Medical Management of Kidney Stones: AUA Guideline

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Abbreviations and Acronyms

AHA = acetohydroxamic acid
AHRQ = Agency for Healthcare Research and Quality
CT = computerized tomography
DASH = Dietary Approaches to Stop Hypertension
HPFS = Health Professionals Follow-up Study
NHANES = National Health and Nutrition Examination Survey
NHS = Nurses' Health Study
PTH = parathyroid hormone
RCT = randomized controlled trial
RDA = recommended dietary allowance
RTA = renal tubular acidosis
UTI = urinary tract infection

The complete guideline is available at http://www.auanet.org/education/guidelines/management-kidney-stones.cfm.

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Purpose: The purpose of this guideline is to provide a clinical framework for the diagnosis, prevention and follow-up of adult patients with kidney stones based on the best available published literature.

Materials and Methods: The primary source of evidence for this guideline was the systematic review conducted by the Agency for Healthcare Research and Quality on recurrent nephrolithiasis in adults. To augment and broaden the body of evidence in the AHRQ report, the AUA conducted supplementary searches for articles published from 2007 through 2012 that were systematically reviewed using a methodology developed *a priori*. In total, these sources yielded 46 studies that were used to form evidence-based guideline statements. In the absence of sufficient evidence, additional statements were developed as Clinical Principles and Expert Opinions.

Results: Guideline statements were created to inform clinicians regarding the use of a screening evaluation for first-time and recurrent stone formers, the appropriate initiation of a metabolic evaluation in select patients and recommendations for the initiation and follow-up of medication and/or dietary measures in specific patients.

Conclusions: A variety of medications and dietary measures have been evaluated with greater or less rigor for their efficacy in reducing recurrence rates in stone formers. The guideline statements offered in this document provide a simple, evidence-based approach to identify high-risk or interested stone-forming patients for whom medical and dietary therapy based on metabolic testing and close follow-up is likely to be effective in reducing stone recurrence.

Key Words: nephrolithiasis, urolithiasis, citrate, hypercalciuria, oxalate

INTRODUCTION

Kidney stone disease is a common malady, affecting nearly 1 in 11 individuals in the United States at some point in their lives.[1] Stones are also likely to recur, with at least 50% of individuals experiencing another stone within 10 years of the first occurrence. For those who have experienced a stone or undergone surgical intervention for a stone, there is strong motivation to avoid a repeat episode. This guideline is aimed at practitioners from a variety of disciplines who are confronted with patients afflicted with stone disease, and it is based on a systematic review of the literature with respect to the evaluation, treatment and follow-up of first-time and recurrent stone formers. Patient preferences and goals must be taken into account by the

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practitioner when considering these guidelines, as the cost, inconvenience and side effects of drugs and dietary measures to prevent stone disease must be weighed against the benefit of preventing a recurrent stone.

METHODOLOGY

The AHRQ systematic review titled *Recurrent Nephrolithiasis in Adults: Comparative Effectiveness of Preventative Medical Strategies* was utilized as the primary source of evidence for guideline development. Additionally, the AUA conducted supplementary searches of PubMed® and EMBASE® for relevant articles published between January 2007 and November 2012, which were systematically reviewed using a methodology developed *a priori*. The AUA conducted an extensive peer review process. The initial draft of this guideline was distributed to 107 peer reviewers of varying backgrounds; 40 responded with comments. The panel reviewed and discussed all submitted comments and revised the guideline as needed.

The AUA nomenclature system explicitly links statement type to body of evidence strength and the Panel's judgment regarding the balance between benefits and risks/burdens. For a complete discussion of the methodology and evidence grading, please refer to the unabridged guideline available at http://www.auanet.org/education/guidelines/management-kidney-stones.cfm .

