

# Photoselective Vaporesction of the Prostate with an End-firing Lithium Triborate Crystal Laser

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## Abstract

**Background:** Photoselective vaporization of the prostate is a technique that is widely used for the treatment of benign prostatic hyperplasia (BPH) and has pronounced advantages compared to the traditional transurethral resection of the prostate. Following the recent introduction of end-firing lithium triborate lasers, we have created a new technique called photoselective vaporesction of the prostate (PVRP). This study described our initial experience using the PVRP technique for the treatment of BPH.

**Methods:** This prospective study included a total of 35 patients with BPH who underwent PVRP from August 2013 to July 2014. The chief clinical parameters were obtained and evaluated during the perioperative period and follow-up, including the International Prostate Symptom Score (IPSS), quality of life (QoL) score, maximum urinary flow rate, and prostate volume. All variables were evaluated for statistically significant differences compared to baseline values using the analysis of variance.

**Results:** The mean subgroup IPSS and QoL scores significantly improved during follow-up; the respective decreases in IPSS storage score, IPSS voiding score, IPSS nocturia score, and QoL score were 75.3%, 83.6%, 51.4%, and 71.7%, respectively (all  $P < 0.001$  compared with baseline). Three patients were diagnosed with prostate cancer based on postoperative pathological examinations. There were no serious perioperative complications.

**Conclusion:** The PVRP technique demonstrates satisfactory short-term clinical outcomes and perioperative safety in the treatment of BPH.

**Key words:** Benign Prostatic Hyperplasia; Lasers; Treatment Outcome

## INTRODUCTION

The occurrence of lower urinary tract symptoms (LUTS) caused by benign prostatic hyperplasia (BPH) is a common problem with a high incidence in the aging male population. Although it is not a life-threatening disease, BPH causes problems that seriously impact the quality of life (QoL).<sup>[1]</sup> Transurethral resection of the prostate (TURP) was previously widely accepted as the gold standard for surgical treatment of BPH;<sup>[2-5]</sup> however, a great number of laser procedures have gradually replaced TURP in recent years. Among these new techniques, photoselective vaporization of the prostate (PVP) with a lithium triborate (LBO) laser can effectively remove prostate tissue through vaporization. However, compared with the TURP, PVP has a longer operative time and a lower tissue clearance rate.<sup>[4]</sup> Moreover, the absence of postoperative pathologic specimens is another crucial challenge in PVP.

The disadvantages of the PVP technique could be eliminated by the use of an end-firing fiber, which would allow the laser to be conducted directly to the tip of the fiber with no deflection; this would also enable intraoperative tissue resection. Limited studies have evaluated the use of an end-firing LBO laser in BPH treatment, which is called photoselective vaporesction of the prostate (PVRP),<sup>[6,7]</sup> and the surgical technique has not been standardized. In the present study, we described our initial experience using the PVRP technique for the treatment of BPH.

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## METHODS

### Study design

This prospective study was approved by the ethics committee of Beijing Hospital. From August 2013 to July 2014, a total of 35 BPH patients were enrolled in this study after signing informed consent. All procedures were performed by one doctor with more than 10 years of experience with TURP and 4 years of experience with thulium laser resection of the prostate. Indications for surgery were according to the European Association of Urology guidelines for nonneurogenic male LUTS.<sup>[8]</sup> Preoperative patient evaluation included present medical history, physical examination, International Prostate Symptom Scores (IPSSs), QoL score, serum level of total prostate-specific antigen, prostate volume determined through transrectal ultrasound, maximum urinary flow rate (Qmax), urinalysis, and urinary bacterial culture. Inclusion criteria were age <85 years, IPSS >8, prostate volume >50 ml, and Qmax <10 ml/s; exclusion criteria were suspected prostate cancer or detrusor dysfunction.

A negative preoperative urine culture was mandatory for all patients, and 1.5 g of cefuroxime was administered at the beginning of the procedure as an antibiotic prophylaxis. Patients with a positive preoperative urine culture (bacteria >10<sup>5</sup> colony-forming units/ml) received appropriate antibiotic therapy as per the urine bacterial culture results for a minimum period of 72 h before the operation. Aspirin and clopidogrel were ceased at least 7 days before surgery.

