizing fluoroscopic control, the availability of fluoroscopy as an adjunctive measure and the lack of training in the vast majority of programs in the technique of blind basket extraction mean that blind basketing without fluoroscopy and safety guide wire cannot be encouraged as a treatment choice. The data from the literature suggest that blind basketing can achieve a 73-percent success rate. Nevertheless, the panel's expert opinion is that guided stone manipulation (concomitant use of fluoroscopy and safety guide wire) or ureteroscopic basketing would be a considerably safer and more efficacious option.

Shock wave lithotripsy and URS are each effective for management of distal ureteral stones. Each has advantages and disadvantages. Shock wave lithotripsy is minimally invasive and can often be performed either without anesthesia or under intravenous sedation, but may require multiple primary treatments for adequate fragmentation and is more likely to require ancillary treatment.

Ureteroscopy has a higher success rate, with the least risk of requiring multiple treatments and the least risk of an ancillary procedure, but is more invasive than SWL. Although not studied by the panel, cost issues will bear on the patient's decision as to which treatment method is more appropriate. Availability is also a factor. Ureteroscopy is widely available in the current era, as is SWL, although the availability of SWL will vary according to whether practitioners are dependent on a mobile machine.

Recommendations: For stones greater than 1 cm in distal ureter

Standard: Blind basketing is not recommended as a treatment choice.

Guideline: Open surgery should not be the first-line treatment for most patients.

Option: Shock wave lithotripsy and ureteroscopy are both acceptable treatment choices.

Large stones in the ureter must be fragmented prior to ureteroscopic extraction, and SWL must fragment large stones into passable fragments. Such stones will likely require more SWL treatments than will smaller stones, and URS may be preferable when such cases can be anticipated. Given the high success rates using SWL and URS, open surgery should not be the first-line treatment in most patients; but open surgery may be preferable for certain very large ureteral stones or in special situations.

Chapter 1 – Methodology

The Ureteral Stones Clinical Guidelines Panel developed the recommendations in this *Report on the Management of Ureteral Calculi* utilizing an explicit approach (Eddy, 1992), as opposed to an approach relying solely on panel consensus without open description of the evidence considered.

The explicit approach attempts to arrive at practice policy recommendations through mechanisms that systematically take into account relevant factors for making selections between alternative interventions. Such factors include estimation of the outcomes from the interventions, consideration of patient preferences and assessment when possible of the relative priority of the interventions for a share of limited health care resources. In estimating the outcomes of interventions, emphasis is placed on the use of scientific evidence. When panel opinion is necessary, the explicit approach calls for explaining why it was necessary and/or discussion of the factors considered.

To develop the recommendations in this report, the panel reviewed the literature on ureteral stones and made an extensive effort to estimate as accurately as possible the outcomes of alternative treatment modalities. For considering patient preferences, the panel members themselves served as patient proxies.

The review of the evidence began with a literature search and extraction of data as subsequently described on this page and on page 9. The data available in the literature were displayed in evidence tables. From these tables, with reference back to the original articles when necessary, the panel developed estimates of outcomes for the following treatment modalities: shock wave lithotripsy, percutaneous stone removal, open removal, blind basketing, ureteroscopy and observation. Other treatment alternatives such as chemolysis were considered, but available evidence was insufficient to yield outcome estimates. The panel used the FAST*PRO meta-analysis software package described on page 9 to combine the evidence from the various studies. The resulting outcome estimates were arrayed for comparison in the outcomes balance sheet tables on pages 18–21.

The panel generated its recommendations based on the outcomes shown in the balance sheet tables and on expert opinion. These recommendations were graded according to three levels of flexibility as determined by strength of evidence and the expected amount of variation in patient preferences. The three levels of flexibility are defined as follows (Eddy, 1992):

- **Standard:** A treatment policy is considered a standard if the health and economic outcomes of the alternative interventions are sufficiently well-known to permit meaningful decisions and there is virtual unanimity about which intervention is preferred.
- **Guideline:** A policy is considered a guideline if (1) the health and economic outcomes of the interventions are sufficiently well-known to permit meaningful decisions and (2) an appreciable but not unanimous majority agree on which intervention is preferred.
- **Option:** A policy is considered an option if (1) the health and economic outcomes of the interventions are not sufficiently well-known to permit meaningful decisions, (2) preferences among the outcomes are not known, (3) patients' preferences are divided among the alternative interventions and/or (4) patients are indifferent about the alternative interventions.

A standard obviously has the least flexibility. A guideline has significantly more flexibility, and options are the most flexible. As noted in the above definition, options can exist because of insufficient evidence or because patient preferences are divided. In the latter case particularly, the panel considered it important to take into account likely preferences of individual patients with regard to health outcomes when selecting from among alternative interventions. For this report, the panel did not consider economic outcomes.

Literature search, article selection and data extraction

Three literature searches were performed using the MEDLINE database, the first one in January of 1994. Retrieved were all articles related to urinary tract calculi published from 1966-1993. Two update searches were performed, one in January 1995 and the second in January 1996. These three searches yielded a total of 1,698 articles. For reasons of practicality and validity, the panel decided that only English-language articles from peer-reviewed journals would be used in the analysis. All of the articles were imported into a Papyrus Bibliography System database (Research Software Design, Portland, Oregon).

The panel as a group then reviewed the abstracts and selected for data extraction the articles relevant to treatment of ureteral calculi. A total of 526 were selected for extraction. The panel devised a comprehensive data extraction form to capture as much pertinent information as possible from each article. A sample of this form is in Appendix C.

The selected articles were divided among panel members, who reviewed the actual articles and transcribed the data onto the forms. Each article was independently reviewed by two panel members who then consulted to reconcile any differences. At this stage, 199 articles were rejected for reasons such as the following: (1) inadequate methods, (2) lack of relevant data, (3) duplication of data in a later article from the same source, (4) article not published in a peer-reviewed English-language publication, (5) lack of primary data (as in a review article). The net result was 327 articles with acceptable outcomes data. All data were entered into an Access database (Microsoft, Redmond, Washington). Entries were double-checked at a later time.

The bar graph in Figure A-1 on page 47 categorizes by year of publication the number of articles retrieved from the literature, the number rejected and the number accepted for data extraction. Most articles used were published after 1986. The graph in Figure A-2 categorizes the articles by source. The majority came from the *Journal of Urology, Urology*, *The Journal of Endourology* and *The British Journal of Urology.*

Evidence combination

The data resulting from the above process were combined to generate the outcome probability estimates for alternative interventions displayed in the balance sheet tables on pages 18–21. Combining outcomes evidence from the literature in order to generate probability estimates can be performed in a variety of ways depending on the nature and quality of the evidence. For example, if there were one good randomized controlled trial, the results of that one trial alone may be used in the balance sheet. Other studies of significantly lesser quality may be ignored. For ureteral stones, however, none of the available randomized trials was considered of sufficient quality to stand alone in the analysis.

If there are no studies of satisfactory quality for certain balance sheet cells or if the studies found are not commensurable, expert opinion may be used to fill in those cells, they may be left blank or "No data" may be indicated.

If a number of studies report data relevant to a particular cell or cells, meta-analytic methods may be used to combine the data from these studies to derive an overall estimate. Different specific methods are available depending on the nature of the evidence. For this report, the panel elected to use the Confidence Profile Method (Eddy 1989; Eddy, Hasselblad and Shachter, 1990), which allows analysis of data both from randomized controlled trials and from single-arm studies that are not controlled. The FAST*PRO computer software package (Eddy and Hasselblad, 1992) was used in the analysis.

Although there are some randomized controlled trials for ureteral stones, none could be used in that form for this report because of problems with the quality of the data. Therefore, FAST*PRO was used to combine the single arms from various clinical series to estimate outcomes for each intervention. Frequently, the series that were combined showed very different results, implying site-to-site variations that may be caused by differences in patient populations, in how the intervention was performed or in the skill of those performing the intervention. Because of the differences, a random effects or hierarchical model was used to combine studies for most outcomes.

Where outcomes were infrequent or if all series had comparable results, a fixed effects Bayesian model was used.

A random effects model assumes that for each site there is an underlying true rate for the outcome being assessed. It further assumes that this underlying rate varies from site to site. This site-to-site variation in the true rate is assumed to be normally distributed. The method of meta-analysis used in analyzing the ureteral stones data attempts to determine this underlying distribution, which is used to estimate the effect on the population as a whole. In a fixed effects model, no site-to-site variation is assumed, and the studies are combined to estimate the effect for the population as a whole.

The results of the Confidence Profile Method are probability distributions. These can be described using a mean or median probability with a confidence interval. In this report, the 95-percent confidence interval (95% CI) is that interval such that the probability (Bayesian) of the true value being outside the interval is 5 percent.

Limitations

The results presented in this report have several limitations. As mentioned previously, there are few randomized controlled trials for ureteral stones. The data come mostly from uncontrolled clinical series. Because of wide variety in stone size, composition and position, patient selection bias is a major potential problem when using data from clinical series. Even when studies report the results of several different interventions, the likelihood is high that the patients who received one intervention differed significantly from those who received another intervention.

Another difficulty is negative publication bias. Studies with poor results are less likely to be published, either because they are never submitted for publication or because they are rejected later. Consequently, analyses such as this one, based on published data, may be overestimating treatment efficacy. On the other hand, in the case of newer interventions, such as ureteroscopic techniques, the majority of the papers describe the authors' initial set of cases using the new technique. Because these papers represent early experience, they may underestimate current efficacy as the techniques have matured.

Variation in reporting complications presents another difficulty. Authors define and record complications differently. Some authors report even the most minor complications. Other authors fail to report complications at all. If a complication is rare and the panel analyzes only those papers that report the complication, the result will be a significant overestimation of the frequency of that complication. The panel dealt with this problem by attempting to determine more appropriate denominators for rare complications, but the possibility of overestimation still exists.

The potential exists for both overestimation and underestimation when individual complications are combined into a category, such as the "significant" and "less significant" categories in the tables on page 20, and probability estimates are generated for the category. If multiple complications occur in single patients and these complications become part of the source data, the probability estimate generated for that category will be an overestimation. If the source data come from studies in which authors did not report all the complications that occurred, therefore omitting some that would be included in the category, the probability estimate for that category will be an underestimation.

Another problem stems from the fact that although authors group patients with ureteral stones according to stone size, different authors use different size categories. For example, one author may divide patients into groups according to whether the stone is greater or less than 0.5 cm in diameter. Another author may use a different point of division. Thus, studies could not always be reliably combined because their patient populations differed based on the sizes included. Because of such differences in reporting, it was not possible to include all the relevant studies in a single meta-analysis. The problem was accentuated when the panel attempted to determine the probability of spontaneous passage for stones of various sizes and location. Not only were stone sizes reported with different division points, but the time points for calculation of passage also varied. As a result, the panel was unable to combine the results of spontaneous passage studies. (See further discussion of limitations on pages 16–17 of Chapter 3.)

Chapter 2 – Ureteral calculi and their management

Background: Stone location, composition and size

Ureteral calculi are stones that usually form in the renal collecting system, then progress down the ureter. They tend to become lodged at sites where the ureter narrows. The three most common entrapment sites are at the ureteropelvic junction, over the iliac vessels and at the ureteral meatus.

With regard to stone location for the purpose of treatment, the ureter used to be divided into thirds. An upper section was demarcated from the ureteropelvic junction to the upper edge of the sacrum, a middle section from the upper edge of the sacrum to the pelvic brim and a lower section from the pelvic brim to the ureteral orifice. This three-part division was consistent with the different surgical approaches required to remove the stone—for example, a flank incision or a Foley muscle-splitting incision for a stone in the upper ureter or a high Gibson incision for a stone in the middle section.

Today, however, open surgery is seldom performed to remove ureteral stones, except in special cases, surgery having given way to treatment methods such as extracorporeal shock wave lithotripsy, ureteroscopy and percutaneous nephrolithotomy. As a result, the ureter is now generally divided into two sections: the proximal or upper ureter (combining the former middle and upper sections) and the distal or lower ureter. The point of division is where the ureter curves over the iliac vessels and narrows, creating an impediment for the ureteroscope. Two-part division of the ureter into proximal and distal sections is the system used in this report.

The composition of ureteral calculi varies, but most stones are composed of calcium salts such as calcium oxalate monohydrate, calcium oxalate dihydrate and calcium phosphate. Less common materials include cystine, uric acid and struvite.

A stone's composition is one of the factors—together with location, size, degree of impaction, shape, surface contour and other considerations—that may influence choice of treatment. A cystine calculus in the distal ureter, for example, is usually fragmented more effectively using an intracorporeal endoscopic method than with extracorporeal shock wave lithotripsy. Intracorporeal lithotripsy devices such as electrohydraulic lithotripsy, pneumatic lithotripsy and certain lasers (e.g., Holmium and Alexandrite lasers) are effective in fragmenting cystine. Coumarin green laser lithotripsy is ineffective because the translucent cystine does not absorb light. However, Tasca, Cecchetti, Zattoni, et al. (1993) used pulsed dye laser lithotripsy to fragment cystine stones by coating the stone with rifamycin, a red dye that increases the light absorption.

Some types of stone materials may be difficult to fragment into small passable pieces by any method. A notable example is calcium oxalate monohydrate, which is both hard and dense. For treatment of distal stones made of such materials, ureteroscopic extraction with basket or forceps may be more effective than attempts at fragmentation. By contrast, a calcium oxalate dihydrate stone fragments easily and is usually a good candidate for extracorporeal shock wave lithotripsy or any form of intracorporeal lithotripsy.

Ureteral calculi vary in size from less than 2 mm to greater than 2 cm in diameter. The majority of stones are less than 4 mm in width, small enough to pass spontaneously in most patients. A stone's size is an important factor—together with symptom severity, degree of obstruction, the presence or absence of infection and level of renal function—in deciding whether to manage the stone initially by observation, awaiting spontaneous passage, or to intervene actively.

Treatment methods

Accepted alternatives for treating patients with ureteral calculi can be grouped into five general categories:

- Observation (also termed “expectant management” and “watchful waiting”);
- Shock wave lithotripsy (SWL);
- Ureteroscopy (URS);
- Percutaneous nephrolithotomy (PNL); and
- Open surgery (referring to any method of open surgical exposure of the ureter and removal of stones)

In addition, laparoscopy has recently been used as a salvage procedure in special circumstances (Fahlenkamp, Schonberger, Liebetruth, et al., 1994; Gaur, Agarwal, Purohit, et al., 1994).

There is also the traditional treatment alternative of blind basketing. However, as practiced with modern methods using guide wires and fluoroscopic control, blind basketing is no longer “blind” and comparatively not the most efficacious therapeutic choice. In the past, some excellent outcomes were achieved with blind basketing in expert hands. Today, other treatment methods are available, especially SWL and URS, that in the panel’s opinion are more efficacious and safer than blind basketing even when the basket removal is augmented by fluoroscopy and guide wires.

Management by observation

As noted previously, the majority of ureteral stones are small enough to pass spontaneously with a controllable degree of patient discomfort. For these stones, observation is an obvious treatment choice. Drugs used to manage ureteral colic in the interim before passage include narcotic analgesics and nonsteroidal anti-inflammatory agents.

Pharmacologic agents have also been used to facilitate stone passage itself. In one randomized, double-blind, placebo-controlled study (Borghi, Meschi, Amato, et al., 1994), a calcium antagonist (nifedipine) was used together with a corticosteroid (methylprednisolone) to facilitate spontaneous ureteral stone passage. Engelstein, Kahan and Servadio (1992), in another randomized controlled study, used a terpenic essential oil preparation, Rowatinex™, to facilitate spontaneous passage. (Rowatinex™ has not been FDA approved for use in the United States.) The potential side effects of such medications are an important consideration if this kind of adjunctive therapy is utilized.

In deciding initially for or against active intervention, the size and location of the stone may be prime factors. Stones with a width of 5 mm or less have perhaps a 50-percent chance of spontaneous passage if in the proximal ureter and a somewhat better chance if in the distal ureter. Accurate estimation of size may be a problem because often a radiograph overestimates actual stone size and may also (about 15 percent of the time) underestimate size (Otnes and Sandnes, 1978).

However, size may not be the most important factor. If a patient is experiencing excruciating pain, active intervention may be appropriate regardless of stone size. If urinary tract infection is present, the kidney is at risk for development of pyelonephritis and/or pyonephrosis. Urgent intervention is indicated, again regardless of stone size.

Another factor is degree of obstruction. At one extreme, a patient with an asymptomatic stone in the distal ureter not causing obstruction may be observed for a year or more before the stone finally passes or a decision is made to choose an active treatment. At the other extreme—total obstruction—renal function starts to deteriorate in two weeks (Gillenwater, 1996). Also, a patient with a solitary kidney and/or transplant kidneys or with borderline renal function may not be able to tolerate any degree of obstruction.

The patient’s employment could be a factor. For example, if a patient frequently travels long distances or spends much time in foreign countries, active treatment may be indicated for even an asymptomatic ureteral stone.

Shock wave lithotripsy

Shock wave lithotripsy (SWL) has become the most frequently utilized method for active management of calculi in the urinary tract (Appendix D, page 64). SWL is based on the principle that a high-pressure shock wave will release energy when passing through areas of differing acoustic impedance. Shock waves generated outside the body can be focused onto a stone using a variety of geometric techniques. The shock wave passes through the body and releases its energy as it passes into the stone. Thousands of such shock waves may be required. The goal is to reduce the stone to particles small enough to pass without significant pain.

Many types of shock wave machines are available today. Although they are all based on the same general principle, they have significant differences with regard to treatment of ureteral calculi. The original machine, the Dornier HM-3, probably the most common machine throughout the world, has the largest focal point and, in its unmodified version, the highest power of all current devices. However, with this machine, visualizing stones in certain parts of the ureter is often difficult. In an effort to facilitate ureteral stone targeting and reduce anesthesia requirements, newer machines were developed with smaller focal points and improved fluoroscopic imaging. The trade-off is that stones treated with these "second-generation" and "third-generation" machines often require more procedures to achieve the same result produced with fewer procedures by other devices. Obviously, for large or hard stones, multiple treatments may be required.

Shock wave lithotripsy has few short-term complications, its noninvasive nature has much appeal and the technique is widely available. SWL does have disadvantages as noted previously for management of hard, dense stones not easily fragmented such as those made of calcium oxalate monohydrate. Also, because multiple treatments may be needed, SWL may not provide the required frequency of service if only mobile SWL is available and ancillary procedures may be necessary for management of fragments. Certain characteristics of individual patients, such as obesity or orthopedic problems, may make these patients poor candidates for SWL.

Concerns have been raised too regarding the use of SWL to treat distal ureteral calculi in women of childbearing age because of the theoretical possibility that unfertilized eggs and/or ovaries may be damaged. To date, no objective evidence has been discovered to support such concerns, but many centers require that women age 40 or younger be fully informed of the possibility and give their consent before treatment with SWL (Carrol and Shi, 1986; Chaussy and Fuchs, 1987; Erturk, Herrman and Cockett, 1993; Miller, Bachor and Hautmann, 1988; Vieweg, Weber, Miller, et al., 1992).

Ureteroscopy

The advent of ureteroscopy in the 1980s dramatically altered the management of symptomatic ureteral calculi. Rigid ureteroscopy has been used in conjunction with ultrasonic lithotripsy, electrohydraulic lithotripsy (EHL), laser lithotripsy and pneumatic lithotripsy to successfully fragment ureteral calculi (Beck, Vaughan and Sosa, 1989; Denstedt, Eberwein and Singh, 1992; Dretler, 1990; Preminger and Roehrborn, 1989; Schulze, Haupt, Piergiovanni, et al., 1993). Also, many stones can be removed with basket extraction under direct vision after dilation of the intramural ureter.

Improvements in fiberoptics and irrigation systems have fostered the use of smaller semirigid ureteroscopes (6.9 to 8.5 F.). The introduction of the semirigid miniscope (Dretler and Cho, 1989) and the flexible deflectable ureteroscopes have made access to the upper ureter and intrarenal collecting system a safer and less tedious procedure (Beck, Vaughan, and Sosa, 1989; Huffman, 1989; Preminger and Roehrborn, 1989). However, the extremely small working channel of the semirigid and flexible instruments, which ranges from 2.4 to 4.0 F., has limited the size and usefulness of instruments that can be passed through these ureteroscopes and used for stone removal. Indeed, for larger stones in the proximal ureter, the 3 F. basket or grasping forceps are often inadequate to accomplish successful stone extraction. The limitation of available instrumentation and the danger of avulsion have prompted use of intracorporeal lithotripsy for the management of larger upper ureteral and intrarenal calculi.

Currently the three most commonly employed methods for intracorporeal lithotripsy of ureteral stones, via the flexible, semirigid or rigid ureteroscope, are EHL, laser lithotripsy and pneumatic lithotripsy. Ultrasonic lithotripsy is occasionally used for lower ureteral calculi, but its use has been supplanted to a large extent by the above three methods. Although the choice of which type of intracorporeal lithotripsy to employ is frequently based on the location and composition of the stone to be treated, more often the experience of the clinician and availability of equipment dictate this choice. (Intracorporeal lithotripsy methods are described in detail on pages 67-69 of Appendix D.)

Percutaneous stone removal

Percutaneous nephrolithotomy (PNL), which became popular as a primary technique for stone removal in the early 1980s (Appendix D, page 69), can theoretically be used for all stones. In practice, shock wave lithotripsy (SWL) and ureteroscopy (URS) are now used in the majority of situations where PNL was once employed to remove ureteral calculi. However, large stones or complex, impacted stones in the proximal ureter are often best managed by PNL.

The procedure may be divided into two parts, access and stone removal. To achieve percutaneous access, the urologist or radiologist places a small flexible guide wire, under fluoroscopic control, through the patient's flank into the kidney and down the ureter. Care is taken to optimize the approach to the kidney through an upper or middle calyx access position so that the best approach to the ureter is obtained. Once access is achieved, the tract is dilated to 24-30 F. and a rigid or flexible nephroscope or ureteroscope is introduced. Under direct vision, the stone may be removed intact or broken up (with some form of intracorporeal lithotripsy) and the pieces removed.

PNL has unquestioned advantages: (1) If the stone can be seen, it can almost always be destroyed. (2) The ureter may be directly inspected so that small fragments may be identified and removed. (3) The process is rapid, with success or failure being obvious immediately.

Hospitalizations are usually 3 to 5 days, with most patients returning to light activity after 1 to 2 weeks. Transfusion rates for PNL in treating ureteral calculi vary from 2 to 6 percent. Retreatment rates, that is, the rate at which the instrument must be reinserted through the tract to remove residual stones, vary from 10 percent in simple situations to 40-50 percent for more complicated problems. Stone-free rates of 75-90 percent are regularly achievable using PNL.

One disadvantage of PNL is that the expertise required for this operation is not as widely available as it once was, because a greater number of urology training programs are focusing less on PNL and more on shock wave lithotripsy and ureteroscopy for stone management.