BACKGROUND

Kidney stone disease is a common condition. According to the most recent National Health and Nutrition Examination Survey, the overall prevalence of self-reported kidney stones from 2007–2010 was 8.8%, with a higher prevalence among men (10.6%) than women (7.1%).[1] This prevalence represents a 70% increase over the last reported prevalence (5.2%) derived from an NHANES sample (1988–1994), and the increased prevalence was observed across all age groups and in both sexes. Although historically kidney stones have occurred more commonly in men than women, by any number of metrics the gender gap is closing.[2,3] The reasons for the observed rise in stone disease among women are not certain, but the impact of obesity, a known risk factor for kidney stones, was found to be greater in women than in men.[4]

Stone disease has been increasingly linked to systemic conditions, although it is not clear if stone disease is a cause of these disorders or if it is a consequence of the same conditions that lead to these disorders. Overweight/obesity,[1,4] hypertension[5] and diabetes[6] have all been shown to be associated with an increased risk of stone disease.

Diet and lifestyle affect the risk of developing stones. A number of dietary measures have been evaluated for their effects on stone formation, and these studies provide compelling reasons to incorporate or avoid a variety of dietary measures. Some drug therapies, most of which are primarily directed against specific metabolic abnormalities, have been shown to be superior to placebo, or no-treatment control groups, in randomized trials.[7] However, randomized controlled trials (RCTs) evaluating drug treatments are relatively sparse, likely because the relative infrequency of the event requires long periods of observation. Diet therapy has never been compared head-to-head with pharmacologic therapy. As such, recommendations incorporate both diet therapy and pharmacotherapy until the superiority of one over the other can be demonstrated.

GUIDELINE STATEMENTS

Evaluation

1. A clinician should perform a screening evaluation consisting of a detailed medical and dietary history, serum chemistries and urinalysis on a patient newly diagnosed with kidney or ureteral stones. (*Clinical Principle*)

A detailed history should elicit from the patient any medical conditions, dietary habits or medications that predispose to stone disease. Nutritional factors associated with stone disease, depending on stone type and risk factors, include calcium intake below or significantly above the recommended dietary allowance, low fluid intake, high sodium intake, limited intake of fruits and vegetables and high intake of animal-derived purines. Patients should be queried regarding their regular use of any stone-provoking medications or supplements.

Dietary history should elicit from the patient their average daily intake of fluids (amount and specific beverages), protein (types and amounts), calcium, sodium, high oxalate-containing foods, fruits and vegetables and over-the-counter supplements.

Serum chemistries should include electrolytes, calcium, creatinine and uric acid that may suggest underlying medical conditions associated with stone disease. Urinalysis should include both dipstick and microscopic evaluation to assess urine pH and indicators of infection and to identify crystals pathognomonic of stone type. Urine culture should be obtained in patients with a urinalysis suggestive of urinary tract infection or in patients with recurrent UTIs.

2. Clinicians should obtain serum intact parathyroid hormone level as part of the screening evaluation if primary hyperparathyroidism is suspected. (*Clinical Principle*)

Primary hyperparathyroidism should be suspected when serum calcium is high or high normal.

3. When a stone is available, clinicians should obtain a stone analysis at least once. (*Clinical Principle*)

Stone composition of uric acid, cystine or struvite implicates specific metabolic or genetic abnormalities, and knowledge of stone composition may help direct preventive measures.[8]

4. Clinicians should obtain or review available imaging studies to quantify stone burden. (*Clinical Principle*)

Multiple or bilateral renal calculi at initial presentation may place a stone former at greater risk of recurrence. Nephrocalcinosis implies an underlying metabolic disorder (e.g. renal tubular acidosis type 1, primary hyperparathyroidism, primary hyperoxaluria) or anatomic condition (medullary sponge kidney) predisposing to stone formation.

5. Clinicians should perform additional metabolic testing in high-risk or interested first-time stone formers and recurrent stone formers. (*Standard; Evidence Strength: Grade B*)

Urinary saturation of stone-forming salts has been shown to correlate with stone composition, suggesting that 24-hour urine testing can be used to inform and monitor treatment protocols.[9] High-risk and/or recurrent stone formers are likely to benefit from metabolic testing and medical therapy.