Operative time, laser emission time, intraoperative blood loss, and intraoperative complications were recorded. Clinical data were also recorded, including postoperative duration of hospital stay, catheterization time, and perioperative complications. All patients were instructed to return for follow-up in the 1<sup>st</sup> and the 3<sup>rd</sup> month postoperatively. Clinical data were obtained at follow-up examinations to appraise the surgery efficacy and evaluate the adverse effects.

### Surgical procedures

The aim of our technique was to investigate the advantages of an end-firing fiber vaporization plus resection. Previous studies on PVRP reported several techniques;<sup>[6,7]</sup> all procedures were performed using an LBO crystal laser with a maximum power of 160 W with an end-firing laser fiber (532 nm, Realton Corp., Beijing, China); meanwhile, a 26F laser resectoscope was used to acquire good vision and enhance the resection efficiency. The key steps of the procedure of PVRP are shown in Figure 1.

#### Prostate partitioning

We first divided the prostate into several regions by vaporization after distending the bladder. Two lines were marked initially; these lines originated at 5 o'clock and 7 o'clock at the bladder neck and continued along the boundaries between the median and lateral lobes before terminating at the proximal margin of the verumontanum. We then vaporized the prostate tissue along these lines

until the prostate capsule emerged. These two lines were merged into one line adjacent to the verumontanum. We then vaporized the tissue at 12 o'clock from the apex of the prostate to the bladder neck by rotating the cystoscope for 180°. This technique enhanced the resection rate of tissue around the prostate roof.

#### Vaporesctioning of the median lobe

We used vaporesction to easily remove the wedge-shaped middle lobe located between the two grooves from 5 o'clock to 7 o'clock. Once vaporesction was completed, we could clearly identify the lower margin of both lateral lobes.

#### Vaporesctioning of the lateral lobes

Before removing the lateral lobes, we prepared another two similar grooves that originated from the bladder neck at 3 o'clock and 9 o'clock to the proximal end of the verumontanum. We then vaporized the tissue along these lines until the prostate capsule appeared. The tissue around the lateral gland was then removed. After this, we began to remove the remnant gland along the existing boundary of the capsule.

#### Channel trimming

When the majority of the tissue had been removed, protruding tissue, especially in the apex of the gland, sometimes disrupted the integrity of the cavity. To avoid intraoperative complications (i.e., capsule perforation or sphincter injury), we used vaporization rather than resection to trim the tissue near the external urethral sphincter and reduced the power below 80 W.

#### Statistical analysis

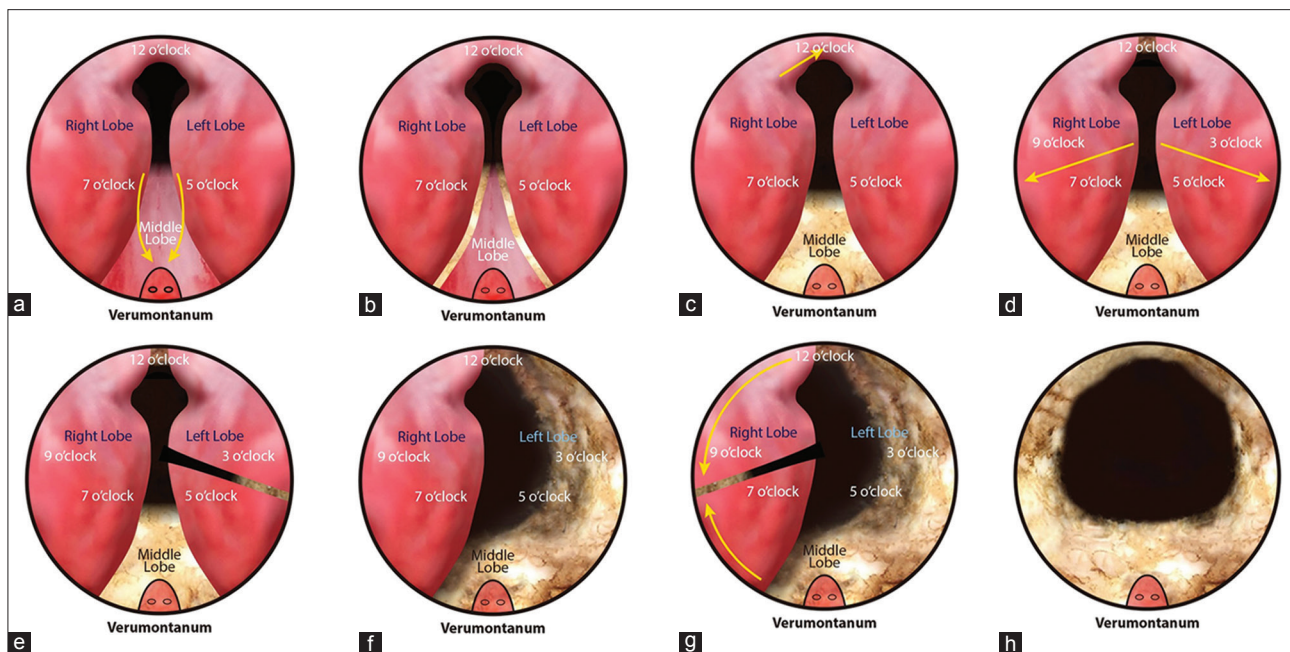
All variables were reported as the mean ± standard deviation (SD). The pre- and peri-operative variables were evaluated for statistically significant differences with the analysis of variance. For appraising the efficacy of the surgery, two-sided  $P < 0.05$  was considered statistically significant. Analyses were performed using Statistical Package for the Social Sciences (SPSS for Windows, version 19.0; IBM, Inc., Chicago, IL, USA).

