Holmium laser use and application in endourology

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ABSTRACT

Introduction: Laser is a highly useful technologic advance that transforms large quantities of energy into electromagnetic radiation that is then emitted as a light beam, which produces a photothermal effect whose wide wavelength (2120 nm) enables diverse procedures to be carried out, such as tissue ablation and cutting, lithotripsy, and tissue vaporization.

Objective: To present different minimally invasive treatments with Holmium laser (VersaPulse® LUMENIS 100W model) in various urologic diseases.

Material and methods: Diverse applications of Holmium laser in endourology are presented, such as endopyelotomy for treating ureteropelvic junction stenosis, internal urethrotomy, bladder neck restructuring for postoperative sclerosis, cystolithotripsy, bladder tumor ablation, and enucleation of the prostate (HoLEP), all employing 100 Watt Holmium laser.

Results: Treatment effectiveness was verified according to studies of choice for each pathology. In the patient that underwent endopyelotomy, renal scintigram was...
**INTRODUCTION**

The LASER (light amplification stimulated emission radiation) system is a technology that was initially developed within the field of chemical physics for use in engineering. Its current applications in the field of medicine cover almost all surgical specialties.\(^1\) The laser has been an extremely beneficial technologic advance in all areas of medicine and its use in urology was first suggested in 1992, initially as treatment for renoureteral lithiasis.\(^2\) The physical principals of Holmium:YAG (yttrium-aluminium-garnet) Laser use are based on laser energy that generates a photothermal effect resulting in stone vaporization.\(^3\) The Holmium laser produces a 2120
nm wavelength, which is within the infrared range of the electromagnetic spectrum. This wavelength is easily absorbed and has a depth of penetration < 0.5mm, making it suitable for carrying out tissue ablation through vaporization. In addition, the laser can coagulate blood vessels of 1 mm in diameter. Pulse (msec) can be transmitted according to the fiber used (from 200 to 1000 μm); frequency (Hz) and energy per pulse can vary from 0.2 to 2.0 Joules (J); the fibers are reusable and a Helium-neon extreme is used to identify their tips. All these factors make the Holmium laser a very flexible tool that can be used in different endourologic procedures.

**METHODS**

The most frequent endourologic pathologies treated in our service were selected: The first case is a woman in the fifth decade of life with no past medical history of chronic degenerative disease. She presented with left pyeloureteral colic and when questioned complained of intermittent colic of five-year progression. During the diagnostic approach, plain abdominal x-ray was taken that showed a radio-opaque silhouette of the left kidney at the level of the renal pelvis. Kidney ultrasound revealed important pyelocaliceal dilation and so renal scintigram with diuretic and mercaptoacetyltriglycine (MAG) was done that showed an effective renal plasma flow (eRPF) of 30%. Computed tomography (CT) scan displayed a hyperdense image, in addition to ureteropelvic junction stricture (Figure 1). Endopyelotomy was then performed through flexible ureteroscopy with a 220 μm Holmium laser fiber (Figure 2) plus nephrolithotripsy, also with a 200 μm Holmium laser fiber at 16 Watts with the direct fragmentation technique (Figure 3) and ipsilateral double-J ureteral catheter placement.

