Efficacy and safety of transurethral resection of the prostate, holmium laser enucleation of the prostate, and photoselective vaporization of the prostate in management of overactive bladder symptoms complicating benign prostatic hyperplasia in patients with moderately enlarged prostates: A comparative study

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ABSTRACT

Introduction: We aimed to compare the effectiveness and safety of transurethral resection of the prostate (TURP), holmium laser enucleation of the prostate (HoLEP), and photoselective vaporization of the prostate (PVP) in management of storage and overactive bladder (OAB) symptoms complicating benign prostatic hyperplasia (BPH) in patients with moderately enlarged prostates.

Methods: The charts of patients with moderately enlarged prostates and BPH complicated by storage and OAB symptoms who were treated by TURP, HoLEP, and PVP at University of Cincinnati hospitals in the period between March 2012 and December 2020 were retrospectively reviewed and analyzed for changes in storage and OAB symptomatology, International Prostate Symptom Score (IPSS), peak flow rates (Qmax), presence of detrusor overactivity (DO), and postvoid residual (PVR) from baseline to up to six months postoperatively.

Results: A total of 204 patients with moderately enlarged prostates and BPH complicated by storage and OAB symptoms were divided into three groups: group 1 (patients who underwent TURP, 89 patients), group 2 (those who underwent HoLEP, 64 patients), and group 3 (those who underwent PVP, 51 patients). TURP, HoLEP, and PVP were associated with significant

improvement in urodynamics study (UDS) parameters, patient storage and OAB symptomatology, and IPSS from preoperatively to both three and six months postoperatively in BPH patients with moderately enlarged prostates with relatively low procedure complication rate and postoperative need for either anticholinergic or procedure.
Conclusions: TURP, HoLEP, and PVP are effective and reliable surgical procedures that can be relied on for BPH patients with moderately enlarged prostates and storage or OAB symptoms with comparable efficacy and relatively low procedure complication rate and postoperative need for anticholinergic or procedure.

INTRODUCTION

Benign prostatic hyperplasia (BPH) is a common health condition in ageing men affecting approximately 50% of men in their 50s and up to 80% of men by their 9th decade (1). Aging has not been the only significant predictor for the development of BPH. The disease has also been highly linked to African race, obesity, diabetes mellitus (DM), alcoholism, physical inactivity, and some dietary patterns (2-5). In general, there are two forms of BPH: microscopic and clinical. Bothersome lower urinary tract symptoms (LUTS) are the main presentation of clinical BPH (6).

These BPH-associated LUTS can be categorized into voiding LUTS (slow stream, splitting or spraying, intermittency, hesitancy, straining, and/or terminal dribbling), storage LUTS (daytime urinary frequency, nocturia, urgency, and/or urinary incontinence), and post-micturition LUTS (sensation of incomplete emptying and/or post-micturition dribbling) (7). It has been reported that while the voiding LUTS are usually more prevalent, the storage LUTS are almost always more bothersome for BPH patients (8).

According to the International Continence Society (ICS) definition, Overactive bladder (OAB) is a subset of storage symptoms that consists of urinary urgency with or without urgency urinary incontinence (UUI) often accompanied by daytime frequency and/or nocturia in the absence of urinary tract infection (UTI) or other obvious pathologies (9, 10). The prevalence of these OAB symptoms has been reported to increase with age and to occur in both sexes at the same rate, although some sex-specific differences in various symptoms have also been reported (11-14). The pathophysiology for the occurrence of these OAB symptoms in BPH patients has been explained by the interplay between bladder outlet obstruction (BOO) caused by prostatic enlargement, primary bladder dysfunction such as detrusor overactivity (DO) or impaired contractility, or a contribution of both factors (15). This hypothesis can be further confirmed by the documented strong association between OAB and BOO and the increased symptoms severity and less favorable outcomes reported when both factors coexist (15). OAB has two types: dry and wet. The wet type is strongly associated with the urodynamic finding of DO (16, 17).