## RESULTS

A total of 35 patients underwent PVRP and were included in this study. The mean patient age was  $72.1 \pm 7.1$  years (range 53–85 years). Ten patients with a history of acute urinary retention received preoperative catheterization.

Perioperative data are listed in Table 1. The mean laser emission time accounted for nearly 50% of the mean operative time. The blood loss in most patients was <200 ml; however, the average deviated due to some moderate bleeding cases. Almost 90% of patients had the catheter removed within 6 days postoperatively. Two patients diagnosed with prostate cancer confirmed by pathology received tailored treatment based on their general conditions and relative risk level stratifications.

All patients returned to the hospital for follow-up examinations at the 1<sup>st</sup> and 3<sup>rd</sup> month postoperatively [Table 2]. Examinations including urinalysis combined with urine



**Figure 1:** Key steps of photoselective vaporessection of the prostate, (a and b) prostate partitioning, (c) vaporessection of the median lobe, (d-g) vaporessection of the lateral lobes, (h) channel trimming.

**Table 1: Perioperative data of 35 patients with benign prostatic hyperplasia who underwent photoselective vaporessection of the prostate**

Parameters	Data
Mean operative time (min)	119.4 ± 41.1
Mean laser time (min)	58.9 ± 22.3
Blood loss (ml)	204.6 ± 129.4
Bladder irrigation during the operation (L)	40.4 ± 14.2
Convert into TURP (n)	4
Postoperative pathology report, n	
BPH	33
Prostate cancer	2
Catheterization time (days)	7.4 ± 2.0
Postoperative hospital stay (days)	7.3 ± 1.4

Data are shown as mean ± SD, or otherwise noted. TURP: Transurethral resection of the prostate; BPH: Benign prostatic hyperplasia; SD: Standard deviation.

culture were performed to check for postoperative urinary tract infection (UTI).

Compared to baseline values, the mean subgroup IPSS and QoL scores improved dramatically during follow-up. The IPSS storage score, IPSS voiding score, IPSS nocturia score, and the QoL score significantly decreased by 75.3%, 83.6%, 51.4%, and 71.7%, respectively (all  $P < 0.001$ ). For the objective parameters, the mean prostate volume and the serum level of total prostate-specific antigen decreased to 42.6% and 36.2%, respectively. The mean Qmax increased nearly 2-fold compared to baseline and reached a maximum of 15.6 ml/s. We did not collect baseline data for the postvoid residual as the catheterization therapy used in some patients may have led to statistical bias. The mean postvoid residual during follow-up was only  $11.9 \pm 6.5$  ml.