The second case is a man in the eighth decade of life with a past medical history of obstructive prostatic hyperplasia (OPH) treated by means of transurethral resection of the prostate (TURP) with a bipolar rectoscope. The patient had recurrence of obstructive lower urinary tract symptoms and an International Prostate Symptom Score (IPSS) of 25 (severe) for which retrograde urethrography plus micturition cystography were carried out and showed a 10 mm long stricture of the proximal bulb urethra that occluded 80% of the urethral opening. He was treated through internal urethrotomy with Holmium laser at the 12 o’clock position. Energy was 1.6 J, frequency was 18 Hz, and a total of 28.8 Watts was applied. The patient was later managed through urinary diversion, using a urethral catheter for three weeks. Another male patient in the eighth decade of life was treated in a similar manner. He had a past medical history of high blood pressure and prostate adenocarcinoma with a Gleason score of 7 (4+3), initial prostate specific antigen (PSA) of 12 ng/mL, and a clinical stage of T1cN0M0 diagnosed in 2004 that was managed with radical retropubic prostatectomy. The patient is currently under control and presented with an adequate surgical nadir at eight weeks (0.0064 ng/mL) with a final pathologic stage of T2 N0 M0. He had a one-year progression of obstructive lower urinary tract symptoms, severe IPSS (25 points), as well as total, silent, gross hematuria with no clot formation. Urethrocystoscopy was done to study the hematuria, and anastomosis fibrosis of the bladder neck and cystolithiasis were found. The patient underwent remodeling of the bladder neck anastomosis fibrosis at the 12, 5, and 7 o’clock positions (Figures 4 and 5), with an energy potency of 1.8 J and 12 J for a total of 21.6 Watts. In addition, cystolithotripsy was carried out with Holmium laser in the same surgical procedure, obtaining total fragmentation of the stone using a total of 28.6 Watts (Figure 6).
Our fourth case is a man in the seventh decade of life with a past medical history of diabetes mellitus (DM) and long-progression high blood pressure (HBP) who had been diagnosed with OPH, had a severe IPSS (25), and flowmetry that showed a Qmax of 9 mL/sec. The patient was managed with alpha blockers (0.4 mg of tamsulosin), producing partial symptomatology improvement. During the diagnostic approach a hyperechogenic ultrasound image that measured 2.8 cm at the greatest diameter was observed and corroborated through cystoscopy and the patient underwent cystolithotripsy using a rigid cystoscope and Holmium laser. Energy use was 28 Watts with the superficial cavity ablation technique (Figure 7).

The fifth case was a man in the seventh decade of life that had a chronic two-year progression of obstructive lower urinary tract symptoms, and was diagnosed with OPH. He had an IPSS of 18, was managed with an alpha blocker for one year with no significant improvement, and had a PSA of 2.2 ng/dL. The patient presented with the complication of acute urine retention that was managed with urethral catheter placement that remained in place for fifteen days. Transrectal ultrasound of the prostate was done that showed a total prostatic volume...
of 135 cc with a transition zone of 92 cc. The proposed surgical management was enucleation of the prostate with Holmium laser (HoLEP), carrying out initial ablation from the mid-lobe to the verumontanum, followed by both lateral lobes, and then the anterior commissure, obtaining a total of 70 g of tissue that was extracted by morcellation, using 80 Watts for the entire procedure (Figure 8).

The sixth case was a man with a past medical history of intense long-progression smoking (20 cigarettes per day), and type 2 diabetes mellitus and chronic terminal renal failure, both diagnosed three years earlier and treated medically. The patient had an approximate one-month progression of total, silent, gross hematuria with amorphous clots, and an approximate 5 kg weight loss. Ultrasonography and urethrocystoscopy revealed an arboriform tumoral lesion located on the right lateral surface and in the retrotrigonal region that was resected in 2010 through TURB. The histopathologic diagnosis was low-grade T1a urothelial carcinoma with no muscle invasion or lymph node involvement. The patient was managed with immunotherapy through Bacillus Calmette-Guérin (BCG) for 6 weeks and then monthly for 6 months. The first two control cystoscopies at 3 and 6 months showed no tumor activity. However, at 9 months cystoscopy revealed an arboriform papillary lesion in the left lateral wall. A magnetic resonance study (Figures 9 and 10) showed no evidence of muscle or extravesical disease and so Holmium laser ablation was performed. Total lesion ablation was achieved using 12.8 Watts (Figures 11 and 12) for the entire procedure.

**RESULTS**

The patient in the first case underwent endopyelotomy with Holmium laser. A control renal scintigram was done at three months with transforming growth factor (TGF) of 74% and 94 mL/hr for the left kidney, and double-J catheter was removed after 6 weeks. Control kidney ultrasound images showed slight residual dilation and no evidence of active stone disease.

Control in the second clinical case was carried out with retrograde urethrogram at three and six months. Adequate contrast medium passage through the bulbary urethra was observed, there have been no stricture data up to the present (follow-up at two years) and IPSS is mild. Likewise, the patient in the third case had micturition cystography control studies at three and six months and he underwent bladder neck remodeling. No obstruction data were found, there was adequate bladder voiding, no residual urine, and the patient has a current PSA of 0.064 ng/dL.

