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More efficient vaporization by the 200-W Thulium laser system than by the GreenLight high-performance system (HPS) 120-W system

Masatake Shinohara[1], Yoshihiko Hirao[1], Kiyohide Fujimoto[2], Toshihisa Saka[1]

[1]The Department of Urology, Osaka Gyoumeikan Hospital, Osaka 554-0012, Japan.
[2]The Department of Urology, Nara Medical University, Nara 634-8521, Japan.

Correspondence to: Dr. Masatake Shinohara, The Department of Urology, Osaka Gyoumeikan Hospital, 5-4-8 Nishikujyo, Konohana-ku, Osaka City, Osaka 554-0012, Japan. E-mail: bonyarishinohara@hotmail.co.jp

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Abstract

Aim: We retrospectively compared and evaluated the safety, efficacy, and 1-year outcomes of 200-W Thulium laser vaporization of the prostate (ThuVAP) and the GreenLight high-performance system (HPS) 120-W system for benign prostatic hyperplasia (BPH).

Methods: Between February 2019 and December 2021, 137 patients with lower urinary tract symptoms secondary to BPH underwent ThuVAP. Between October 2014 and April 2019, 233 patients underwent GreenLight HPS 120-W vaporization of the prostate (HPS-PVP). Prostate-specific antigen (PSA) levels, International Prostate Symptom Scores (IPSS), quality of life (QOL) scores, overactive bladder symptom scores (OABSS), post-void residual (PVR), and maximum flow rates (Qmax) were evaluated before and 1, 3, 6, and 12 months after surgery.

Results: Mean ages in the ThuVAP and HPS-PVP groups were 73.7 and 73.4 years, respectively. Prostate volumes (PV) were 77.0 and 61.4 mL ($P < 0.001$), respectively. Significant improvements were observed in IPSS, QOL scores, OABSS, Qmax, and PVR in both groups 1 to 12 months after surgery. Laser and hospitalization times were significantly shorter and approximate tissue removal (ΔPV) was significantly larger in the ThuVAP group than in the HPS-PVP group (means, 49.4 min *vs.* 62.5 min, $P < 0.001$, means, 4.9 days *vs.* 5.4 days, $P = 0.007$, means, 50.4 mL *vs.* 27.8 mL, $P < 0.001$, respectively). Vaporization efficiency (ΔPV/laser time) was > 2-fold higher in the ThuVAP group than in the HPS-PVP group (1.1 mL/min *vs.* 0.5 mL/min). There were significantly fewer

postoperative complications in the ThuVAP group than in the HPS-PVP group (13.9% *vs.* 23.6%, $P = 0.030$).

Conclusion: Both procedures are safe and useful for BPH obstruction. Based on shorter operating and hospitalization times, fewer complications, and more efficient tissue removal, ThuVAP is a more favorable and effective treatment than HPS-PVP.

Keywords: Benign prostate hyperplasia, Thulium laser vaporization, GreenLight HPS 120-W system, prostate surgery, prostate vaporization

INTRODUCTION

Transurethral resection of the prostate (TURP) is still the gold standard surgical treatment for benign prostatic hyperplasia (BPH). However, it is associated with a number of perioperative complications, including bleeding requiring transfusion, hyponatremia, and long-term indwelling urethral catheterization. Furthermore, this procedure requires the operator to be skilled, and its outcomes are dependent on the skill of the operator.

Laser vaporization for BPH, as typified by photoselective vaporization of the prostate (PVP), was initially performed in the 1980s to overcome the complications associated with TURP and is now conducted worldwide. Previous studies demonstrated that laser vaporization, particularly GreenLight laser vaporization, of the prostate was as safe and as efficient as TURP[1,2].

A high-powered Thulium laser was initially introduced for the treatment of BPH in 2005[3]. Since the thulium laser is strongly absorbed by water (abundant in all tissues), its cutting and vaporization speeds remain relatively constant during procedures regardless of tissue vascularization. Furthermore, its wavelength achieves an extremely low penetration (0.1-0.2 mm), efficient tissue ablation, and effective hemostasis[4]. Several techniques using the Thulium laser have been described for laser prostatectomy, including Thulium vapoenucleation, Thulium laser resection of the prostate (the 'tangerine' technique), and Thulium laser enucleation[5-7]. Although the Thulium laser is well suited for vaporization, the safety and efficacy of 200-W Thulium laser vaporization of the prostate (ThuVAP) have only recently been reported[8]. Therefore, we herein compared the efficacy and safety of ThuVAP and GreenLight 120-W high-performance system (HPS) photoselective vaporization of the prostate (HPS-PVP).