Open surgery

A variety of specific operations may be performed in order to remove a ureteral calculus. Depending on anatomy and stone location, a ureterolithotomy may be performed either through a flank, dorsal or anterior skin incision. However, standard ureterolithotomy is rarely performed today, except in cases of complex patient anatomy or large volume ureteral calculi.

Hospitalization in current practice ranges from 2 to 7 days. Average postoperative disability is 4 to 6 weeks, based on the fact that a typical incision has regained about 80 percent of its preoperative strength by then; but recent investigation suggests that months may pass before many patients feel completely normal (Assimos, Wrenn, Harrison, et al., 1991). As of 1996, the incidence of open surgery for the treatment of all stones was about 1 to 2 percent. In most cases, the surgery was used to treat renal staghorn calculi.

Stenting

Although not a major treatment option, ureteral stenting may play an important adjunctive role in overall management of patients with ureteral stones. For example, patients with sepsis and associated obstruction may require internal drainage (using a stent) or external drainage (using percutaneous nephrostomy). Stents may also provide a "bail out" option in difficult interventions, as in cases of impacted stones.

Chapter 3 – Outcomes analysis for ureteral calculi treatment alternatives

For purposes of comparative analysis, outcomes of a therapeutic medical intervention can be categorized as either beneficial or harmful (Eddy, 1990, 1992). The Ureteral Stones Clinical Guidelines Panel analyzed in detail available outcomes data for the main potential benefit (being stone free) and the main potential harms (possible complications) of alternative approaches to treating ureteral stones. The panel also analyzed outcomes data for the number of primary and secondary procedures per patient with each approach.

Results of the panel's analysis are summarized as probability estimates in the outcomes balance sheet tables on pages 18–21 and in the more detailed outcomes balance sheet tables on pages 48-62 of Appendix B. The data extraction and evidence combination processes that produced the probability estimates are described on pages 9–10 of Chapter 1. The evidence tables showing the raw data are available in the *Evidence Working Papers* for this report.

Combined outcomes data

The outcomes balance sheet tables

The term "balance sheet," as applied to the display of outcomes information, refers to a table or tables that list "beneficial and harmful health outcomes and their magnitudes, including a range of uncertainty for each" (Eddy, 1992). This form of summary display, Eddy notes, allows the "simultaneous consideration of all the important outcomes."

The outcomes balance sheet tables on pages 18–21 summarize results following Confidence Profile (FAST*PRO) meta-analyses of combined outcomes data from the ureteral calculi treatment literature. The meta-analytic process used is described in Chapter 1. Results are displayed in the tables as outcome probability estimates in the form of percentages. In most cases, a 95-percent confidence interval (95% CI) is reported along with a median probability. It should be noted that "median" in these tables is the median of the probability distribution resulting from FAST*PRO meta-analysis (Eddy, Hasselblad and Shachter, 1990). It is not the median of an array of individual study results. A table's G/P columns show the number of patient groups (G) for a given outcome and the total number of patients (P) in those groups. A cell marked "No data" indicates insufficient extractable data for a given outcome.

The three major types of probability estimates in the tables mirror the three types of outcomes analyzed by the panel: stone-free rate, number of primary and secondary procedures per patient and treatment complications. The panel stratified all outcomes by stone location in either the proximal or the distal ureter (see page 11 for definition). The tables therefore display probability estimates separately for the proximal ureter and the distal ureter, either in separate tables or in two separate sets of columns within a table. Stone-free rates and numbers of procedures per patient are further stratified in the tables by two categories of stone size: less than or equal to 1.0 cm and greater than 1.0 cm in diameter. Stone-free rates are also represented graphically in Figures 1 and 2 on page 22, stratified by both location and size. A third set of columns in each of the outcomes balance sheet tables displays unstratified outcome probability estimates under the heading "Overall."

The outcomes balance sheet tables provide outcome probability estimates for the following treatment alternatives:

- Extracorporeal shock wave lithotripsy (SWL);
- Ureteroscopy (URS);
- Percutaneous nephrolithotomy (PNL);
- Blind basket extraction;
- Open surgery; and
- Observation.

The outcome estimates for blind basket extraction, in the tables for the distal ureter, are based on data for basket manipulation of distal stones without use of guide wires and fluoroscopic control. The panel does not recommend such “truly blind” blind basketing (see pages 12 and 28). However, published data for basket extraction with guide wires and fluoroscopy were insufficient to generate outcome estimates for the balance sheet.

There are also no outcome estimates in the outcomes balance sheet tables for blind basket manipulation of stones in the proximal ureter. Because of the high risk of morbidity, blind basketing is seldom used to extract proximal stones and few data are available for this procedure. For similar reasons, the balance sheet also omits outcome estimates for PNL in the distal ureter. PNL is rarely used to remove distal stones. The procedure has been used only in special circumstances such as for patients who have failed both SWL and URS or patients with a ureteral stricture distal to the stone that impedes passage of fragments or the introduction of a ureteroscope.

For SWL, the panel stratified the outcome estimates by three specific treatment methods: (1) pushback (stone manipulation back into the renal collecting system); (2) bypass of the stone with an externalized or internalized stent; (3) in situ (with no ureteral manipulation). Estimates are displayed in the balance sheet’s SWL tables with a separate row for each of these three methods. A fourth row shows combined results for all methods.

URS results could not be stratified by type of method—stone retrieval or intracorporeal lithotripsy—because the designs of most URS studies with extractable data would not permit such analysis. Open surgery could not be stratified by incisional approach because the approach was too often not specified. Laparoscopic ureterolithotomy was not included as a treatment alternative because of the paucity of reported cases and the small number of urologists who routinely perform laparoscopic procedures. Similarly, only the results from treating patients with single ureteral stones could be analyzed because of the paucity of data on treatment of patients with multiple stones.

SWL stone-free rates in the outcomes balance sheet tables are based on combined results from both mobile and fixed lithotripters. Studies by Cass and by Mobley, Myers, Jenkins, et al. produced results for the largest numbers of treated patients (see Table A-1 in Appendix A, Papyrus numbers 3114, 3546, 3889, 5023 and 5369). These results were achieved by a large number of treating physicians who performed SWL using mobile lithotripters. Because of the large numbers, the panel performed an analysis to assess whether results reported in the Cass and Mobley studies were different from results reported by other studies in which fixed lithotripsy sites were used. The panel found overlap in most instances and therefore decided to combine the data. The panel was unable to determine relative efficacy of different lithotripters, even though studies reporting results employed a variety of devices, because the design of these studies did not permit a valid comparison.

Data regarding acute and long-term SWL complications were, for the most part, not reported from mobile sites. The panel therefore used only SWL data from fixed sites to generate probability estimates for complications. Data were available from mobile sites regarding primary and secondary procedures per patient. However, the retreatment rate was significantly lower in the mobile site data as compared to the data from fixed sites. The panel felt this lower rate was the result of the limited, intermittent availability of the mobile sites and decided to use only data from fixed sites in analyzing primary and secondary procedures per patient.

General limitations to combining outcomes data

Those outcome estimates in the outcomes balance sheet tables with wide confidence intervals suggest considerable uncertainty in the medical knowledge base. One reason may be data limitations because of relatively few studies of a given treatment alternative or because of few studies reporting a given outcome directly. The short duration of many studies introduces uncertainty as well.

Two major reasons for outcome estimates with wide confidence intervals are: (1) wide variations from study to study in reported incidence of certain outcomes (such as acute complications) and (2) the wide variability in how studies have reported treatment data. For example, the definition of ureteral calculi may differ significantly among various investigators, and some of the reports do not specify such factors as the size of the stones. Thus, not all studies may be comparing treatment outcomes for stones of similar size, composition or location within the ureter. In these cases, the panel attempted to extrapolate from existing information to equate the treatment outcomes.

The combined analysis may be weakened too by the quality of individual studies. As noted previously, there are currently few randomized, controlled trials for treatment of ureteral calculi. Therefore, most of the data analyzed by the panel came from clinical series. The limitations of including these types of studies are obvious. (See the discussion of limitations on page 10 of Chapter 1.) Yet, if clinical series were not included, little could be said about the benefits and harms of various treatments for ureteral stones.

It should also be remembered that management of patients with ureteral stones is unique in that the majority of patients with a "disease" (a symptomatic stone) are spontaneously "cured" (the stone passes). This fact and the fact that it is not always possible to predict the behavior of the stone mean that the results of treatment could be inadvertently biased. In an extreme example, treatment with SWL of a series of stones less than 4 mm in diameter would yield spectacular but meaningless results.

Despite such limitations, the panel believes that the confidence intervals contain the true probability of a given outcome for most study sites. Better estimates, narrower confidence intervals and greater certainty about treatment differences can be obtained through large, well-controlled studies that test different treatments in the same patient population. However, until these types of outcome studies are completed, guidance can still be given to the physicians and patients who need to make decisions at the present time.

Analysis of outcomes in balance sheet tables

The following sections discuss the analysis used to generate the outcome probability estimates in the outcomes balance sheet tables. The information is organized in relation to major types of outcomes, beginning with stone-free rates. As noted previously (page 15), additional tables are contained in Appendix B (pages 48-62) and in the *Evidence Working Papers*. These additional tables include FAST*PRO analysis tables.

Stone-free rate

In the panel's expert opinion, the stone-free rate provides an objective outcome measure for evaluating the efficacy of treatment. Stone-free status is especially important for patients with ureteral stones because residual fragments are much less likely to remain "clinically dormant" in the ureter than are most fragments (other than struvite) remaining in the kidney.

Estimated probabilities of being stone free after SWL, URS, PNL, blind basket extraction and open surgery are displayed in two balance sheet tables on page 18, one for the proximal ureter and one for the distal ureter. The reported stone-free rates may be slightly overestimated because the majority of studies in the present analysis utilized only a plain abdominal radiograph (KUB) to assess stone-free status. This radiographic method may underestimate the incidence of residual fragments in the ureter. The degree of error, however, is not so high as when a KUB is used to detect renal fragments.

Each of the two balance sheet tables on page 18 contains three categories of stone-free rates. Two of the categories stratify rates by stone size (≤ 1.0 cm and > 1.0 cm). The third is an "Overall" category that displays stone-free rates unstratified by stone size. The data used to generate stone-free rates in the "Overall" category came from many sources. These sources include the studies that provided stone-free data for the two size categories, but they include many other studies as well. This is evident from the much larger numbers in the G/P column under "Overall." Thus, the stone-free rates in the "Overall" category, based partly on different data, should be considered independently from the stone-free rates categorized by stone size.

To determine likelihood of being stone free with management by observation rather than active intervention, the panel sought to combine available data on spontaneous passage and develop probability estimates in relation to such factors as stone size and location. Unfortunately, because of differences in how results have been reported in various studies, the available data were incompatible and could not be combined. The studies differed, for example, not only in their groupings of patients by stone size, but in their time frames for spontaneous passage.

(*continued on page 23*)

Outcomes balance sheet

Stone - free rates

(includes data from fixed and mobile lithotriptor articles)

PROXIMAL URETER	Overall			Stones <= 1.0 cm			Stones > 1.0 cm		
	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%
SWL overall	78 / 17,742	83%	(81 - 85)%	17 / 8,052	84%	(83 - 85)%	14 / 2,708	72%	(68 - 76)%
SWL w pushback	17 / 1,697	88%	(83 - 92)%	3 / 348	77%	(72 - 81)%	1 / 127	65%	(56 - 72)%
SWL w bypass	14 / 3,749	82%	(77 - 86)%	3 / 2,039	83%	(77 - 88)%	3 / 846	76%	(62 - 87)%
SWL in situ	52 / 9,744	82%	(79 - 85)%	11 / 5,167	87%	(85 - 88)%	9 / 1,427	76%	(73 - 79)%
PNL	22 / 612	86%	(82 - 89)%	2 / 8	76%	(33 - 98%)	3 / 37	74%	(53 - 89)%
Ureteroscopy	62 / 1,769	72%	(70 - 74)%	9 / 54	56%	(43 - 70)%	5 / 42	44%	(28 - 60)%
Open surgery	10 / 265	97%	(93 - 99)%	1 / 68	99%	(96 - 100)%	2 / 2	71%	(23 - 98)%

DISTAL URETER	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%
SWL overall	66 / 9,422	85%	(83 - 88)%	11 / 4,267	85%	(84 - 86)%	8 / 1,025	74%	(71 - 77)%
SWL w pushback	1 / 15	79%	(56 - 94)%			No data			No data
SWL w bypass	7 / 1,012	86%	(79 - 92)%	2 / 481	83%	(78 - 87)%	2 / 207	68%	(59 - 75)%
SWL in situ	47 / 7,211	86%	(83 - 88)%	8 / 3,676	85%	(82 - 88)%	6 / 810	76%	(66 - 83)%
Blind basket extraction	11 / 943	73%	(64 - 81)%	2 / 93	85%	(72 - 93)%	1 / 12	50%	(24 - 76)%
Ureteroscopy	59 / 3,978	90%	(88 - 92)%	5 / 130	89%	(82 - 95)%	6 / 100	73%	(63 - 82)%
Open surgery	6 / 72	87%	(73 - 96)%	1 / 2	90%	(33 - 100)%	1 / 1	84%	(15 - 100)%

SPONTANEOUS PASSAGE

Ranges as reported in the literature

	<=5mm	5 - 10 mm
Proximal Ureter	29 - 98%	10 - 53%
Distal Ureter	71 - 98%	25 - 53%

[1]G = number of groups/treatment arms extracted / P =number of patients in those groups
[2]CI = Confidence interval

Outcomes balance sheet *(continued)*

Procedures per Patient - DISTAL URETER

	Overall				
	Primary		Secondary		Total
	G/P[1]	Procs[2]	G/P[1]	Procs[2]	Procs[2]
SWL overall	49 / 3,758	1.21	29 / 2,627	0.08	1.29
SWL w pushback	1 / 15	1.00	No data		1.00
SWL w bypass	6 / 434	1.13	4 / 346	0.05	1.18
SWL in situ	31 / 2,335	1.24	20 / 1,743	0.09	1.33
Blind basket extraction	11 / 1,175	1.04	7 / 1,052	0.07	1.11
Ureteroscopy	42 / 2,283	1.01	15 / 847	0.07	1.08
Open surgery	6 / 72	1.01	2 / 17	0.12	1.13

	Stones <= 1.0 cm				
	Primary		Secondary		Total
	G/P[1]	Procs[2]	G/P[1]	Procs[2]	Procs[2]
SWL overall	5 / 95	1.27	1 / 43	0.09	1.36
SWL w pushback	No data		No data		0.00
SWL w bypass	No data		No data		0.00
SWL in situ	4 / 94	1.28	1 / 43	0.09	1.37
Blind basket extraction	1 / 1	1.00	1 / 1	1.00	2.00
Ureteroscopy	5 / 129	1.00	2 / 31	0.13	1.13
Open surgery	1 / 2	1.00	No data		1.00

	Stones > 1.0 cm				
	Primary		Secondary		Total
	G/P[1]	Procs[2]	G/P[1]	Procs[2]	Procs[2]
SWL overall	3 / 19	2.37	No data		2.37
SWL w pushback	No data		No data		0.00
SWL w bypass	No data		No data		0.00
SWL in situ	2 / 16	2.63	No data		2.63
Blind basket extraction	No data		No data		0.00
Ureteroscopy	5 / 69	1.07	1 / 22	0.05	1.12
Open surgery	1 / 1	1.00	No data		1.00

Procedures per patient - PROXIMAL URETER

	Overall				
	Primary		Secondary		Total
	G/P[1]	Procs[2]	G/P[1]	Procs[2]	Procs[2]
SWL overall	58 / 5,875	1.25	30 / 2,727	0.15	1.40
SWL w pushback	15 / 1,328	1.11	6 / 639	0.11	1.22
SWL w bypass	9 / 449	1.04	6 / 312	0.10	1.14
SWL in situ	31 / 2,334	1.32	15 / 1,126	0.17	1.49
PNL	20 / 594	1.02	13 / 513	0.11	1.13
Ureteroscopy	48 / 1,193	1.04	19 / 631	0.29	1.33
Open surgery	8 / 227	1.00	1 / 20	0.10	1.10

	Stones <= 1.0 cm				
	Primary		Secondary		Total
	G/P[1]	Procs[2]	G/P[1]	Procs[2]	Procs[2]
SWL overall	8 / 199	1.10	2 / 124	0.06	1.16
SWL w pushback	1 / 9	1.00	No data		1.00
SWL w bypass	No data		No data		0.00
SWL in situ	5 / 117	1.12	No data		1.12
PNL	2 / 8	1.00	No data		1.00
Ureteroscopy	8 / 37	1.00	1 / 16	0.38	1.38
Open surgery	1 / 68	1.00	No data		1.00

	Stones > 1.0 cm				
	Primary		Secondary		Total
	G/P[1]	Procs[2]	G/P[1]	Procs[2]	Procs[2]
SWL overall	5 / 215	1.40	2 / 256	0.25	1.65
SWL w pushback	No data		No data		0.00
SWL w bypass	No data		No data		0.00
SWL in situ	3 / 57	1.86	No data		1.86
PNL	3 / 37	1.05	1 / 34	0.09	1.14
Ureteroscopy	5 / 42	1.14	1 / 26	0.38	1.52
Open surgery	1 / 1	1.00	No data		1.00

[1]G =number of groups/treatment arms extracted / P = number of patients in those groups
[2]Procs = Procedures

Outcomes balance sheet *(continued)*

Acute Complications

DEATH

ALL Modalities: Death is rare in the treatment of ureteral stones. Consequently, there are insufficient reported data to calculate meaningful rates. The risk, in the panel's opinion, is extremely low.

LOSS of KIDNEY

ALL Modalities: Loss of kidney, like death, is a rare event in the treatment of ureteral stones. Although reported data are insufficient to calculate meaningful rates, in the panel's opinion, the risk is extremely low.

TRANSFUSION

ALL Modalities: Transfusion data, as reported in the literature for treatment of ureteral stones, are insufficient to calculate meaningful rates for the various modalities; but transfusion rates are likely to be higher for invasive procedures such as PNL and open surgery than for noninvasive and minimally invasive procedures.

	Overall			Proximal Ureter			Distal Ureter		
SIGNIFICANT	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%
SWL overall	15 / 1,931	2%	(1 -3)%	4 / 516	4%	(2 - 7)%	4 / 334	4%	(2 - 7)%
SWL w pushback	2 / 336	2%	(1 - 3)%	2 / 336	2%	(1 - 3)%			No data
SWL w bypass	1 / 47	3%	(0 - 10)%	1 / 47	3%	(0 - 10)%			No data
SWL in situ	7 / 733	4%	(3 - 6)%	4 / 469	4%	(2 - 7)%	1 / 97	3%	(1 - 8)%
PNL	7 / 230	8%	(5 - 13)%	5 / 159	9%	(5 - 15)%	n/a	n/a	n/a
Blind basket extraction	9 / 2,117	7%	(3 - 12)%	n/a	n/a	n/a	5 / 775	5%	(3 - 8)%
Ureteroscopy	31 / 3,260	4%	(3 - 6)%	4 / 110	11%	(5 - 18)%	3 / 83	9%	(3 - 20)%
Open surgery	6 / 584	13%	(10 - 16)%	3 / 65	8%	(2 - 19)%			No data
LESS SIGNIFICANT	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%
SWL overall	14 / 1,527	4%	(3 - 7)%	9 / 803	6%	(3 - 9)%	2 / 95	9%	(1 - 26)%
SWL w pushback	5 / 831	4%	(3 - 6)%	5 / 831	5%	(3 - 7)%			No data
SWL w bypass	3 / 91	17%	(9 - 28)%	3 / 91	17%	(9 - 28)%			No data
SWL in situ	6 / 492	5%	(2 - 8)%	4 / 356	4%	(2 - 7)%	1 / 39	16%	(7 - 29)%
PNL	12 / 544	12%	(7 - 19)%	10 / 425	13%	(7 - 21)%	n/a	n/a	n/a
Blind basket extraction	5 / 1,355	1%	(1 - 3)%	n/a	n/a	n/a	2 / 215	3%	(1 - 6)%
Ureteroscopy	58 / 7,545	6%	(5 - 7)%	4 / 163	11%	(5 - 18)%	5 / 1,124	1%	(1 - 2)%
Open surgery	7 / 389	6%	(4 - 10)%	4 / 126	10%	(5 - 19)%	2 / 55	8%	(2 - 21)%

[1]G = number of groups/treatment arms extracted / P = number of patients in those groups
[2]CI = Confidence interval

Outcomes balance sheet *(continued)*

Secondary Interventions

	Overall			Proximal Ureter			Distal Ureter		
	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%
SWL overall	72 / 8,350	12%	(10 - 14)%	30 / 2,727	15%	(12 - 19)%	29 / 2,627	10%	(8 - 12)%
SWL w pushback	7 / 688	13%	(8 - 19)%	6 / 639	12%	(10 - 15)%			No data
SWL w bypass	10 / 667	10%	(7 - 14)%	7 / 312	12%	(8 - 18)%	4 / 346	6%	(2 - 11)%
SWL in situ	45 / 4,660	12%	(10 - 15)%	15 / 1,126	17%	(13 - 23)%	20 / 1,743	10%	(8 - 12)%
PNL	15 / 584	16%	(12 - 21)%	13 / 513	15%	(10 - 21)%	n/a	n/a	n/a
Blind basket extraction	19 / 2,568	12%	(8 - 18)%	n/a	n/a	n/a	7 / 1,052	10%	(5 - 16)%
Ureteroscopy	80 / 8,744	11%	(10 - 12)%	19 / 631	27%	(22 - 33)%	15 / 847	7%	(5 - 10)%
Open surgery	5 / 234	9%	(6 - 15)%	1 / 20	11%	(2 - 28)%	2 / 17	18%	(4 - 45)%

Long - Term Complications

	Overall			Proximal Ureter			Distal Ureter		
STRICTURE	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%	G/P[1]	Median	CI[2] (2.5 - 97.5)%
SWL overall			No data			No data			No data
SWL w pushback			No data			No data			No data
SWL w bypass			No data			No data			No data
SWL in situ			No data			No data			No data
PNL	7 / 166	8%	(4 - 14)%	4 / 93	8%	(3 - 16)%	n/a	n/a	n/a
Blind basket extraction	3 / 483	2%	(1 - 4)%	n/a	n/a	n/a	1 / 193	1%	(0 - 3)%
Ureteroscopy	38 / 3,414	2%	(1 - 2)%	7 / 218	2%	(1 - 4)%	7 / 450	1%	(0 - 2)%
Open surgery	2 / 108	3%	(0 - 11)%	1 / 50	1%	(0 - 5)%			No data

[1]G = number of groups/treatment arms extracted / P = number of patients in those groups
[2]CI = Confidence interval