Based on the above, the American Urological Association (AUA) has developed the International Prostate Symptom Score (IPSS) as a reliable method to evaluate the severity of

BPH-associated LUTS and to help urologists in determining the most appropriate treatment option for BPH (18).

Although the treatment of OAB is mainly pharmacological, BPH is managed in a stepwise manner depending on the severity of symptoms, presence of urinary retention, patient preferences, and presence of other comorbidities. Management of BPH usually starts with conservative management and lifestyle modification in mild cases and continues through a trial of pharmacological therapy in non-responding cases to end with surgical interventions in patients with complicated obstructive symptoms and in refractory cases with severe symptoms not responding to conservative and pharmacological therapy (19-21).

Currently, Transurethral Resection of the Prostate (TURP) and laser therapies are the most frequently uses surgical modalities for management of BPH due to their lower complication rates as compared to open prostatectomy (22-24).

We performed our study with the aim to compare the effectiveness and safety of TURP, Holmium Laser Enucleation of the Prostate (HoLEP), and Photoselective Vaporization of the Prostate (PVP) in management of storage and OAB symptoms complicating BPH in patients with moderately enlarged prostates.

METHODS

After approval by the Institutional Review Board at the University of Cincinnati (IRB ID:2020-0504), we started reviewing the charts of all patients who underwent TURP, HoLEP, and PVP at University of Cincinnati hospitals in the period between March 2012 and December 2020. All patients had routine initial evaluation with complete medical history, digital rectal examination (DRE), IPSS questionnaire, urinalysis, serum creatinine level, determination of serum prostate-specific antigen (PSA) when needed, transrectal ultrasonography (TRUS), peak flow rate (Qmax), post-void residual (PVR), and urodynamic study (UDS) before proceeding to any surgical intervention. Prostate volume was measured using TRUS and calculated using a conventional formula (length * width* height * $\pi/6$).

Inclusion criteria included a diagnosis of BPH with a moderately enlarged prostate (40-80 mL) complicated by BOO and storage or OAB symptoms. All patients had transrectal ultrasonographic evidence of BPH with prostate volumes of ≥25 ml (25). The BOO was defined as BOO index >40 using ICS nomogram (26). Predominance of storage or OAB symptoms was confirmed both subjectively and objectively. Subjective parameters included patient complaints of urgency (sudden compelling desire to void, which is difficult to defer), urinary frequency (micturition ≥ 8/24 hours), nocturia (1 or more experience/night), and urgency urinary incontinence (sudden strong urge to micturate followed by involuntary leakage of urine). Analysis of symptoms was performed by the attending physician at the patient's first presentation via asking the patient an open-ended question about the patient's main complaint that urged him to seek medical care followed by closed-ended or binary questions to confirm the absence of the other relevant symptoms. On the other hand, objective parameters included

volume to first contraction less than 350 mL and demonstration of DO (Involuntary detrusor contraction ≥ 10 cm H2O) on UDS (27).

Patients with previous prostatic or urethral surgery, bladder stones, bladder diverticulum, urinary retention, pelvic radiotherapy, recurrent urinary tract infections (UTI), history of urethral stricture, uncontrolled diabetes mellitus (HbA1c > 7), stroke (recent event or sequelae), parkinsonism, previous spinal or pelvic surgery, PVR ≥ 150 ml, and on medications that may mimic or aggravate the LUTS such as antidepressants, diuretics, bronchodilators, anticholinergics, sympathomimetics, and antihistamines (28) were excluded. In cases of suspected prostate cancer by DRE, TRUS or elevated serum PSA level, TRUS-guided biopsies were taken, and patients with cancer were also excluded.

Four surgeons performed standardized TURP, HoLEP, and PVP techniques on the study participants. The choice of the type of surgery was based on the decision of the multi-disciplinary team (MDT) taking into consideration the anatomy of the prostate, the treating surgeon's initial assessment, and the individual patient's preference after discussing the different treatment options with the patients.

