Chapter 3

Alternative Treatments for Urinary Stones

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INTRODUCTION

The past decade has seen a great expansion in the physician's armamentarium of tools to treat and prevent urinary stones. Medical management of stone-forming patients has become more sophisticated and effective, and the diffusion of less invasive surgical procedures and safe, effective stone fragmentation tools has provided physicians with a wide array of choices with which to treat patients. Although the introduction of the Dornier lithotripter on the U.S. market in 1984 has attracted the most attention, in fact there are a number of alternative techniques, both complementary and substitutive, to treat patients with urinary stones.

This first part of this chapter reviews the most widely recognized approaches to treatment, other than extracorporeal shock wave lithotripsy (ESWL), currently available: medical management, including dietary regimens and drug treatment to prevent recurring stones; traditional open surgery to remove stones; transurethral removal of stones; and percutaneous stone removal, a less traumatic surgical procedure to remove upper urinary stones that is gaining increasing acceptance. Because ESWL is discussed in great detail in the next chapter, it will not be included here. The second part of this chapter describes the tools that are used in transurethral and percutaneous procedures to remove, fragment, and dissolve stones. Both the treatment techniques and the instruments employed in them are areas undergoing rapid technological change,

APPROACHES TO STONE TREATMENT

Dietary and Medical Management

Most patients with symptomatic urinary stones initially consult their physicians because of pain (colic) or blood in the urine (hematuria). The majority of these stones are sufficiently small to pass spontaneously, although frequently painfully. Thus, analgesics to relieve pain are a fundamental tool in the management of urinary stone disease (44). Although smooth muscle relaxants have been used to relieve spasm and to promote passage of the stone (121), they are of doubtful value (112). In addition to treatment for pain, acute medical management of stones usually includes a high fluid intake to increase urine flow and encourage the stone to pass.

The size and location of a stone at the time of clinical presentation help to predict its often erratic behavior. Large stones found in the upper urinary tract at the time of diagnosis are the least likely to pass spontaneously and involve the greatest risk of serious complications. In one series of 292 cases, 91 percent of stones **5** mm or smaller passed spontaneously or with the help of endoscopic procedures (described below), but *60* percent of larger stones required surgery (55). Results from other studies have indicated that stones over 7 mm in size impacted in the upper ureter rarely pass spontaneously (146). Stones that have not passed and have remained symptomatic after 6 weeks of conservative therapy are generally considered for removal, Evidence of infection above the stone, refractory pain, ureteral obstruction, and anuria (lack of urine flow) are considered absolute indications for stone removal (112).

Effective long-term medical management is an important preventive measure for any patient who has had a urinary stone. The most basic preventive management includes a prescription to increase fluid intake; in many cases a dietary regi-

[1]This chapter draws extensively from J .A. Showstack, E.J. Perez-Stable, and E. Sawitz, "Extracorporeal Shock Wave Lithotripsy: Clinical Application and Medicare Physician Payment, " paper prepared for Office of Technology Assessment, Washington, DC, Aug. 1, 1985.

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men and/or drug therapy are also prescribed. It has been suggested that dietary management is often overlooked or underappreciated (163), perhaps because patient compliance can be difficult. Appropriate diet and medication therapy requires that the patient be evaluated thoroughly to identify metabolic abnormalities, because preventive treatment depends on the underlying metabolic disorder.

For calcium stones, research suggests that a fluid intake that guarantees a minimum urine output of 2 liters per day can decrease recurrence rates in up to *60* percent of patients (77), A moderate calcium restriction of 400 to 600 mg per day may be useful in patients with absorptive hypercalciuria, while other patients with idiopathic calcium stones (those of unknown origin) should avoid an excess of 1 gram of calcium intake per day (119). Dietary restrictions of oxalate, animal proteins, and sodium are occasionally prescribed for patients who have had calcium stones. Table 3 gives some examples of foods high in calcium and oxalate.

A number of drugs to prevent certain types of stones exist and are often useful components of medical management. Evaluations of calcium stone formers can identify the presence of metabolic risk factors, such as excess calcium and/or uric acid in the urine, in about 60 percent (33).