METHODS

In this single institutional retrospective study, we collected data on 137 men who underwent ThuVAP (200-W Cyber TM) for BPH between February 2019 and December 2021 and 233 men who underwent HPS-PVP between October 2014 and April 2019. Twenty-two out of 137 patients in the ThuVAP group and 54 out of 233 in the HPS-PVP group received anticoagulant therapy, and all underwent surgery without the cessation of this treatment.

We utilized a Storz 23Fr laser resectoscope. Both procedures were initiated under general anesthesia, and a cavity similar to that of TURP was formed in the prostatic urethra. Hemostasis was confirmed with an emptied bladder and the removal of any tissue pieces or clots. The bladder was then re-filled, an 18F 2-way catheter was gently introduced, and its balloon was inflated with 20 cc of saline.

Prostate-specific antigen (PSA) levels, International Prostate Symptom Scores (IPSS), quality of life (QOL) scores, overactive bladder symptom scores (OABSS), post-void residual (PVR), maximum flow rates

(Qmax), and prostate volumes (PV) were assessed in all patients before surgery. Eighty-two out of 137 patients in the ThuVAP group and 198 out of 233 in the HPS-PVP group underwent a pressure flow study (PFS) before surgery. Patients were followed up 1, 3, 6, and 12 months after surgery.

Complications were prospectively described in the present study and included OABS, stress urinary incontinence, dysuria, urinary tract infection, urinary retention, hematuria, and urethral stricture. Complications were categorized according to the Clavien-Dindo classification[9].

All data are shown as the mean ± standard deviation. The Mann-Whitney *U* test was performed to analyze the significance of differences. Significance was defined as a *P* value < 0.05. All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). More precisely, it is a modified version of R commander designed to add statistical functions frequently used in biostatistics.

RESULTS

The present study included 137 men who underwent ThuVAP using the Cyber TM 200-W Thulium laser and 233 men who underwent HPS-PVP using the GreenLight 120-W HPS system [Table 1]. The ThuVAP group was followed up for 12 months [mean: 7.8 months; confidence interval (CI): 7.0-8.5; median: 12 months], and 69 out of 137 patients completed the 12-month follow-up. The HPS-PVP group was also followed up for 12 months (mean: 7.1 months; CI: 7.5-8.6; median: 12 months), and 119 out of 233 patients completed the 12-month follow-up. The mean ages of patients in the ThuVAP and HPS-PVP groups were 73.7 (51-92) and 73.4 (44-96) years, respectively. PV were 77.0 (15-273) and 61.4 (17-170) mL ($P < 0.001$), respectively. Preoperative PFS revealed detrusor overactivity in 45 out of 82 patients (54.9%) in the ThuVAP group and 113 out of 198 (57.1%) in the HPS-PVP group [Table 2]. Mean detrusor pressure values at Qmax were 77.9 cmH_2O in the ThuVAP group and 83.0 cmH_2O in the HPS-PVP group, with mean bladder outlet obstructive indexes of 65.3 and 68.6 and mean bladder contractility indexes of 112.7 and 113.9, respectively.

Regarding surgical parameters [Table 3], mean laser times during the surgical procedure were 49.4 (10-103) and 62.5 (10-147) min in the ThuVAP and HPS-PVP groups ($P < 0.001$), respectively, with mean total energy expenditures of 513.2 (57.4-1201.0) and 305.3 (35.8-641.8) kj per surgery ($P < 0.001$), respectively. After surgery, the mean decrease in blood hemoglobin was mild in both groups (0.7 and 0.6 mg/dL, respectively). Mean postoperative Foley catheterization times in the ThuVAP and HPS-PVP groups were 34.2 and 33.0 h, respectively. Mean differences in PV before and after surgery (ΔPV) were 50.4 (8-154) and 27.8 (5-66) mL ($P < 0.001$), respectively. Therefore, average adenoma evaporation volumes per min (vaporization efficiency: ΔPV/laser time) in the ThuVAP and HPS-PVP groups were 1.1 (0.4-2.3) and 0.5 (0.1-1.2) mL/min ($P < 0.001$), respectively.