Treatment efficacy, which was the primary outcome, was evaluated by comparing the preoperative UDS parameters, patient symptomatology, and IPSS with their postoperative counterparts. Patient storage symptomatology (frequency, urgency, nocturia, and urgency urinary incontinence) and IPSS were reported at baseline, 3-month, and 6-month postoperatively. We collected, analyzed, and compared them among the three groups. Qmax, PVR, and demonstration of DO were reported twice: at baseline and at the 6-month follow-up visit. We also collected and compared them among the three groups. For the secondary outcome (treatment safety), any reported complication within the first 6 postoperative months was collected and analyzed. We also collected, analyzed, and compared the postoperative need for anticholinergic or procedure (Botox injection or urethral dilatation) within the first six postoperative months among the three groups.

Statistical analysis

All statistical analyses were conducted using the SPSS software (SPSS, Inc., Chicago, IL, USA; version 26). Quantitative variables are presented as means ± standard deviation, and qualitative variables are expressed as frequencies with percentages. Results were compared between two groups using Student's *t*-test and Mann-Whitney U test for quantitative variables and chi-square test and McNemar's test for qualitative variables. A P-value of < 0.05 was considered significant.

RESULTS

Of 523 patients, a total of 204 patients met the inclusion criteria, had complete follow-up data in their charts with preoperative and postoperative documentation of various storage symptomatology, IPSS and UDS parameters, and were included in the study. Patients were divided into three groups based on the surgical intervention they underwent: Group 1 included

patients who underwent TURP (89 patients), group 2 included patients who underwent HoLEP (64 patients), and group 3 included patients who underwent PVP (51 patients).

There were no differences between the three groups regarding demographic and baseline characteristics (Table 1). Notably, all patients demonstrated DO on baseline UDS. There was a significant improvement in the objective outcome parameters represented by Qmax, PVR, and presence of DO on UDS from baseline to 6 months postoperatively in each of the three studied groups at p-value of <0.001. There was also significant improvement in the subjective parameters of IPSS, frequency, urgency, nocturia, and urinary incontinence from baseline to both 3- and 6- months postoperatively in each of the three studied groups (Table 2).

Although there was significant improvement in UDS parameters from baseline to 6-month postoperatively in the three groups, significantly larger number of patients in the PVP group (88.24%) demonstrated resolution of preoperative DO than in the TURP (66.29%) and HoLEP (68.75%) groups at p-values of 0.004 and 0.013, respectively. Coincidingly, the decrease in the IPSS was more significant in the PVP group than in both the TURP and HoLEP groups at the 3-month (p-values of 0.007 and 0.029, respectively) and 6- month (p-values of 0.003 and 0.023, respectively) follow-up visits. There was also a more significant reduction in the complaint of urgency in the PVP group than in the TURP and HoLEP groups at the 3-month follow-up visit (P-values of 0.007 and 0.036, respectively). Interestingly, frequency was the symptom that improved the most in the three groups at the 3-month follow-up visits, while nocturia was the symptom that improved the most in the three groups at the 6-month follow-up visits (Table 3).

Additionally, we reported procedure complications and postoperative need for anticholinergic or secondary procedure. UTI was the most frequently encountered complication occurring in 26 patients (12.74%) out of the 204 patients included in the study followed by urinary incontinence, bleeding, and lastly urethral stricture. There was no significant difference among the three groups in the complication rate or the postoperative need for anticholinergic or secondary procedure within the first six postoperative months (Table 4).

DISCUSSION

To the best of our knowledge, we performed the first large study comparing the outcomes of TURP, HoLEP, and PVP in BPH patients with moderately enlarged prostates and storage or OAB symptoms using objective parameters (Qmax, PVR, and demonstration of DO on UDS), subjective parameters (storage symptomatology and IPSS), procedure complication rate, and postoperative need for anticholinergic or secondary procedure. Although there was more significant improvement in IPSS, urgency, and presence of postoperative DO in the PVP group, the efficacy of both TURP and HoLEP in management of BPH patients with storage or OAB symptoms was still confirmed based on two observations. First, the more significant improvement in the previously mentioned parameters in the PVP group can be explained by the already lower, although non-significantly, preoperative IPSS in the PVP group than in the TURP

and HoLEP groups. Second, there was already significant improvement in all studied parameters from preoperatively to both 3- and 6-months postoperatively in each of the three group.