Figure 1. Stone-free rates: Proximal ureter

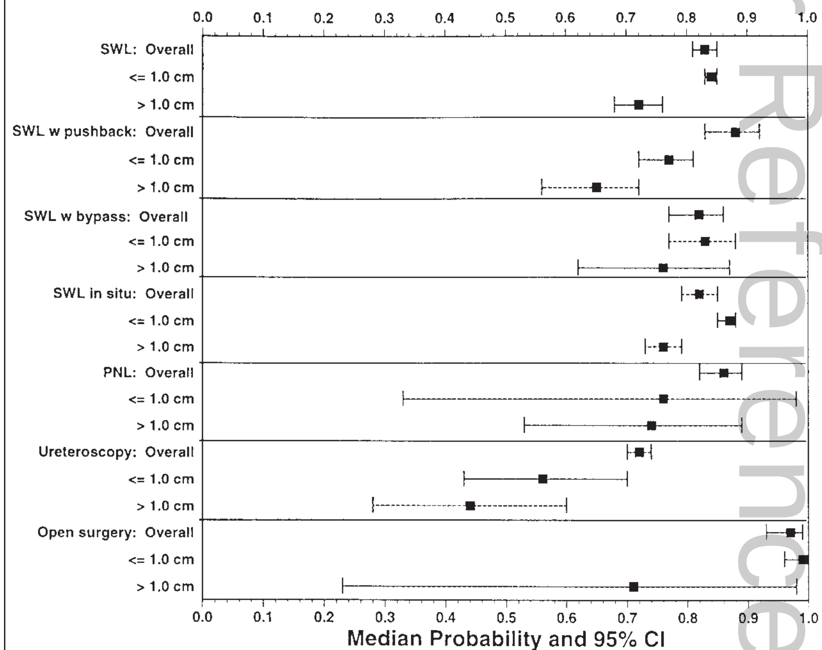
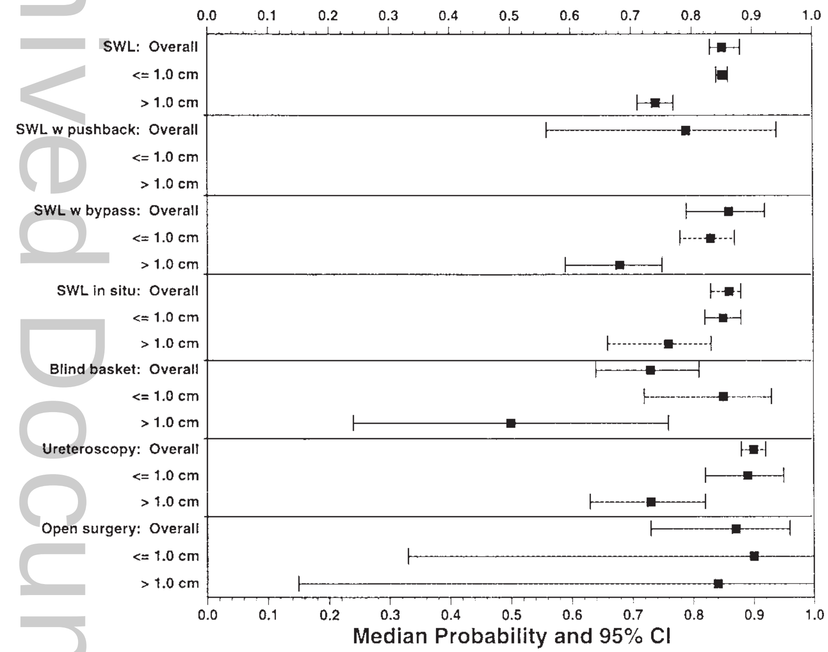


Figure 2. Stone-free rates: Distal ureter



Figures 1 and 2 compare in graphic form the stone-free rates of the various treatment modalities for the proximal and distal ureter. The graph's horizontal axis is marked off (top and bottom) in gradations from 0.0 to 1.0. Down the vertical axis (left) are listed the treatment modalities. For each treatment, there is a set of two brackets representing a 95 percent confidence interval. The dark square on the line between the brackets represents the median probability estimate. For comparing treatment modalities with regard to stone-free rate, note where the brackets and squares are located along the horizontal axis. Note also the distance between the two brackets in each set. Narrower brackets (confidence intervals) indicate greater certainty regarding the probability estimate.

Unable to develop probability estimates for spontaneous passage, the panel decided simply to display in the balance sheet the lows and highs in reported percentages of stones passing spontaneously, stratified by location in either the proximal or the distal ureter and by two size categories (5 mm or less and 5-10 mm). Not surprisingly, stones 5 mm or less in diameter located in the distal ureter appear most likely to pass spontaneously. The lowest percentage reported is relatively high at 71 percent, and the range from low to high is relatively narrow. Tables 1 and 2 on this page and page 24 show the raw data for spontaneous passage of ureteral stones as reported in six studies.

Procedures per patient (primary and secondary)

The number of procedures per patient to achieve a successful result is an important outcome. A primary procedure is considered the initial type of intervention used for stone removal. For example, if an individual first underwent SWL and subsequently required another SWL treatment, the patient would have been subjected to two primary procedures. A secondary procedure is any other intervention used for stone removal or management of a complication. For illustration, if a patient initially was subjected to PNL for treatment of a proximal ureteral stone, then required SWL to be rendered stone free as well as angiographic embolization for management of a PNL-induced arteriovenous fistula, the individual would have undergone one primary procedure and two secondary procedures.

The panel decided to use only data from fixed lithotripsy centers for this analysis because of the possibility of altered practice patterns due to lithotripter availability in mobile sites (see page 16). A stratification based on stone location (proximal or distal) was possible. However, there were not sufficient data to analyze the effects of stone size on these parameters. The mean numbers of primary and secondary interventions per patient are listed in the outcomes balance sheet tables for active interventions.

Table 1. Spontaneous passage of small ureteral stones

Source	Stone size as reported	Location as reported	Sample size	Percentage passed in time frame
Brown, 1985	<5 mm	Ureter	100	88% in 3 months 98% in 1 year
Ueno et al., 1977	1-5 mm width 1-5 mm length	Ureter Ureter	311 138	75% in 1 year 88% in 1 year
Morse and Resnick, 1991	1-5 mm 1-5 mm	Proximal ureter Middle ureter Distal ureter	65 25 267	22% in 300 days 60% in 300 days 71% in 300 days
Ohkawa et al., 1993	1-5 mm	Ureter	846	91% unspecified
Kinder et al., 1987	<5 mm	Upper 1/3 Middle 1/3 Lower 1/3 Vesico-ureteric junction	84 total	75% unspecified 100% unspecified 100% unspecified 94% unspecified
Sandegaard, 1956	<4 mm	Upper ureter	42	26% in 1 week 43% in 2 weeks 55% in 4 weeks 69% in 12 weeks 81% in 18 months
		Lower ureter	192	70% in 1 week 82% in 2 weeks 85% in 4 weeks 90% in 12 weeks 93% in 18 months

Table 2. Spontaneous passage of large ureteral stones

Source	Stone size as reported	Location as reported	Sample size	Percentage passed in time frame
Brown, 1985	5-7 mm	Ureter	16	44% in 1 year
Ueno et al., 1977	6-9 mm width 6-35 mm length	Ureter Ureter	199 359	19% in 1 year 41% in 1 year
Morse and Resnick, 1991	6 mm	Distal ureter	8	25% in 300 days
Ohkawa et al., 1993	6-10 mm 11-15 mm 16-20 mm >20 mm	Ureter Ureter Ureter Ureter	1080 845 176 178	53% unspecified 10% unspecified 2% unspecified 0% unspecified
Kinder et al., 1987	≥6 mm	Upper 1/3 Middle 1/3 Lower 1/3 Vesico-ureteric junction	32 total	10% unspecified 14% unspecified 40% unspecified 45% unspecified
Sandegaard, 1956	4-6mm	Upper ureter Lower ureter	51 39	2% in 1 week 2% in 2 weeks 2% in 4 weeks 2% in 12 weeks 12% in 18 months 18% in 1 week 23% in 2 weeks 26% in 4 weeks 33% in 12 weeks 46% in 18 months

Acute complications

In the panel's opinion, patients would be most concerned about the risks of four acute complications: (1) death, (2) loss of kidney, (3) transfusion requirement and (4) the need for unplanned secondary interventions. Therefore, information regarding these outcomes is provided separately in the balance sheet.

The data extraction form (Appendix C) lists a number of other acute complications. These were categorized as either significant or less significant complications for the outcomes balance sheet tables on page 20. More detailed tables are on pages 48-62 of Appendix B. Significant complications include ureteral avulsion, visceral injury, sepsis, vascular injury, hydro- or pneumothorax, pulmonary embolism and urinoma. Avulsion is a potential major complication of URS for proximal ureteral stones. Reported data were limited, but the panel believes the risk is less than 1.0 percent. Examples of less significant complications are ureteral perforation, perirenal hematoma, ileus, steinstrasse, wound infection, UTI and stent migration.

Because complications were not reported based on stone size in any of the series, risks for complications are stratified in the outcomes balance sheet tables only by stone location in either the proximal or the distal ureter.

The majority of the articles abstracted did not mention mortality risks. Therefore, the risk for this complication is listed as very low in the balance sheet for all treatment options. The same is true for the risk of kidney loss. Regarding transfusion, data reported for all treatment alternatives (including PNL and open surgery) were too limited to calculate meaningful probability estimates. In the panel's opinion, however, the risks are clearly greater for PNL and open surgery.

For distal stones, the data are sparse regarding development of significant acute complications after SWL and after open surgical removal. The estimated risk for in situ SWL calculated by FAST*PRO analysis was 3.0 percent (95% CI

1.0-8.0 percent), but the estimated risks for bypass and pushback techniques could not be determined from the available data. However, the estimated overall risk of significant complications after SWL (for distal calculi) using any of these techniques was 4.0 percent (95% CI 2.0-7.0 percent). In the panel's opinion, this estimate is applicable to SWL of distal stones using stent bypass or pushback as it is somewhat higher than the in situ rate and reflects the more invasive nature of these treatments. An estimated risk for development of significant acute complications after open surgical removal of distal calculi could not be generated with the FAST*PRO technique. In the panel's opinion, the risk would be equivalent to the risk after open surgical removal of proximal ureteral calculi.

Long-term complications

The development of ureteral stricture was the only long-term complication reported with sufficient extractable data for any of the treatment options. Stricture is not always secondary to the intervention, but may be induced by an inflammatory reaction from the stone, especially when impacted. The actual risk of stricture is probably higher than reported for some treatments since development of this problem is often clinically silent and many patients are not routinely subjected to postoperative upper urinary tract radiographic studies. However, with ureteroscopic removal, the current stricture rate may be lower since many of the data for this therapeutic approach were from earlier series when surgeons had neither the technical experience they have today nor the smaller semirigid and flexible ureteroscopes and array of intracorporeal lithotripsy devices available today.

The estimated risk for stricture after treatment of proximal ureteral stones, as determined by FAST*PRO analysis, was 8.0 percent (95% CI 3.0-16.0 percent) for PNL, 2.0 percent (95% CI 1.0-4.0 percent) for ureteroscopic removal and 1.0 percent (95% CI 0-5.0 percent) for open surgery. No data were available for SWL. The relatively high estimated risk after treatment by PNL (8.0 percent) may reflect the selection for PNL of large, hard, impacted or multiple proximal stones that have failed other treatments.

The estimated risk for stricture after removal of distal ureteral stones was 1.0 percent (95% CI 0-2.0 percent) for ureteroscopy. Data were not sufficient to generate distal stone probability estimates for SWL, blind basketing or open surgery.

Chapter 4 – Ureteral calculi treatment recommendations

The Ureteral Stones Clinical Guidelines Panel generated the recommendations in this chapter based primarily on outcome estimates derived from data reported in the literature. Where reported data were insufficient, the panel added its expert opinion in making recommendations. The methodology is described in Chapter 1.

Panel conclusions from literature review and data analysis

The panel concluded from reviewing the literature and analyzing the data that the following outcome probabilities are the most significant in setting forth recommendations for management of ureteral calculi:

- the probability of being stone free following treatment;
- the probability of undergoing more than one primary procedure;
- the probability of undergoing secondary, unplanned procedures; and
- the probability of having complications or other morbidity associated with treatment.

There are six methods for primary management of ureteral stones: (1) shock wave lithotripsy (SWL); (2) ureteroscopy (URS); (3) percutaneous removal of ureteral stones (PNL); (4) open surgery; (5) blind basket extraction; and (6) observation.

Most stones in the United States are managed by either endourology or shock wave lithotripsy, and most training programs in the U.S. and Canada emphasize nonsurgical approaches. As noted on page 12, oral pharmacologic agents have also been used in an effort to optimize stone passage (Borghi, Meschi, Amato, et al., 1994; Engelstein, Kahan and Servadio, 1992).

In the panel's opinion, open surgery should not be the first-line treatment in most standard patients (see panel recommendations below). This opinion is grounded in the fact that, in most patients, hospitalization and postoperative morbidity are significantly less with SWL and endourology than with any open surgical technique.

Shock wave lithotripsy is the least invasive option available, but also the most likely to require multiple primary treatments and secondary interventions in both the proximal and distal ureter.

Ureteroscopy, particularly in the distal ureter, has the highest stone-free rates but is more invasive than SWL.

Although PNL is theoretically an effective treatment modality for any ureteral stone, on a practical basis it is almost always used as a salvage procedure for unsuccessful SWL or URS or in special situations such as large proximal impacted ureteral calculi.

Standard and nonstandard patients

Panel recommendations for the treatment of ureteral calculi apply to standard and nonstandard patients as delineated by the following criteria:

The **standard patient** is defined as a nonpregnant adult:

- who has a solitary ureteral stone composed of material other than cystine or uric acid;
- who has not been previously treated for this stone;
- whose medical condition, including renal functional status, body habitus and urinary tract anatomy, permit performance of any of the accepted active treatment modalities including use of anesthesia;
- whose situation is such that all accepted modalities are available and that permits use of any of these modalities.

Nonstandard patients are defined as prepubescent children and other patients who do not meet the above criteria delineating the standard patient. For nonstandard patients, the choice of available treatment options may be limited.

Panel recommendations

The terms “standard,” “guideline” and “option,” as used in the panel’s recommendations, refer to the three levels of flexibility for practice policies defined in Chapter 1 (page 8). A standard is the least flexible of the three, a guideline more flexible and an option the most flexible. Options can exist because of insufficient evidence or because patient preferences are divided. In the latter case particularly, the panel considered it important to take into account likely preferences of individual patients when selecting from among alternative interventions.

The first three recommendations below apply to both proximal and distal ureteral stones. Subsequent recommendations are categorized, first, by whether the stone is located in the proximal or distal ureter and, second, by whether the stone is 1 cm or less in diameter or greater than 1 cm in diameter. The proximal or upper ureter is divided from the distal or lower ureter at the point where the ureter narrows as it curves over the iliac vessels.

Recommendation: For stones with low probability of spontaneous passage

> **Standard:** A patient who has a ureteral stone with a low probability of spontaneous passage must be informed about the existing active treatment modalities, including the relative benefits and risks associated with each modality.

The decision that a stone has a low probability of spontaneous passage is based on both the facts of the case and professional experience. Factors that weigh in the decision are the size of the stone, the shape of the stone, the patient’s internal anatomy and the history of previous stone passage. In general, patients whose stones are 0.5 cm or less in diameter have a good chance of spontaneous passage, whereas the chance of spontaneous passage for larger stones diminishes considerably.

Although, as a practical matter, it is evident that the availability of equipment and the expertise of an individual practitioner may affect the choice of a treatment intervention, it is unacceptable to withhold certain treatments from the patient and not offer them as alternatives because of personal inexperience or unfamiliarity with one of the accepted treatment modalities or because of the local unavailability of equipment or expertise.

Recommendation: For stones with high probability of spontaneous passage

> **Guideline:** In a patient who has a newly diagnosed proximal or distal ureteral stone with a high probability of spontaneous passage, and whose symptoms are controlled, observation with periodic evaluation is recommended for initial treatment.

Up to 98 percent of stones less than 0.5 cm in diameter, especially in the distal ureter, may be expected to pass spontaneously. How long until passage occurs, over what period of time passage takes place and the degree of colic or other symptoms are all unpredictable and often bear heavily on the decision to intervene in such patients. In the panel’s opinion, for most of these patients the high probability of spontaneous passage justifies observation as the initial treatment. However, difficulties in tolerating pain, multiple trips to the emergency room or other factors may mandate treatment in a patient whose stone might otherwise be expected to pass.

Recommendation: For treatment by shock wave lithotripsy

> **Guideline**: Routine stenting to increase efficiency of fragmentation is not recommended as part of shock wave lithotripsy.

It has become common practice to place a ureteral stent, usually a double-J stent, for more efficient fragmentation of ureteral stones using SWL. The data analyzed by the panel did not support the routine use of such stents when the goal is to improve the stone-free results of SWL. The data showed no improved fragmentation with stenting. Routine stenting may be justifiable for other purposes such as management of symptoms associated with the passage of stones.

Recommendations: For stones of 1 cm or less in proximal ureter

> **Standard:** Open surgery should not be the first-line active treatment.
>
> **Guideline:** Shock wave lithotripsy is recommended as first-line treatment for most patients.

Although open surgery will usually be successful, relatively longer hospitalization and greater postoperative morbidity with open surgery mean that SWL should be the first-line treatment for most patients. Ureteroscopy and PNL are acceptable choices in situations where SWL may not be appropriate or as salvage procedures for failed SWL.

Recommendations: For stones greater than 1 cm in proximal ureter

> **Guideline:** Open surgery should not be the first-line treatment for most patients.
>
> **Option:** Shock wave lithotripsy, percutaneous nephrolithotomy and ureteroscopy are all acceptable treatment choices.

Treatment results for large stones in the upper ureter are less predictable than for small stones. Shock wave lithotripsy, PNL and URS are all acceptable options in the upper ureter, but URS may become less appropriate as the stones encountered become larger. Open surgery, despite the excellent stone-free results, should not be the first-line treatment in most patients with large stones. The reasons are the same as for patients with small stones: relatively greater postoperative morbidity and longer hospitalization. Open surgery may well be appropriate for nonstandard patients and is certainly an acceptable alternative as a salvage measure.

Recommendations: For stones of 1 cm or less in distal ureter

> **Standard:** Open surgery should not be the first-line treatment.
>
> **Guideline:** Blind basketing without fluoroscopy and guide wire cannot be encouraged as a treatment choice.
>
> **Option:** Shock wave lithotripsy and ureteroscopy are both acceptable treatment choices.

Blind basketing refers to basket manipulation of distal ureteral stones as practiced prior to the advent of ureteroscopy and fluoroscopy around 1981. The high success rates attending ureteroscopic stone removal utilizing fluoroscopic control, the availability of fluoroscopy as an adjunctive measure and the lack of training in the vast majority of programs in the technique of blind basket extraction mean that blind basketing without fluoroscopy and safety guide wire cannot be encouraged as a treatment choice. The data from the literature suggest that blind basketing can achieve a 73-percent success rate. Nevertheless, the panel's expert opinion is that guided stone manipulation (concomitant use of fluoroscopy and safety guide wire) or ureteroscopic basketing would be a considerably safer and more efficacious option.

Shock wave lithotripsy and URS are each effective for management of distal ureteral stones. Each has advantages and disadvantages. Shock wave lithotripsy is minimally invasive and can often be performed either without anesthesia or under intravenous sedation, but may require multiple primary treatments for adequate fragmentation and is more likely to require ancillary treatment.

Ureteroscopy has a higher success rate, with the least risk of requiring multiple treatments and the least risk of an ancillary procedure, but is more invasive than SWL. Although not studied by the panel, cost issues will bear on the patient's decision as to which treatment method is more appropriate. Availability is also a factor. Ureteroscopy is widely available in the current era, as is SWL, although the availability of SWL will vary according to whether or not a practitioner is dependent on a mobile machine.

Recommendations: For stones greater than 1 cm in distal ureter

> **Standard:** Blind basketing is not recommended as a treatment choice.
>
> **Guideline:** Open surgery should not be the first-line treatment for most patients.
>
> **Option:** Shock wave lithotripsy and ureteroscopy are both acceptable treatment choices.

Large stones in the ureter must be fragmented prior to ureteroscopic extraction, and SWL must fragment large stones into passable fragments. Such stones will likely require more SWL treatments than will smaller stones, and URS may be preferable when such cases can be anticipated. Given the high success rates using SWL and URS, open surgery should not be the first-line treatment in most patients; but open surgery may be preferable for certain very large ureteral stones or in special situations.

Current trends and recommendations for further research

The relatively recent development of small (7.5 to 10.5 F.), actively deflectable, flexible ureteroscopes has improved endoscopic access to the upper ureter. Meanwhile, intracorporeal lithotripsy devices have become more powerful with the introduction of the Holmium laser (Ho:YAG). Recent articles suggest that this laser can effectively fragment virtually any type of urinary calculus (Bagley and Erhard, 1995; Erhard and Bagley, 1995; Grasso, 1996; Shroff, Watson, Parikh, et al., 1996). Moreover, because the laser light can be carried through small, flexible quartz fibers, Holmium lasers are particularly well suited for use with small-diameter flexible ureteroscopes in the upper ureter. The use of flexible ureteroscopes in combination with the Holmium laser may allow the efficacy of ureteroscopy in the upper ureter to approach the efficacy achieved in the lower ureter. However, the numbers of cases reported as of this writing are still too small to significantly alter the stone-free rates displayed in the outcomes balance sheet tables (e.g., 72 percent overall for ureteroscopy in the proximal ureter).

Although shock wave lithotripsy machines have improved in ease of localization of ureteral stones, and the requirement for anesthesia has decreased, there has been no increase in power or effectiveness over the original Dornier HM-3. Improvements in the fragmentation ability, and therefore the efficacy, of shock wave machines await further advances in the understanding of shock waves, their generation and their stone and tissue interactions.

Three major challenges in stone research are:

1. **Stone prevention:** Any kidney stone is potentially preventable. The symptoms, the risks of treatment and the trauma of the stone event could in theory be prevented by appropriate metabolic evaluation and treatment of identified problems. Such prevention research, which could eventually result in savings of hundreds of millions of dollars each year, would require a high degree of physician-patient cooperation.
2. **A uniform system of stone reporting:** Lack of such a system has hampered the panel in developing both the *Report on the Management of Ureteral Calculi* and the previous *Report on the Management of Staghorn Calculi*. Mr. David Tolley and colleagues have devised a uniform system of reporting which, if accepted by the major journals, would go a long way toward standardizing the reporting of stone results and thus making comparison of stone results easier and more practical (Tolley, Wallace and Tiptaft, 1991).
3. **Ability to predict the response of a stone to shock wave lithotripsy:** Ureteral stone management would be optimized if the degree to which a given stone could be fragmented were predictable. At present, such prediction is possible only in the most general way.