Table 3.—Foods Containing High Levels of Calcium or Oxalate

High calcium	High oxalate
Milk	Beet root
Cheese	Spinach
Ice cream	Rhubarb
Yogurt	Parsley
Foods containing flour	Runner beans
All beans (except green beans)	Chocolate, cocoa, instant coffee, Ovaltine, tea
Lentils	
Fish with bones, e.g., sardines, kippers, herring, salmon	
Dried fruit, nuts	
Chocolate, cocoa, Ovaltine, Horlicks, Bournvita, milk drinks	
Sauces containing milk	

SOURCE: B.E.C Nordin, A. Hodgkinson, M. Peacock, et al , "Urinary Tract Calculi, " *Nephrology*, J Hamburger, J. Crosnier, and J, Grünfeld (eds.) (New York John Wiley & Sons, 1979)

Treatment of these patients with one or more of the available drugs has been shown to significantly alter the natural history of recurrent stone formers (32,50,118); some researchers believe they can prevent recurring calcium stones in 97 percent of their patients (130).

Thiazide diuretics, sodium cellulose phosphate, orthophosphates, potassium citrate, and allopurinol are all medications prescribed to help prevent calcium stone recurrence, although none of these drugs is appropriate for all patients with calcium stones. Thiazides, for example, decrease the urinary excretion of calcium by stimulating its reabsorption in the kidney and are especially useful in patients with excess urinary calcium (104). Sodium cellulose phosphate, a medication only recently approved for marketing by the Food and Drug Administration, prevents calcium oxalate stone formation by acting as an ion exchange resin and reducing dietary calcium absorption. Orthophosphates (preparations of acid, neutral, or alkaline phosphates) have been used for some time and also reduce calcium excretion. Potassium citrate, another new drug, acts by alkalinizing the urine and correcting low levels of urinary citrate, which prevents crystallization of calcium salts. Allopurinol therapy is often used as a preventive therapy for recurrent calcium stone formers with uric acid disorders (162).

It is important to note that there is no universal agreement among physicians regarding the effectiveness of the various drug therapies. Some drugs, such as sodium cellulose phosphate and potassium citrate, have been in general use for only a short time. Others, such as the thiazides, have been in use for some time, but the range over which they are effective is still not unequivocably established (29). Some researchers have suggested that dietary modification may be a favorable alternative to drug therapy in many patients with calcium oxalate stones (199).

Medical management of noncalcium stones is likewise vital to preventing recurring stones. Struvite stones are usually associated with repeated urinary tract infections and frequently recur. Medical therapy to eliminate these stones once they have formed has had some encouraging results, but it has been hampered in wide application by

drug side effects and lack of efficacy (207). Prevention of future struvite stones in a patient, however, is usually effective and can be achieved by the administration of acetohydroxamic acid, a bacterial enzyme that helps prevent the formation of struvite stones but has only marginal effects on formed stones (207). Uric acid stones can often be associated with an identifiable metabolic disorder, and in these cases dietary limits on animal protein intake may help prevent stone recurrence. These patients may also be given medications to alkalinize the urine. (An alkaline medication can be as simple as sodium bicarbonate, common baking soda.) Cystine stones result from an inherited renal disorder; as with many uric acid stones, preventive therapy for these stones usually includes administration of an alkaline substance to buffer the acid urine (44).

Open Surgery

Major surgery to remove stones in the kidney (nephrolithotomy) or ureter (ureterolithotomy) has been standard treatment for large or troublesome upper urinary stones for many years. Since surgery for removal of stones, like any other major surgical procedure, carries a significant morbidity, a small risk of death, and an increased risk of kidney damage with subsequent surgeries, it has usually been prescribed only for stones accompanied by intractable pain, severe or recurrent infection, urinary obstruction, or other complications *(84).* A typical patient undergoing open stone surgery requires a 10-day hospitalization and a convalescence of about 6 weeks (129,170).