Many studies investigated the prevalence of LUTS and demonstrated many variations in LUTS prevalence which were always attributed to different study population, geographical, ethnical, age, and gender considerations (29). The EPIC (**E**uropean **P**rospective **I**nvestigation into **C**ancer and **N**utrition) study is one of the largest studies which investigated the issue, and it reported 11.8% prevalence of LUTS in 19,165 individuals studied in 4 different European countries. It also demonstrated that the prevalence of LUTS increases linearly with age and that the addition of OAB to BPH in aging men exaggerates the severity of symptoms and adds many challengers to the treatment plan (30).

Although the management of OAB is determined based on the severity of symptoms, the presence of associated medical conditions, and the presence of BOO with its concomitant PVR values, the coexistence of BPH plays the leading role in determining the appropriate management approach (31).

In our study, TURP, HoLEP, and PVP were associated with significant improvement in Qmax, DO, PVR, IPSS and storage or OAB symptoms. Similarly, Ruszat et al, 2008 investigated the efficacy of PVP in management of BPH-associated LUTS and demonstrated that PVP is associated with significant improvement in both subjective and objective outcomes beside having an equivalent complication rate to that of TURP (32). Also, Rigatti et al, 2006 demonstrated that HoLEP and TURP have comparable efficacy with regards to improvement in Qmax and IPSS (33) coinciding with our findings. In agreement with our results, Hu et al 2016 reported significant reduction in Qmax, IPSS, and OAB symptoms in patients who underwent TURP using plasmakinetic system (transurethral plasmakinetic resection of the prostate) (34).

Our study confirms that TURP, HoLEP, and PVP are associated with significant improvement in urodynamics study (UDS) parameters, patient storage and OAB symptomatology, and IPSS from preoperatively to both 3- and 6- months postoperatively in BPH patients with moderately enlarged prostates with relatively low procedure complication rate and postoperative need for either anticholinergic or procedure.

Limitations

The retrospective nature of the study and the lack of 12-month follow-up data are limitations to our study. Although the improvement in patient preoperative symptomatology and UDS parameters was already significant at both 3- and 6-month follow-up, we would have preferred to have 12-month follow-up time frame.

Other limitations to the study include the possibility of selection bias, possible incomplete data from retrospective charts, and the subjective definitions of storage symptoms.

CONCLUSIONS

TURP, HoLEP, and PVP are effective and reliable surgical procedures that can be relied on for BPH patients with moderately enlarged prostates and storage or OAB symptoms with comparable efficacy and relatively low procedure complication rate and postoperative need for anticholinergic or procedure.

