11. Techniques of Laser Lithotripsy

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Abstract

A tunable pulsed dye laser has been used for the treatment of 157 patients with renal and ureteral calculi. All calculi treated were too large to be extracted by ureteroscopy or were not appropriate candidates for ESWL. In 106 cases, the stone was completely fragmented with the laser. The laser was used in combination with ESWL in 34 cases. In ten cases the laser had no action on the calculus. There were three instances of machine failure. The first two patients in the series developed ureteral strictures well below the level of laser action. One required operative repair. A newly developed 7.2 Fr. semi-rigid ureteroscope has enhanced the use of the laser. The current uses of laser include lower ureteral stones, calculi in the upper ureter unable to be treated by ESWL, stones in narrow ureter unable to be traversed by larger ureteroscopes, steinstrasse, for disimpaction of UPJ stones, and for percutaneous treatment of renal calculi via the flexible nephroscope.

Introduction

The introduction of the pulsed dye laser has allowed the use of laser energy for the fragmentation of urinary calculi. This laser light acts by photofragmentation rather than heat energy. Pulsations of light at 60 millijoules per pulse for a duration of a microsecond at 5 Hz cause a “plasma” to form on the surface of the stone and create a mini shock wave which causes stress fractures to occur within the calculus.

The instruments currently available for the treatment of urinary calculi by ureteroscopic and percutaneous methods were designed for use with conventional baskets, electrohydraulic or ultrasonic probes. However, the use of a 250 micron silica-coated quartz fiber and the need for a small amount of water for irrigation does not demand a large working channel. In fact, placing the small fiber in the large working channel of the available ureteroscopes makes the procedure more technically difficult. Therefore, adaptations have been necessary to use the laser fiber effectively. The ability to introduce small caliber instruments directly into the ureter without the need for ureteral dilatation and the controlled fragmentation of stones in situ without the need for basket entrapment have altered the technique of ureteroscopic stone management. Finally, a new class of instruments is being developed specifically for use with the pulsed dye laser. Herein is reported a summary of the techniques employed during laser lithotripsy and the instruments developed to date.

Materials and Methods

One hundred fifty-seven renal and ureteral calculi have been treated at the Massachusetts General Hospital by laser fragmentation. These calculi have been located at the ureteral meatus, in the intramural ureter, in the lower, middle, upper one-third of the ureter, and at the ureteropelvic
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junction. Recently, calculi in the renal pelvis and lower and upper calices have been treated by flexible, steerable ureterorenoscopy and by percutaneous ureteroscopy and nephroscopy.

**Techniques**

**Cleaving the Fiber.** The silica-coated quartz fiber loses power if it has a jagged edge. Therefore, a diamond-tipped pencil is used to "cleave" the fiber so that its tip is flat. This is done by circumferentially scoring the fiber with the cleaver and then snapping the fiber at that point. Measuring the laser power will indicate the squareness of the cut. If the fiber is snapped off during the procedure, cleaving can be done on the cystoscopy working table. A simple way of measuring the squareness of the cut is to aim the fiber at the floor and turn on the laser - a round image on the floor indicates a good cleave. After cutting the beveled tip from a 4 Fr. ureteral catheter, the laser fiber is placed within the catheter with the tip of the laser fiber protruding 3 mm. A clip from IV tubing is used to hold the fiber within the ureteral catheter without crushing it. The catheter and laser are placed in the working channel of a cystoscope or a 9.5 Fr. ureteroscope. The latter is used if, as usually happens, the stone starts to migrate within the tunnel during fragmentation. Meatotomy is not necessary, as the 9.5 ureteroscope may be advanced directly into the dilated meatus.

**Intramural Tunnel.** Calculi impacted in the intramural tunnel are often difficult to approach with an ultrasonic sonotrode because the tunnel cannot be dilated to accept the large caliber instrument, and electrohydraulic lithotripsy is dangerous in such a confined space. Intramural ureteral calculi may be approached with the 9.5 Fr. ureteroscope and catheter-carrying laser fiber. A Braasch bulb or a small caliber (4.5 Fr.) dilating balloon that passes through the operating port of the ureteroscope is used to dilate the ureter to the point of intramural obstruction.

Recently, a new class of instruments for use within the tunnel have been developed: the semi-rigid ureteroscope which is a 7.2 Fr. ureteroscope (distal 7 inches) that has flexible fibers within the metal cylinder. The small caliber allows the metal to bend but the flexible, light-carrying fibers prevent the loss of vision which occurs with many rigid instruments. This new ureteroscope has a 0.025 laser channel and a 0.025 inch irrigation channel. In the female, it may be directly introduced without a guide wire or it may be advanced over a 0.025 inch guide wire. In the male, it is advanced over a 0.025 inch guide wire. Damage to the urethra is prevented by the use of a 12 Fr. peel-away sheath placed in the bladder through the cystoscope. Forceful hand irrigation is essential with this small caliber instrument. The true advantage of the semi-rigid instrument is that its small caliber allows introduction without the need for ureteral dilatation. It is excellent for impacted intramural tunnel calculi and could be used with topical anesthesia for distal stones in females.

**Ureteral Calculi.** It is not necessary to hold most calculi with a basket as is required with ultrasonic lithotripsy. However, when the calculi are mostly brown or black and composed of difficult-to-fragment calcium oxalate monohydrate or calcium hydrogen phosphate (brushite), direct fragmentation may not be complete enough to allow spontaneous fragment passage. Therefore, the major stone pieces must be manually extracted. When extraction of stone fragments is anticipated, a "laser basket" which is a conventional helical or flat wire basket with a laser channel may be utilized. Once the yellow, fragile dihydrate coating is chipped from the monohydrate core of the stone, the stone is trapped in a basket and then held firmly while the laser is used to chip at the stone. Monohydrate stones are composed of aggregated spherules. These spherules are joined by dihydrate or apatite crystals. If the laser is aimed at the junctions of the spherules, 1 mm to 2 mm chips may be removed. Persistence is required. We always set the laser at the maximal allowable energy (60 millijoules). With hard-to-fragment calculi, increasing the laser frequency from 5 to 10 Hz may speed the process. Whereas fragmentation of a calcium oxalate dihydrate stone may take a minute or less, fragmentation of harder calculi may require 10 to 15 minutes. Once the calculus is chipped down to extractable size, the basket is used to complete the procedure.

We have used flexible non-steerable ureteroscopes (7 and 9 Fr.) for calculi in the ureter, occasionally as initial treatment of upper ureteral calculi and also when the 9.5 Fr. rigid ureteroscope could not be advanced to the level of the calculus. Success was achieved in only 9 of 20 attempts because of the inability to direct the ureteroscope and laser simultaneously. Application of the laser was possible only if a direct view of the stone was obtained. Recently, we have begun to use the 9.8 Fr. flexible steerable ureteroscope for laser fragmentation of ureteral calculi. It was not made specifically for the laser and is bigger than necessary. If 2 Fr. were removed from its caliber, it could be introduced without the need for ureteral dilatation.