Identification of metabolic and environmental risk factors can help direct dietary and medical therapy. Specific nutritional therapy, informed by both diet assessment and metabolic testing, has been shown to be more effective than general dietary measures in preventing recurrent stones.[10]

6. Metabolic testing should consist of one or two 24-hour urine collections obtained on a random diet and analyzed at minimum for total volume, pH, calcium, oxalate, uric acid, citrate, sodium, potassium and creatinine. (*Expert Opinion*)

Either one or two 24-hour urines may be obtained, although two collections are preferred by the Panel. Other urinary parameters may be helpful in the initial and follow-up evaluation of stone formers. In stone formers with known cystine stones or a family history of cystinuria or for those in whom cystinuria is suspected, urinary cystine should additionally be measured. Primary hyperoxaluria should be suspected when urinary oxalate excretion exceeds 75 mg/day in adults without bowel dysfunction.

7. Clinicians should not routinely perform "fast and calcium load" testing to distinguish among types of hypercalciuria. (*Recommendation; Evidence Strength: Grade C*)

Use of the fast and oral calcium load test to distinguish among types of hypercalciuria has not been shown to change clinical practice.[11]

Diet Therapies

8. Clinicians should recommend to all stone formers a fluid intake that will achieve a urine volume of at least 2.5 liters daily. (*Standard; Evidence Strength: Grade B*)

Urine volume is a major determinant of the concentration of lithogenic factors. Fluid intake is the main determinant of urine volume, and as such, high fluid intake is a critical component of stone prevention. Although there is no definitive threshold for urine volume and increased risk (the relationship is continuous and may not be linear), an accepted goal is at least 2.5 liters of urine daily.

Observational studies have found that certain beverages may be associated with risk of stone formation beyond their impact on urine volume. Alcoholic beverages, coffee (caffeinated and decaffeinated), tea, wine and orange juice have been shown in observational studies to be associated with a lower risk of stone formation,[12–14] while sugar-sweetened beverages demonstrated an increased risk.[15] However, these beverages have not been evaluated in randomized trials.

9. Clinicians should counsel patients with calcium stones and relatively high urinary calcium to limit sodium intake and consume 1,000–1,200 mg per day of dietary calcium. (*Standard; Evidence Strength: Grade B*)

Prospective observational studies consistently show an independent reduced risk of stone formation with higher dietary calcium intake.[16–19] Dietary salt (sodium chloride) has also been linked to urinary calcium excretion.[20] The Panel supports a target of $\leq$100 mEq (2,300 mg) sodium intake daily.

A five-year randomized controlled clinical trial compared stone recurrence in men with a history of calcium oxalate nephrolithiasis and idiopathic hypercalciuria assigned to a diet lower in calcium (400 mg/day) or to a diet with normal calcium content (1,200 mg/day) and lower amounts of animal protein and sodium; both groups were advised to limit oxalate intake.[21] At study end, the risk of developing a recurrent stone on the normal calcium diet was 51% lower than on the lower calcium diet, although the independent effect of calcium could not be ascertained.

Supplemental calcium, in contrast, may be associated with an increased risk of stone formation.

In an observational study of older women, calcium supplement users were 20% more likely to form a stone than women who did not take supplements.[17]

Many patients are able to obtain adequate daily calcium from traditional and calcium-fortified foods and beverages, many of which are non-dairy; calcium supplementation is not necessary in these patients.

10. Clinicians should counsel patients with calcium oxalate stones and relatively high urinary oxalate to limit intake of oxalate-rich foods and maintain normal calcium consumption. (*Expert Opinion*)

Restricting oxalate-rich foods has generally been recommended for calcium stone formers. An extensive list of the oxalate content of foods is available online from the Harvard School of Public Health (https://regepi.bwh.harvard.edu/health/Oxalate/files/Oxalate%20Content%20of%20Foods.xls).

Urinary oxalate is also modulated by calcium intake, which influences intestinal oxalate absorption. Patients with hyperoxaluria and a history of calcium oxalate stones should be advised to consume calcium from foods and beverages primarily at meals to enhance gastrointestinal binding of oxalate, but total calcium intake should not exceed 1,000−1,200 mg daily.

Of note, however, patients with enteric hyperoxaluria and high levels of urinary oxalate, such as those with malabsorptive conditions (e.g., inflammatory bowel disease or Roux-en-Y gastric bypass) may benefit from more restrictive oxalate diets as well as from higher calcium intakes, which may include supplements, specifically timed with meals.[22]

Other factors that may contribute to higher urinary oxalate include vitamin C and other over-the-counter nutrition supplements.