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Figures and Tables

Table 1. Demographic and baseline characteristics of the three groups				
Variables	**TURP (n=89)**	**HoLEP (n=64)**	**PVP (n=51)**	**p**
Age (years) (mean±SD)	75.21±5.47	74.88±5.53	74.35±5.01	TURP vs. HoLEP: 0.691 TURP vs. PVP: 0.372 HoLEP vs. PVP: 0.635
Prostate volume (mL) (mean±SD)	67.53±12.18	67.81±11.88	67.84±12.22	TURP vs. HoLEP: 0.923 TURP vs. PVP: 0.871 HoLEP vs. PVP: 0.944
Prior medications, n (%)	89 (100%)	64 (100%)	51 (100%)	
α-blocker + antimuscarinic, n (%)	45 (50.56%)	29 (45.31%)	24 (47.06%)	TURP vs. HoLEP: 0.522 TURP vs. PVP: 0.690 HoLEP vs. PVP: 0.852
α-blocker, n (%)	25 (28.09%)	23 (35.94%)	16 (31.37%)	TURP vs. HoLEP: 0.302 TURP vs. PVP: 0.681 HoLEP vs. PVP: 0.607
α-blocker+5α-reductase, n (%)	19 (21.35%)	12 (18.75%)	11 (21.57%)	TURP vs. HoLEP: 0.693 TURP vs. PVP: 0.976 HoLEP vs. PVP: 0.707
Peak flow rate (Qmax) (mL/s) (mean±SD)	12.01±1.72	12.09±1.62	11.43±1.85	TURP vs. HoLEP: 0.892 TURP vs. PVP: 0.066 HoLEP vs. PVP: 0.054
Postvoiding residual urine (PVR) (mL) (mean±SD)	105.73±22.43	104.69±22.57	100±22.78	TURP vs. HoLEP: 0.782 TURP vs. PVP: 0.163 HoLEP vs. PVP: 0.284
Maximum cystometric capacity (MCC) (mL) (mean±SD)	221.91±29.23	221.25±22.50	228.82±27.25	TURP vs. HoLEP: 0.817 TURP vs. PVP: 0.162 HoLEP vs. PVP: 0.072
Voiding detrusor pressure at Qmax (Pdet@Qmax) (cmH_2O) (mean±SD)	76.42±6.95	77.14±6.58	77.27±6.76	TURP vs. HoLEP: 0.464 TURP vs. PVP: 0.475 HoLEP vs. PVP: 0.933
Bladder outlet obstruction index (BOOI) (mean±SD)	52.39±8	52.95±7.06	54.41±7.24	TURP vs. HoLEP: 0.662 TURP vs. PVP: 0.121 HoLEP vs. PVP: 0.190
International Prostate Symptom Score (IPSS) (mean±SD)	26.87±3.05	26.91±2.99	26.59±2.33	TURP vs. HoLEP: 0.940 TURP vs. PVP: 0.550 HoLEP vs. PVP: 0.505
Frequency, n (%)	75 (84.27%)	54 (84.38%)	42 (82.35%)	TURP vs. HoLEP: 0.986 TURP vs. PVP: 0.768 HoLEP vs. PVP: 0.772
Urgency, n (%)	66 (74.16%)	48 (75%)	39 (76.47%)	TURP vs. HoLEP: 0.906 TURP vs. PVP: 0.761 HoLEP vs. PVP: 0.855

Nocturia, n (%)	72 (80.90%)	52 (81.25%)	42 (82.35%)	TURP vs. HoLEP: 0.956 TURP vs. PVP: 0.831 HoLEP vs. PVP: 0.879
Urinary incontinence, n (%)	27 (30.34%)	26 (40.63%)	17 (33.33%)	TURP vs. HoLEP: 0.187 TURP vs. PVP: 0.713 HoLEP vs. PVP: 0.422

HoLEP: holmium laser enucleation of prostate; PVP: photoselective vaporization of prostate; TURP: transurethral resection of prostate.

Table 2. Changes in objective and subjective parameters at months 3 and 6 in each of the three groups and comparison with baseline