Table 3 presents the peri- and post-operative complications. According to the modified Clavien-Dindo classification system,<sup>[9]</sup> only two cases were Grade 3B and all others were Grade 1 or 2. Prostate capsule perforation was identified in a single case, which did not require specific therapy. No other perioperative complications were found. Three patients experienced high febrility due to acute UTI caused by extended-spectrum beta-lactamase *Escherichia coli* on postoperative days 5–6; all three patients received antibiotics and recovered rapidly. Five patients were diagnosed with UTI at the first follow-up due to unrelieved LUTS and urinalysis results; all recovered after effective antibiotic courses. Only a single patient experienced persistent urinary incontinence in the early postoperative period without evidence of UTI; this urinary incontinence was fully resolved after pelvic floor muscles training for several weeks. Another patient with difficulty in voiding was diagnosed with bladder neck contracture through cystoscopy; this was resolved after a bladder neck incision was performed under general anesthesia on the 40<sup>th</sup> day after PVRP.

## DISCUSSION

Although TURP is still accepted as the gold standard in BPH surgical treatment, laser surgeries have gradually become more popular due to better tolerance, less intraoperative blood loss, satisfactory efficacy, and shorter postoperative recovery.<sup>[10–12]</sup> Currently, the most commonly used BPH laser procedure worldwide uses laser generated by lithium potassium titanyl phosphate or LBO crystals;<sup>[13]</sup> traditionally, these are classified as side-firing lasers compared to other types of laser, such as holmium laser and thulium laser. PVP surgery was initially associated with a longer operative time

**Table 2: Pre- and post-operative functional parameters of 35 patients with benign prostatic hyperplasia who underwent photoselective vaporresection of the prostate**

Parameters	Preoperative (n = 35)	Postoperative 1 month (n = 35)	Postoperative 3 months (n = 35)	F	P
Storage scores in IPSS	8.9 ± 3.3* <sup>†</sup>	4.4 ± 3.6 <sup>‡</sup>	2.2 ± 1.9	33.03	<0.001
Voiding score in IPSS	11.0 ± 3.2* <sup>†</sup>	4.1 ± 3.9 <sup>‡</sup>	1.8 ± 1.7	86.58	<0.001
Nocturia score in PSS	3.7 ± 1.1* <sup>†</sup>	2.4 ± 1.1 <sup>‡</sup>	1.8 ± 0.9	29.15	<0.001
QoL score	4.6 ± 0.9* <sup>†</sup>	2.3 ± 1.5 <sup>‡</sup>	1.3 ± 1.0	107.08	<0.001
Prostate volume (ml)	81.1 ± 36.6* <sup>†</sup>	35.4 ± 14.2 <sup>‡</sup>	34.0 ± 14.1	45.83	<0.001
Qmax (ml/min)	5.3 ± 3.9* <sup>†</sup>	12.5 ± 3.4 <sup>‡</sup>	16.0 ± 4.3	58.84	<0.001
tPSA (µg/L)	5.8 ± 4.6* <sup>†</sup>	3.1 ± 2.8 <sup>‡</sup>	2.1 ± 1.7	12.21	<0.001

Data are shown as mean ± SD. \*Significant differences between pre- and post-operative 1 month groups; <sup>†</sup>Significant differences between pre- and post-operative 3 months groups; <sup>‡</sup>Significant differences between postoperative 1 month and postoperative 3 months groups. IPSS: International Prostate Symptom Score; QoL: Quality of life; Qmax: Maximal urinary flow rate; tPSA: Total prostate-specific antigen; SD: Standard deviation.

**Table 3: Peri- and post-operative complications in 35 patients with benign prostatic hyperplasia who underwent photoselective vaporresection of the prostate**

Complications	Patients, n (%)	Grade
Intraoperative		
Acute urinary tract infection	3 (8.6)	2
Prostate capsule perforation	1 (2.9)	3b
Blood transfusion	0	2
TURP syndrome	0	4
Bladder wall injury	0	2
Ureteric orifice injury	0	2
Urethra sphincter injury	0	2
Postoperative		
Urinary tract infection	5 (14.3)	2
Urinary incontinence	1 (2.9)	1
Bladder neck contracture	1 (2.9)	3b
Postoperative bleeding	0	2

Complications were graded according to the modified Clavien-Dindo classification system. TURP: Transurethral resection of the prostate.

compared to TURP due to limitation of the output power.<sup>[10]</sup> Recently, this disadvantage was resolved by the introduction of high output power equipment that significantly decreased the operative time, particularly for cases with massive prostates.<sup>[14]</sup> Furthermore, the incidence of the fatal perioperative complication known as TURP syndrome has considerably declined due to saline irrigation,<sup>[15,16]</sup> and the reliable efficacy of LUTS with PVP compared to other types of lasers was verified by a series of studies.<sup>[17-19]</sup> However, PVP associated with side-firing laser emission also has some disadvantages, including an energy loss of nearly 20% and a short lifespan of the laser fiber.<sup>[20-24]</sup> Moreover, PVP increases the possibility of missed diagnosis in prostate cancer due to complete tissue vaporization.