11. Clinicians should encourage patients with calcium stones and relatively low urinary citrate to increase their intake of fruits and vegetables and limit non-dairy animal protein. (*Expert Opinion*)

Urinary citrate is a potent inhibitor of calcium stone formation.[23] Metabolic acidosis or dietary acid loads enhance renal citrate reabsorption, thereby reducing urinary excretion. Medical conditions such as renal tubular acidosis and chronic diarrhea, and some medications, such as carbonic anhydrase inhibitors, may promote hypocitraturia.[24] Acidosis can arise from a diet that is inordinately rich in foods with a high potential renal acid load compared to low-acid (i.e., alkaline) foods.

If diet assessment suggests that the acid load of foods contributes to low urinary citrate, patients should be instructed to increase fruit and vegetable intake and reduce intake of high-acid foods.

Dietary alkali citrate has been proposed as an alternative to pharmacologic citrate to increase citrate excretion.[14,25]

12. Clinicians should counsel patients with uric acid stones or calcium stones and relatively high urinary uric acid to limit intake of non-dairy animal protein. (*Expert Opinion*)

No relevant studies were identified to either refute or confirm the use of diet to manage high urinary uric acid in uric acid or calcium stone formers. Nonetheless, if diet assessment suggests that purine intake is contributory to high urinary uric acid, patients may benefit from limiting high and moderately high purine containing foods.

Uric acid crystal formation and growth occur in more acidic urine.[26] Thus, patients with a history of uric acid stones should be counseled to increase the alkali load and decrease the acid load of their diet in an effort to increase urine pH and reduce urinary acidity.

13. Clinicians should counsel patients with cystine stones to limit sodium and protein intake. (*Expert Opinion*)

Dietary therapy should be offered in combination with pharmacological therapy. Because cystine stone formation is largely driven by cystine concentration, high fluid intake is particularly important in cystine stone formers. The target for urine volume is typically higher than that recommended to other stone formers because of the need to decrease urinary cystine concentration below 250 mg/L.[27] Oral intake of at least four liters per day is often required to meet this goal. Dietary sodium restriction should also be advised as lower sodium intake has been shown to reduce cystine excretion.[28,29] A reasonable goal for sodium intake in individuals with cystinuria is 100 mEq (2,300 mg) or less daily.

Limiting animal protein intake has been suggested as a means to decrease cystine substrate load, as all foods of animal origin are rich in cystine and methionine, which is metabolized to cystine.

Pharmacologic Therapies

14. Clinicians should offer thiazide diuretics to patients with high or relatively high urine calcium and recurrent calcium stones. (*Standard; Evidence Strength: Grade B*)

Thiazide dosages associated with a hypocalciuric effect include hydrochlorothiazide (25 mg orally, twice daily; 50 mg orally, once daily), chlorthalidone (25 mg orally, once daily), and indapamide (2.5 mg orally, once daily). Dietary prescription, especially restriction of sodium intake, should be continued when thiazides are prescribed, in order to maximize the hypocalciuric effect and limit potassium wasting. Potassium supplementation (either potassium citrate or chloride) may be needed when thiazide

therapy is employed. The addition of amiloride or spironolactone may avoid the need for potassium supplementation. Triamterene should be avoided as stones of this compound have been reported.

Thiazides should be considered appropriate for both calcium oxalate and calcium phosphate stone formers. Although studies were performed exclusively on patients with recurrent stone formation, the Panel believes that some high-risk first-time stone formers might also benefit from thiazide therapy, such as those with a solitary kidney, hypertension or a large stone burden, or individuals who are refractory to other risk-mitigating maneuvers.

15. Clinicians should offer potassium citrate therapy to patients with recurrent calcium stones and low or relatively low urinary citrate. (*Standard; Evidence Strength: Grade B*)

Prospective RCTs have demonstrated that potassium citrate therapy is associated with reduced risk of recurrent calcium stones in patients with low or low normal 24-hour urinary citrate excretion.[30–33] Calcium stone-forming patients with normal citrate excretion but low urinary pH may also benefit from citrate therapy. Additionally, potassium citrate therapy should be offered to calcium phosphate stone formers with hypocitraturia because citrate is a known potent inhibitor of calcium phosphate crystallization. Increased fluid intake, sodium restriction, ample fruits and vegetables to counterbalance foods that confer an acid load (see Guideline Statement 11), and thiazides to lower urinary calcium excretion may increase the safety and efficacy of citrate therapy.