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Appendix A – Data Presentation

Table A-1 Articles extracted by Papyrus reference number

Papyrus	Journal	Year	Volume	Pages	Title	Authors
45	British Journal of Urology	1968	40	560-563	Endoscopic removal of lower ureteric stones	MacDougall, J.A., Mayo, M.E.
76	International Urology & Nephrology	1972	4	215-220	Treatment of ureteral calculi with the Zeiss loop	Nagel, R., Marquardt, H., and Grull, S.
97	Journal of Urology	1974	112	33-35	Management of ureteral calculi: series of 574 cases with special emphasis on use of Davis loop extractor	Constantian, H.M.
131	Journal of Urology	1972	107	365-368	Pull-through ureterolithotomy	Maynard, J.F., Landsteiner, E.K.
135	Journal of Urology	1973	110	178-180	Loop catheter delivery of ureteral calculi	Bowers, L.
136	Journal of Urology	1973	110	387-388	A critical review of stone manipulation: a 5-year study	Mahon, F.B., Jr., Waters, R.F.
145	Journal of the Irish Medical Association	1973	66	1-4	Management of ureteric calculi: a review of 500 cases	Butler, M.R., O'Flynn, J.D.
178	Scandinavian Journal of Urology & Nephrology	1968	1	Suppl1:1-180	Ureteral stones. An experimental and clinical study of the mechanism of the passage and arrest of ureteral stones	Holmlund, D.
202	Urology	1973	1	301-304	Forceful endoscopic extraction of ureteral calculi	Lamensdorf, H., Compere, D.E., and Begley, G.F.
224	Australian Family Physician	1980	9	360-364	Ureteric stone. When do we need to intervene?	Hamilton, M., Sloman, R.
235	British Journal of Urology	1976	48	231-233	Vaginal ureterolithotomy	O'Boyle, P.J., Gibbon, N.O.
242	British Journal of Urology	1980	52	436-438	The treatment of ureteric stones: report on 1120 patients	O'Flynn, J.D.
243	British Journal of Urology	1980	52	439-442	Transurethral ureterolithotomy	McLean, P.A., McDermott, T.E., and Walsh, A.
311	Journal of Urology	1978	119	320-321	Semi-closed basket extraction of ureteral calculi	Klompus, W.H., Owens, J.
367	Journal of Urology	1977	117	34-38	Management of urinary calculous disease in patients with ureterocele	Amar, A.D.
370	Journal of Urology	1976	116	422-423	Management of the ureterotomy incision in 100 consecutive ureterolithotomies	Maddocks, R., Jewell, E., Decenzo, J.M., and Leadbetter, G.W., Jr.
380	Journal of Urology	1976	116	559-561	The surgical fate of ureteral calculi: review of Mayo Clinic experience	Furlow, W.L., Bucchiere, J.J.
418	Scandinavian Journal of Urology & Nephrology	1977	11	35-40	Transurethral stone extraction with a vibrating basket catheter	Pettersson, S., Jonsson, O., Sivertsson, R., Säve-Söderbergh, J., and Zachrisson, B.E.
425	Surgery, Gynecology & Obstetrics	1978	146	604-608	The management of ureteral calculi during pregnancy	Strong, D.W., Murchison, R.J., and Lynch, D.F.
456	Urology	1977	10	544-546	Relation of spontaneous passage of ureteral calculi to size	Ueno, A., Kawamura, T., Ogawa, A., and Takayasu, H.
474	Urology	1976	8	329-333	Anterior transperitoneal approach for removal of renal stones	Linke, C.A., Linke, C.L., Davis, R.S., and Barbaric, Z.
545	British Journal of Urology	1982	54	223-225	Delivery of low ureteric stones with the Zeiss indwelling probe	Ipiéns-Aznar, A.
546	British Journal of Urology	1985	57	281-283	Ureteroscopy. An alternative view	Tolley, D.A., Beynon, L.L.
577	European Urology	1983	9	93-96	12-year experience using the dormia basket for the extraction of ureteric stones	Harrison, G.S., Davies, G.A., and Holdsworth, P.J.
586	European Urology	1985	11	199-202	Antegrade ureteroscopy for stone removal	Gumpinger, R., Miller, K., Fuchs, G., and Eisenberger, F.

Papyrus	Journal	Year	Volume	Pages	Title	Authors
621	Journal of Urology	1982	128	591-592	Single stage percutaneous nephroureterolithotomy using a special ultrasonically guided pyeloscope	Saitoh, M., Watanabe, H., and Ohe, H.
648	Journal of Urology	1983	129	266-270	Dorsovertical lumbotomy approach for surgery of upper urinary tract calculi	Das, S., Harris, C.J., Amar, A.D., and Egan, R.M.
677	Journal of Urology	1983	130	35-36	Multiple ureteral tubation for stones	Macalalag, E.V.
681	Journal of Urology	1985	134	1166-1167	Percutaneous stone removal in children	Woodside, J.R., Stevens, G.F., Stark, G.L., Borden, T.A., and Ball, W.S.
682	Journal of Urology	1985	134	29-32	Percutaneous management of ureteral calculi facilitated by retrograde flushing with carbon dioxide or diluted radiopaque dye	Hulbert, J.C., Reddy, P.K., Hunter, D.W., Young, A.T., Castaneda-Zuniga, W.R., Amplatz, K., and Lange, P.H.
718	Journal of Urology	1985	134	662-665	Percutaneous removal of renal and ureteral calculi: experience with 400 cases	Reddy, P.K., Hulbert, J.C., Lange, P.H., Clayman, R.V., Marcuzzi, A., Lapointe, S., Miller, R.P., Hunter, D.W., Castaneda-Zuniga, W.R., and Amplatz, K.
759	Radiology	1983	146	832	Ureteric stone displacement using a new technique	Twomey, B.P., Wilkins, R.A.
848	Urology	1984	23	336-339	Extravesical transmural ureterolithotomy	Rosemberg, S.K.
851	Urology	1984	23	29-36	Ureteroscopy and ureteropyeloscopy	Lyon, E.S., Huffman, J.L., and Bagley, D.H.
856	Urology	1985	25	391-392	Combined retrograde and antegrade manipulations for percutaneous nephrolithotomy of ureteric calculi: "push-pull" technique	Kellett, M.J., Wickham, J.E., and Payne, S.R.
865	Urology	1983	21	15-16	Dorsal approach to upper urinary tract	Freiha, F., Zeineh, S.
867	Urology	1982	20	437	Dormia basket: standard technique, observations, and general concepts	Dormia, E.
888	Annals of the Royal College of Surgeons of England	1986	68	70-72	Endoscopic management of upper urinary tract stones	Tolley, D.A., Buist, T.A.
891	British Journal of Urology	1986	58	621-624	Rigid transurethral ureteroscopy	Hosking, D.H., Ramsey, E.W.
899	British Journal of Urology	1987	59	137-141	Ureteric stone surgery in practice	Bishop, M.C., Lawrence, W.T., and Lemberger, R.J.
900	British Journal of Urology	1987	60	23-27	Transurethral ureteroscopy. Safety guide wire as an aid to a more aggressive approach	Ekman, P., Husain, I., Sharma, N.D., and Al-Faqih, S.R.
901	British Journal of Urology	1987	59	401-404	Endoscopic ureteric stone extraction. Experience with the short ureteroscope	Tolley, D.A.
906	British Journal of Urology	1986	58	499-503	Rigid ureteroscopy for the treatment of ureteric calculi: experience in 120 cases	el-Kappany, H., Gaballah, M.A., and Ghoneim, M.A.
943	European Urology	1987	13	233-237	Basket extraction--its place in the current treatment of the lower ureteric stone: clinical experience	Van Haverbeke, J., Morelle, V., and Fonteyne, E.
960	Israel Journal of Medical Sciences	1987	23	243-248	Shock-wave treatment for stones in the kidney and ureter. The Jerusalem experience	Pode, D., Caine, M., Pfau, A., Shapiro, A., Lencovsky, Z., Katz, G., and Davidson, J.T.
967	Journal of Urology	1987	137	386-389	Pulsed dye laser fragmentation of ureteral calculi: initial clinical experience	Dretler, S.P., Watson, G., Parrish, J.A., and Murray, S.
974	Journal of Urology	1986	136	1190-1193	An algorithm for the management of ureteral calculi	Dretler, S.P., Keating, M.A., and Riley, J.
981	Journal of Urology	1987	137	629-632	Operative fiberoptic nephroureteroscopy: removal of upper ureteral and renal calculi	Aso, Y., Ohtawara, Y., Fukuta, K., Sudoko, H., Nakano, M., Ushiyama, T., Ohta, N., Suzuki, K., and Tajima, A.
987	Journal of Urology	1986	135	1172-1174	Ureteral stone management: emerging concepts	Lingeman, J.E., Sonda, L.P., Kahnoski, R.J., Coury, T.A., Newman, D.M., Mosbaugh, P.G., Mertz, J.H., Steele, R.E., and Frank, B.

1001	Journal of Urology	1987	137	1122-1123	The treatment of 100 consecutive patients with ureteral calculi in a British stone center	Coptcoat, M.J., Webb, D.R., Kellett, M.J., Whitfield, H.N., and Wickham, J.E.
1012	Journal of Urology	1986	136	386-389	Late sequelae of the management of ureteral calculi with the ureterorenoscope	Stackl, W., Marberger, M.
1017	Journal of Urology	1987	138	566-567	Ureteral meatotomy by Sachse urethrotome in the management of lower ureteral stones	Donovan, M.G., Hegarty, J., Fitzpatrick, J.M., and Butler, M.
1040	Radiology	1986	160	189-192	Ureteral calculi: percutaneous removal using modified basket extractors and fluoroscopy	Hare, W.S.
1043	Radiology	1987	163	655-659	Extracorporeal shock wave lithotripsy: impact on the radiology department of a stone treatment center	Cochran, S.T., Barbaric, Z.L., Mindell, H.J., Chaussy, C.D., Fuchs, G.J., and Lupu, A.N.
1047	Radiology	1986	159	643-645	Upper and midureteral calculi: percutaneous extraction with an occlusion balloon catheter	Beckmann, C.F., Roth, R.A., and Luedke, M.D.
1052	Scandinavian Journal of Urology & Nephrology	1987	21	43-45	Transurethral ureteroscopic extraction of stone from the ureter and renal pelvis	Toftgaard, C., Nielsen, H.V.
1063	Seminars In Urology	1987	5	208-211	Ureteroscopy: experience with 268 cases	Pastor, J., Hertle, L., Fischer, C., Graff, J., and Senge, T.
1085	Urology	1986	27	179-183	Forceps extraction of ureteral stones	Daughtry, J.D., Bean, W.J., and Rodan, B.A.
1087	Urology	1986	27	331-334	Percutaneous antegrade flexible ureteroscopy	Bagley, D.H., Rittenberg, M.H.
1100	Urology	1987	29	531-532	Transurethral ultrasonic ureterolithotripsy using a solid-wire probe	Chaussy, C., Fuchs, G., Kahn, R., Hunter, P., and Goodfriend, R.
1106	Urology	1986	27	555	Endoscopic transvesical lower ureterolithotomy	Li, R., Shapiro, P.
1109	Urology	1987	30	39-42	Ureteroscopy in management of ureteral calculi	Politis, G., Griffith, D.P.
1134	American Journal of Diseases of Children	1988	142	279-282	Extracorporeal shock-wave lithotripsy for children	Mininberg, D.T., Steckler, R., and Riehle, R.A., Jr.
1162	Annals of the Academy of Medicine, Singapore	1989	18	55-58	Antegrade ureteroscopy and ultrasonic lithotripsy in the treatment of difficult upper and middle ureteric stones	Tan, E.C., Tung, K.H., Foo, K.T., Kwok, R., and Hoe, J.
1178	British Journal of Urology	1989	64	130-133	Primary endoscopic surgery for ureteric stones	Tolley, D.A.
1179	British Journal of Urology	1989	64	117-121	Extracorporeal shock wave lithotripsy with the Lithostar lithotriptor	Grace, P.A., Gillen, P., Smith, J.M., and Fitzpatrick, J.M.
1186	British Journal of Urology	1990	65	326-328	Endoscopic transvesical extramural ureterolithotomy	Lloyd, S.N., Kennedy, C.
1187	British Journal of Urology	1988	62	301-305	1500 cases of renal and ureteric calculi treated in an integrated stone centre	Das, G., Dick, J., Bailey, M.J., Fletcher, M.S., Birch, B., Coptcoat, M.J., Webb, D.R., Kellett, M.J., Whitfield, H.N., and Wickham, J.E.
1195	British Journal of Urology	1989	63	243-244	Ureterolithotripsy: report of 1000 cases	Kostakopoulos, A., Sofras, F., Karayiannis, A., Kranidis, A., and Dimopoulos, C.
1197	British Journal of Urology	1990	65	141-143	Transurethral ureterorenoscopic lithotripsy and retrieval of ureteric calculi under local anaesthesia and sedation	Chan, P.S., Fenn, J., and Li, A.K.
1199	British Journal of Urology	1989	64	1-4	Extracorporeal shockwave lithotripsy using ultrasonic imaging: urologists' experience	Kiely, E.A., Ryan, P.C., McDermott, T.E., and Butler, M.R.
1215	Chung Hua i Hsueh Tsa Chih - Chinese Medical Journal	1989	43	147-152	Extracorporeal shock wave lithotripsy in the management of upper third ureteral stones	Jiaan, B.P., Yin, J.H., Chen, M.T., Chang, L.S., and Huang, J.K.
1228	European Urology	1988	14	111-114	Treatment of upper ureteral stones	Sanseverino, R., Canton, F., Salas, M., Martin, X., Gelet, A., and Dubernard, J.M.
1229	European Urology	1989	16	250-252	Treatment of distal ureteral calculi with extracorporeal shock wave lithotripsy. Experience with 264 cases	Zehntner, C., Casanova, G.A., Marth, D., and Zingg, E.J.
1231	European Urology	1989	16	343-348	Two years clinical experiences with extracorporeal shock-wave lithotripsy and transurethral ureterolithotripsy for ureteral stones at Osaka City University Hospital	Kishimoto, T., Yamamoto, K., Sugimoto, T., Sugimura, K., Nakatani, T., Wada, S., Ikemoto, S., Iimori, M., Senju, M., Kanazawa, T., et al.

Papyrus	Journal	Year	Volume	Pages	Title	Authors
1234	European Urology	1989	16	7-11	Extracorporeal shock wave lithotripsy for urinary stone disease: clinical experience with the electromagnetic lithotriptor 'Lithostar'	Simon, J., Corbusier, A., Mendes Leal, A., Van den Bossche, M., Wespes, E., Van Regemorter, G., and Schulman, C.C.
1245	European Urology	1990	17	200-202	Shockwave treatment of ureteric stones in situ with second-generation lithotriptor	Simon, J., Vanden Bossche, M., and Schulman, C.C.
1252	European Urology	1988	15	223-226	Ureteral stone extraction with the Steffens lasso loop. A neglected procedure	Steffens, J., Kranz, A., Vossaert, P., and Steffens, L.
1309	Journal of Urology	1989	141	275-279	First clinical experience with a Q-switched neodymium:YAG laser for urinary calculi	Hofmann, R., Hartung, R., Schmidt-Kloiber, H., and Reichel, E.
1311	Journal of Urology	1990	143	13-17	Electrohydraulic lithotripsy of renal and ureteral calculi	Denstedt, J.D., Clayman, R.V.
1314	Journal of Urology	1990	143	273-274	Laser ureterolithotripsy with combined rigid and flexible ureterorenoscopy	Higashihara, E., Horie, S., Takeuchi, T., Kameyama, S., Asakage, Y., Hosaka, Y., Honma, Y., Minowada, S., and Aso, Y.
1315	Journal of Urology	1990	143	267-272	An evaluation of ureteral laser lithotripsy: 225 consecutive patients	Dretler, S.P.
1328	Journal of Urology	1988	139	916-918	Treatment of prevesical ureteral calculi by extracorporeal shock wave lithotripsy	Becht, E., Moll, V., Neisius, D., and Ziegler, M.
1329	Journal of Urology	1988	139	911-915	Extracorporeal shock wave lithotripsy in the prone position: treatment of stones in the distal ureter or anomalous kidney	Jenkins, A.D., Gillenwater, J.Y.
1336	Journal of Urology	1989	141	504-509	Treatment options for proximal ureteral urolithiasis: review and recommendations	Liong, M.L., Clayman, R.V., Gittes, R.F., Lingeman, J.E., Huffman, J.L., and Lyon, E.S.
1342	Journal of Urology	1990	143	481-482	In situ extracorporeal shock wave lithotripsy for upper ureteral stones using the EDAP LT-01 lithotriptor	Tung, K.H., Tan, E.C., and Foo, K.T.
1343	Journal of Urology	1988	139	1188-1191	Use of a prototype 3F electrohydraulic electrode with ureteroscopy for treatment of ureteral calculous disease	Begun, F.P., Jacobs, S.C., and Lawson, R.K.
1346	Journal of Urology	1988	139	1177-1179	The transvesical approach for the removal of distal ureteral calculi	Hanany, Y., Nativ, O., Madgar, I., Jonas, P., and Goldwasser, B.
1353	Journal of Urology	1988	139	1180-1183	Ureteropyeloscopic removal of ureteral calculi	Seeger, A.R., Rittenberg, M.H., and Bagley, D.H.
1355	Journal of Urology	1988	140	957-958	Safety and efficacy of electrohydraulic lithotripsy by ureteroscopy	Willscher, M.K., Conway, J.F., Jr., Babayan, R.K., Morrisseau, P., Sant, G.R., and Bertagnoll, A.
1360	Journal of Urology	1988	139	510-512	Ureteroscopy	Blute, M.L., Segura, J.W., and Patterson, D.E.
1363	Journal of Urology	1990	143	483-484	Clinical experience with a new pulsed dye laser for ureteral stone lithotripsy	Zerbib, M., Flam, T., Belas, M., Debre, B., and Steg, A.
1364	Journal of Urology	1988	139	1192-1194	Treatment of ureteral calculi by extracorporeal shock wave lithotripsy at a multi-use center	Fetner, C.D., Preminger, G.M., Seger, J., and Lea, T.A.
1365	Journal of Urology	1988	139	513-516	Extracorporeal shock wave lithotripsy for ureteral stones: a retrospective analysis of 417 cases	Graff, J., Pastor, J., Funke, P.J., Mach, P., and Senge, T.
1366	Journal of Urology	1988	140	280-282	Treatment of lower ureteral calculi with extracorporeal shock wave lithotripsy	Selli, C., Carini, M.
1370	Journal of Urology	1990	143	685-686	Pulsed dye laser fragmentation of ureteral calculi: a review of the first 50 cases performed at Virginia Mason Medical Center	Govier, F.E., Gibbons, R.P., Correa, R.J., Brannen, G.E., Weissman, R.M., and Pritchett, T.R.
1375	Journal of Urology	1989	142	955-957	Treatment of distal ureteral stones in the horse riding position	Ackaert, K.S., Dik, P., Lock, M.T., Kurth, K.H., and Schröder, F.H.
1377	Journal of Urology	1989	142	958-960	Long-term results of transurethral lithotripsy with the rigid ureteroscope: injury of intramural ureter	Ono, Y., Ohshima, S., Kinukawa, T., Matsuura, O., Hirabayashi, S., and Yamada, S.
1378	Journal of Urology	1989	142	37-39	Ureteral stones: the results of primary in situ extracorporeal shock wave lithotripsy	Holden, D., Rao, P.N.

1381	Journal of Urology	1988	139	689-694	Piezoelectric extracorporeal lithotripsy by ultrashort waves with the EDAP LT 01 device	Vallancien, G., Aviles, J., Munoz, R., Veillon, B., Charton, M., and Brisset, J.M.
1388	Journal of Urology	1989	142	674-678	Extracorporeal shock wave lithotripsy monotherapy: experience with piezoelectric second generation lithotriptor in 642 patients	Kim, S.C., Moon, Y.T., and Kim, K.D.
1392	Journal of Urology	1988	139	704-705	The role of posterior lumbotomy in the management of surgical stone disease	Hudnall, C.H., Kirk, J.F., and Radwin, H.M.
1399	Journal of Urology	1989	142	1186-1188	Management of simultaneous renal and ureteral calculi: combined extracorporeal shock wave lithotripsy and ureteroscopy under a single anesthetic	Jarowenko, M.V., Belis, J.A., and Rohner, T.J., Jr.
1415	Lasers In Surgery & Medicine	1988	8	363-370	The pulsed dye laser versus the Q-switched Nd:YAG laser in laser-induced shock-wave lithotripsy	Thomas, S., Pensel, J., Engelhardt, R., Meyer, W., and Hofstetter, A.G.
1427	Radiology	1990	174	103-108	In situ lithotripsy of ureteral calculi: review of 261 cases	Barr, J.D., Tegtmeyer, C.J., and Jenkins, A.D.
1442	Scandinavian Journal of Urology & Nephrology	1990	24	113-115	Ureteroscopic manipulation of stones in the ureter: four years experience	Adolfsson, J., Lindström, A.C., Carbin, B.E., and Ekman, P.
1460	Seminars In Urology	1989	7	25-29	The pulsed dye laser in the treatment of ureteral calculi. [Review]	Beck, E.M., Vaughan, E.D., Jr., and Sosa, R.E.
1489	Urologia Internationalis	1989	44	227-230	Management of ureteral stones by extracorporeal shock wave lithotripsy. 3 years of experience	Recker, F., Jaeger, P., Alund, G., Konstantinidis, K., Knoenagel, H., and Hauri, D.
1492	Urologia Internationalis	1989	44	32-34	Ureterorenoscopy in the management of renal and ureteric calculi	Olsen, J.B., Pedersen, F.M., Wamberg, P.A., and Nielsen, H.V.
1533	Urology	1988	32	328-334	Rigid ureteroscopy: pitfalls and remedies	Thomas, R.
1537	Urology	1990	35	250-252	Ureteroscopic stone manipulation during pregnancy	Vest, J.M., Warden, S.S.
1540	Urology	1988	31	34-37	Endourologic management of upper and mid ureteral calculi: percutaneous antegrade extraction vs transurethral ureteroscopy	Streem, S.B., Hall, P., Zelch, M.G., Risius, B., and Geisinger, M.A.
1554	Urology	1990	35	412-416	Removal of upper urinary tract calculi with flexible ureteropyeloscopy	Bagley, D.H.
1583	British Journal of Urology	1974	46	11-14	An aggressive approach to stones in the lower ureter	Walsh, A.
1632	Urology	1974	3	661-662	Low ureterolithotomy. Simple technique	Spiro, L.H., Levine, B.
1644	British Journal of Urology	1975	47	613-616	Transperitoneal ureterolithotomy	Bose, T.K., Shaw, R.E.
1669	International Urology & Nephrology	1979	11	185-192	Extraction of ureteral calculi with the Dormia basket	Streit, B., Pösta, B., and Schnauzer, J.
1703	Journal of Urology	1976	116	784-785	An improved helical stone basket	Rutner, A.B., Fucilla, I.S.
1722	Scandinavian Journal of Urology & Nephrology	1978	12	157-159	Transurethral extraction of ureteral stone guided by television fluoroscopy	Borck, L., Gottfries, A., and Movin, A.
1736	Transactions of the American Association of Genito-Urinary Surgeons	1978	70	19	Ureteral calculus: experience with 521 stone extractions	Lutzeyer, W., Hering, F.J., Vander, H., and Hautmann, R.
1753	Urology	1977	10	310-311	Management of simple ureterolithotomy closure	Carpiniello, V.L., Hanno, P.M., Malloy, T.R., and Wein, A.J.
1761	American Journal of Roentgenology	1985	144	795-799	Upper ureteral calculi: extraction via percutaneous nephrostomy	Bush, W.H., Brannen, G.E., Lewis, G.P., and Burnett, L.L.
1776	Australian & New Zealand Journal of Surgery	1985	55	51-54	A success and cost analysis study of the methods of managing impacted lower ureteric calculi	Brown, R.B.
1782	British Journal of Urology	1985	57	402-405	A simple loop catheter for ureteric calculus retrieval	Kotwal, S.V., Kochhar, G.S., Gupta, N.P., and Singh, S.M.
1784	British Journal of Urology	1984	56	602-603	The impact of transurethral ureteroscopy on the management of ureteric calculi	Ford, T.F., Payne, S.R., and Wickham, J.E.
1785	British Journal of Urology	1982	54	220-222	Transperitoneal ureterolithotomy for stones in the lower third of the ureter	Bristol, J.B., Smith, P.J.