The introduction of an end-firing fiber successfully overcame all of the above-mentioned disadvantages of PVP. First, the tip is capable of transmitting laser to the tissues with almost no energy loss intraoperatively. Second, when fiber debris collects on the tip, it is straightforward to maintain the ideal output power by simply removing the affected parts. Finally, laser resection enables the collection of specimens for postoperative

pathologic examination. Hence, using an end-firing fiber could enhance the tissue removal rate and improve the intraoperative safety.

Herein, we share our preliminary experiences with PVRP. First, PVRP enabled better exposure of the prostate capsule with proper demarcation and reduced the risk of capsule perforation. Second, tissue removal should be carried out along the surgical capsule, especially with the groove at 12 o'clock, which facilitates tissue resection around the roof of the prostatic urethra and provides a satisfactory tissue removal rate. Third, it is essential to remove the middle lobe initially to acquire a wider channel in the prostatic urethra and enhance the operative visualization. In cases with large middle lobes with bladder neck involvement, we strongly recommend that markers should be drawn on the middle lobe before it is removed separately. Fourth, unlike the thulium laser, LBO laser cannot be absorbed by water; thus, the potential risk of tissue perforation is increased when the laser beam is concentrated at a certain place for a long time. This issue can be easily avoided by distending the bladder, frequently moving the fiber tip and decreasing the output power when the fiber tip is close to the bladder neck and prostate apex. Finally, for the great majority of the glands, the LBO laser produced a satisfactory hemostatic effect. We usually decrease the output power to about 50 W and maintain an appropriate distance between the fiber tip and hemorrhage site, otherwise excessive tissue vaporization might incur capsule perforation. The exception to this is bleeding in the bladder neck where the vascularity shows huge variability among patients; in highly vascular areas, LBO laser may be inappropriate for the management of hemorrhage. The likelihood of severe bleeding seems to correlate with the prostate volume, and bipolar TURP loop should be employed in these cases. In this study, four of 35 procedures were converted to TURP to achieve hemostasis. Other researchers reached a similar conclusion that bleeding is the most common intraoperative complication and is also the main reason for longer operative time.<sup>[15]</sup> A hemostat can reportedly help manage intractable bleeding during the procedure.<sup>[6]</sup> There is a learning curve for beginners to fully grasp the hemostasis technique.

In the study, LBO laser showed a significant advantage for the treatment of BPH and markedly improved both the subjective and objective parameters of patients compared to their baseline data. All perioperative complications were classified as a mild or moderate according to the modified Clavien-Dindo system. In a follow-up of 3 months, the efficacy remained stable among all patients and no adverse events were reported. In addition, the PVRP technique enabled the collection of specimens for pathological examination. The operative time in the study seems to be longer than that in previous studies;<sup>[6,7]</sup> this might be attributed to the preponderance of large prostates and our stage of limited experience.

There are several limitations in this study. First, the small number of subjects and short-term postoperative follow-up might impair the reliability of the results. However, the primary objective of this study was to introduce the novel PVRP technique and outline the key steps of the procedure. We will include a larger number of cases in a future study to confirm the results of PVRP. Second, a control arm of patients undergoing TURP should be established before the study. Third, the limitations of PVRP should not be avoided; we consider that PVRP would not be superior to traditional techniques in cases involving a small prostate.

In conclusion, PVRP demonstrates satisfactory short-term clinical outcomes and safety in the treatment of LUTS caused by BPH. In addition, this promising technique has apparent advantages in enhancing tissue resection rate and obtaining pathological specimens. A larger quantity of cases and long-term follow-up data are needed to confirm the efficacy, durability, and safety of PVRP.

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### Conflicts of interest

There are no conflicts of interest.

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