Potassium citrate is preferred over sodium citrate, as the sodium load in the latter may increase urine calcium excretion.[34]

16. Clinicians should offer allopurinol to patients with recurrent calcium oxalate stones who have hyperuricosuria and normal urinary calcium. (*Standard; Evidence Strength: Grade B*)

A prospective randomized controlled trial demonstrated that allopurinol reduced the risk of recurrent calcium oxalate stones in the setting of hyperuricosuria (urinary uric acid excretion >800 mg/day) and normocalciuria.[35] Whether the drug is effective in patients with hypercalciuria has not been established. Hyperuricemia is not a required criterion for allopurinol therapy.

17. Clinicians should offer thiazide diuretics and/or potassium citrate to patients with recurrent calcium stones in whom other metabolic abnormalities are absent or have been appropriately addressed and stone formation persists. (*Standard; Evidence Strength: Grade B*)

Thiazides and potassium citrate therapy have been shown to prevent recurrent stones in patients with normal range urinary calcium and citrate, respectively.[30,36,37] Therefore, it may be appropriate to utilize these therapies for patients with recurrent stones who do not demonstrate specific urinary abnormalities.

For patients with no identified risk factors for nephrolithiasis, potassium citrate may be the preferred first-line therapy, given its relatively low side effect profile.

18. Clinicians should offer potassium citrate to patients with uric acid and cystine stones to raise urinary pH to an optimal level. (*Expert Opinion*)

The solubility of uric acid and cystine is increased at higher urinary pH values.[38] Potassium citrate therapy provides an alkali load that leads to increased urine pH. For uric acid stone formers, urine pH should be increased to 6.0, and for cystine stone formers, a urine pH of 7.0 should be achieved.

19. Clinicians should not routinely offer allopurinol as first-line therapy to patients with uric acid stones. (*Expert Opinion*)

Most patients with uric acid stones have low urinary pH rather than hyperuricosuria as the predominant risk factor.[39] Reduction of urinary uric acid excretion with the use of allopurinol in patients with uric acid stones will not prevent stones in those with unduly acidic urine. Therefore, first-line therapy for patients with uric acid stones is alkalinization of the urine with potassium citrate.

20. Clinicians should offer cystine-binding thiol drugs, such as alpha-mercaptopropi onylglycine (tiopronin), to patients with cystine stones who are unresponsive to dietary modifications and urinary alkalinization, or have large recurrent stone burdens. (*Expert Opinion*)

First-line therapy for patients with cystine stones is increased fluid intake, restriction of sodium and protein intake, and urinary alkalinization. If these modifications are not sufficient, cystine-binding thiol drugs constitute the next line of therapy. Tiopronin is possibly more effective and associated with fewer adverse events than d-penicillamine and should be considered first.[40]

21. Clinicians may offer acetohydroxamic acid to patients with residual or recurrent struvite stones only after surgical options have been exhausted. (*Option; Evidence Strength: Grade B*)

Struvite stones occur as a consequence of urinary infection with a urease-producing organism. Patients treated for struvite stones may still be at risk for recurrent UTI after stone removal, and in some patients surgical stone removal is not feasible.

These patients are at increased risk for stone recurrence or progression, and an aggressive medical approach is required to mitigate this risk.[41] The use of a urease inhibitor, AHA, may be beneficial in these patients, although the extensive side effect profile may limit its use.[42]

Follow-up

22. Clinicians should obtain a single 24-hour urine specimen for stone risk factors within six months of the initiation of treatment to assess response to dietary and/or medical therapy. (*Expert Opinion*)

The aim of dietary/medical therapy of nephrolithiasis is to promote changes in the urinary environment to reduce stone recurrence or growth. There are a number of observational and case-control studies demonstrating that such changes are associated with a reduction in stone activity.[43,44]

23. After the initial follow-up, clinicians should obtain a single 24-hour urine specimen annually or with greater frequency, depending on stone activity, to assess patient adherence and metabolic response. (*Expert Opinion*)

Longitudinal monitoring of urinary parameters allows for the assessment of patient adherence, the identification of patients who become refractory to therapy and more timely adjustments in therapy for those individuals with active stone formation.[45,46] If patients remain stone free for an extended period of time on their treatment regimen, discontinuation of follow-up testing may be considered.