Twenty-two patients were receiving anticoagulant therapy at the time of surgery in the ThuVAP group, and no significant differences were observed in the length of the catheter time, length of the hospital stay, or decreases in serum hemoglobin levels between those treated with or without anticoagulants. In contrast, 54 patients were receiving anticoagulant therapy at the time of surgery in the HPS-PVP group, and a significant difference was noted in the length of the catheter time between those treated with or without anticoagulants (39.9 and 30.9 h, $P = 0.001$) [Table 4].

Table 1. Baseline characteristics

	ThuVAP (*n* = 137)		HPS-PVP (*n* = 233)		*P* value
	mean ± SD	Range	mean ± SD	Range	
Age (years)	73.7 ± 8.3	51-92	73.4 ± 7.7	44-96	0.797*
PSA (ng/mL)	6.3 ± 6.5	0.2-39.0	4.8 ± 7.5	0.3-94.9	0.006*
Prostate volume (mL)	77.0 ± 36.6	15-273	61.4 ± 25.5	17-169.5	< 0.001*
IPSS	23.2 ± 9.3	3-35	22.1 ± 9.4	0-35	0.284*
QOL score	5.4 ± 0.7	3-6	5.1 ± 1.2	0-6	0.11*
OABSS	7.0 ± 3.6	0-15	6.3 ± 3.5	0-15	0.057*
Uroflowmetry					
Maximum flow rate (mL/s)	6.9 ± 3.3	1.0-16.0	7.6 ± 3.8	1.2-25.1	0.204*
Average flow rate (mL/s)	4.19 ± 2.12	0.9-10.0	4.4 ± 2.4	1.0-16.2	0.817*
Voided volume (mL)	150.1 ± 94.6	10-483	167.2 ± 101.9	5-663	0.128*
Residual volume (mL)	107.0 ± 98.8	0-450	102.1 ± 144.9	0-1600	0.242*
Anticoagulant therapy	22/137 (16.1%)		54/233 (23.2%)		0.098**

*Mann-Whitney *U* test. **Student's *t*-test. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate; PSA: prostate-specific antigen; IPSS: International Prostate Symptom Score; QOL: quality of life; OABSS: overactive bladder symptom score.

Table 2. Baseline characteristics

	ThuVAP (*n* = 82)		HPS-PVP (*n* = 198)		*P* value
	mean ± SD	Range	mean ± SD	Range	
PFS Maximum cystometric capacity (mL)	256.1 ± 108.9	35-567	264.6 ± 165.5	28-1736	0.978*
Pdet Qmax	77.9 ± 33.3	14-165	83.0 ± 33.9	19-280	0.456*
Detrusor overactivity (positive)	45/82 (54.9%)		113/198 (57.1%)		0.737**
Bladder outlet obstructive index	65.3 ± 32.3	0.6-161.0	68.6 ± 34.2	-6.4-262.0	0.632*
Bladder contractility index	112.7 ± 37.7	27.0-201.5	113.9 ± 42.9	0-325.0	0.894*

*Mann-Whitney *U* test. **Student's *t*-test. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate; Pdet Qmax: detrusor pressure at maximum flow rates; PFS: pressure flow study.

Table 3. Surgical parameters

	ThuVAP (*n* = 137)		HPS-PVP (*n* = 233)		*P* value
	mean ± SD	Range	mean ± SD	Range	
Laser time (min)	49.4 ± 19.2	10-103	62.5 ± 19.1	10-147	< 0.001
Total energy delivery (kj)	513.2 ± 222.2	57.4-1201.0	305.3 ± 92.8	35.8-641.8	< 0.001
Catheter time (h)	34.2 ± 23.7	20-120	33.0 ± 20.8	20-120	0.746
Serum sodium decrease (mEq/L)	0.7 ± 2.3	-7-6	0.4 ± 2.1	-7-12	0.049
Hemoglobin decrease (g/dL)	0.7 ± 0.7	-1.3-2.2	0.6 ± 0.8	-2.4-3.1	0.294
Hospital stay (day)	4.9 ± 2.1	2-14	5.4 ± 2.1	2-14	0.007
ΔPV (mL)	50.4 ± 23.9	8-154	27.8 ± 11.4	5-66	< 0.001
ΔPV/laser time (mL/min)	1.1 ± 0.4	0.4-2.3	0.5 ± 0.2	0.1-1.2	< 0.001

Mann-Whitney *U* test. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate; PV: prostate volume; ΔPV: mean difference in PV before and after surgery.