Problems such as persistent pain, infection, and obstruction are more common with stones located in the ureter than with stones located in the kidney, and indications for ureter stone removal through surgery are consequently clearer. Ureterolithotomy is successful in removing stones in 99 percent of cases, and failures are usually *re*lated to surgical difficulties in locating the ureter or the stone (112). In one series of 445 patients undergoing ureterolithotomy, 18.4 percent had surgical complications, including three deaths (58).

Indications for surgical removal of stones lodged in the kidney are less clear and often depend on the physician's judgment regarding whether the stone is likely to pass spontaneously. Struvite stones associated with recurrent infections are an exception, and surgery has been the standard of care (161). A retrospective review of 951 open surgical procedures for stone removal reported an associated mortality rate of *0.6* percent; serious complications, including hemorrhage in excess of 1 liter, were found in an additional 13 percent of cases (15), Investigators studying a *re*cent series of 100 patients undergoing nephrolithotomy reported that 4 percent had stones left behind (18). Partial nephrectomy (removal of part of the kidney) is necessary to remove some stones

Photo credit National Institutes of Health, Bethesda, MD

Open surgery for treatment of urinary stones has been performed for centuries. This lithograph shows such an operation performed in 1682.

and is associated with overall morbidity rates as high as 40 percent; mortality in one series of 96 patients was 1.7 percent (35). The risk of losing kidney function increases with successive surgeries.

Traditional open surgery for removal of stones is now on the decline, largely due to the existence of safer, less costly, and less traumatic alternatives that appear to be equally effective in most instances. However, it will continue to be the treatment of choice in a small proportion of cases not suited to other approaches (134).

Transurethral Manipulation

Removal of urinary stones can be attempted "from below," that is, an instrument can be passed up through the urethra and the bladder into the ureter, often making surgery unnecessary. Transurethral procedures are useful primarily for lower urinary stones; use of these procedures for upper stones results in fewer successful removals and a higher complication rate (45). Sometimes tools to extract the stone are not even necessary since mechanical dilation of the ureter may allow passage of the stone; simple catheterization (insertion of a tube) of the ureter, with or without dilatation, induces spontaneous passage of stones in 21 to 37 percent of cases (112). If passage does not occur, the stone may be grasped and removed. Transurethral meatotomy (opening the mouth of the ureter where it enters the bladder) is indicated when the stone or grasping instrument is impacted at the junction of the ureter and the bladder, but this maneuver should not usually be necessary (45).

Stones in the lower third of the ureter may be extracted transurethrally by use of a wire or nylon basket. The success rate of this procedure varies, but it has been reported to be between 69 and 77 percent in two series of 173 and 121 patients, respectively (95,114). A basket extraction technique using a specially designed angioplasty balloon to dilate the ureter had a reported success rate of 95 percent in 39 patients (145). Transurethral removal of stones in the upper portions of the ureter has been attempted using a variety of basketing, grasping, and fragmenting instruments, but the safety and usefulness of this procedure are not yet generally accepted (8,197).

Photo credit: National Institutes of Health, Bethesda, *MD*

Some urinary stones can be removed endoscopically, with tools passed up the urinary tract. A stone basket, used to trap and extract ureteral stones, can be faintly seen protruding from the end of a ureteroscope in this X-ray.

Complications of transurethral extraction techniques include perforation at the junction of the ureter and the bladder, damage to ureteral integrity, stone movement into the kidney, renal colic, bleeding, and infection (43). Evidence of bleeding is present in 10 to 15 percent of cases at the conclusion of the procedure but is usually no longer demonstrable 48 hours later (95). Open surgical procedures are required in 5 to 10 percent of patients after attempted stone removal by transurethral manipulation (95,112,145).

Percutaneous Procedures

Endourologic equipment and techniques developed during the past 15 years allow percutane-

'For the purposes of this study, "transurethral manipulation" includes procedures that extend up into and through the ureter as well.

ous access to stones in the upper urinary tract without resorting to open surgery. In combination with ESWL, these percutaneous or "through the skin" techniques will most likely replace traditional open surgery for most renal and upper ureteral stones. In the most common form of percutaneous procedure, a tube is passed into the renal pelvis through a small incision in the lower back and a variety of techniques may be used to remove the stone.