24. Clinicians should obtain periodic blood testing to assess for adverse effects in patients on pharmacological therapy. (*Standard; Evidence Strength: Grade: A*)

The majority of medications prescribed for stone prevention are associated with potential adverse effects, some of which can be detected with blood testing. For example, thiazide therapy may promote hypokalemia and glucose intolerance; allopurinol and tiopronin may cause an elevation in liver enzymes; AHA and tiopronin may induce anemia and other hematologic abnormalities; potassium citrate may result in hyperkalemia.

25. Clinicians should obtain a repeat stone analysis, when available, especially in patients not responding to treatment. (*Expert Opinion*)

A change in stone composition may account for the lack of response to dietary/medical therapy. Therefore, repeat stone analysis is justified in this setting. Changes in stone composition have been reported in calcium oxalate stone formers who have converted to forming calcium phosphate stones.

26. Clinicians should monitor patients with struvite stones for reinfection with urease-producing organisms and utilize strategies to prevent such occurrences. (*Expert Opinion*)

Due to the infected nature of struvite stones, patients may continue to be at risk for persistent or recurrent UTI even after stone removal. Therefore, close monitoring of these patients is recommended to identify and treat recurrent infection. Patients with altered lower urinary tract anatomy may be at particular risk for re-infection and recurrence. Monitoring should include periodic urine culture testing. In some cases long-term, prophylactic antibiotic therapy may prevent recurrence.[41]

27. Clinicians should periodically obtain follow-up imaging studies to assess for stone growth or new stone formation based on stone activity (plain abdominal imaging, renal ultrasonography or low dose computerized tomography). (*Expert Opinion*)

Other than stone passage, imaging is the most sensitive way to detect stone activity, defined as either existing stone growth or new stone formation. Plain abdominal imaging has the advantages of being readily available and associated with limited radiation exposure and lower cost compared to other modalities. Plain radiography provides an acceptable assessment of stone activity in most patients with radiopaque stones, while renal ultrasonography is preferred for most patients with radiolucent stones, as there is no exposure to ionizing radiation, and it typically is less costly than CT. A one-year imaging interval is recommended for stable patients, but this may be tailored based on stone activity or clinical signs.[47,48]

FUTURE RESEARCH

For a disease with relatively high incidence and prevalence, research in the prevention of kidney stone disease is surprisingly sparse, perhaps because of the sporadic occurrence and transient symptoms associated with kidney stones as well as a perception that the pharmaceutical industry is not likely to find substantial profit in stone prevention. The recent AHRQ-sponsored review of medical management identified only 28 RCTs performed through 2012.[49]

The interest in kidney stones has grown in recent years for two important reasons. First, kidney stones appear to be increasing in prevalence,[1] perhaps related to changes in diet and the growing epidemics of metabolic syndrome, diabetes and obesity. Second, stones have consistently been shown to be associated with more morbidity than previously expected. Associations with coronary artery disease,[50] hypertension[5] and diabetes[6] have

led to questions about the potential connection between stone disease and these conditions.

The effort to prevent stones needs to be broadened to other populations of practitioners. Primary care practitioners and physician extenders are experts at counseling weight loss, exercise and smoking cessation. Implementation of stone prevention regimens could also be extended to emergency rooms and primary care offices, such that stone metaphylaxis would fall under the purview of a larger pool of practitioners without a sophisticated view of urine chemistry.

We note that although both dietary manipulation[21] and medications such as thiazides, allopurinol and citrate[49] have all been shown to have efficacy in kidney stone prevention, the relative merits of diet and medications have never been compared head-to-head.

In summary, there is no dearth of important kidney stone research questions to be raised. Strong evidence from an admittedly low number of clinical trials demonstrates that stones are indeed preventable.[36] There is now not only a need for new research into the causative and exacerbating factors associated with stones, but also a need to ensure that the acquired knowledge to prevent stones is shared with every stone former in a clinical setting.