Functional outcomes were reported before and 1, 3, 6, and 12 months after surgery [Table 5]. In the ThuVAP group, the mean values for IPSS, QOL, OABSS, Qmax, and PVR were 23.2, 5.4, 7.0, 6.9 mL/s, and 107.0 mL, respectively, before surgery and 4.1, 1.2, 2.4, 22.5 mL/s, and 6.6 mL, respectively, 1 year after

Table 4. Surgical parameters in patients treated with and without anticoagulant therapy

	ThuVAP			HPS-PVP		
	Anticoagulant therapy (*n* = 22) Mean ± SD	No anticoagulant therapy (*n* = 115) Mean ± SD	*P* value	Anticoagulant therapy (*n* = 54) Mean ± SD	No anticoagulant therapy (*n* = 179) Mean ± SD	*P* value
Laser time (min)	45.3 ± 15.7	50.2 ± 19.8	0.200	60.7 ± 18.5	63.0 ± 19.2	0.376
Total energy delivery (kj)	473.5 ± 196.9	520.8 ± 226.0	0.444	297.1 ± 89.9	307.8 ± 93.5	0.461
Catheter time (h)	40.6 ± 26.4	33.0 ± 23.0	0.097	39.9 ± 23.1	30.9 ± 19.6	0.001
Serum sodium decrease (mEq/l)	1.6 ± 1.7	0.6 ± 2.4	0.095	0.2 ± 1.9	0.5 ± 2.1	0.373
Hemoglobin decrease (g/dl)	0.6 ± 0.6	0.7 ± 0.7	0.545	0.7 ± 0.7	0.6 ± 0.9	0.365
Hospital stay (day)	5.1 ± 2.3	4.8 ± 2.1	0.743	5.8 ± 2.5	5.2 ± 2.0	0.239

Mann-Whitney *U* test. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate.

Table 5. Functional outcomes before and 1, 3, 6, and 12 months after surgery

Outcomes	ThuVAP					
	Preoperative mean (95% confidence interval) *n* = 137	Months				*P* value
		1 *n* = 137	3 *n* = 117	6 *n* = 96	12 *n* = 71	
IPSS	23.2 (21.6-24.8)	8.3 (7.4-9.2)	6.3 (5.4-7.1)	4.7 (4.1-5.3)	4.1 (3.6-4.7)	< 0.001
QOL	5.4 (5.3-5.5)	2.2 (1.9-2.4)	1.6 (1.4-1.8)	1.3 (1.1-1.5)	1.2 (1.0-1.4)	< 0.001
OABSS	7.0 (6.4-7.6)	4.6 (4.1-5.1)	3.4 (3.0-3.8)	2.8 (2.4-3.1)	2.4 (2.1-2.7)	< 0.001
Qmax (mL/s)	6.9 (6.4-7.5)	15.6 (14.5-16.7)	20.0 (15.3-24.7)	21.8 (14.9-28.8)	22.5 (15.5-29.5)	< 0.001
PVR (mL)	107.0 (90.2-123.8)	15.5 (10.9-20.0)	10.9 (7.7-14.1)	6.9 (4.6-9.1)	6.6 (4.6-8.6)	< 0.001
PSA (ng/mL)	6.3 [*n* = 133] (5.2-7.4)		2.7 [*n* = 85] (2.3-3.1)			< 0.001
Outcomes	**HPS-PVP**					
	Preoperative mean (95% confidence interval) *n* = 233	**Months**				***P* value**
		1 *n* = 213	**3 *n* = 200**	**6 *n* = 179**	**12 *n* = 118**	
IPSS	22.1 (20.9-23.3)	8.0 (7.2-8.8)	5.4 (4.9-5.9)	5.0 (4.4-5.5)	4.7 (4.2-5.1)	< 0.001
QOL	5.1 (4.9-5.2)	2.1 (1.9-2.3)	1.5 (1.3-1.6)	1.4 (1.2-1.5)	1.3 (1.1-1.4)	< 0.001
OABSS	6.3 (5.8-6.7)	4.3 (3.9-4.7)	2.9 (2.6-3.2)	2.5 (2.3-2.7)	2.4 (2.1-2.6)	< 0.001
Qmax (mL/s)	7.6 (7.1-8.0)	16.2 (14.4-18.1)	17.9 (16.9-18.9)	18.2 (17.1-19.2)	17.6 (16.7-18.6)	< 0.001
PVR (mL)	102.1 (83.4-120.9)	12.5 (9.5-15.6)	10.7 (7.5-13.9)	11.6 (8.6-14.6)	8.0 (5.7-10.2)	< 0.001
PSA (ng/mL)	4.8 [*n* = 220] (3.8-5.7)		1.9 [*n* = 155] (1.6-2.1)			< 0.001