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1786	British Journal of Urology	1983	55	626-628	Transurethral ureteroscopic retrieval of ureteric stones	Ford, T.F., Watson, G.M., and Wickham, J.E.
1814	European Urology	1984	10	36-39	Endoscopic surgery of calculi in ureteroceles	Rodriguez, J.V.
1829	Journal of Urology	1984	131	868-871	Percutaneous nephrolithotomy: extraction of renal and ureteral calculi from 100 patients	Clayman, R.V., Surya, V., Miller, R.P., Castaneda-Zuniga, W.R., Smith, A.D., Hunter, D.H., Amplatz, K., and Lange, P.H.
1841	Journal of Urology	1983	130	31-34	Transurethral removal of large ureteral and renal pelvic calculi using ureteroscopic ultrasonic lithotripsy	Huffman, J.L., Bagley, D.H., Schoenberg, H.W., and Lyon, E.S.
1844	Journal of Urology	1985	134	1077-1081	Percutaneous removal of kidney stones: review of 1,000 cases	Segura, J.W., Patterson, D.E., LeRoy, A.J., Williams, H.J., Jr., Barrett, D.M., Benson, R.C., Jr., May, G.R., and Bender, C.E.
1848	Journal of Urology	1984	132	250-253	Ureteroscopy with rigid instruments in the management of distal ureteral disease	Goodman, T.M.
1862	Journal of Urology	1985	133	767-770	Early experience with direct vision electrohydraulic lithotripsy of ureteral calculi	Green, D.F., Lytton, B.
1893	Radiology	1985	156	341-348	Percutaneous removal of ureteral calculi: clinical and experimental results	Hunter, D.W., Castaneda-Zuniga, W.R., Young, A.T., Cardella, J., Lund, G., Rysavy, J.A., Hulbert, J., Lange, P., Reedy, P., and Amplatz, K.
1942	Urology	1984	24	359-360	Modified Johnson basket for antegrade stone extraction	Carson, C.C., Braun, S., Weinerth, J.L., and Dunnick, N.R.
1969	Annales Chirurgiae Et Gynaecologiae	1986	75	48-50	Surgical treatment of ureteric stones	Hjortrup, A., Andersen, F., Vilmann, P., and Moesgaard, F.
1971	Annals of the Academy of Medicine, Singapore	1987	16	546-549	Transurethral ultrasonic lithotripsy for ureteric stones under direct vision	Foo, K.T., Tung, K.H., and Tan, E.C.
1975	British Journal of Urology	1986	58	625-628	Complications associated with ureteroscopy	Carter, S.S., Cox, R., and Wickham, J.E.
1978	British Journal of Urology	1987	60	506-508	Ureteroscopy and ureteric calculi: how useful?	Kinder, R.B., Osborn, D.E., Flynn, J.T., and Smart, J.G.
1991	European Urology	1987	13	289-292	Elective treatment of ureteral stones with extracorporeal shock wave lithotripsy	Carini, M., Selli, C., and Fiorelli, C.
1993	European Urology	1986	12	377-386	Efficacy of in situ extracorporeal shock wave lithotripsy for upper ureteral calculi	Rassweiler, J., Lutz, K., Gumpinger, R., and Eisenberger, F.
1996	European Urology	1986	12	305-307	Extracorporeal shockwave lithotripsy of distal ureteral calculi	Miller, K., Bubeck, J.R., and Hautmann, R.
2009	Journal of Urology	1987	137	865-866	Ureteroscopy: results and complications	Schultz, A., Kristensen, J.K., Bilde, T., and Eldrup, J.
2011	Journal of Urology	1987	137	380-383	The ureteral access system: a review of the immediate results in 43 cases	Newman, R.C., Hunter, P.T., Hawkins, I.F., and Finlayson, B.
2012	Journal of Urology	1987	137	384-385	Complications of ureteroscopy in relation to experience: report of survey and author experience	Weinberg, J.J., Ansong, K., and Smith, A.D.
2015	Journal of Urology	1987	137	649-653	Complications of ureteral endoscopy	Lytton, B., Weiss, R.M., and Green, D.F.
2016	Journal of Urology	1986	135	239-243	Endourological treatment of ureteral calculi	Kahn, R.I.
2022	Journal of Urology	1986	135	831-834	Extracorporeal shock wave lithotripsy of ureteral stones: clinical experience and experimental findings	Mueller, S.C., Wilbert, D., Thueroff, J.W., and Alken, P.
2024	Journal of Urology	1987	138	720-723	Management of upper ureteral calculi with extracorporeal shock wave lithotripsy	Lingeman, J.E., Shirrell, W.L., Newman, D.M., Mosbaugh, P.G., Steele, R.E., and Woods, J.R.
2031	Journal of Urology	1987	138	485-490	Comparison of results and morbidity of percutaneous nephrostolithotomy and extracorporeal shock wave lithotripsy	Lingeman, J.E., Coury, T.A., Newman, D.M., Kahnoski, R.J., Mertz, J.H., Mosbaugh, P.G., Steele, R.E., and Woods, J.R.
2059	Surgery, Gynecology & Obstetrics	1987	164	1-8	Treatment of calculi in the upper ureter with extracorporeal shock wave lithotripsy	Riehle, R.A., Jr., Näslund, E.B.

2116	British Journal of Urology	1988	61	487-489	Lasertripsy for ureteric stones in 120 cases: lessons learned	Coptcoat, M.J., Ison, K.T., Watson, G., and Wickham, J.E.
2117	British Journal of Urology	1988	62	525-530	Is extracorporeal shockwave lithotripsy suitable treatment for lower ureteric stones?	Cole, R.S., Shuttleworth, K.E.
2122	British Journal of Urology	1988	62	13-18	Primary choice of intervention for distal ureteric stone: ureteroscopy or ESWL?	el-Faqih, S.R., Husain, I., Ekman, P.E., Sharma, N.D., Chakrabarty, A., and Talic, R.
2124	British Journal of Urology	1990	65	137-140	Antegrade ureterolitholapaxy in the treatment of obstructing or incarcerated proximal ureteric stones	Anselmo, G., Bassi, E., Fandella, A., Merlo, F., Felici, E., and Maccatrozzo, L.
2147	European Urology	1988	14	93-95	The steinstrasse: a legacy of extracorporeal lithotripsy?	Coptcoat, M.J., Webb, D.R., Kellet, M.J., Whitfield, H.N., and Wickham, J.E.
2154	European Urology	1990	17	269-272	Is routine dilation of the ureter necessary for ureteroscopy?	Rodrigues Netto, N., Jr., Caserta Lemos, G., Levi D'Ancona, C.A., Ikari, O., Ferreira, U., and Francisco de Almeida Claro, J.
2158	European Urology	1989	16	405-409	ESWL management of ureteral calculi without anesthesia: an alternative to invasive procedures	Bauer, E., Baur, H., Schneider, W., and Altwein, J.E.
2159	European Urology	1988	14	261-265	Local shock-wave lithotripsy of distal ureteral calculi	Voges, G.E., Wilbert, D.M., Stöckle, M., and Hohenfellner, R.
2180	Irish Journal of Medical Science	1989	158	141-143	Endoscopic treatment of urinary tract calculi	Ryan, P.C., Kiely, E.A., Grainger, R., Moloney, M., Fitzpatrick, J.M., Hurley, G.D., and Butler, M.R.
2190	Journal of Urology	1988	139	33-36	Ureteral stone manipulation before extracorporeal shock wave lithotripsy	Evans, R.J., Wingfield, D.D., Morollo, B.A., and Jenkins, A.D.
2201	Journal of Urology	1988	139	1184-1187	Percutaneous removal of renal and ureteral stones with and without concomitant transurethral manipulation by a urologist using antegrade and retrograde techniques without a radiologist's assistance	Leal, J.J.
2204	Journal of Urology	1988	140	950-953	Pressure-controlled hydraulic dilation of the ureter: "one-step" ureteroscopy	Eshghi, M.
2205	Journal of Urology	1988	140	732-736	A modified algorithm for the management of ureteral calculi: 100 consecutive cases	Dretler, S.P., Weinstein, A.
2225	Journal of Urology	1988	139	710-713	Ureteroscopic results and complications: experience with 130 cases	Daniels, G.F., Jr., Garnett, J.E., and Carter, M.F.
2226	Journal of Urology	1988	139	116-117	A new alternative treatment for entrapped stone basket in the distal ureter	Durano, A.C., Jr., Hanosh, J.J.
2230	Journal of Urology	1989	142	1425-1427	Lessons learned in patients with large steinstrasse	Weinerth, J.L., Flatt, J.A., and Carson, C.C., III.
2251	Scandinavian Journal of Urology & Nephrology	1988	22	179-182	Ureteroscopic stone manipulation in the upper third of ureter and the pelvicaliceal system	Pedersen, F.M., Olsen, J.B., and Nielsen, H.V.
2293	Urology	1988	32	427-428	Ureteroscopic diagnosis and treatment of urinary calculi during pregnancy	Rittenberg, M.H., Bagley, D.H.
2315	Medical Journal of Australia	1986	145	574-579	The visual endourological removal of ureteric calculi	Harewood, L.M., Cleeve, L.K.
2329	Journal of Urology	1975	113	762-764	Ureteral calculi: review of 17 years of experience at a community hospital	Henry, H.H., Tomlin, E.M.
2349	Journal of Urology	1986	135	689-693	Ureteroscopy: the initial experience	Keating, M.A., Heney, N.M., Young, H.H., Kerr, W.S., Jr., O'Leary, M.P., and Dretler, S.P.
2354	International Urology & Nephrology	1988	20	577-583	Extracorporeal shock wave lithotripsy of stones in the ureter	Patrashkov, T., Michailov, P., Lilov, A., Nikolov, S., and Damianov, C.
2387	Journal of Endourology	1987	1	1-8	Extracorporeal shock wave lithotripsy of distal-ureteral calculi: Is it worthwhile?	Chaussy, C.G., Fuchs, G.J.

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2392	Journal of Endourology	1987	1	31-35	Ureteral stone extraction utilizing nondeflectable flexible fiberoptic ureteroscopes	Preminger, G.M., Kennedy, T.J.
2418	Journal of Endourology	1987	1	205-207	Extracorporeal shock wave lithotripsy for ureteral calculi in patients with spinal cord injuries	Pintauro, W.L., Saltzman, B., and Sotolongo, J.R.
2429	Journal of Endourology	1988	2	1-9	Techniques and results of extracorporeal shock wave lithotripsy in the ureter	Puppo, P., Bottino, P., Germinale, F., Caviglia, C., Ricciotti, G., and Giuliani, L.
2436	Journal of Endourology	1988	2	41-45	Ureteral meatotomy as a treatment of steinstraasse following extracorporeal shock wave lithotripsy	Sigman, M., Laudone, V., and Jenkins, A.D.
2445	Journal of Endourology	1988	2	107-111	Extracorporeal shock wave lithotripsy of stones in the upper, mid, and lower ureter	Manzone, D.J., Chiang, B.
2446	Journal of Endourology	1988	2	113-115	Extracorporeal shock wave lithotripsy in the prone position: Technique, indications, results	Miller, K., Bachor, R., and Hautmann, R.
2472	Journal of Endourology	1990	4	123-127	Role of ureteral stents in extracorporeal shock wave lithotripsy of ureteral calculi	Lee, K.K., Burns, J.R.
2478	Journal of Endourology	1990	4	155-160	Flexible ureteroscopic lithotripsy using pulsed-dye laser	Grasso, M., Bagley, D.H.
2479	Journal of Endourology	1990	4	161-167	Laser lithotripsy: Further experience with Nd: YAG laser	Maghraby, H., Knipper, A., Muschter, R., and Hofstetter, A.G.
2486	Journal of Endourology	1989	3	361-365	Efficacy of electrohydraulic and laser lithotripsy in the ureter	Schoborg, T.W.
2489	Journal of Endourology	1989	3	375-380	Pediatric ureteroscopy for calculus extraction	Van Arsdalen, K.N., Smith, J.E., Shortliffe, L.D., and Snyder, H.M.
2508	Journal of Endourology	1990	4	71-78	De Novo extracorporeal shock wave lithotripsy or lower ureteral calculi: Treatment of choice	Keeler, L.L., McNamara, T.C., Dorey, F.O., and Milsten, R.E.
2517	Journal of Endourology	1989	3	295-300	Management of ureteral calculi: The impact of anesthesia-free ESWL	Miller, K., Sauter, T., Bachor, R., and Hautmann, R.
2519	Journal of Endourology	1989	3	307-313	Lithostar: An electromagnetic acoustic shock wave unit for extracorporeal lithotripsy	Clayman, R.V., McClennan, B.L., Garvin, T.J., Denstedt, J.D., and Andriole, G.L.
2520	Journal of Endourology	1989	3	315-319	Experience with a new multifunctional lithotripter, the Dornier MFL 5000: Results of 415 treatments	Graff, J., Benkert, S., Pastor, J., and Senge, T.
2697	Journal of Urology	1990	144	628-630	Percutaneous antegrade fiberoptic ureterorenoscopic treatment of ureteral calculi	Berkhoff, W.B., Meijer, F.
2787	European Urology	1990	18	1-5	First experience with the Lithoring in the management of urinary stones	Puppo, P., Bottino, P., Germinale, F., and Giuliani, L.
2794	Journal of Urology	1990	144	253-254	In situ extracorporeal shock wave lithotripsy for ureteral calculi	Rodrigues Netto N. Jr., Lemos, G.C., and Claro, J.F.
2811	British Journal of Urology	1990	65	638-640	Extracorporeal shockwave lithotripsy monotherapy for paediatric urinary tract calculi	Thornhill, J.A., Moran, K., Mooney, E.E., Sheehan, S., Smith, J.M., and Fitzpatrick, J.M.
2832	Journal of Urology	1990	144	489-491	Lithostar extracorporeal shock wave lithotripsy in children	Abara, E., Merguerian, P.A., McLorie, G.A., Psihramis, K.E., Jewett, M.A., and Churchill, B.M.
2833	Journal of Urology	1990	144	484-485	Endoscopic manipulation of ureteral calculi in children by rigid operative ureterorenoscopy	Caione, P., De Gennaro, M., Capozza, N., Zaccara, A., Appetito, C., Lais, A., Gallucci, M., and di Silverio, F.
2875	Journal of Urology	1991	145	484-488	Extracorporeal shock wave lithotripsy of urinary calculi: experience in treatment of 3,278 patients using the Siemens Lithostar and Lithostar Plus	el-Damanhoury, H., Schärfe, T., Rüth, J., Roos, S., and Hohenfellner, R.
2887	Journal of Urology	1991	145	949-951	Endoscopic laser lithotripsy: safe, effective therapy for ureteral calculi	Fugelso, P., Neal, P.M.
2905	Journal of Urology	1991	145	25-28	Endourological experience with cystine calculi and a treatment algorithm	Kachel, T.A., Vijan, S.R., and Dretler, S.P.

2912	Journal of Urology	1991	145	489-491	Treatment of steinstrasse with repeat extracorporeal shock wave lithotripsy: experience with piezoelectric lithotriptor	Kim, S.C., Oh, C.H., Moon, Y.T., and Kim, K.D.
2914	Nippon Jinzo Gakkai Shi	1990	32	919-922	Fiberoptic transurethral lithotripsy prefers smaller impacted ureteral calculi rather than large renal stones	Kitamura, T., Murahashi, I.
2915	Journal of Urology	1991	145	715-718	The clinical implications of brushite calculi	Klee, L.W., Brito, C.G., and Lingeman, J.E.
2938	Journal of Urology	1991	145	263-265	Ureteral calculi: natural history and treatment in an era of advanced technology	Morse, R.M., Resnick, M.I.
2941	British Journal of Urology	1991	67	18-23	The impact of extracorporeal piezoelectric lithotripsy on the management of ureteric calculi: an audit	Parr, N.J., Ritchie, A.W., Moussa, S.A., and Tolley, D.A.
2950	European Urology	1990	18	237-241	Modulith SL 10/20--experimental introduction and first clinical experience with a new interdisciplinary lithotriptor	Rassweiler, J., Köhrmann, U., Heine, G., Back, W., Wess, O., and Alken, P.
3031	British Journal of Urology	1991	67	358-361	Prognostic factors in the conservative treatment of ureteric stones	Ibrahim, A.I., Shetty, S.D., Awad, R.M., and Patel, K.P.
3061	European Urology	1991	19	225-229	Long-term follow-up after extracorporeal shock wave lithotripsy in children	Frick, J., Sarica, K., Köhle, R., and Kunit, G.
3073	International Urology & Nephrology	1991	23	121-127	Retrograde ureterorenoscopy in the management of ureteral calculi	Amin el-Baz, M.
3087	Journal of Urology	1991	145	1146-1150	High energy pulsed dye laser lithotripsy: management of ureteral calcium oxalate monohydrate calculi	Vandeursen, H., Pittomvils, G., Boving, R., and Baert, L.
3088	Journal of Urology	1991	146	742-745	Balloon dilation of the distal ureter to 24F: an effective method for ureteroscopic stone retrieval	Garvin, T.J., Clayman, R.V.
3104	Journal of Urology	1991	146	8-12	Anesthesia-free in situ extracorporeal shock wave lithotripsy of ureteral stones	Tiselius, H.G.
3105	Journal of Urology	1991	146	5-7	Treatment options for ureteral calculi: endourology or extracorporeal shock wave lithotripsy	Netto, N.R., Jr., Claro, J.F., Lemos, G.C., and Cortado, P.L.
3113	Journal of Urology	1991	146	737-741	Treatment of ureteral calculi with extracorporeal shock wave lithotripsy using the Lithostar device	Ahlawat, R.K., Bhandari, M., Kumar, A., and Kapoor, R.
3114	Journal of Urology	1991	146	290-293	Equivalence of mobile and fixed lithotriptors for upper tract stones	Cass, A.S.
3127	Singapore Medical Journal	1991	32	151-153	Ureterorenoscopy: factors influencing success	Ravintharan, T., Lim, P.H., and Chng, H.C.
3148	Urology	1991	38	51-53	ESWL treatment with ventral shock-wave application: therapy of iliac and distal ureteral calculi	Zehntner, C.H., Marth, D., and Zingg, E.J.
3161	Journal of Endourology	1990	4	347-351	Intracorporeal electrohydraulic lithotripsy with flexible ureterorenoscopy	Feagins, B.A., Wilson, W.T., and Preminger, G.M.
3162	Journal of Endourology	1990	4	353-359	Treatment of proximal and midureteral calculi: a randomized trial of in situ and pushback extracorporeal lithotripsy	Hendrikx, A.J.M., Bierkens, A.F., Oosterhof, G.O.N., and Debruyne, F.M.J.
3171	Journal of Endourology	1990	4	399-406	Extracorporeal shock wave lithotripsy of calculi in lower third of the ureter: randomized comparison of in situ treatment v treatment with loop catheter	Bierkens, A.F., Hendrikx, A.J.M., and Debruyne, F.M.J.
3187	Journal of Endourology	1991	5	195-196	Extracorporeal shock wave lithotripsy of upper ureteral stones: in situ v push and smash treatment	Koch, J., Balk, N., Wilbert, D.M., Strohmaier, W.L., and Bichler, K.H.
3188	Journal of Endourology	1991	5	197-199	Extracorporeal shock wave lithotripsy for in situ ureteral stones: comparison of two catheter strategies	Naidich, J.B., Greenberg, R.W., Benetos, F.C., Badillo, F.L., and Waldbaum, R.S.
3189	Journal of Endourology	1991	5	201-203	Ureteral calculus monotherapy with second-generation lithotripter	Robles, J.E., Isa, W., Rosell, D., Aguera, L.G., Sanchez, P.L., Zudaire, J.J., and Berian, J.M.
3265	Urology	1991	38	443-446	Lumbar ureteric stones: which is the best treatment?	Netto, N.R., Jr., Claro, J.F., Ferreira, U., and Lemos, G.C.
3272	Journal of Urology	1991	146	1228-1231	Clinical experience with high power (140 mj.), large fiber (320 micron) pulsed dye laser lithotripsy	Dretler, S.P., Bhatta, K.M.

