Benign Prostatic Hyperplasia Treatment by Transurethral Enucleation of the Prostate Using a 2- μ m Laser

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Received: 12 December 2013 / Accepted: 6 August 2014 / Published online: 12 June 2015
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Abstract This study investigates the efficacy of benign prostatic hyperplasia (BPH) treatment by prostate transurethral enucleation using a 2- μ m laser. A total of 107 patients with BPH were treated by prostate transurethral enucleation using a RevoLix 2- μ m laser surgery system. Bleeding volume, operation time, catheterization time, voiding situation, maximum urinary flow rate, and hospital stay were observed. The mean operation time was 74 min $\pm$ 12 min (range 45 to 150 min), the mean follow-up period was 2 to 6 months, the mean catheter time was 5 days, and the mean peak urinary flow rate increased from 6.3 $\pm$ 0.6 to 17.5 $\pm$ 1.5 mL/s. The International Prostate Symptom Score and quality of life significantly declined ($p<0.01$). No significant differences were observed in the hemoglobin and blood electrolytes before and after operation. Prostate transurethral enucleation using a 2- μ m laser is safe and efficient for BPH treatment.

Keywords 2 μ m lasers · Enucleation · Benign prostatic hyperplasia · Treatment

Introduction

Transurethral resection of the prostate (TURP) is the standard treatment for benign prostatic hyperplasia (BPH) [1]. However, TURP is associated with a high complication rate, including bleeding that requires blood transfusion, transurethral resection (TUR) syndrome, and myocardial arrhythmia [2, 3]. The 2- μ m continuous-wave laser (2- μ m laser) is a new laser system that has been verified by numerous studies as safe

and efficient [4]. Transurethral enucleation of the prostate using a 2- μ m laser is a new, minimally invasive technique for BPH treatment. From 2009 to 2010, we performed transurethral enucleation of the prostate using a 2- μ m laser to treat 107 BPH patients and retrospectively analyzed the records.

Materials and Methods

Patients

We investigated 107 patients who underwent transurethral enucleation of the prostate using a 2- μ m laser for BPH treatment from January 2009 to January 2010. Inclusion criteria included an International Prostate Symptom Score (IPSS) >7 , failure to respond to medical therapy, maximum urinary flow rate (Qmax) ≤ 15 mL/s, transvesically measured postvoid residual volume ≥ 60 mL, and adenoma weight ≥ 80 mL on transrectal ultrasonography. Twenty patients in each group with suspicious changes in ultrasonography or prostate-specific antigen (PSA) >10 ng/mL were administered a 12-core needle biopsy of the prostate under transrectal ultrasonic guidance to exclude prostate cancer. Patients with previous prostatic or urethral surgery, neurovesical dysfunction, or carcinoma of the prostate were excluded from this study.

Equipment and Surgical Technique

The 2- μ m continuous-wave laser surgery system (LISA, Germany) was used with power set at 70 W. A laser resectoscope (KARL STORZ Endoscopy, Germany) (F24.5, 30°) with continuous flow irrigation was utilized. Normal saline was used for irrigation, with an irrigation pressure of 40 to 60 cm.

All patients were in lithotomy position under epidural or general anesthesia. The resectoscope was placed into the bladder to ascertain the bladder neck, verumontanum, and

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the size and configuration of the prostate (Fig. 1a). Two longitudinal grooves were first made deep into the surgical capsule between the bladder neck and the verumontanum at the 5 and 7 o'clock positions (Fig. 1b). The incisions were then distally lengthened along both sides of the verumontanum in an arc shape, ending on the interior of the external urethral sphincter. Next, the urethral mucosa at the leading edge of the verumontanum was deeply incised to the level of the surgical capsule. The distal mid lobe and mucosa were dissected in retrograde toward the bladder neck by the tip of the resectoscope sheath (Fig. 1c). The laser was used to cut off the adenoma and adhesive fibers between the lobe and the surgical capsule, and to coagulate hemorrhage spots. Extremely large median lobes were cut and vaporized.

The third incisions were made at the 12 o'clock position, and bilateral lobes along the surgical capsule were similarly detached to the 1 and 11 o'clock positions. Only two cord-like pedicles of the adenoma were retained to fix and hang in the crypt at this point for easy resection of the adenoma (Fig. 1d–g). The adenoma was directly vaporesected by laser if the prostate volume was less than 60 mL. The loop electrode was used to reduce the increase in resection rate if the prostate volume was more than 60 mL. About 4 % mannitol served as irrigation fluid while the loop electrode was used.

A standard 22-Fr three-way catheter was inserted after extracting tissue pieces using a Braun plastic bottle. Bladder irrigation was necessary until hematuria was efficiently resolved.

Outcome Assessment

We determined the preoperative and postoperative IPSS, quality of life (QOL) score, and Qmax. The operation time, catheter indwelling time, voiding situation, and post-operation

time were observed. We also measured preoperative and postoperative levels of serum sodium, potassium, chloride, and hemoglobin at day 1.