Mann-Whitney *U* test. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate; IPSS: International Prostate Symptom Score; QOL: quality of life; OABSS: overactive bladder symptom score; Qmax: maximum flow rate; PVR: post-void residual; PSA: prostate-specific antigen.

surgery. In the HPS-PVP group, the mean values for IPSS, QOL, OABSS, Qmax, and PVR were 22.1, 5.1, 6.3, 7.6 mL/s, and 102.1 mL, respectively, before surgery and 4.7, 1.3, 2.4, 17.6 mL/s, and 8.0 mL, respectively, 1 year after surgery. All functional outcomes significantly improved from baseline and appeared to be maintained during the follow-up period. Mean changes in PSA levels from baseline were 3.6

and 2.9 in the ThuVAP and HPS-PVP groups, respectively.

Complications categorized according to the Clavien-Dindo classification are listed in Table 6. Two (1.5%) patients in the ThuVAP group and nine (3.9%) in the HPS-PVP group were treated for stress urinary incontinence 1 month after surgery. Furthermore, two (1.5%) patients in the ThuVAP group and 19 (8.2%) in the HPS-PVP group had urinary retention 1 month after surgery, which required treatment with urinary catheterization for a few days. In addition, hematuria was detected in three (2.2%) and one (0.9%) patients in the ThuVAP group 1 and 3 months after surgery, respectively, and in seven (3.0%) and one (0.4%) in the HPS-PVP group 1 and 12 months after surgery, respectively, which required treatment with a hemostatic agent. Regarding bladder pain, three (2.2%) patients in the ThuVAP group developed pelvic pain that was exacerbated by bladder filling 1 month after surgery. Two patients in the ThuVAP group and seven in the HPS-PVP group had a confirmed diagnosis of bladder neck contracture by cystoscopy within 6 and 12 months of surgery, respectively, which required transurethral incision. Nineteen patients (13.9%) in the ThuVAP group and 55 (23.6%) in the HPS-PVP group ($P = 0.030$) developed at least one complication.

In the ThuVAP group, a multivariate analysis of risk factors for postoperative complications identified preoperative balloon catheter placement as a significant risk factor (OR: 8.270, $P = 0.012$) [Table 7]. Conversely, no significant risk factors for postoperative complications were identified in the HPS-PVP group by univariate or multivariate analysis.

DISCUSSION

The Thulium laser (2013 nm) is strongly absorbed by water and may be operated in a continuous wave; therefore, a coagulated layer easily forms in tissue and the hemostatic power of the laser is high. Since the Thulium laser is a direct-injected fiber, it may be used for a number of purposes, such as enucleation, resection, and vaporization[10]. Furthermore, it is reusable and has a high energy limit; therefore, it is cost-efficient and effective for large BPH. In recent years, there have been a number of conference presentations on the use of the 200-W high-powered Thulium laser for ThuVAP.

ThuVAP is associated with a low risk of bleeding and its safety has been demonstrated; therefore, it may be performed on very elderly and high-risk patients receiving anticoagulant therapy. Although the Thulium laser is commonly used for vapoenucleation or resection of the prostate, limited information is currently available on ThuVAP. In vapoenucleation or resection of the prostate using the Thulium laser, 0.6%-7.1% of patients required perioperative blood transfusions. However, it remains unknown whether a perioperative blood transfusion is needed for ThuVAP[5,6,11].

In 2014, Pariser *et al.* reported the short-term outcomes of 150-W (CyberTM) thulium laser vaporization of the prostate (150-W ThuVP) over a period of 3 months[8]. Fifty-nine patients with a mean PV of 57 ± 30.2 mL underwent 150-W ThuVP; 47% were receiving anticoagulants. The majority (78%) of patients were discharged on the same day of surgery. Although a significant change was observed in hemoglobin levels from baseline (13.1-12.4 g/dL), no patients received blood transfusions.