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3287	Journal of Endourology	1991	5	277-281	Extracorporeal shock wave lithotripsy for proximal ureteral calculi: to stint or not to stint?	Albala, D.M., Clayman, R.V., and Meretyk, S.
3291	Journal of Endourology	1991	5	301-305	Pulsed dye laser lithotripsy--which laser fiber is preferable? Critical evaluation in 204 consecutive lasertripsies	VanDeursen, H., Pottomvils, G., Boving, R., and Baert, L.
3326	Journal of Urology	1989	142	949-954	Flexible, actively deflectable fiberoptic ureteronephroscopy	Kavoussi, L.R., Clayman, R.V., and Basler, J.
3465	Journal of Endourology	1992	6	47-50	Minimally invasive ureteroscopy using adjustable electrohydraulic lithotripsy	Vorreuther, R.
3520	Journal of Urology	1992	147	1243-1244	Advantage of a smaller caliber fiberscope and learning curve on transurethral lithotripsy	Minowada, S., Higashihara, E., Kameyama, S., Oshi, M., Homma, Y., and Aso, Y.
3522	British Journal of Urology	1992	69	253-256	Ureteric stone management using a second generation lithotriptor	Mishriki, S.F., Wills, M.I., Mukherjee, A., Feneley, R.C., and Gingell, J.C.
3525	Journal of Urology	1992	147	1010-1012	Laser lithotripsy of the difficult ureteral calculus: results in 122 patients	Psihramis, K.E.
3526	Journal of Urology	1992	147	1006-1009	Lithostar extracorporeal shock wave lithotripsy: the first 1,000 patients.	Psihramis, K.E., Jewett, M.A., Bombardier, C., Caron, D., and Ryan, M.
3530	Journal of Urology	1992	147	1238-1242	Ureteroscopy without routine balloon dilation: an outcome assessment	Stoller, M.L., Wolf, J.S., Jr., Hofmann, R., and Marc, B.
3545	Australian & New Zealand Journal of Surgery	1992	62	283-286	Extracorporeal shock-wave lithotripsy for distal ureteric calculi	Cameron-Strange, A.
3546	Journal of Urology	1992	147	349-351	Do upper ureteral stones need to be manipulated (push back) into the kidneys before extracorporeal shock wave lithotripsy?	Cass, A.S.
3547	International Urology & Nephrology	1991	23	543-547	Results of selected Zeiss basket applications during transurethral interventions and open surgery	Çetinkaya, M., Saglam, H., and Beyribey, S.
3568	Scandinavian Journal of Urology & Nephrology - Supplementum	1991	138	25-29	Outpatient-based extracorporeal shock wave lithotripsy using EDAP LT-01	Grenabo, L., Wang, Y., Bratell, S., Dahlstrand, C., Haraldsson, G., Hedelin, H., Henriksson, C., Wikholm, G., Pettersson, S., and Zachrisson, B.F.
3581	Scandinavian Journal of Urology & Nephrology - Supplementum	1991	138	31-33	Pulsed dye laser treatment of ureteral calculi	Jensen, V.J., Krarup, T., and Walter, S.
3721	British Journal of Urology	1992	69	358-362	Pulsed dye laser lithotripsy--the Toa Payoh Hospital experience	Ng, F.C., Ravi, T., Lim, P.H., and Chng, H.C.
3723	European Urology	1991	20	269-271	Lithotripsy with the alexandrite laser: our initial 100 clinical cases	Pertusa, C., Albisu, A., Acha, M., Blasco, M., Llarena, R., and Arregui, P.
3739	Journal of Urology	1992	147	1499-1501	Treatment strategy for piezoelectric shock wave lithotripsy of upper ureteral calculi	Creagh, T., Gleeson, M., Grainger, R., McDermott, T.E., and Butler, M.R.
3745	International Urology & Nephrology	1992	24	15-19	In situ extracorporeal shock wave lithotripsy for upper ureteral stones: experience with 65 patients	Basar, I., Gurpinar, T., and Erkan, A.
3757	British Journal of Urology	1992	69	465-469	Extracorporeal shock wave lithotripsy with the Storz Modulith SL20: the first 500 patients	Liston, T.G., Montgomery, B.S., Bultitude, M.I., and Tiptaft, R.C.
3771	Journal of Endourology	1992	6	213-215	Experience with extracorporeal shock wave lithotripsy for cystine calculi in 20 renal units	Harada, M., Ko, Z., and Kamidono, S.
3811	Journal of Urology	1992	148	1088-1090	The Swiss Lithoclast: a new device for intracorporeal lithotripsy	Denstedt, J.D., Eberwein, P.M., and Singh, R.R.
3812	Journal of Urology	1992	148	1086-1087	Management of ureteral stones by extracorporeal shock wave lithotripsy using Lithostar lithotriptor	el-Gammal, M.Y., Fouda, A.A., Meshref, A.W., Abu-el-Magd, A.N., Farag, F.A., and el-Katib, S.E.
3814	European Urology	1992	21	192-194	Extracorporeal shock wave lithotripsy with ultrasound-guided lithostar plus	Fictner, J., Burger, R.A., Witzsch, U., and Hohenfellner, R.
3819	Journal of Urology	1992	148	1095-1096	Cost and efficacy of extracorporeal shock wave lithotripsy versus ureteroscopy in the treatment of lower ureteral calculi	Kapoor, D.A., Leech, J.E., Yap, W.T., Rose, J.F., Kabler, R., and Mowad, J.J.

3839	Journal of Urology	1992	148	1097-1101	In situ extracorporeal shock wave lithotripsy of ureteral calculi with the MPL-9000X lithotriptor	Rauchenwald, M., Colombo, T., Petritsch, P.H., Vilits, P., and Hubmer, G.
3841	Journal of Urology	1992	148	1112-1113	Extracorporeal shock wave lithotripsy of radiolucent urinary calculi using the Siemens Lithostar Plus	Rodrigues Netto, N., Jr.; Claro, J.F., and Cortado, P.L.
3861	Seminars In Urology	1992	10	199-201	Treatment of ureteral calculi measuring 1 cm or greater in their largest dimension, using the pulsed-dye laser or extracorporeal shock-wave lithotripsy	Evans, R.M., Reddy, P.K., Hulbert, J.C., and Hernandez-Graulau, J.M.
3886	Journal of Endourology	1992	6	309-314	Extracorporeal piezoelectric lithotripsy: experience in 930 patients	Virgili, G., Vespasiani, G., Mearini, E., DiStasi, S., and Micali, M.
3887	Journal of Endourology	1992	6	315-318	De novo extracorporeal shock wave lithotripsy for ureteral stones	Cass, A.S.
3888	Journal of Endourology	1992	6	319-322	Middle ureteral stones: results of in situ extracorporeal shock wave lithotripsy with EDAP LT-01 lithotripters	Mashimo, S., Suyama, K., Goh, M., Kasai, I., Uchida, T., Sato, M., and Kanzaki, M.
3889	Journal of Endourology	1992	6	323-326	Extracorporeal shock wave lithotripsy for mid and lower ureteral stones	Cass, A.S.
4055	Journal D Urologie	1992	98	98-100	Rowatinex for the treatment of ureterolithiasis	Engelstein, D., Kahan, E., and Servadio, C.
4077	Urology	1992	40	430-434	Extracorporeal shock-wave lithotripsy with Lithostar lithotriptor	Rodrigues Netto, N., Jr., Lemos, G.C., and Claro, J.F.
4083	British Journal of Urology	1992	70	252-257	Management of impacted upper ureteric calculi: results of lithotripsy and percutaneous litholapaxy	Srivastava, A., Ahlawat, R., Kumar, A., Kapoor, R., and Bhandari, M.
4084	Journal of Urology	1992	148	1383-1387	Renal colic in pregnancy	Stothers, L., Lee, L.M.
4164	International Urology & Nephrology	1992	24	369-373	In situ prone ESWL for the treatment of lower ureteral stones: experience with 28 patients	Basar, I., Gurpinar, T., and Erkan, A.
4192	Urologia Internationalis	1992	49	167-170	ESWL of stones in the mid-ureter	Ruckdeschel, M., Bauer, E., Schneider, W., and Altwein, J.E.
4195	Journal of Urology	1993	149	15-18	The Swiss Lithoclast: a new device for endoscopic stone disintegration	Schulze, H., Haupt, G., Piergiovanni, M., Wisard, M., von Niederhausern, W., and Senge, T.
4210	European Urology	1992	22	134-136	Original lithotomy positioning for transperineal extracorporeal shockwave lithotripsy for distal ureteric calculi with Tripter X1	Andrianne, R., Vandeberg, C., Bonnet, P., Nicolas, H., Coppens, L., Bouffioux, C., and de Leval, J.
4213	British Journal of Urology	1992	70	600-602	Extracorporeal lithotripsy of ureteric calculi using the Dornier HM-3 lithotriptor	Benizri, E., Augusti, M., Azoulai, G., Charbit, L., and Cukier, J.
4226	British Journal of Urology	1992	70	594-599	Extracorporeal shock wave lithotripsy of ureteric stones with the Modulith SL 20	Rassweiler, J., Henkel, T.O., Joyce, A.D., Kohrmann, K.U., Manning, M., and Alken, P.
4235	Journal of Endourology	1992	6	403-410	Treatment of renal and ureteral stones with lithocut C-3000 lithotripter	Grabe, M., Kinn, A.C., Ahlgran, G., and Carbin, B.E.
4237	Journal of Endourology	1992	6	411-412	Extracorporeal electromagnetic shock wave lithotripsy of ureteric stones in situ	Kirkali, Z., Mungan, U., and Sade, M.
4241	Journal of Endourology	1992	6	429-432	Lithoclast: new and inexpensive mode of intracorporeal lithotripsy	Hofbauer, J., Hobarth, K., and Marberger, M.
4261	Journal of Lithotripsy and Stone Disease	1990	2	39-41	Laser lithotripsy of ureteral calculi: initial experience with a new pulsed dye laser	Zerbib, M., Steg, A., Belas, M., Flam, T., and Debre, B.
4263	Journal of Lithotripsy and Stone Disease	1990	2	46-49	Immediate in situ ESWL as monotherapy in acute obstructive urolithiasis: useful or not?	Baert, L., Willemen, P.
4277	Journal of Lithotripsy and Stone Disease	1991	3	45-47	Extracorporeal shock wave lithotripsy in situ treatment for ureteral stones	D'Hallewin, Marie-A., Baert, L.
4301	The Journal of Stone Disease	1992	4	227-234	Management of lower and middle ureteral calculi "in situ" using the Dornier MFL-5000 lithotripter	Saada, S.
4322	Minimally Invasive Therapy	1993	2	19-22	Laparoscopic lithotomy for ureteral stones	Lipsky, H., Wuernschimmel, E.

Papyrus	Journal	Year	Volume	Pages	Title	Authors
4370	Acta Paediatrica Sinica	1992	33	357-362	Extracorporeal shock wave lithotripsy in children: experience with the multifunctional lithotripter MFL 5000	Lin, C.M.
4411	Urologia Internationalis	1993	50	153-158	Spontaneous passage of upper urinary tract calculi in relation to composition	Ohkawa, M., Tokunaga, S., Nakashima, T., Yamaguchi, K., Orito, M., and Hisazumi, H.
4432	World Journal of Urology	1993	11	54-58	ESWL in situ or ureteroscopy for ureteric stones?	Hofbauer, J., Tuerk, C., Hobarth, K., Hasun, R., and Marberger, M.
4448	Journal of Urology	1993	149	1082-1084	Safety and efficacy of pediatric ureteroscopy for management of calculous disease	Thomas, R., Ortenberg, J., Lee, B.R., and Harmon, E.P.
4453	World Journal of Urology	1993	11	19-25	Developments in the ureteroscopes, techniques and accessories associated with laser lithotripsy	Watson, G.M., Landers, B., Nauth-Misir, R., and Wickham, J.E.
4511	Journal of Urology	1993	149	1425-1426	Extracorporeal shock wave lithotripsy for distal ureteral stones	Erturk, E., Herrman, E., and Cockett, A.T.
4530	British Journal of Urology	1993	71	512-515	Laser lithotripsy with the Candela MDL-2000 LaserTripter	MacDermott, J.P., Grove, J., and Clark, P.B.
4546	Journal of Urology	1993	149	1427-1430	An innovative approach to management of lower third ureteral calculi	Thomas, R., Macaluso, J.N., Vandenberg, T., and Salvatore, F.T.
4590	Journal of Urology	1993	150	824-826	Extracorporeal shock wave lithotripsy in situ or after push-up for upper ureteral calculi: a prospective randomized trial	Danuser, H., Ackermann, D.K., Marth, D.C., Studer, U.E., and Zingg, E.J.
4594	Journal of Urology	1993	150	827-829	The fate of the iatrogenic retroperitoneal stone	Evans, C.P., Stoller, M.L.
4627	European Urology	1993	24	177-184	Extracorporeal shock wave lithotripsy for obstructed proximal ureteral stones. A prospective randomized study comparing in situ, stent bypass and below stone catheter with irrigation strategies	Chang, S.C., Kuo, H.C., and Hsu, T.
4647	Journal of Endourology	1993	7	201-204	Lasertripsy of ureteral calculi using pulsed-dye laser with automatic shut-off after tissue contact	Schmidt, A., Eisenberger, F.
4796	Journal of Urology	1993	150	1803-1805	Comparison of 2 pulsed lasers for lithotripsy of ureteral calculi: report on 154 patients	Benizri, E., Wodey, J., Amiel, J., and Toubol, J.
4803	Journal of Urology	1993	150	1395-1398	Ureteroscopic treatment of lower ureteral calculi in the era of extracorporeal shock wave lithotripsy: from a developing country point of view	Chang, S.C., Ho, C.M., and Kuo, H.C.
4808	Irish Journal of Medical Science	1993	162	348-350	In situ ESWL for ureteric calculi: the optimum treatment?	Creagh, T.A., Williams, N.N., Cronin, K., Kerin, M.J., Smith, J.M., and Fitzpatrick, J.M.
4895	Journal of Endourology	1993	7	285-287	Anesthesia-free extracorporeal shock wave lithotripsy of distal ureteral stones without a ureteral catheter	Tiselius, H.G.
4953	British Journal of Urology	1993	72	683-687	Extracorporeal shock wave lithotripsy for ureteric calculi with the Dornier MFL5000 lithotriptor at a multi-user centre	Watson, R.B., James, A.N.
5018	Keio Journal of Medicine	1993	42	209-211	Pulsed dye laser lithotripsy for ureteral stone fragmentation	Baba, S., Asanuma, H., and Tazaki, H.
5023	Urology	1994	43	178-181	Nonstent or noncatheter extracorporeal shock-wave lithotripsy for ureteral stones	Cass, A.S.
5040	Journal of Endourology	1993	7	501-503	Retroperitoneal endoscopic ureterolithotomy: our experience in 12 patients	Gaur, D.D.
5062	Urologia Internationalis	1994	52	17-20	Extracorporeal shock wave lithotripsy using the Dornier MPL 9000 lithotriptor	Ohshima, S., Ono, Y., Sahashi, M., Matsuura, O., Takeuchi, N., Tanaka, K., Yamada, S., Kamihira, O., Kuriki, O., Mizutani, K., et al.
5081	Annals of the Academy of Medicine, Singapore	1993	22	905-907	Extracorporeal shockwave lithotripsy using Storz Modulith SL20--the Singapore General Hospital experience	Wong, M.Y., Li, M.K., and Foo, K.T.
5212	British Journal of Urology	1993	72	13-16	Extracorporeal shock wave lithotripsy for treatment of ureterolithiasis in patients with cystinuria	Katz, G., Kovalski, N., and Landau, E.H.
5235	Journal of Urology	1994	151	1185-1187	Ureteroscopy: an outpatient procedure?	Wills, T.E., Burns, J.R.

5249	Annals of the Academy of Medicine, Singapore	1994	23	43-45	Laser lithotripsy for ureteric stones	Foo, K.T., Wujanto, R., and Wong, M.Y.
5250	Urologia Internationalis	1994	52	98-101	Extracorporeal shock wave lithotripsy for ureteral stones using the Dornier lithotriptor MFL5000	Fujimoto, N., Kyo, M., Ichikawa, Y., and Nagano, S.
5254	Journal of Endourology	1994	8	13-14	Ureteral extracorporeal shock wave lithotripsy utilizing Dornier MFL 5000	Ilker, N.Y., Alican, Y., Simsek, F., Turkeri, L.N., and Akdas, A.
5341	Journal of Urology	1994	152	62-65	Optimal therapy for the distal ureteral stone: extracorporeal shock wave lithotripsy versus ureteroscopy	Anderson, K.R., Keetch, D.W., Albala, D.M., Chandhoke, P.S., McClennan, B.L., and Clayman, R.V.
5349	Journal of Urology	1994	152	49-52	Bilateral same session ureteroscopy	Camilleri, J.C., Schwalb, D.M., and Eshghi, M.
5355	Urology	1994	43	776-781	In situ extracorporeal shock wave lithotripsy for primary ureteric calculi	Farsi, H.M., Mosli, H.A., Alzimaity, M., Bahnassay, A.A., and Ibrahim, M.A.
5358	British Journal of Urology	1994	73	487-493	In situ echoguided extracorporeal shock wave lithotripsy of ureteric stones with the Dornier MPL 9000: a multicentric study group	Frabboni, R., Santi, V., Ronchi, M., Gaiani, S., Costanza, N., Ferrari, G., Ferrari, P., Corrado, G., Concetti, S., and Fornarola, V.
5364	Journal of Urology	1994	152	320-323	Should upper ureteral calculi be manipulated before extracorporeal shock wave lithotripsy? A prospective controlled trial	Kumar, A., Kumar, R.V., Mishra, V.K., Ahlawat, R., Kapoor, R., and Bhandari, M.
5369	Journal of Urology	1994	152	53-56	Effects of stents on lithotripsy of ureteral calculi: treatment results with 18,825 calculi using the Lithostar lithotriptor	Mobley, T.B., Myers, D.A., Jenkins, J.M., Grine, W.B., and Jordan, W.R.
5378	British Journal of Urology	1994	73	480-486	The scope and place of ultrasound-monitored extracorporeal shock wave lithotripsy in a multimodality setting and the effects of experiential, audit-evoked changes on the management of ureteric calculi	Talati, J., Khan, L.A., Noordzij, J.W., Mohammad, N., Memon, A., and Hotiana, M.Z.
5401	International Urology & Nephrology	1994	26	13-16	Morbidity associated with patient positioning in extracorporeal shock wave lithotripsy of distal ureteral calculi	Guntekin, E., Kukul, E., Kayacan, Z., Baykara, M., and Sevuk, M.
5487	Journal of Urology	1994	152	1095-1098	Nifedipine and methylprednisolone in facilitating ureteral stone passage: a randomized, double-blind, placebo-controlled study	Borghi, L., Meschi, T., Amato, F., Novarini, A., Giannini, A., Quarantelli, C., and Mineo, F.
5503	Journal of Pediatric Surgery	1994	29	761-764	Pediatric urolithiasis: to cut or not to cut	Moazam, F., Nazir, Z., and Jafarey, A.M.
5536	Journal of Urology	1994	152	1379-1385	Extracorporeal shock wave lithotripsy: multicenter study of kidney and upper ureter versus middle and lower ureter treatments	Ehreth, J.T., Drach, G.W., Arnett, M.L., Barnett, R.B., Govan, D., Lingeman, J., Loening, S.A., Newman, D.M., Tudor, J.M., and Saada, S.
5538	Journal of Urology	1994	152	1549-1551	Laparoscopic laser ureterolithotomy	Fahlenkamp, D., Schonberger, B., Liebetruth, L., Lindeke, A., and Loening, S.A.
5552	Scandinavian Journal of Urology & Nephrology Supplementum	1994	157	159-163	Primary in situ extracorporeal shock wave lithotripsy for ureteral calculi	Mogensen, P., Andersen, J.T.
5716	Urologia Internationalis	1994	53	87-91	In situ extracorporeal shockwave lithotripsy of distal ureteral stones: parameters for therapeutic success	Mattelaer, P., Schroder, T., Fischer, N., and Jakse, G.
5720	Journal of Urology	1995	153	453-457	Pediatric low energy lithotripsy with the Lithostar	Myers, D.A., Mobley, T.B., Jenkins, J.M., Grine, W.B., and Jordan, W.R.
5722	British Journal of Urology	1994	74	694-698	Treatment of ureteric stones. Comparison of laser and pneumatic lithotripsy	Naqvi, S.A., Khaliq, M., Zafar, M.N., and Rizvi, S.A.
5748	British Journal of Urology	1994	74	699-702	Intracorporeal lithotripsy with the Swiss lithoclast	Wadhwa, S.N., Hemal, A.K., and Sharma, R.K.
5769	Journal of Endourology	1994	8	341-343	Outpatient fragmentation of ureteral calculi with mini-ureteroscopes and laser lithotripsy	Boline, G.B., Belis, J.A.
5784	Journal of Urology	1995	153	623-625	Electrohydraulic versus pneumatic disintegration in the treatment of ureteral stones: a randomized, prospective trial	Hofbauer, J., Hobarth, K., and Marberger, M.

Papyrus	Journal	Year	Volume	Pages	Title	Authors
5796	Journal of Endourology	1994	8	331-334	Piezolith extracorporeal shockwave lithotripsy: the Hotel-Dieu de France experience	Merhej, S., Nemr, E., Armache, K., Chalouhy, E., Chaiban, R., Moukarzel, M., and Khoury, R.
5873	Urology	1995	45	372-376	The case for primary endoscopic management of upper urinary tract calculi: II. Cost and outcome assessment of 112 primary ureteral calculi	Grasso, M., Beaghler, M., and Loisides, P.
5926	European Urology	1994	26	291-297	Endourological treatment of lumbar and iliac ureteral stones. A comparative study of 49 cases	Piergiovanni, M., Cussenot, O., Nguyen, H.V., Teillac, P., and Le Duc, A.
5984	British Journal of Urology	1995	75	395-400	Experience with ureteroscopy in children	Shroff, S., Watson, G.M.
6251	Journal of Endourology	1995	9	255-258	Preliminary experience with holmium: YAG laser lithotripsy	Denstedt, J.D., Razvi, H.A., Sales, J.L., and Eberwein, P.M.
6253	Journal of Endourology	1995	9	225-231	Safety and effectiveness of Lithostar shock tube C in the treatment of urinary calculi	Elabbady, A., Mathes, G., Morehouse, D.D., Honey, J., Pahira, J., Zeman, R., Paquin, J.M., Faucher, R., and Elhilali, M.M.
6275	Urology	1995	46	550-552	Extracorporeal shock-wave lithotripsy in children	Longo, J.A., Rodrigues Netto, N., Jr.
6286	British Journal of Urology	1995	76	435-439	In situ piezoelectric extracorporeal shock wave lithotripsy of ureteric stones	Robert, M., Delbos, O., Guiter, J., and Grasset, D.
6295	Journal of Urology	1995	154	1660-1663	Ureteroscopy in pregnancy	Ulvik, N.M., Bakke, A., and Hoisaeter, P.A.