Statistical Analysis

All data were presented as mean $\pm$ SD. Student's *t* test was used. Statistical analysis was performed using SPSS version 16.0 (SPSS Inc., Chicago, IL). *p* values <0.05 were considered statistically significant.

Results

The characteristics of the 107 patients who underwent transurethral enucleation of the prostate using a 2- μ m laser are shown in Table 1. The age at surgery was 67.9 years (range 52 to 85 years). All patients had lower urinary tract symptoms to BPH (range 5 to 60 months). Among the patients, two were administered suprapubic catheters, eight were given indwelling urinary catheters for acute urinary retention, and ten had a history of vesical calculi. The mean prostate volume based on ultrasound measurement was 72.5 mL $\pm$ 17.6 mL (range 45 to 158 mL). The mean PSA was 3.1 ng/mL $\pm$ 2.9 ng/mL (0.2 to 17.5 mL). No incidental prostate cancer was detected during the histopathological evaluation.

All patients successfully underwent transurethral enucleation of the prostate using a 2- μ m laser. Mean postoperative catheter time was 5 days (range 4 to 6 days). Postoperative hospital stay durations were 10 to 15 days. Follow-up after surgery was 5.9 $\pm$ 3.3 months (range 2 to 12 months).

The average operation time was 74 min $\pm$ 12 min (range 45 to 150 min). Five cases required blood transfusion. No TUR

Fig. 1 **a** Inside view of the prostatic urethra. The left- and right-side lobes (LSL, RSL) and verumontanum (V) are identified preoperatively. **b** Incisions from the bladder neck to verumontanum at the 5 to 7 o'clock positions. Enucleation from the leading edge of the verumontanum (Fib fiber). **c** The pale surgical capsule (SC) and supply vessels (SV). Laser is used to coagulate denuded supply vessels and hemorrhage spots and block the blood supply. **d** The right-side lobe (RSL) completely detached

from the surgical capsule (BN bladder neck). **e** The left-side lobe (LSL) is detached from the surgical capsule at the bladder neck. **f** The urethral mucosa (UM) hanging around the urethral sphincter (UES) is cut with laser. **g** The view at the level of the urethral sphincter (UES), after a greater part of the bilateral lobes is detached. **h** The prostatic nodular hyperplasia (PNH) in the endoscopic field

Table 1 Characteristics of the 107 patients

Item	Mean±SD
Age (years)	67±9
IPSS	26.4±5.5
QOL	4.6±0.5
Qmax (mL/s)	6.3±0.6
PSA (ng/mL)	3.1±2.9
Transrectal ultrasound vol (mL)	72.5±17.6
Operative time (min)	74±12
Catheterization (days)	5
Follow-up (months)	5.9±3.3

syndrome developed in any patient. Urethral stricture did not occur, and no urinary incontinence appeared except in one patient who recovered in 1 month. Postoperative secondary bleeding was not observed.

The initial average Qmax was 6.3 mL/s±0.6 mL/s, but it increased to 17.5 mL/s±1.5 mL/s after operation ($p<0.01$). IPSS and QOL decreased from 26.4±5.5 and 4.6±0.5 to 9.3±2.1 and 2.8±0.3, respectively. A significant difference was observed at $p<0.01$.

The values of preoperative serum sodium, potassium, chloride, and hemoglobin were 4.8 mmol/L±0.8 mmol/L, 141.2 mmol/L±4.5 mmol/L, 105.5 mmol/L±7.1 mmol/L, and 137.8 g/L±8.3 g/L, respectively. The values of serum sodium, potassium, chloride, and hemoglobin decreased to 4.4 mmol/L±0.7 mmol/L, 140.6 mmol/L±4.9 mmol/L, 102.4 mmol/L±8.3 mmol/L, and 132.2 g/L±7.1 g/L, respectively, after operation. No significant differences in the hemoglobin and blood electrolytes were found before and after operation ($p>0.05$) (Table 2).

Discussion

As the gold standard for BPH surgical treatment, TURP has been applied with significant success rates for years [1]. However, complications can be observed in up to 20 % of cases following a successful intervention. These complications include bleeding, TUR syndrome, urinary incontinence, and residual gland, especially for large glands [5–7]. Open surgery (prostatic adenoma enucleation) is effective with less residual gland, but is very difficult to coagulate and may result in more complications. Thus, several studies have been conducted to find a new, safe, and efficient technology that combines the advantages of open and minimally invasive surgery [2, 8]. Laser prostatectomy is a promising surgical technique [9–11].