In comparison with HPS-PVP, the present results demonstrated the safety of ThuVAP. Mean PV in the ThuVAP group was 77 ± 36.6 mL and 16% of patients were receiving anticoagulants. Average postoperative catheterization and hospitalization times were 34.2 h and 4.9 days, respectively, and no significant differences were observed in these times between patients treated with and without anticoagulants. Although a significant change was noted in hemoglobin levels from baseline (14.2-13.5 g/dL, $P < 0.001$) in the present study, no patients received blood transfusions and no significant differences were detected in

Table 6. Complications of 200W Thulium laser and 120-W HPS-PVP

		ThuVAP				HPS-PVP				*P* value
		Months				Months				
		< 1	1-3	3-6	6-12	< 1	1-3	3-6	6-12	
	Number of patients	137	117	96	71	233	200	179	118	
The Clavien-Dindo classification	Stress urinary incontinence (%)	2 (1.5)	0	0	0	9 (3.9)	0	0	0	
Minor: I/II	Urinary retention (%)	2 (1.5)	0	0	0	19 (8.2)	0	0	0	
	Hematuria (%)	3 (2.2)	1 (0.9)	0	0	7 (3.0)	0	0	1 (0.4)	
	Bladder pain (%)	3 (2.2)	0	0	0	0	0	0	0	
	UTI (%)	6 (4.4)	0	0	0	5 (2.1)	1 (0.5)	0	1 (0.4)	
	urethral stenosis (%)	0	0	0	0	1 (0.4)	3 (1.5)	1 (0.6)	0	
Major: IIIa/IIIb	Bladder neck contracture / urethral stenosis (%)	0	0	2 (2.1)	0	0	0	3 (1.7)	4 (3.4)	
Total	Number of patients (%)	19 (13.9)				55 (23.6)				0.030

Mann-Whitney *U* test. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate; UTI: urinary tract infection.

this decrease between patients treated with and without anticoagulants.

Vargas *et al.* reported the outcomes of 150-W ThuVP in 52 patients without anticoagulants (mean PV of 42.5 ± 17.4 mL) in a 6-month follow-up[12]. Significant improvements were observed in mean IPSS (reduction of 17 points) and Qmax (mean improvement of 9.33 mL/s). In the present study, preoperative IPSS was 23.2 points, with 21% of patients exhibiting urinary retention at the time of surgery. A marked reduction was noted in IPSS 1 month after surgery (mean 8.3 points), and it continued to gradually decrease until 12 months (mean 4.1 points). This result suggests immediate improvements in obstructive urinary symptoms, whereas the attenuation of bladder storage symptoms was slower. IPSS was 82.3% (19.1 points) in the 12-month follow-up, which was lower than the baseline. Regarding urodynamic parameters, improvements were observed in mean Qmax (6.9-22.5 mL/s) and PVR (107.0-6.6 mL) from preoperative parameters. Although the average PV (77.0 ± 36.6 mL) in the present study was significantly larger than those in two previous 150-W ThuVP studies, the results obtained were similar. We suggest that an improved Thulium laser output (previous studies: 150-W, our study: 200-W) resulted in similar surgical outcomes for large BPH.

A reduction in PSA levels is associated with the holmium laser enucleation of the prostate as a surrogate marker for BPH adenoma removal, and is a useful parameter for evaluating the success of other BPH obstruction surgeries. In the present study, mean PSA levels decreased to 3.6 and 2.9 ng/mL from baseline after three months in the ThuVAP and HPS-PVP groups, respectively. ΔPV were 50.4 and 27.8 mL ($P < 0.001$) in the ThuVAP and HPS-PVP groups, respectively, while mean ΔPV/laser times (vaporization efficiency) (mL/min) were 1.1 and 0.5 ($P < 0.001$), respectively. Hueber *et al.* reported that HPS-PVP retreatment rates were significantly higher for prostates > 100 cc[13]. Due to the limited energy use of the fiber in HPS-PVP, which may only be used once, this procedure may increase the reoperation rate during the long course of residual adenoma in large BPH.