Figure A-1. Articles Reviewed and Extracted by Year of Publication

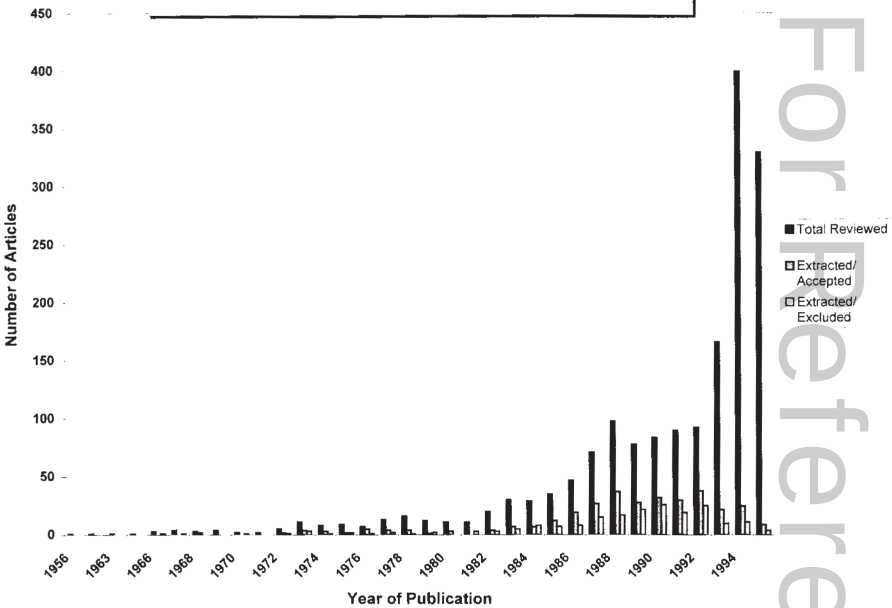


Figure A-2. Articles Reviewed and Extracted by Journal Source

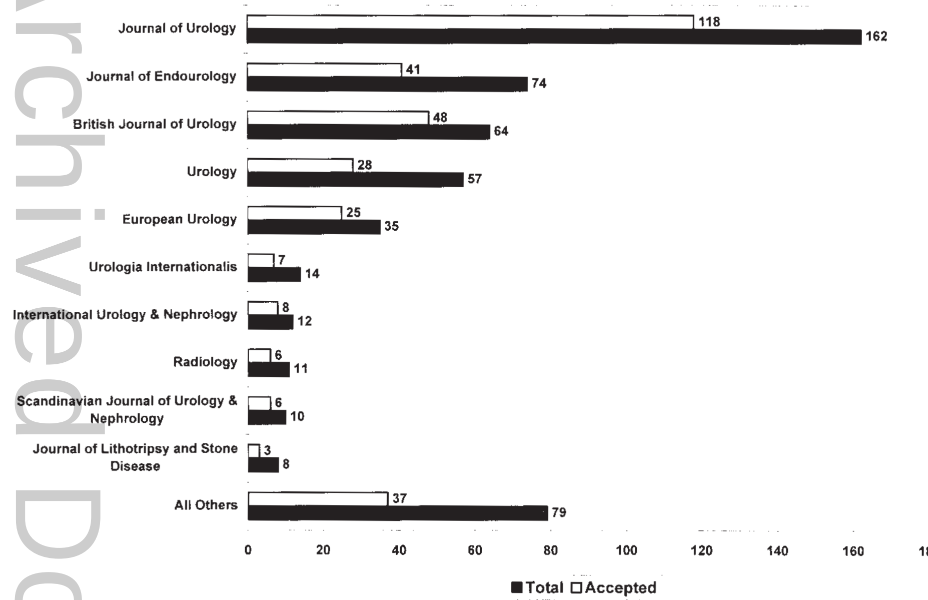
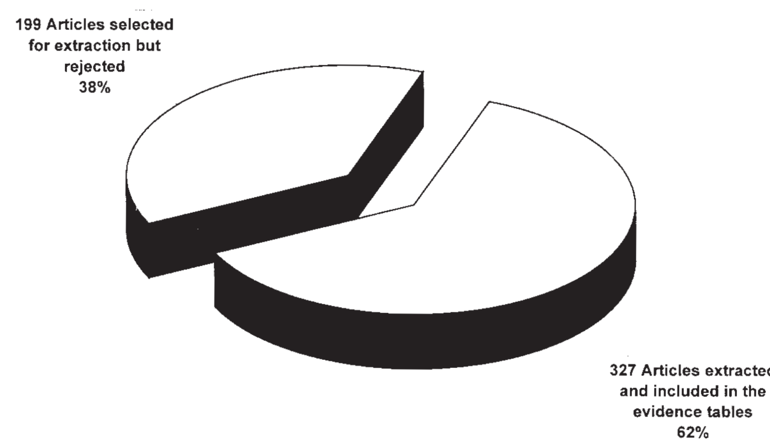


Figure A-3. Articles Selected for Data Extraction (N = 526 of 1,698)

Figure A-4. Articles Extracted (N = 327 of 526)



Appendix B – Detailed outcomes tables: Secondary interventions and complications

Table B-1. Secondary interventions

PROXIMAL URETER

		SWL							
		SWL overall		Pushback		Bypass		In situ	
		G/P		G/P		G/P		G/P	
Angiographic embolization	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Blind basket extraction	Median:	3	.060	2	.030			2	.110
	95 % CI:	223	.015 to .152	470	.014 to .054		n/a	70	.032 to .248
Open surgery	Median:	20	.051	2	.028	2	.078	11	.046
	95 % CI:	1,867	.037 to .070	495	.011 to .056	94	.010 to .251	971	.032 to .066
Percutaneous nephrostomy	Median:	9	.064	1	.050	2	.084	3	.080
	95 % CI:	1,019	.042 to .095	417	.033 to .076	126	.024 to .193	353	.042 to .134
PNL	Median:	5	.057	2	.016	1	.019	2	.045
	95 % CI:	438	.037 to .087	448	.007 to .030	116	.004 to .054	115	.013 to .106
Retrograde ureteral stent	Median:	12	.080	2	.007	1	.047	5	.109
	95 % CI:	1,313	.045 to .128	442	.002 to .018	25	.004 to .172	639	.057 to .181
Stone manipulation	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
SWL	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
URS	Median:	22	.086	5	.035	6	.069	10	.104
	95 % CI:	1,736	.070 to .105	608	.020 to .055	263	.038 to .113	664	.070 to .152

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-2. Secondary interventions

PROXIMAL URETER

		PNL G/P	PNL	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Angiographic embolization	**Median:**	1	.032						
	95 % CI:	37	.003 to .119		n/a		n/a		n/a
Blind basket extraction	**Median:**	1	.006					2	.085
	95 % CI:	195	.001 to .024		n/a		n/a	234	.019 to .221
Open surgery	**Median:**	9	.089	16	.120			2	.219
	95 % CI:	430	.060 to .128	498	.085 to .167		n/a	152	.039 to .547
Percutaneous nephrostomy	**Median:**	2	.048	2	.157				
	95 % CI:	71	.009 to .138	57	.065 to .295		n/a		n/a
PNL	**Median:**			7	.183				
	95 % CI:		n/a	267	.117 to .264		n/a		n/a
Retrograde ureteral stent	**Median:**	1	.422	2	.097	1	.107		
	95 % CI:	19	.223 to .641	56	.016 to .281	20	.021 to .284		n/a
Stone manipulation	**Median:**								
	95 % CI:		n/a		n/a		n/a		n/a
SWL	**Median:**	3	.101	9	.204			2	.489
	95 % CI:	78	.036 to .210	323	.150 to .271		n/a	126	.309 to .672
URS	**Median:**	6	.064					1	.059
	95 % CI:	307	.031 to .112		n/a		n/a	104	.024 to .115

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-3. Significant acute complications

PROXIMAL URETER

		SWL							
		SWL overall		Pushback		Bypass		In situ	
		G/P		G/P		G/P		G/P	
Mortality	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Transfusion	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

		SWL overall		Pushback		Bypass		In situ	
		G/P		G/P		G/P		G/P	
Avulsion	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Basket entrapment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Bowel injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
CV	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Hydro/Pneumothorax	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Liver injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Overall significant	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Pancreatic injury	Median:			1	.004				
	95 % CI:		n/a	301	.000 to .015		n/a		n/a
PE	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Sepsis	Median:	4	.040	2	.012	1	.025	4	.042
	95 % CI:	516	.019 to .072	336	.004 to .028	47	.002 to .095	469	.021 to .071
Splenic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Urinoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Vascular	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-4. Significant acute complications

PROXIMAL URETER

		PNL G/P	PNL	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Mortality	Median:	2	.003	1	.005	1	.005		
	95 % CI:	71	.000 to .035	45	.000 to .054	50	.000 to .049		n/a
Transfusion	Median:	2	.014			1	.005		
	95 % CI:	86	.001 to .053		n/a	50	.000 to .049		n/a

		PNL G/P	PNL	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Avulsion	Median:	1	.024	2	.040				
	95 % CI:	49	.002 to .091	81	.008 to .113		n/a		n/a
Basket entrapment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Bowel injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
CV	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Hydro/Pneumothorax	Median:	1	.061						
	95 % CI:	19	.006 to .221		n/a		n/a		n/a
Liver injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Overall significant	Median:	1	.121	1	.620				
	95 % CI:	34	.041 to .256	8	.295 to .881		n/a		n/a
Pancreatic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
PE	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Sepsis	Median:	1	.044	2	.049	2	.088		
	95 % CI:	49	.009 to .125	70	.009 to .142	30	.018 to .236		n/a
Splenic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Urinoma	Median:	1	.034			2	.088		
	95 % CI:	34	.003 to .129		n/a	35	.018 to .236		n/a
Vascular	Median:	2	.058						
	95 % CI:	57	.011 to .161		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-5. Significant and less significant acute complications

PROXIMAL URETER

		SWL overall G/P	SWL overall	Pushback G/P	Pushback	Bypass G/P	Bypass	In situ G/P	In situ
Loss of kidney	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Readmission	Median:	3	.122	1	.125	1	.125	3	.136
	95 % CI:	137	.050 to .232	25	.035 to .287	25	.035 to .287	112	.048 to .276
Clotting	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Colic	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Extraureteral stone fragment migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Hematoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Ileus	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Perforation	Median:	5	.084	2	.032	3	.161	1	.034
	95 % CI:	305	.032 to .169	326	.011 to .072	91	.071 to .294	34	.003 to .129
Perirenal hematoma	Median:	2	.015	2	.013	1	.047	1	.010
	95 % CI:	148	.003 to .043	326	.004 to .029	25	.004 to .172	123	.001 to .037
Rectal bleeding	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Renal impairment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Retention	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Steinstrasse	Median:	4	.044	2	.051			2	.050
	95 % CI:	375	.019 to .084	470	.029 to .081		n/a	199	.018 to .107
Stent migration	Median:			1	.051				
	95 % CI:		n/a	35	.029 to .081		n/a		n/a
Stone migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
UTI	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Wound infection	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-6. Significant and less significant acute complications

PROXIMAL URETER

Complication		PNL G/P	PNL	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Loss of kidney	Median:					1	.009		
	95 % CI:		n/a		n/a	24	.000 to .098		n/a
Readmission	Median:			1	.195				
	95 % CI:		n/a	21	.068 to .392		n/a		n/a
Clotting	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Colic	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Extraureteral stone fragment migration	Median:	2	.090						
	95 % CI:	56	.026 to .205		n/a		n/a		n/a
Hematoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Ileus	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Perforation	Median:	10	.117	4	.109				
	95 % CI:	425	.062 to .193	163	.052 to .192		n/a		n/a
Perirenal hematoma	Median:					1	.077		
	95 % CI:		n/a		n/a	15	.007 to .272		n/a
Rectal bleeding	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Renal impairment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Retention	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Steinstrasse	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stent migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stone migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
UTI	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Wound infection	Median:					3	.101		
	95 % CI:		n/a		n/a	111	.034 to .217		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-7. Significant long-term complications

PROXIMAL URETER

		SWL							
		SWL overall		Pushback		Bypass		In situ	
		G/P		G/P		G/P		G/P	
Loss of kidney	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Necrosis of ureter	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Overall significant	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Renal impairment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stricture	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-8. Significant long-term complications

PROXIMAL URETER

		PNL G/P	PNL	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Loss of kidney	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Necrosis of ureter	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Overall significant	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Renal impairment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stricture	Median:	4	.055	7	.019	1	.005		
	95 % CI:	93	.021 to .114	218	.006 to .043	50	.000 to .049		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-9. Secondary interventions

DISTAL URETER

		SWL overall G/P	SWL overall	Pushback G/P	Pushback	Bypass G/P	Bypass	In situ G/P	In situ
Angiographic embolization	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Blind basket extraction	Median:	7	.033			1	.029	4	.042
	95 % CI:	620	.019 to .052		n/a	142	.010 to .066	261	.019 to .079
Open surgery	Median:	14	.029			2	.039	9	.030
	95 % CI:	1,258	.020 to .042		n/a	94	.007 to .117	823	.018 to .046
Percutaneous nephrostomy	Median:	6	.049					2	.102
	95 % CI:	313	.022 to .092		n/a		n/a	32	.019 to .275
PNL	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Retrograde ureteral stent	Median:	7	.055					3	.075
	95 % CI:	727	.034 to .082		n/a		n/a	424	.032 to .142
Stone manipulation	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
SWL	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
URS	Median:	25	.072			2	.088	18	.071
	95 % CI:	2,225	.058 to .090		n/a	134	.035 to .172	1,595	.054 to .094

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-10. Secondary interventions

DISTAL URETER

		Blind basket ext. G/P	Blind basket ext.	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Angiographic embolization	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Blind basket extraction	Median:			1	.057	1	.221	2	.217
	95 % CI:		n/a	38	.011 to .158	5	.023 to .629	377	.166 to .278
Open surgery	Median:	8	.063	12	.047			1	.089
	95 % CI:	1,245	.034 to .103	688	.032 to .069		n/a	103	.044 to .153
Percutaneous nephrostomy	Median:	1	.008	3	.065	1	.096		
	95 % CI:	260	.002 to .024	146	.015 to .166	12	.009 to .329		n/a
PNL	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Retrograde ureteral stent	Median:	1	.006						
	95 % CI:	193	.001 to .024		n/a		n/a		n/a
Stone manipulation	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
SWL	Median:			5	.061			1	.155
	95 % CI:		n/a	290	.032 to .104		n/a	33	.060 to .301
URS	Median:							2	.049
	95 % CI:		n/a		n/a		n/a	307	.024 to .086

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-11. Significant acute complications

DISTAL URETER

		SWL							
		SWL overall		Pushback		Bypass		In situ	
		G/P		G/P		G/P		G/P	
Mortality	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Transfusion	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Avulsion	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Basket entrapment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Bowel injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
CV	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Hydro/Pneumothorax	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Liver injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Overall significant	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Pancreatic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
PE	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Sepsis	Median:	4	.038					1	.033
	95 % CI:	334	.016 to .074		n/a		n/a	97	.009 to .080
Splenic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Urinoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Vascular	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-12. Significant acute complications

DISTAL URETER

Complication		Blind basket ext. G/P	Blind basket ext.	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Mortality	Median:	2	.005	1	.004				
	95 % CI:	453	.001 to .014	55	.000 to .044		n/a		n/a
Transfusion	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Avulsion	Median:	3	.013	2	.041				
	95 % CI:	392	.005 to .028	77	.011 to .100		n/a		n/a
Basket entrapment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Bowel injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
CV	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Hydro/Pneumothorax	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Liver injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Overall significant	Median:	3	.059						
	95 % CI:	400	.028 to .104		n/a		n/a		n/a
Pancreatic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
PE	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Sepsis	Median:	1	.019	1	.186				
	95 % CI:	115	.004 to .055	6	.019 to .558		n/a		n/a
Splenic injury	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Urinoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Vascular	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-13. Significant and less significant acute complications

DISTAL URETER

		SWL overall G/P	SWL overall	Pushback G/P	Pushback	Bypass G/P	Bypass	In situ G/P	In situ
Loss of kidney	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Readmission	Median:	1	.036					1	.036
	95 % CI:	312	.019 to .060		n/a		n/a	312	.019 to .060
Clotting	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Colic	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Extraureteral stone fragment migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Hematoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Ileus	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Perforation	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Perirenal hematoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Rectal bleeding	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Renal impairment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Retention	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Steinstrasse	Median:	2	.087					1	.157
	95 % CI:	95	.013 to .264		n/a		n/a	39	.067 to .290
Stent migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stone migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
UTI	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Wound infection	Median:								
	95 % CI:		n/a		n/a		n/a		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-14. Significant and less significant acute complications

DISTAL URETER

Complication	Statistic	Blind basket ext. G/P	Blind basket ext.	Ureteroscopy G/P	Ureteroscopy	Open surgery G/P	Open surgery	Observation G/P	Observation
Loss of kidney	Median:	2	.005						
	95 % CI:	450	.001 to .014		n/a		n/a		n/a
Readmission	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Clotting	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Colic	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Extraureteral stone fragment migration	Median:			3	.019				
	95 % CI:		n/a	222	.006 to .042		n/a		n/a
Hematoma	Median:					1	.096		
	95 % CI:		n/a		n/a	12	.009 to .329		n/a
Ileus	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Other	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Perforation	Median:	2	.019	3	.023				
	95 % CI:	215	.006 to .044	967	.006 to .061		n/a		n/a
Perirenal hematoma	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Rectal bleeding	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Renal impairment	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Retention	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Steinstrasse	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stent migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Stone migration	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
UTI	Median:								
	95 % CI:		n/a		n/a		n/a		n/a
Wound infection	Median:					1	.050		
	95 % CI:		n/a		n/a	43	.010 to .141		n/a

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-15. Significant long-term complications

DISTAL URETER

		SWL							
		SWL overall		Pushback		Bypass		In situ	
		G/P		G/P		G/P		G/P	
Loss of kidney	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Necrosis of ureter	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Overall significant	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Renal impairment	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Stricture	Median:		n/a		n/a		n/a		n/a
	95 % CI:								

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Table B-16. Significant long-term complications

DISTAL URETER

		Blind basket ext.		Ureteroscopy		Open surgery		Observation	
		G/P		G/P		G/P		G/P	
Loss of kidney	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Necrosis of ureter	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Overall significant	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Renal impairment	Median:		n/a		n/a		n/a		n/a
	95 % CI:								
Stricture	Median:	1	.011	8	.011		n/a		n/a
	95 % CI:	193	.002 to .033	450	.004 to .024				

G=number of groups/treatment arms extracted/P=number of patients in those groups
CI=confidence interval
n/a indicates either lack of data or inapplicability to the treatment modality
Note: These tables are based on preliminary analysis.

Appendix C – Data extraction form

NEPHROLITHIASIS GUIDELINES PANEL
URETERAL STONES
DATA ABSTRACTION SHEET

Papyrus Reference

Cover Sheet

Journal:

Year: Volume: Pages:

Title:

Authors:

Institution:

Reviewer: Review Date:

Study Type: (enter code)

A Clinical Series - Retrospective or Prospective
B Randomized
C Case Report
D Selected, X = ______
E Retro. Selected, X = ______

	Y		Y		Y
Pediatric Patients:		Renal Insufficiency: Cr >		Aneurysm:	
Asymptomatic:		Pacemaker:		Blood Loss:	
Obesity:		Pregnancy:		Economic Data:	
Neurogenic Bladder/Diversion:		Coagulopathy:		Radiation Exposure Data:	
		Hypertension:		Convalescence Data:	

Accepted: (circle Y or N) Y N
Secondary Review: (circle Y or N) Y N
Group Review: (circle Y or N) Y N

Reviewer:
Review Date:
Review Date:

Other References:
(list by number or attach bibliography)

Comments:

Number of minutes to extract this article:

Revision 1.5 June, 1994

NEPHROLITHIASIS GUIDELINES PANEL
URETERAL STONES
DATA ABSTRACTION SHEET

Papyrus Reference

Group Definitions and General Comments

No. of Groups: (Total number described below. Include Group 0 in total, if used)

Group No.	Definition of Groups and Stratifications
0.	Predefined:
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	

Comments: (Please describe any biases, challenges to validity, or other difficulties with the article. In addition, indicate any data which does not fit on the form and may be of interest to the panel.)

Revision 1.5 June, 1994

NEPHROLITHIASIS GUIDELINES PANEL
URETERAL STONES
DATA ABSTRACTION SHEET

Papyrus Reference

Treatments

GROUP:

1. Population: Total Patients: Total Renal Units:

2. Treatment Modalities:

Primary Modality: (enter code) Definition if Other

Auxiliary Modality: (enter code) Definition if Other

ESWL Machine Type: (enter code)
Mobility Code:

Pre-Op:	x	P/R
Therapeutic Stent:		
Percutaneous Nephrostomy:		
Drainage, Not Specified:		

Method of Removal:

Percutaneous: (enter code)
Ureteroscopic: (enter code)

Ureteroscopes:

Code	Size	Size	Size	Size

Ureteroscopic Removal:	x	P/R
Stent Preureteroscopy		
Perc Tube Preureteroscopy		
Dilation		

3. Other:

Chemolysis Codes:
Follow-up Method Codes:
Functional Assessment Codes:

4. Anesthesia:

	x	P/T		x	P/T
General			Local + IV		
Regional			Tens		
Sedation IV			None		
Sedation PO			Unspecified		
Local			Other		

5. Comments:

Revision 1.5 June, 1994

NEPHROLITHIASIS GUIDELINES PANEL
URETERAL STONES
DATA ABSTRACTION SHEET

Papyrus Reference

Results

GROUP: Stratification Codes:

1. Population: Total Patients: Total Renal Units:

	Mean	Median	Min	Max
Post-Op Hospitalization (Days):				
Total Hospitalization (Days):				
Follow-up Interval (Months):				

	x	y	P/R
Renal Function Stable:			
Renal Function Improved:			
Renal Function Reduced:			
UTI at Follow-up:			

2. Stone Free Status:

	x	y
Patients:		
Renal Units:		

3. Acute Complications:

Code	x	y	P/R	Definition if Other

4. Secondary Interventions:

Code	x	y	P/R	Definition if Other

5. Number of Primary Procedures:

	x	y
Patients:		
Renal Units:		

6. Long Term Complications:

Code	x	y	P/R	Definition if Other

7. Comments: (continue on back if necessary)

Revision 1.5 June, 1994

Appendix D – Techniques for managing urinary calculi

Historical background

Recorded attempts to treat patients with urinary tract stone disease date back to ancient Egypt (Dretler, 1995). For bladder stones, the Egyptians attached a diamond to the end of a hollow reed with gum and inserted it through the urethra into the bladder. The goal was to fragment the stone with the diamond as the patient walked around.

In the first century, A.D., perineal lithotomy was used by Roman physicians to treat patients with bladder stones. Perineal lithotomy remained the accepted method for bladder stone removal until the 19th century. The stone was crushed and/or extracted with a forceps through the perineal incision. The procedure, without anesthesia, required four or five strong men to hold the patient down. Without sterilized instruments, sepsis was a common complication. Also common were severe bleeding, perforated rectum and urinary fistulae—and frequently the patient died.

Surgery under such conditions was obviously something to be avoided if possible. In Luchnow, India, in 1782, a Colonel Martin, who was also a physician, faced the lithotomist's knife himself because of a bladder stone that would not pass. Having exhausted all the nonsurgical remedies of his day—including bladder instillation of a powdered mixture of lye and pigeon dung—the colonel was desperate. Finally, he created a file that could be inserted through his urethra into his water-filled bladder. By leaning forward so that the stone was above the bas-fond, he could gently file the stone—which he did three times a day for nearly seven months. The stone disintegrated at last, and he voided the fragments (Thorwald, 1957).

Advances in the 19th century included a method of intracorporeal lithotripsy invented by the French surgeon Civiale. A three-prong forceps could be inserted into the bladder and opened to trap the stone, which was then crushed by tightening an adjusting screw. There were other advances in the 19th and early 20th centuries, including such landmarks as the development of general anesthesia and the invention of the cystoscope. Young (1902) reported the first ureteral dilation for successful manipulation of ureteral stones. However, the major advances in treatments for stone disease have come just in the last few decades. Extracorporeal shock wave lithotripsy, ureteroscopy and percutaneous nephrolithotomy, along with newer methods of intracorporeal lithotripsy such as laser lithotripsy, have truly revolutionized the management of urinary calculi.

Extracorporeal shock wave lithotripsy

Ever since the first patient with a renal calculus was successfully treated with shock wave lithotripsy in 1980, this form of stone therapy has rapidly gained widespread acceptance to become the treatment of choice for the majority of renal and ureteral calculi. Worldwide clinical series have documented the efficacy of shock-wave lithotripsy (Chaussy, Schmiedt, Jocham, et al., 1982; Brown and Preminger, 1988).