Many endoscopic laser techniques that have evolved for the treatment of BPH have been associated with less morbidity

Table 2 Preoperative and postoperative parameters

Characteristic	Pre-operation (mean±SD)	Post-operation (mean±SD)	<i>p</i> value
Qmax	6.3±0.6	17.5±1.5	<0.01
IPSS	26.4±5.5	9.3±2.1	<0.01
QOL	4.6±0.5	2.8±0.3	<0.01
Serum sodium (mmol/L)	4.8±0.8	4.4±0.7	>0.05
Serum potassium (mmol/L)	141.2±4.5	140.6±4.9	>0.05
Serum chloride (mmol/L)	105.5±7.1	102.4±8.3	>0.05
Hemoglobin (g/L)	137.8±8.3	132.2±7.1	>0.05

than TURP with shorter hospital stay. The use of laser during an operation has many advantages, such as less trauma, less bleeding, and quicker recovery. At present, laser usage has enabled frequent performance of prostatectomy for small- and medium-sized prostates in an almost bloodless field and without irrigant absorption [12, 13].

Neodymium laser was applied early. But, its wavelength is 1,064 nm and has a small water absorption coefficient. Neodymium laser penetrates deep into the organization, scattering to cause extensive thermal damage. The hemostatic effect of neodymium laser is good, but it does not have a cutting function. The 2-μm laser is a new, highly intensive, fiber-coupled, diode-pumped, solid infrared laser system. The laser absorption peak of water molecules inside the tissue is close to 1.94 μm. The real wavelength of the 2-μm laser is 2,013 nm, compared with that of the holmium laser which is 2,140 nm, and is more easily absorbed by water. The radiation of the 2-μm laser is emitted in a continuous-wave mode. Compared with the holmium laser “explosive tear” which uses a pulsed beam to instantly produce high energy, the 2-μm laser does not produce pressure waves and damages the surrounding tissues and organs. The 2-μm laser energy can be fully absorbed to enable the tissue to be vaporized and instantly cut. In addition, holmium laser has a thermal damage depth of 0.5–1.0 mm and results in coagulation and necrosis in 3–4 mm of the organization, while the 2-μm laser has a penetration depth into the organization of less than 0.5 mm to avoid damage to surrounding tissues [4, 9, 14].

In our study, there were no significant differences in the hemoglobin concentration from 137.8 g/L±8.3 g/L pre-operation to 132.2 g/L±7.1 g/L post-operation. It was similar for serum sodium (4.8 mmol/L±0.8 mmol/L vs 4.4 mmol/L±0.7 mmol/L), potassium (141.2 mmol/L±4.5 mmol/L vs 140.6 mmol/L±4.9 mmol/L), and chloride (105.5 mmol/L±7.1 mmol/L vs 102.4 mmol/L±8.3 mmol/L). Only five cases required blood transfusion. There was no case of postoperative bleeding. No TUR syndrome developed in any patient. These less bleeding outcomes were most likely due to the use of

a 2- μ m laser and an enucleation technique with the resectoscope sheath.

BPH treatment using a 2- μ m laser has good short-term effects for small- and medium-sized prostates. A variety of surgical methods are available, such as “orange peel” type [15], “fish scale” type [16], and transurethral dividing vaporesction [17]. Recently, more studies have verified the safety and efficiency of the enucleation technique to treat BPH since the report of Gilling et al. [10, 18].

For operation time, the average time was 74 min $\pm$ 12 min (range 45 to 150 min) in this study. By a mean of 6 months follow-up, the mean Qmax increased to 17.5 mL/s $\pm$ 1.5 mL/s, IPSS decreased to 9.3 $\pm$ 2.1, and QOL decreased to 2.8 $\pm$ 0.3. But, for the prevention of urethral stricture complication, the mean catheterization time was 5 days. It was longer than in other reports and caused longer hospital stays. However, there were few postoperative complications. Only one patient developed urinary incontinence and recovered in 1 month. These data suggest that the transurethral enucleation of the prostate using a 2- μ m laser is a nearly bloodless procedure.

In this study, we used transurethral enucleation to show the surgical capsule clearly. Resecting the entire prostate during the operation is usually difficult because of significant fibrosis or nodular hyperplasia of the gland [10]. This novel technique resulted in complete resection of the hyperplastic tissue because the microscope clearly showed the tissue plane between the adenoma and the surgical capsule. The adenoma was completely anatomically enucleated with the resectoscope sheath to achieve a clear operative field and to reduce surgery risk and bleeding, especially urethral sphincter injury. Furthermore, the anatomical enucleation of the adenoma reduced the risk of voiding irritation. The urinary flow rate also significantly improved after surgery.

The results of our research showed that the prostatic adenoma enucleation technique using a 2- μ m laser can maintain a clear operative field to enable the surgeon to resect accurately along the surgical capsule, maximize the prevention of accidental injury, and incur less bleeding, especially in the treatment of large-volume BPH (>80 g). Our study suggests that transurethral enucleation of the prostate using a 2- μ m laser is a safe, effective, and minimally invasive treatment with few complications and results in a brief convalescence.

Acknowledgments This study was supported by the Beijing Science and Technology research project (Z090507017709031).

Ethical Approval All investigations were performed after informed consent for study participation was obtained from all patients. The study protocol was approved by the ethical committee of the General Hospital of the Air Force of the Chinese People's Liberation Army.

Conflict of Interest None.

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