	Variables	Baseline	3 months	6 months	p	
					3 months	6 months
TURP (n=89)	Qmax (mL/s) (mean±SD)	12.01±1.72	–	15.55±1.65	–	**<0.001**
	PVR (mL) (mean±SD)	105.73±22.43	–	48.71±15.46	–	**<0.001**
	DO, n (%)	89 (100%)	–	30 (33.70%)	–	**<0.001**
	IPSS (mean±SD)	26.87±3.05	18.45±4.42	10.63±5.18	**<0.001**	**<0.001**
	Frequency, n (%)	75 (84.27%)	35 (39.33%)	24 (26.97%)	**<0.001**	**<0.001**
	Urgency, n (%)	66 (74.16%)	44 (49.44%)	14 (15.73%)	**<0.001**	**<0.001**
	Nocturia, n (%)	72 (80.90%)	36 (40.45%)	9 (10.11%)	**<0.001**	**<0.001**
	Urinary incontinence, n (%)	27 (30.34%)	11 (12.36%)	4 (4.49%)	**<0.001**	**<0.001**
HoLEP (n=64)	Qmax (mL/s) (mean±SD)	12.09±1.62	–	15.63±1.65	–	**<0.001**
	PVR (mL) (mean±SD)	104.69±22.57	–	48.28±15.26	–	**<0.001**
	DO, n (%)	64 (100%)	–	20 (31.25%)	–	**<0.001**
	IPSS (mean±SD)	26.91±2.99	18.28±4.34	10.31±5.14	**<0.001**	**<0.001**
	Frequency, n (%)	54 (84.38%)	24 (37.50%)	16 (25%)	**<0.001**	**<0.001**
	Urgency, n (%)	48 (75%)	30 (46.88%)	10 (15.63%)	**0.001**	**<0.001**
	Nocturia, n (%)	52 (81.25%)	26 (40.63%)	6 (9.38%)	**<0.001**	**<0.001**
	Urinary incontinence, n (%)	26 (40.63%)	13 (20.31%)	7 (10.94%)	**0.0016**	**<0.001**
PVP (n=51)	Qmax (mL/s) (mean±SD)	11.43±1.85	–	15.53±1.67	–	**<0.001**
	PVR (mL) (mean±SD)	100±22.78	–	47.06±14.29	–	**<0.001**
	DO n (%)	51 (100%)	–	6 (11.76%)	–	**<0.001**
	IPSS (mean±SD)	26.59±2.33	16.59±3.02	7.94±2.53	**<0.001**	**<0.001**
	Frequency, n (%)	42 (82.35%)	12 (23.53%)	6 (11.76%)	**<0.001**	**<0.001**
	Urgency, n (%)	39 (76.47%)	15 (29.41%)	9 (17.65%)	**<0.001**	**<0.001**
	Nocturia, n (%)	42 (82.35%)	18 (35.29%)	6 (11.76%)	**<0.001**	**<0.001**
	Urinary incontinence, n (%)	17 (33.33%)	8 (15.69%)	3 (5.88%)	**0.0389**	**<0.001**

DO: detrusor overactivity; HoLEP: holmium laser enucleation of prostate; IPSS: International Prostate Symptom Score; PVP: photoselective vaporization of prostate; PVR: postvoid residual; Qmax: peak flow rate; TURP: transurethral resection of prostate.