Shock waves are high-energy amplitudes of pressure generated in the air or water by an abrupt release of energy in a small space. They propagate according to the physical laws of acoustics and are transmitted through media with low attenuation. When a shock wave encounters a boundary between substances of differing acoustic impedance (density), compressive stresses are generated that may overcome the tensile strength of that object. Shock waves travel through water and the soft tissues of the body with low attenuation because these materials have similar densities.

However, when kidney or ureteral stones of any composition are contacted by a shock wave of sufficient energy, a compression wave is induced along the front face of the stone. As a result, the stone surface facing the shock wave begins to crumble. As a shock wave crosses the opposite surface of the stone, part of the energy is reflected, creating tensile stress and fragmentation. Repeated shock waves eventually reduce the stone to small fragments, ideally 2 mm or less in diameter, which may be passed spontaneously.

Extensive clinical testing has determined that the compression tensile wave phenomenon results in an implosion rather than an explosion of the fragments and that the total kinetic energy of all fragments can be minimized by using a large number of relatively low-energy shock waves rather than fewer shocks of higher energy.

Although the basic principles of shock wave lithotripsy have not changed, a myriad of technological advances and modifications in the currently available lithotripters have significantly expanded the clinical applications.

Lithotripter instrumentation

All lithotripters share four main features: an energy source, a focusing device, a coupling medium and a stone-localization system. The original Dornier HM-3 design utilizes a spark plug energy generator with an elliptical reflector for focusing the shock waves. A water bath or water-filled cushion transmits the shock waves to the patient with stone localization provided by biplanar fluoroscopy. Modifications of the four basic components of the HM-3 lithotripter have now provided a new class of lithotripters of which ten machines are currently either available commercially or undergoing clinical trials. This section on new instrumentation reviews the features and principal differences between these lithotripters with regard to shock wave generation, focusing, patient coupling and stone localization.

Shock wave generation

The two basic types of energy sources for generating shock waves are point sources and extended sources. The electrohydraulic devices (Dornier, Direx, Medstone, Northgate and Technomed) utilize point sources for energy generation, whereas extended sources are incorporated in the piezoelectric devices (Diasonics, EDAP and Wolf) and the electromagnetic devices (Siemens).

The electrohydraulic shock wave generator is located at the base of a water bath and produces shock waves by an electric spark-gap of 15,000 to 25,000 volts of one microsecond duration. The high-voltage spark discharge produces rapid evaporation of water, which generates a shock wave by expanding the surrounding fluid at the first focal point (F1). This electrohydraulic generator is located within an ellipsoidal reflector that concentrates the reflected shock waves at the second focal point (F2).

Multiple, repeated electrohydraulic shock waves from a first-generation machine produce pain at the skin level and within the focal region, thus requiring general or regional anesthesia during lithotripsy.

Anesthesia-free second-generation electrohydraulic lithotripters have been developed by widening the aperture of the ellipse and decreasing the overall energy intensity of the shock wave generator. However, some form of analgesia, sedation or local anesthesia is usually required with the majority of second-generation electrohydraulic lithotripters.

Piezoelectric shock waves are generated by the sudden expansion of ceramic elements excited by a high-frequency, high-voltage energy pulse. The motion of the piezoceramic elements generates an ultrasonic wave which in turn produces a shock wave directed to the focal point. The shock wave is then propagated through either a water-filled bag (EDAP and Diasonics) or basin (Wolf). The spherical focusing mechanism of the piezoelectric lithotripters provides a wide region of shock wave entry at the skin's surface and a very small focal region (4 x 8 mm in the Wolf lithotripter). The combination of a wide aperture of the focusing sphere, a larger skin-entry zone, a small focal region and lower peak pressures generated by the piezoelectric machines has provided an anesthesia-free form of lithotripsy.

In the electromagnetic device (Siemens), shock waves are generated when an electrical impulse moves a metallic membrane that is housed within a shock tube. The resulting shock wave produced in the water-filled shock tube cylinder is focused by an acoustic lens and coupled to the body surface with a water cushion. Some form of sedation and/or local anesthesia is usually required during treatment with this electromagnetic lithotripter due to the smaller aperture and moderate peak pressures generated. The Dornier DLC Compact lithotripter also utilizes an electromagnetic generator and is currently undergoing clinical trials in the United States.

Shock wave focusing

Once shock waves are generated, they must be focused on the target calculus. The method of focusing is dictated by the type of shock wave generation. Machines that utilize point sources, such as the electrohydraulic lithotripters, generate shock waves that travel in an expanding circular pattern and require ellipsoidal reflectors for focusing the shock waves at the second focal point. The array of piezoceramic elements is positioned on a spherical disc, which allows focusing at a very small focal region, whereas the vibrating metal membranes of the electromechanical lithotripter produce an acoustical wave that requires a lens for focusing the shock wave.

Coupling of the shock wave

The coupling media currently utilized by the different lithotripters ranges from a 1,000-liter water bath to an enclosed water cushion. The water bath requires unique positioning of the patient in the tub so that the calculus is at the second focal point. Modifications in the patient gantry system of the first-generation Dornier HM-3 lithotripter now allow the treatment of children as well as distal ureteral calculi.

Second-generation machines have adopted designs for coupling that minimize the space requirements as well as the physiological and functional disadvantages of a large water bath. Current models use either an enclosed water cushion, a small exposed pool of water or a totally contained shock tube. The water-filled cushions and shock tubes contain the shock wave source, conditioned water and a coupling membrane to allow simplified positioning and dry lithotripsy. However, the direct water-skin interface utilized by two units (Technomed and Wolf) is believed by some to offer improved shock wave coupling.

Stone localization

Stone localization during lithotripsy is accomplished with either fluoroscopy or ultrasonography. Fluoroscopy provides the urologist with a familiar modality and has the added benefits of effective ureteral stone localization. Moreover, fluoroscopy facilitates the use of contrast material to help delineate the anatomy of the collecting system. However, fluoroscopy requires more space and carries the inherent risk of ionizing radiation to both the patient and medical staff. Yet, fluoroscopy remains the preferred method of localizing ureteral calculi.

Ultrasonography is becoming an increasingly important modality for the urologist. Sonography-based lithotripters offer the advantages of stone localization with continuous monitoring and effective identification of radiolucent stones, without radiation exposure (Preminger, 1989). Additionally, ultrasound has been documented to be effective in localizing stone fragments as small as 2 mm. The major disadvantages of ultrasound stone localization include the need for basic mastery of ultrasonic techniques by the urologist and the difficulty in localizing ureteral stones.

Instrumentation for newer lithotripters

Currently there are a number of lithotripters in clinical trials that attempt to incorporate many of the characteristics of an ideal lithotripter.

The basic design of the newer machines includes dual-imaging capabilities as well as variable shock wave power. Among these machines are the Dornier MFL 5000 (HM5), Dornier MPL 9000X, EDAP LT-02, Siemens Lithostar Plus, Storz, Modulith SL-20 and Wolf Piezolith 2500.

Dual imaging

Dual-imaging capabilities entail having both fluoroscopic and sonographic localization systems available in the same machine. Such a design has the advantage of utilizing fluoroscopy for imaging stones within the ureter, while having the option to use sonography for identifying radiolucent calculi. Moreover, sonographic capabilities allow one to initially target a stone using fluoroscopy and then switch over to ultrasound to avoid an excessive amount of ionizing radiation. Having fluoroscopy capabilities may also lessen the learning curve for many urologists who are unfamiliar with sonographic stone-localization procedures.

Interestingly, whereas the Dornier, Siemens and Storz machines have all added ultrasound capabilities to provide dual imaging, none of these systems provides in-line imaging for both the fluoroscopic or sonographic localization devices. For example, with the Dornier and Siemens devices, one can utilize sonography to target a radiolucent or biliary tract calculus; yet the patient must be moved blindly to the fluoroscopy unit which is in line with the shock wave generator.

Alternatively, it is possible to utilize the fluoroscopic localization system with the Storz machine, but only the ultrasound is in line with the shock wave generator.

Of these devices, only the Wolf Piezolith 2500 and EDAP LT-02 at this time have both the fluoroscopy and sonography in line with the piezoelectric shock wave generator. This design permits rapidly changing from fluoroscopic to sonographic stone localization without moving the patient off the treatment dish.

Variable power

All six of the aforementioned third-generation devices have variable power shock wave generators that allow the operator to apply the appropriate amount of shock wave energy for a particular stone. One can turn down the generator power to provide significantly reduced anesthesia/analgesia requirements with the Dornier, EDAP, Siemens and Storz machines, as well as to provide totally anesthesia/analgesia-free lithotripsy with the Wolf device. Moreover, the shock wave intensity can be increased with all four machines to allow adequate fragmentation of extremely hard or large calculi. However, when using these lithotripters in the high-power mode, various forms of anesthesia/analgesia are necessary.

Thus, no one has yet developed the ultimate shock wave which allows totally anesthesia-free lithotripsy with maximum efficiency. Yet, by varying the shock wave energy, one can administer a highly efficient shock wave with the need for anesthesia/analgesia when high shock wave pressures are indicated. On the other hand, with a small or soft stone, the shock wave energy can be significantly decreased to provide minimal-anesthesia lithotripsy.

Ureteroscopy (URS)

Ureteroscopic stone removal was first reported in 1980 (Perez-Castro-Ellendt and Martinez-Pineiro, 1980). It quickly replaced blind basketing and open surgery for removing stones in the lower ureter and today is SWL's chief rival as a treatment choice for these stones. URS allows removal of stones by basket extraction or with grasping forceps under direct vision after ureteral dilation. URS is often the method of choice (rather than PNL) for fragmenting stones using one of four methods of intracorporeal lithotripsy described below: ultrasonic lithotripsy, electrohydraulic lithotripsy, laser lithotripsy or pneumatic lithotripsy.

Ultrasonic lithotripsy (UL)

Ultrasonic lithotripsy was first described by Alken in 1982. He had used PNL to fragment kidney stones. Commercially available units consist of a power generator and an ultrasound transducer and a probe, both forming the sonotrode. A piezoceramic element in the handle of the sonotrode is stimulated to resonate, and this converts electrical energy into ultrasound waves (with a frequency of 23,000-27,000 Hz) which then are transmitted along the hollow metal probe to create a vibrating action at its tip. When the vibrating tip is brought in contact with the surface of a stone, the calculus can be disintegrated.

The probe must be rigid because sound waves cannot be transmitted without energy loss along flexible probes. The probes come in sizes of 10 F. and 12 F. and are passed through the straight working channel of a rigid ureteroscope or nephroscope. Suction tubing can be connected to the end of the sonotrode probe, thus converting the unit into a vacuum cleaner for stone fragments. Normal saline at body temperature should be used as irrigant.

Ultrasonic lithotripsy is generally used for fragmentation of large stones. However, some uric acid, calcium oxalate monohydrate or cystine stones may not break up easily, thereby necessitating EHL.

Besides the risk for perforation and extravasation of irrigant, UL is associated with noise levels of around 90 dB several inches from the transducer. For lengthy UL sessions, ear plugs are recommended. Depending on the location of the stones, retained fragments are seen in 3-35 percent of all cases treated with ultrasonic lithotripsy. This cannot be considered a failure in many cases because the UL is often performed for the debulking of large stones, to be followed by shock wave lithotripsy as part of a planned two-stage procedure.

Electrohydraulic lithotripsy (EHL)

The principles of electrohydraulic lithotripsy (EHL) were described and developed by a

Russian engineer in 1950. This technology has been used extensively for the destruction of bladder stones, and in 1975 reports were published on its use for the fragmentation of kidney stones (Raney and Handler, 1975)]. The EHL unit has a probe, a power generator and a foot pedal. The probe consists of a central metal core and two layers of insulation with another metal layer between them. Probes are flexible and available in multiple sizes to be used through rigid and flexible nephroscopes.

Commercially available EHL units are manufactured with power up to 120 volts. The electrical discharge is transmitted to the probe where it generates a spark at the tip. The intense heat production in the immediate area surrounding the tip results in a cavitation bubble which produces a shock wave that radiates spherically in all directions. Collapse of the bubble causes a second shock wave. These shock waves, repeated at a frequency of 50-100 per second, result in destruction of the stone.

EHL will effectively fragment all kinds of urinary calculi including the very hard cystine, uric acid and calcium oxalate monohydrate stones. Since the probes are small and flexible, they can be used through flexible nephroscopes and ureteroscopes to fragment stones in calyces inaccessible by UL through a rigid instrument. The primary disadvantage of EHL is its inability to efficiently remove the stone fragments. All particles have to be either washed out during intraoperative irrigation or grasped with forceps. It is advantageous to fragment the stone into the smallest number of particles that allow extraction with grasping devices (usually < 1 cm). There is no virtue in transforming a large stone into hundreds of small particles, or even sand-like material, because a significant amount of time is required to remove the debris. Overall, EHL should be the second choice for routine stone fragmentation in the kidney, but may be the procedure of choice in the ureter.

The first experience with electrohydraulic lithotripsy in the ureter entailed a 6 F. EHL probe that was fluoroscopically guided to the obstructing calculus (Reuter and Kern, 1973). The most common cause of failure in this early experience was secondary to the operator's inability to pass the probe to the level of the stone. An additional early experience using EHL within the ureter described the use of a 9 F. probe which provided excellent fragmentation of the stone. However, 40 percent of the patients had ureteral extravasation following the lithotripsy procedure (Raney, 1975). This high complication rate was attributed to the large probe size. The use of a smaller 5 F. EHL probe through the rigid ureteroscope was compromised by decreased stone visualization because the probe occupied most of the working channel of the rigid ureteroscope (Green and Lytton, 1985).

The development of a smaller 3 F. EHL probe, used through a flexible ureteroscope, was reported in 1988 (Begun, Jacobs and Lawson, 1988). More recently, a 1.9 F. EHL probe has been developed. It has been quite successful in fragmenting ureteral and intrarenal stones. An additional benefit of these small-caliber probes is improved visualization through the flexible ureteroscope, as a larger portion of the working channel is available for irrigation (Denstedt and Clayman, 1990; Feagins, Wilson and Preminger, 1990).

Laser lithotripsy

Laser lithotripsy was originally developed for the management of ureteral calculi; and significant advances in laser fibers and power-generation systems have made laser lithotripsy, in many practitioners' hands, the treatment of choice for fragmentation of ureteral stones (Dretler, 1987).

The pulsed dye laser delivers short one-microsecond pulsations at 5-10 Hz produced from a coumarin green dye. A plasma is formed at the stone surface, resulting in a highly localized shock wave. The 504-nanometer wave length produced by the dye laser is selectively absorbed by the stone and not the surrounding ureteral wall. Because the energy is delivered in short pulses, the heat generated is minimal, thus protecting the ureter (Coptcoat, Ison, Watson, et al., 1987; Dretler, 1987; Dretler, Watson, Parrish, et al., 1987).

Initial experience has yielded fragmentation rates from 64 to 95 percent (Hofmann and Hartung, 1988; Higashihara, Horie, Takeuchi, et al., 1990; Morgentaler, Bridge and Dretler, 1990). Failures have been related to equipment malfunction (4 to 19 percent) or more often to stone composition. Also, the use of EHL and/or basketing has been necessary as an adjunctive measure with the laser in some cases of successful stone removal. Use of the pulsed dye laser in the ureter in all series appears to be safe. No significant intraoperative or postoperative complications have been noted.

Continued development of laser technology has yielded larger diameter laser fibers able to fragment hard calculi more effectively. Newer 300- and 320-micrometer fibers are superior to the 200-micrometer fibers in fragmentation of calcium oxalate monohydrate and cystine stones (Dretler and Bhatta, 1991). Fragmentation rates of greater than 90 percent have been obtained with the newer fibers.

As the field continues to advance, new lasers (Alexandrite, q-switched YAG and Holmium) are now being used as sources for laser lithotripsy units (Weber, Miller, Rüschoff, et al., 1991). Initial reports of clinical experience with the Holmium laser (Ho:YAG) have been especially favorable (Bagley and Erhard, 1995; Erhard and Bagley, 1995; Grasso, 1996; Shroff, Watson, Parikh, et al., 1996; Yiu, Liu, Yiu, et al., 1996). The reported results indicate that the Ho:YAG effectively fragments all types of urinary calculi, wherever they are located and whatever their composition, including cystine stones.

The Ho:YAG produces light of 2,100 nm, with tissue penetration of less than 0.5 mm. It is also a pulsed laser. Various low-water-density, quartz-fiber delivery systems and various combinations of endoscopes and laser fibers have been developed for specific applications. In combination with the actively deflectable, flexible ureteroscope, the Ho:YAG has proven ideally suited for fragmenting stones in the upper ureter (Bagley and Erhard, 1995). Potential complications of the Ho:YAG, when used to fragment ureteral stones, include stricture and possible perforation of the ureteral wall (Shroff, Watson, Parikh, et al., 1996). This laser can also be used to cut or ablate soft tissue, such as bladder neck contracture, ureteral and urethral strictures and prostate tissue.

Pneumatic lithotripsy

Pneumatic lithotripsy uses a device (frequently called a lithoclast), in which a compressed air system is connected to a pressure box which is connected to a metal rod. Air pulses in the pressure box drive a metallic bullet that strikes the end of the rod, driving it against the stone to be fragmented. Each air pulse has a pressure of three atmospheres, and pulsation frequency is 12-16 Hertz (Schulze, Haupt, Piergiovanni, et al., 1993). Rods are 2.4 F. to 6 F. in diameter. They can be used with nephroscopes and cystoscopes for fragmenting renal or bladder stones and with semirigid or rigid ureteroscopes for fragmenting ureteral stones.

Pneumatic lithotripsy has at least three advantages (Dretler, 1995). One, it effectively fragments even the hardest large stones (Denstedt, Eberwein and Singh, 1992). Two, it is relatively inexpensive. Three, it is relatively safe, with only an occasional perforation of the ureter. Its disadvantages are that it cannot be used through a flexible ureteroscope and that it tends to push the stone cephalad.

Percutaneous nephrolithotomy (PNL)

Percutaneous endoscopic manipulation of stones in the renal collecting system, in its development, has no precedent in the history of urologic surgery. The technique evolved, within a decade, from a procedure undertaken by a few physicians to a procedure performed routinely by thousands of urologists worldwide—only to then be forced into the background by an even more revolutionary procedure for stone treatment, namely extracorporeal shock wave lithotripsy.

The PNL procedure begins with a percutaneous nephrostomy tract, which needs to be established in order to gain access to the intrarenal collecting system. The access tract should enter the kidney through a posterior calyx, which is usually facilitated by positioning the patient at 30 degrees on the fluoroscopy table. In most cases, the lower or middle pole calyces may be accessed below the 12th rib, but occasionally a supracostal approach is necessary to optimally reach the targeted stone (Segura, Patterson, LeRoy, et al., 1985). One should anticipate possible cephalad renal movement during nephrostomy access placement, which may alter the proposed approach (Preminger, Schultz, Clayman, et al., 1987).

The nephrostomy tract is formed by dilating the skin, fascia, muscles and renal tissues over a guide wire. Nephrostomy tract dilatation can be performed using graduated dilators or a balloon catheter. After the nephrostomy tract has been dilated up to a 30 F. (10 mm diameter) size, a hollow plastic sheath is placed into the renal pelvis. A variety of endoscopic instruments may then be passed directly into the renal collecting system to perform various manipulations.

Endoscopy is begun by performing rigid or flexible nephroscopy. Although specially designed nephroscopes with a 30-degree side-arm viewing system are available, a traditional panendoscope of 24 F. is equally well suited for rigid nephroscopy and allows visualization and manipulation inside the renal collecting system. Once the renal pelvis and those calyces that are accessible to a rigid nephroscope have been visualized and the surgeon is familiar with the intrarenal anatomy, flexible nephroscopy can be performed to inspect individual calyces that may not be within reach of the rigid instrument. With the help of these flexible instruments, the entire collecting system can be visualized by taking advantage of the tip deflection and rotating the instrument inside the kidney.

The internal diameter of the working sheath is usually 30 F., which equals about 1 cm. Stones up to this size can be extracted intact through the sheath. For fragmentation of stones inside the renal collecting system or ureter that are too large to be extracted (greater than 1 cm), the four intracorporeal lithotripsy modalities are available: ultrasonic lithotripsy (UL), electrohydraulic lithotripsy (EHL), laser lithotripsy and pneumatic lithotripsy.

Open surgery

Whereas shock wave lithotripsy, ureteroscopy and percutaneous nephrolithotomy have become widely embraced as treatments of choice for the majority of renal and ureteral calculi, the indications for open surgery have decreased dramatically. Assimos, Boyce, Harrison, et al. (1989) found that, of 893 stone procedures performed since the introduction of lithotripsy at their institution, 4.1 percent required open surgery for renal calculi. The most common indication for open surgery was failure of lithotripsy or percutaneous nephrolithotomy.

Morbidly obese patients often require open surgery. Their body habitus precludes fluoroscopic or sonographic localization or effective treatment of renal calculi because the shock waves become attenuated in the excess tissue. Also, the large amount of adipose tissue in the flank may prevent placement of an Amplatz sheath into the renal pelvis during percutaneous nephrostolithotomy.

Stones in a collecting system with distal obstruction may require open surgery with concomitant pyeloplasty. In addition, obstructed or scarred calyceal infundibula can be repaired with calyorrhaphy or calycoplasty after removal of the stone (Resnick, 1981). Coagulum pyelolithotomy may be helpful in patients with many small stones in multiple calyces. This procedure could also be of benefit for clearing small residual calculi in patients who have undergone anatrophic nephrolithotomy (Patel, 1973).

For branched renal calculi, surgical procedures beyond simple open pyelolithotomy may be necessary for stone removal. Anatrophic nephrolithotomy is based on the blood supply to the kidney, using the relatively avascular plane of Brodel's line for the lateral renal parenchymal incision prior to entering the collecting system. This approach permits wide exposure of the renal pelvis enabling en bloc removal of the branched calculi with minimal residual calculi (Blandy and Singh, 1976). Patients with complex stones or evidence of parenchymal loss may benefit from either partial or complete nephrectomy for stone disease (Assimos, Boyce, Harrison, et al., 1989).

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This report on the Management of Ureteral Calculi was developed by the Female Stress Urinary Ureteral Stones Guidelines Panel of the American Urological Association, Inc.

This report is intended to furnish to the skilled practitioner a consensus of clear principles and strategies for quality patient care, based on current professional literature, clinical experience, and expert opinion. It does not establish a fixed set of rules or define the legal standard of care, pre-empting physician judgment in individual cases.

An attempt has been made to recommend a range of generally acceptable modalities of treatment, taking into account variations in resources and in patient needs and preferences. It is recommended that the practitioner articulate and document the basis for any significant deviation from these parameters.

Finally, it is recognized that conformance with these guidelines cannot ensure a successful result. The parameters should not stifle innovation, but will, themselves, be updated and will change with both scientific knowledge and technological advances.

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