Table 7. Multivariate analysis of risk factors for postoperative complications related to ThuVAP and HPS-PVP

	ThuVAP						HPS-PVP					
	Univariate analysis			Multivariate analysis			Univariate analysis			Multivariate analysis		
	OR	95%CI	*P* value	OR	95%CI	*P* value	OR	95%CI	*P* value	OR	95%CI	*P* value
Age	1.050	0.984-1.110	0.149				1.030	0.989-1.070	0.150			
PV	1.010	0.996-1.020	0.209				0.991	0.979-1.000	0.184			
PVR	1.000	0.999-1.010	0.164				1.000	0.999-1.000	0.377			
IPSS	1.050	0.989-1.110	0.118				1.030	0.993-1.060	0.123			
QOL	1.970	0.848-4.560	0.115				0.968	0.758-1.240	0.793			
Bladder outlet obstruction index	0.989	0.964-1.010	0.393				0.994	0.983-1.010	0.300			
Diabetes	1.980	0.636-6.190	0.238				1.800	0.783-4.110	0.167			
Anticoagulant therapy	4.010	1.360-11.80	0.012				1.910	0.973-3.730	0.060			
Preoperative balloon catheter placement	5.790	2.080-16.10	0.001	8.270	1.600-42.60	0.012	1.220	0.593-2.510	0.588			

Logistic regression analysis. ThuVAP: 200-W Thulium laser vaporization of the prostate; HPS-PVP: GreenLight HPS 120-W vaporization of the prostate; PV: prostate volume; PVR: post-void residual; IPSS: International Prostate Symptom Score; QOL: quality of life; Pdet Qmax: detrusor pressure at maximum flow rates.

In contrast, 200-W ThuVAP is characterized by a high fiber output and increased energy availability, the vaporization efficiency of which is more than 2-fold higher than that of the GreenLight HPS 120-W system and allows for the sufficient vaporization of large BPH.

In the present study, overall complication rates were 13.9 and 23.6% ($P = 0.030$), while major complication rates were 1.5 and 3.0% in the ThuVAP and HPS-PVP groups, respectively, and a multivariate analysis identified anticoagulant therapy and preoperative balloon catheter placement as risk factors for complications in the ThuVAP group. Although anticoagulant therapy was a risk factor in the ThuVAP group, no significant differences were observed in the length of the catheter time or hospital stay between those treated with or without anticoagulants. Preoperative balloon catheter placement has been identified as a risk factor for postoperative febrile urinary tract infections (fUTIs). We performed urine cultures before surgery and administered antibiotics to patients with a positive culture one day before surgery. Although preoperative balloon catheter placement is a risk factor for postoperative fUTIs, the present results will facilitate the prevention of postoperative fUTIs in the future.

In the present study, overall complication rates were significantly lower in the ThuVAP group than in the HPS-PVP group. This result may have initially been attributed to the introduction of the HPS-PVP system, and then to the ThuVAP system after we gained experience performing vaporization.

However, based on our experience of HPS-PVP and ThuVAP, we recognize that ThuVAP has contributed to marked improvements in vaporization efficiency while retaining the safety of previous vaporization systems, such as HPS-PVP. ThuVAP is a relatively new surgical procedure and since limited information is currently available on its outcomes, further studies are warranted.

The results obtained on 137 patients who underwent 200-W Cyber TM ThuVAP with a 1-year follow-up in the present study confirmed very few complications and improvements in IPSS, QOL scores, OABSS, Qmax, and PVR from 1 to 12 months after surgery. It is important to note that the ThuVAP group had significantly fewer postoperative complications than the HPS-PVP group and vaporization efficiency was more than two-fold higher.

There are some limitations that need to be addressed. The present study included a small sample size and had a short follow-up period. It was also a retrospective analysis of a prospectively maintained database of one institution. Despite these limitations, the present results support the safety, utility, and cost-effectiveness of 200-W Cyber TM ThuVAP, which is beneficial not only for patients, but also for medical personnel.

In conclusion, HPS-PVP and ThuVAP are both safe and useful surgical procedures for patients with BPH. Based on shorter operating and hospitalization times, fewer complications, and more efficient tissue removal, ThuVAP is a more favorable and effective treatment than HPS-PVP. The 200-W Thulium laser is suitable for vaporization of the prostate, which may be completed by vaporization alone even if it is very large.

DECLARATIONS

Authors' contributions

Conception and design of the study and performed: Shinohara M, Hirao Y
Data analysis and interpretation: Shinohara M, Hirao Y, Fujimoto K, Saka T

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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None.

Conflicts of interest

All authors declare that there are no conflicts of interest.

Ethical approval and consent to participate

The present study was performed in accordance with the ethical principles of the Declaration of Helsinki. The protocol was approved by the Ethics Committee of Osaka Gyoumeikan Hospital (IRB approval number: 21-0017).

Consent for publication

Not applicable.

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