Percutaneous nephrostomy (the creation of a passage to the kidney through a small opening in the skin) was first described in 1955 (65), but the technique was not widely applied to the therapy of urinary tract stones until the late 1970s (167). Access to the renal collecting system is achieved by direct puncture under fluoroscopic or ultrasound guidance; a guide wire or catheter is inserted through the needle and advanced down the ureter to maintain the tract (160). The nephrostomy tract is then progressively dilated under local or general anesthesia. The procedure is frequently performed in two stages, particularly for stones larger than 1.5 cm *(129)* or in cases where bleeding after dilatation obscures visibility, In this two-stage procedure, nephrostomy and dilatation are performed first, and further dilatation and stone extraction are performed at a later time. However, percutaneous nephrostomy has also been accomplished as a one-stage procedure (129).

The development and modification of equipment to dilate the nephrostomy tract rapidly and to destroy stones prior to removal have increased the applicability of percutaneous nephrostomy (155). Average hospital stays of 5 to 8 days have been reported for patients undergoing percutaneous stone removal (17, 129,132,151) and may be declining; outpatient percutaneous lithotripsy has recently been reported (128).

The nephrostomy procedure and tract dilatation in order to pass the nephroscope are associated with the majority of significant complications of percutaneous procedures. Stables reviewed the experience of 1,207 patients and reported a 4-percent incidence of significant complications, mostly hemorrhage and infection, and one death (166). In general, most problems with nephrostomy tubes are mechanical, involving displacement or blockage. Failed attempts at placement are rare *(142),*

The Mayo Clinic, after experience with 1,032 percutaneous manipulations for stone removal, reported a delayed bleeding rate of nearly 1 percent from significant vascular injuries (120). Seven patients were treated successfully with transcatheter embolization techniques, two resolved spontaneously with observation, and one underwent an emergency flank exploration resulting in nephrectomy (120). Other researchers have found that perforations of the renal collecting system usually heal spontaneously after 24 to 48 hours (18). Percutaneous lithotripsy using ultrasound instruments does not appear to negatively affect the function of the operated kidney, at least in the short run (101).

INSTRUMENTS FOR STONE DESTRUCTION AND REMOVAL

Mechanical and Chemical Removal

A variety of mechanical tools is available to crush or extract stones, Loops and wire baskets to ensnare stones are standard supplementary tools for transurethral manipulation of lower ureteral stones, although their usefulness in transurethral manipulation of upper urinary stones is debatable (45). Wire baskets and forceps are useful adjuncts to percutaneous renal stone extraction (97,160), and a "stone punch" to mechanically crush the stone has also been successfully employed in a percutaneous procedure (159). Although "power lithotripsy" to fragment stones for easy passage or removal is becoming common, mechanical removal is likely to remain an option for small stones and large fragments, particularly for lower urinary stones.

Chemolysis, the prolonged application of drugs to a stone to dissolve or reduce it, has not been widely accepted as a therapeutic alternative to sur-

gical or mechanical removal. The long hospital stay (up to 2 months) necessitated by irrigation therapy, which is usually administered through a nephrostomy tract, limits the usefulness of the technique. However, chemolysis does seem to have a role in certain situations. In one series of 150 patients with symptomatic stones treated by percutaneous chemolysis, for example, complete dissolution was achieved in 70 percent and another 15 percent had only tiny fragments remaining (122). Progress was monitored every 3 to 4 days by X-rays, and the total duration of irrigation was 1 to 4 weeks (122).