The patient in the fourth case had a control plain abdominal x-ray that showed no radio-opaque images suggestive of stones. He had an improved IPSS at 14

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**Figure 9.** Nuclear Magnetic Resonance in T2 showing the lesion in the left lateral bladder wall that is suggestive of tumor activity.

**Figure 10.** Control cystoscopy one year after TURB, in which an approximately 4 cm-long lesion in the left bladder wall can be seen.

**Figure 11.** Holmium laser bladder tumor resection in which the initial incision can be seen.

**Figure 12.** Bladder tumor resection showing the base of the resection site.
points and did not present with clinical data of hematuria in the follow-up appointments. There was no residual lithiasis in the control cystoscopy.

The patient in the fifth case had follow-up through control appointments and improvement was seen with a postoperative IPSS of 12. The patient had been released from the hospital 48 hours after the procedure. His catheter had been removed and he had spontaneous micturition. The histopathologic study reported fibromuscular and glandular hyperplasia, and subsequent evaluation through urodilometry showed a Qmax of 14 mL/s with a baseline of 9 mL/s.

The patient in the sixth case went through his postoperative period in good general condition. He had spontaneous micturition upon catheter removal and the control cystoscopy at one month after bladder lesion ablation with laser showed no tumor activity data and there was adequate cicatrization of the surgical bed.

**DISCUSSION**

The LASER system has certain advantages over other tissue cutting systems such as: the transmission of large quantities of energy through flexible fibers, a high degree of safety and efficiency, tissue-specific selectivity according to wavelength due to the low risk of adjacent structure injury, and a wide action margin because of the capacity to regulate both the quantity of the emission of transmitted energy and its frequency. These characteristics have given it a broad range of applications in the field of endourology. Currently it is the criterion standard for resolving stone disease and it is also used in obstructive prostatic hyperplasia (OPH), through resection and ablation techniques, as well as through enucleation of this tissue.

In addition, it enables tumor resection at the level of the entire urothelium, allowing for the treatment of tumors throughout the urinary tract, practically from the urethra to the renal cavities. These procedures are carried out in clear surgical fields and with scant quantities of blood loss. It should be mentioned that even long-term response rates are high compared with previously used methods, such as cold knife incision, which has the disadvantage of not allowing for hemostasis, and there is also no precise control of the depth of the cut. For these reasons the use of Holmium laser has gained ground in the field of endourology and is currently the first-line therapeutic option, even compared with prostatic tissue.5

With respect to the different pathologies of the urinary tract, the following specifications should be mentioned:

**Stones:** The fiber should remain in direct contact at a low energy and frequency; on occasion, a greater quantity of energy is needed for adequate stone fragmentation. High pulse frequency facilitates stone fragmentation but also causes greater stone movement. One of the advantages of Holmium laser lithotripsy is that it produces little stone retropropulsion because it generates relatively low intraurethral pressure peaks (wavelengths of <20 bars). This enables total stone fragmentation because the energy penetration allows for the disintegration and enucleation of even large volume bladder stones.

**Bladder tumors:** Contact is not necessary and the laser is used at a high energy and low frequency, stimulating a more homogeneous energy distribution. Because the laser has a great affinity for water, the edges of the surgical bed are able to be partially vaporized, leaving tumor-free margins, and thus reducing the possibility of local recurrence.

**Stricture:** With Holmium laser incisions there is a minimal risk of hemorrhage and of adjacent tissue injury at high energy levels. Cutting is performed through direct contact of the fiber with the tissue in a linear manner, and a catheter is left in place for 4 weeks.

**CONCLUSIONS**

Both short-term and long-term results in different applications of Holmium laser have shown effectiveness in treatment documented through the control study of choice for each pathology. The use of laser in urology has rapidly gained ground because of its apparent superiority in effectiveness and safety. The diffusion of this technology has made it more accessible, even at the institutional level, because it has become more cost-efficient, with the advantage that the same fiber can be
reused for various procedures, and in this way reducing the cost. In our hospital Holmium laser use has been implemented in the field of endourology and has gained acceptance and become the criterion standard for stone pathology. Endourology is a fundamental area of general urology, and therefore the training in and use of laser technology is one of the biggest challenges in the professional formation of the urologist.

REFERENCIAS