Table 3, Comparison of change in objective and subjective parameters at months 3 and 6 among the three groups								
Variables	**TURP (n=89)**		**HoLEP (n=64)**		**PVP (n=51)**		**p**	
	3 months	**6 months**	**3 months**	**6 months**	**3 months**	**6 months**	**3 months**	**6 months**
Increase in Qmax (mL/s) (mean±SD)		3.54±1.63		3.53±1.89		4.10±2.14		TURP vs. HoLEP: 0.736 TURP vs. PVP: 0.160 HoLEP vs. PVP: 0.169
Decrease in PVR (mL) (mean±SD)		57.02±24.84		56.41±24.86		52.94±25.52		TURP vs. HoLEP: 0.899 TURP vs. PVP: 0.455 HoLEP vs. PVP: 0.574
Decrease in DO, n (%)		59 (66.29%)		44 (68.75%)		45 (88.24%)		TURP vs. HoLEP: 0.749 TURP vs. PVP: 0.004 HoLEP vs. PVP: 0.013
Decrease in IPSS (mean±SD)	8.42±3.32	16.24±4.59	8.63±3.40	16.59±4.65	10±3.32	18.65±3.46	TURP vs. HoLEP: 0.704 TURP vs. PVP: 0.007 HoLEP vs. PVP: 0.029	TURP vs. HoLEP: 0.621 TURP vs. PVP: 0.003 HoLEP vs. PVP: 0.023
Decrease in frequency, n (%)	40 (44.94%)	51 (57.30%)	30 (46.88%)	38 (59.38%)	30 (58.82%)	36 (70.59%)	TURP vs. HoLEP: 0.813 TURP vs. PVP: 0.114 HoLEP vs. PVP: 0.203	TURP vs. HoLEP: 0.798 TURP vs. PVP: 0.119 HoLEP vs. PVP: 0.212
Decrease in urgency, n (%)	22 (24.72%)	52 (58.42%)	18 (28.13%)	38 (59.38%)	24 (47.06%)	30 (58.82%)	TURP vs. HoLEP: 0.636 TURP vs. PVP: 0.007 HoLEP vs. PVP: 0.036	TURP vs. HoLEP: 0.906 TURP vs. PVP: 0.863 HoLEP vs. PVP: 0.952
Decrease in nocturia, n (%)	36 (40.45%)	63 (70.79%)	26 (40.63%)	46 (71.88%)	24 (47.06%)	36 (70.59%)	TURP vs. HoLEP: 0.983 TURP vs. PVP: 0.447 HoLEP vs. PVP; 0.489	TURP vs. HoLEP: 0.883 TURP vs. PVP: 0.980 HoLEP vs. PVP: 0.880
Decrease in urinary incontinence, n (%)	16 (17.98%)	23 (25.84%)	13 (20.31%)	19 (29.69%)	9 (17.65%)	14 (27.45%)	TURP vs. HoLEP: 0.716 TURP vs. PVP: 0.961 HoLEP vs. PVP: 0.718	TURP vs. HoLEP: 0.599 TURP vs. PVP: 0.835 HoLEP vs. PVP: 0.792

DO: detrusor overactivity; HoLEP: holmium laser enucleation of prostate; IPSS: International Prostate Symptom Score; PVP: photoselective vaporization of prostate; PVR: postvoid residual; Qmax: peak flow rate, TURP: transurethral resection of prostate.

Table 4. Comparison of procedure complication rate and postoperative need for anticholinergic or procedure within the first 6 postoperative months among the three groups				
	TURP (n=89)	**HoLEP (n=64)**	**PVP (n=51)**	**p**
Bleeding, n (%)	7 (7.9%)	4 (6.3%)	3 (5.9%)	TURP vs HoLEP: 0.703 TURP vs PVP: 0.661 HoLEP vs PVP: 0.025
Urinary tract infection, n (%)	14 (15.7%)	6 (9.4%)	6 (11.8%)	TURP vs HoLEP: 0.250 TURP vs PVP: 0.519 HoLEP vs PVP: 0.667
Urinary incontinence, n (%)	4 (4.5%)	7 (10.9%)	3 (5.9%)	TURP vs HoLEP: 0.128 TURP vs PVP: 0.717 HoLEP vs PVP: 0.339
Urethral stricture, n (%)	6 (6.7%)	3 (4.7%)	1 (2%)	TURP vs HoLEP: 0.594 TURP vs PVP: 0.212 HoLEP vs PVP: 0.428
Postoperative need for anticholinergic, n (%)	14 (15.7%)	6 (9.4%)	7 (13.7%)	TURP vs HoLEP: 0.250 TURP vs PVP: 0.749 HoLEP vs PVP: 0.464
Postoperative need for secondary procedure, n (%)	14 (15.7%)	8 (12.5%)	3 (5.9%)	TURP vs HoLEP: 0.574 TURP vs PVP: 0.086 HoLEP vs PVP: 0.231
Botox injection, n (%)	8 (9%)	5 (7.8%)	2 (3.9%)	TURP vs HoLEP: 0.797 TURP vs PVP: 0.263 HoLEP vs PVP: 0.386
Urethral dilatation, n (%)	6 (6.7%)	3 (4.7%)	1 (2%)	TURP vs HoLEP: 0.594 TURP vs PVP: 0.212 HoLEP vs PVP: 0.428

HoLEP: holmium laser enucleation of prostate; PVP: photoselective vaporization of prostate; TURP: transurethral resection of prostate.