Struvite, uric acid, and cystine stones are the most amenable to chemolysis (160). Some calcium-containing stones can also be dissolved in this manner, but calcium oxalate and calcium phosphate stones resist dissolution therapy (160). Chemolysis carries with it a substantial risk of infection, and death as a result of complications is not unknown (152). Nonetheless, the procedure seems to have a place in the urologist's armamentarium. Combination therapy with ESWL has been attempted by at least two groups (47,149), and it may be a comfortable niche for future application of chemolysis,

Electrohydraulic Lithotripsy

Electrohydraulic lithotripsy is the oldest form of "power" lithotripsy. The electrohydraulic lithotripter releases high impulse discharges from an electrode at the tip of a flexible probe, which is placed next to the stone. The shock waves generated by these discharges are of sufficient force to disrupt the hardest stone. Electrohydraulic lithotripsy has been used with both transurethral and percutaneous endoscopic techniques.

Transurethral electrohydraulic lithotripsy is a highly effective means of bladder stone removal and has become an accepted practice for this use (108). Application of electrohydraulic lithotripsy to percutaneous techniques has been limited to small series (30,63), and there is far less reported experience than for ultrasonic lithotripsy (see below). The electrohydraulic lithotripsy probe must not be used 5 mm or closer to soft tissue or severe damage will result, making it inappropriate in most cases for ureteral stones (106). However, it may be useful for fragmenting stones in the renal pelvis and calices. A British group has reported the safe removal of such stones in 17 patients without a single perforation, and they believe that electrohydraulic lithotripsy is superior to ultrasonic lithotripsy for all but very soft stones (107).

Ultrasonic Lithotripsy

Percutaneous ultrasonic lithotripsy was first performed in 1977 (87), but clinical experience has expanded greatly since that time (13,17,18,30,151), and the safety and usefulness of the technique are widely accepted (8). The ultrasound probe emits high-frequency ultrasonic energy that has a simple drilling effect upon direct exposure to the stone (155). Direct contact of the probe tip and stone is essential for effectiveness of ultrasonic lithotripsy. A suction channel is attached to the hollow probe in order to continuously remove stone fragments, an advantage of ultrasonic over electrohydraulic lithotripsy (97), Transurethral application of ultrasonic lithotripsy to bladder stones is considered effective (79), and experience with stones in the ureter and renal pelvis is expanding rapidly.

As with many technologies, use of ultrasonic lithotripsy as the stone removal technique in percutaneous procedures demonstrates a "learning

Photo credit National *Institutes of Health,* ***Bethesda,*** *MD*

Kidney stones can be fragmented and removed through a percutaneous tract using ultrasonic or electrohydraulic probes, requiring only a small incision.

curve" effect for both efficacy in removing stones and reduction of serious complications *(150,204).* A number of groups have reported considerable experience with this method. Segura and colleagues successfully removed *96* percent of *148* kidney stones and *86* percent of *50* ureteral stones by percutaneous ultrasonic lithotripsy *(151). Major* complications were encountered in *3.2* percent of this series, including two patients who required open surgery (1.51). Brannon and colleagues have reported their 2-year experience with *250* consecutive patients, in which targeted stones were removed in 97 percent of patients by percutaneous ultrasonic lithotripsy *(18).* A repeat nephrostomy was performed in *20* patients (8 percent), and 32 patients (13 percent) required an additional procedure (e.g., transurethral manipulation) to remove the stone. The overall complication rate was 6.8 percent, but significant delayed bleeding occurred in eight patients *(3.2* percent), and three of these required angiographic embolization to control hemorrhaging *(18).*

A community hospital urology *group* has *reported* an *87* percent success rate in removing stones from *38* patients by percutaneous ultrasonic lithotripsy, with an overall complication rate of 7.8 percent (13).

Experimental Endoscopic Lithotripsy Instruments

Laser lithotripters and and microexplosion techniques are being investigated as potential methods to fragment stones endoscopically, but both are currently still in the early experimental stages. Lasers are being investigated as a power source to fragment stones extracorporeally as well as endoscopically, but neither method has yet undergone clinical trials (11 *,201,202).* Microexplosion lithotripsy, based on a small controlled explosion incorporated into a catheter that creates shock waves, is also being investigated as a possible method of fragmenting urinary stones. It has been used on a small number of patients in Japan with bladder stones, with some success. The small number of bladder stones in developed countries makes ureteral and renal stones the more widespread goal of this therapy, but these uses are still highly experimental *(200).*