Conflict of Interest Disclosures

All panel members completed COI disclosures. Relationships that have expired (more than one year old) since the panel's initial meeting, are listed. Those marked with (C) indicate that compensation was received; relationships designated by (U) indicate no compensation was received. **Consultant/ Advisor: Dean G. Assimos:** Oxalosis and Hyperoxaluria Foundation (OHF) (U); **Gary Curhan, MD:** Allena Pharmaceuticals (C); **David S. Goldfarb, MD:** Takeda (C), Astra Zeneca (C), **Brian R. Matlaga, MD:** Boston Scientific (C); **Manoj Monga, MD:** Bard (C), Coloplast (C), Histosonics (C), Olympus (C), US Endoscopy (C) (Expired); **Glenn M. Preminger, MD:** Boston Scientific (C), Mission Pharmacal (C); **Health Publishing: Dean George Assimos, MD:** Med Review in Urology (C), Urology Times (C); **Gary Curhan, MD: Manoj Monga, MD:** Brazilian Journal of Urology (U), Indian Journal of Urology (U), Journal of Endourology (U), Practical Reviews in Urology (C); **Glenn M. Preminger, MD:** UpToDate (C)**. Leadership Position: Gary Curhan, MD:** American Society of Nephrology (C); **Manoj Monga, MD,** CMS SCIP (U), Endourology Society (U); **Glenn M. Preminger, MD:** Endourological Society (C). **Meeting Participant or Lecturer: David S. Goldfarb, MD**, Quintiles (C) (Expired); **Manoj Monga, MD:** Cook Urological (C), Mission Pharmacal (C) (expired); **Glenn M. Preminger, MD:** Olympus (C).**Scientific Study or Trial: Dean George Assimos, MD:** National Institute of Health (NIH) (C); **Manoj Monga, MD:** Taris Biomedical (C) (Expired), Xenolith (C) (Expired); **Owner, Product Development: David S. Goldfarb, MD:** The Ravine Group (C); **Other: Dean George Assimos, MD:** Piedmont Stone (C) (Expired); **Gary Curhan, MD:** UpToDate (C); **Manoj Monga, MD:** Fortec (C).

Disclaimer

This document was written by the Medical Management of Kidney Stones Guidelines Panel of the American Urological Association Education and Research, Inc., which was created in 2013. The Practice Guidelines Committee (PGC) of the AUA selected the committee chair. Panel members were selected by the chair. Membership of the committee included urologists and other clinicians with specific expertise on this disorder. The mission of the committee was to develop recommendations that are analysis-based or consensus-based, depending on Panel processes and available data, for optimal clinical practices in the treatment kidney stones.

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While these guidelines do not necessarily establish the standard of care, AUA seeks to recommend and to encourage compliance by practitioners with current best practices related to the condition being treated. As medical knowledge expands and technology advances, the guidelines will change. Today these evidence-based guidelines statements represent not absolute mandates but provisional proposals for treatment under the specific conditions described in each document. For all these reasons, the guidelines do not pre-empt physician judgment in individual cases.

Treating physicians must take into account variations in resources, and patient tolerances, needs, and preferences. Conformance with any clinical guideline does not guarantee a successful outcome. The guideline text may include information or recommendations about certain drug uses ('off label') that are not approved by the Food and Drug Administration (FDA), or about medications or substances not subject to the FDA approval process. AUA urges strict compliance with all government regulations and protocols for prescription and use of these substances. The physician is encouraged to carefully follow all available prescribing information about indications, contraindications, precautions and warnings. These guidelines and best practice statements are not in-tended to

provide legal advice about use and misuse of these substances.

Although guidelines are intended to encourage best practices and potentially encompass available technologies with sufficient data as of close of the literature review, they are necessarily time-limited. Guidelines cannot include evaluation of all data on emerging technologies or management, including those that are FDA-approved, which may immediately come to represent accepted clinical practices.

For this reason, the AUA does not regard technologies or management which are too new to be addressed by this guideline as necessarily experimental or investigational.

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